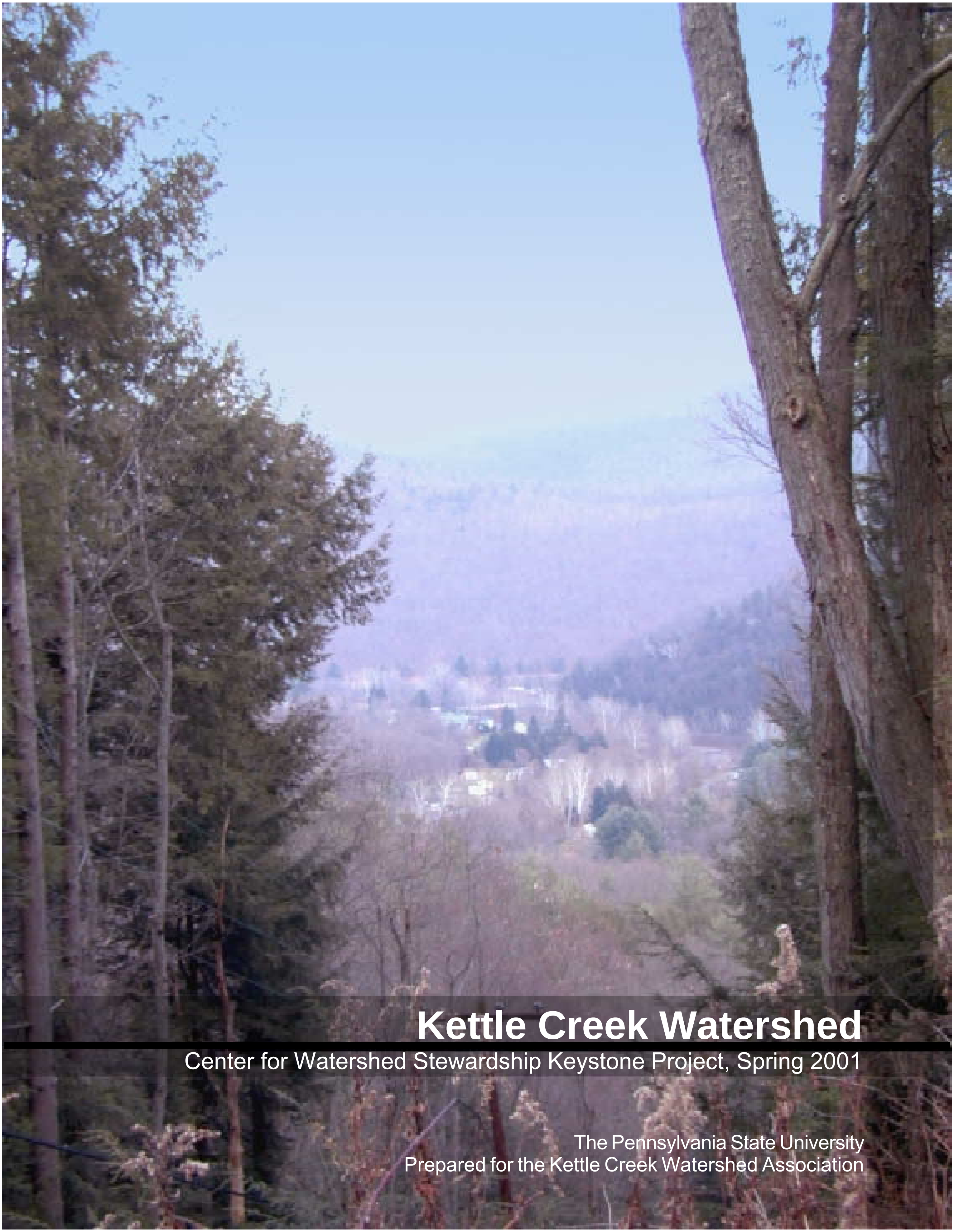

Kettle Creek Watershed

Center for Watershed Stewardship Keystone Project, Spring 2001

The Pennsylvania State University
Prepared for the Kettle Creek Watershed Association

Kettle Creek Watershed

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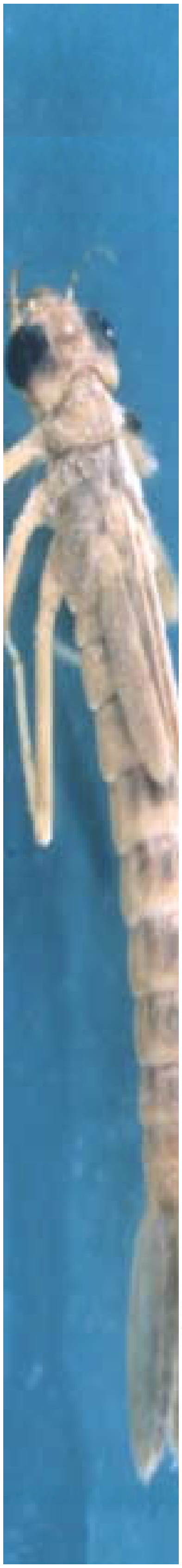
TABLE OF
CONTENTS

Landuse

Water Quality

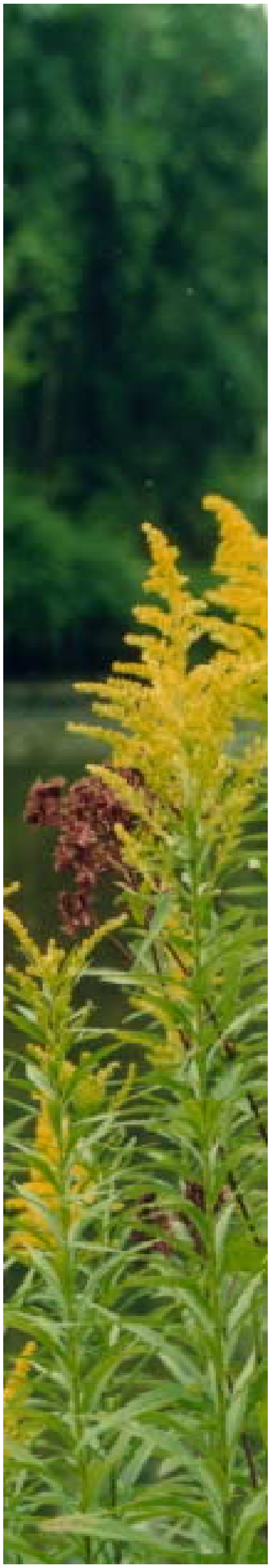
RECOMMENDATIONS

APPENDICES



LIST OF FIGURES

Chapter 5 - Water Quality



INTRODUCTION

The Kettle Creek Watershed Stewardship document which follows is a product of a two-semester "Keystone Project" practicum carried out by a team of graduate students enrolled in the Watershed Stewardship Option offered within five degree-granting programs at The Pennsylvania State University, University Park Campus. Keystone Projects are designed to provide an enhanced educational experience for students focused on water resources by engaging them in a case problem analysis of a Pennsylvania watershed. Most importantly, Keystone Projects are conducted in close collaboration with a community-based sponsor and its network of cooperating agencies, individuals, and organizations concerned with the long-term environmental protection, socio-economic vitality, and quality of life of the study watershed.

Kettle Creek was selected from 22 candidate projects as the 2000/2001 Keystone Project based on a joint proposal of the Kettle Creek Watershed Association (KCWA) and Trout Unlimited (TU) through the "Home Rivers Initiative". The Home Rivers Initiative is a national program designed to promote scientifically-grounded, watershed scale conservation on important coldwater rivers and to serve as a catalyst for the establishment of sustainable, locally-led watershed organizations.

The KCWA/TU proposal set forth several primary elements and objectives of a Keystone Project, summarized below.

* Perform a comprehensive watershed assessment and analysis with emphasis on: fisheries resources, aquatic ecology, and stream habitat conditions; cultural and historical attributes of the watershed and; non-point source impacts on water quality focused on thermal regimes, sedimentation problems, and impairment by abandoned mine drainage.

* Create a Geographic Information System (GIS) database of assessment information and analyses performed by the student team on selected topics such as riparian canopy coverage of major tributaries, and sediment production potential from dirt and gravel roads in critical subwatersheds.

* Produce a Watershed Stewardship Plan of management strategies and actions recommended for implementation by KCWA and its partners to achieve environmental quality and resource conservation goals and to build a strong foundation of community support and participation.

* Provide graphic images and text on a variety of topics addressed in the Watershed Stewardship Plan to facilitate KCWA's Education and Outreach activities via web-based and printed documents, workshops, and other media.

On August 22, 2000, a Student Technical Experience in Problem Solving (STEPS) Memorandum of Agreement was executed between KCWA and the Center for Watershed Stewardship (CWS) at Penn State. The STEPS agreement acknowledged that the academic goal to "...support the education and training of students" was paramount in the conduct of the Keystone Project. Consistent with the University's service mission to citizens and communities of the Commonwealth, the project was to be accomplished pro bono through pre-professional services of students and the commitment of CWS faculty time, University equipment, facilities, and other resources in furtherance of KCWA's efforts in the public interest. The STEPS agreement specified the working arrangement between KCWA and CWS and details of the project scope, sponsor support and reimbursement of certain direct costs, timetable, benchmarks of progress, and project outcomes.

The overarching objective of the Kettle Creek Keystone Project was to provide KCWA with a framework to enable the organization to advance integrated, sustainable initiatives to achieve its mission to "enhance, preserve, monitor, and protect the Kettle Creek watershed." The report submitted herein is offered as a vehicle to fulfill that objective.

Authorship of the document's component parts was assigned to individual team members according to their disciplinary background, prior experience, and relevance of a particular topic or area of inquiry to their graduate research interests and professional career goals. The document is a team product, completed through the collaboration of individuals. Latitude is given by the course instructors to accommodate differences in writing style, syntax, and modes of communication appropriate to the diverse subject matter. Narrative, anecdotal description enlivens Kettle Creek's rich cultural history while quantitative, scientific terminology better suits the presentation of water quality assessment data, for instance. We are mindful, too, of the intended audience and purpose to communicate material of a technical nature in the most straightforward and understandable way possible.

The Kettle Creek Keystone Project team was comprised of the graduate students and CWS faculty listed below (principal areas of responsibility are noted for each):

Michelle Brummer
Master's degree, Landscape Architecture
(Cultural history, visual corridor analysis, watershed identity, education and outreach tools)

Angela Happel
Master's degree, Forest Resources
(Thermal impacts, habitat assessment, water quality, acidic deposition)

Zach Henderson
Master's degree, Forest Resources
(Sedimentation sources, non-point source management, water quality)

Leslie Leckvarcik
Master's degree, Wildlife and Fisheries Science
(Fisheries management anthology, habitat assessment)

Brian Lee
Ph.D. in Forest Resources
(Riparian canopy assessment, GIS database, community capacity)

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(Visual corridor analysis, recreation, wild & scenic river analysis)

Sandeep Walia
Master's degree, Landscape Architecture
(Cultural history, land use)

Jim Walker
Master's degree, Ecology
(Wetlands, wildlife, water resources, acid mine drainage)

Leah Wasser
Master's degree, Landscape Architecture
(Social analysis, land use, community infrastructure, coordination of report production)

Lysle S. Sherwin, Director, CWS

Charles Andrew Cole, Ph.D., Associate Director, CWS

ACKNOWLEDGEMENTS

The Kettle Creek Keystone Project would not have been possible without the cooperation of many people and organizations. We want to thank Kettle Creek Watershed Association and National Trout Unlimited for giving us the opportunity to help their work on a truly "exceptional value " watershed. Amy G. Gottesfeld, Kettle Creek coordinator, initiated the process (and she was our primary liaison on all aspects throughout the project) in close cooperation with Joseph M. McGurrin, director of resources, TU National Office. Kettle Creek Watershed Association officers and directors were instrumental in organizing and conducting the project: John Larson (president); Dick Sodergren (vice president and chair, fish habitat advisory committee); Karen Labant (secretary); and Mary Hirst (membership chair).

David Flack at Quiet Oaks Campground hosted our initial overnight field trip that included "first ever" black bear and elk close encounters for many members of the team. From the onset, Pennsylvania Bureau of Forestry staff provided a wealth of GIS and other data: thanks to Dr. James Grace, Butch Davy, Tom Wallace, Greg McPherson and Mac Waskiewicz. Mary Herrold, Bureau of State Parks, shared considerable information on the region's cultural history and recreational resources. Arlene Hoffmann, Clinton County History Society, and Bob Currin, Potter County Historical Society, provided much of the historical documentation.

Water resources expertise on a wide range of subjects and information in many forms came from these sources: Bruce Hollender and Rick Spear, PA Fish and Boat Commission; David Putnam, U.S. Fish and Wildlife Service; Tony Shaw and Mike Klimkos, PA Department of Environmental Protection; John Nance, U.S. Geologic Service; Mike Moore, PA Geological Survey; and Stan Brua, U.S. Army Corps of Engineers. Kevin Abbey, Steve Blosser, and Woody Colbert, PA Dirt and Gravel Road Program, and Sandy Thompson, Potter County Conservation District, assisted greatly on the important issue of road-generated sediment impacts to Kettle tributaries.

Personal discussions with township supervisors were most helpful to understand their perspectives on how rural municipalities relate to watershed stewardship goals. From Potter County, Robert Fowler, West Branch Township chairman, Martin Godra, Stewardson Township chairman, and James Weaver, Wharton Township, were interviewed as was Ed Berry from Leidy Township, Clinton County.

Tim Holladay and James Watson of Clinton County Planning gave us planning documents, GIS data and personal interviews; Karl Lang, Potter County planner, did likewise for the upper watershed. Kierstin Carlson, Western Pennsylvania Conservancy, conducted a Pennsylvania Natural Diversity Inventory (PNDI) search and Dennis Dusza, PA Game Commission, supplied information on wildlife resources and management.

We are especially grateful to the KCWA members and residents of the watershed who participated in the "Tell Us About Your Watershed" conversations with the team in November and our April 26 presentation to the community, both held at Kettle Creek Hose Company in Cross Fork. Participants at one or both events (not including people already mentioned) were Dennis Barner, Lisa Wertz, Dale Van Sickle, Jack Bruro, William Duynam, Ray Gyurina, Dave and Sharon McIntyre, Carol Camm, Edie Sodergren, Garland Gingerich, and Al Lyons.

The Kettle Creek Keystone Project also received assistance from faculty, colleagues, and other graduate students at Penn State. Landscape Architecture (LARCH) faculty Dan Jones and Tom Yahner advised on the visual corridor analysis. LARCH faculty Sam Dennis, Dan Nadenicek, Madis Philak, Ken Tamminga, and Tom Yahner served on committees for independent research by four students related to Kettle Creek. Neil Kelley, computer network support specialist, aided in the production of large format posters for the community presentation and KCWA's educational programming.

School of Forest Resources (SFR) faculty Dr. Robert Carline, Dr. David DeWalle, and Dr. William Sharpe and Bryan Swistock, extension associate, advised team members in the HOBO thermal assessment work, acidic deposition, and biotic indices as did SFR graduate students Anthony Buda and Susan LeFevre. Dr. Wayne Myers, Joseph Bishop and Jeff Grimm at SFR provided GAP analysis, acid deposition and habitat data. Barry Evans, Environmental Resources Research Institute, provided training to the team on the AVGWLF watershed model he

helped developed, as well as the Kettle Creek information.

It is our sincere hope that the end result of this collaboration will serve to protect and improve Kettle Creek for present and future generations who are fortunate to live, work, and recreate in an extraordinary watershed.

Kettle Creek Keystone Project Team

University Park, Pennsylvania

May 4, 2001

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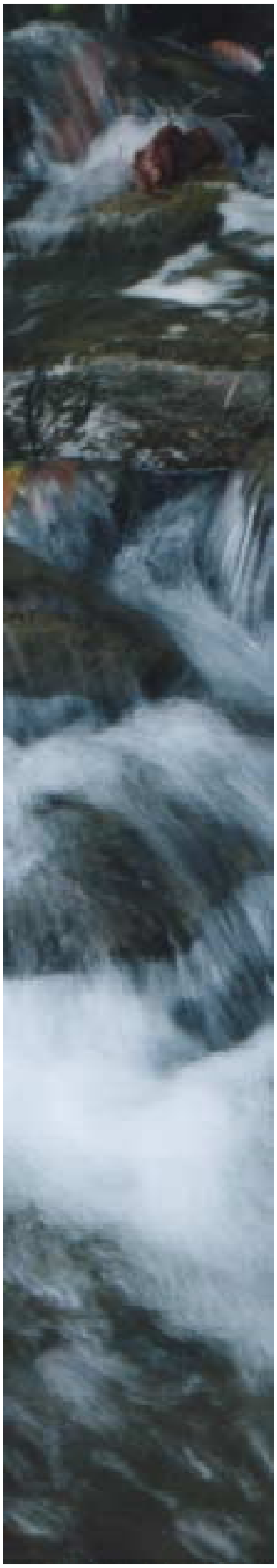


EXECUTIVE SUMMARY

A. Project Background

This document is the result of a two-semester graduate student "Keystone Project" carried out through the Center for Watershed Stewardship at the Pennsylvania State University. Keystone Projects are experiential learning opportunities that allow graduate students to work in close collaboration with community-based sponsors, agencies, and individuals concerned with the environmental and socio-economic issues of a particular Pennsylvania watershed. Eleven graduate students, from five academic programs at Penn State, participated in this effort.

The Kettle Creek Watershed Association (KCWA), in conjunction with Trout Unlimited, sponsored this year-long assessment of the Kettle Creek watershed. The objectives were to perform a comprehensive watershed assessment, create a GIS database of the assessment information, produce a watershed management plan, and provide materials to assist the KCWA in its education and outreach activities. What follows is a summary of the assessment and the management recommendations for the Kettle Creek watershed.

B. Assessment

Physical Setting

Kettle Creek is located in the mountainous, north central region of Pennsylvania. The watershed terrain varies from rolling to extremely rugged in the deep, dissected tributary valleys. The geology of the region has led to coal and gas extraction activities over the past century. There are more than 400 miles of streams in the watershed, from several tributaries that are sizable in their own right, including Cross Fork Creek and Hammersley Fork, to very small tributaries, such as Walters Run. On occasion, flooding of Kettle Creek's main stem has been a problem for floodplain residents. While the construction of the Alvin Bush Dam in the late 1950s, in the lower watershed, alleviated much of the flooding issues, its construction inundated the town of Leidy.

Cultural Setting

History. The Kettle Creek watershed was occupied by Native Americans for centuries prior to the arrival of European settlers. The Iroquois and Delaware tribes both claimed portions of the watershed. The watershed was blanketed in forests, dominated by hemlock, pine, oak, and chestnut and typical of what would become Pennsylvania. Wildlife was abundant, including elk and wolves. Europeans explored the region in the mid-1700s and early settlers periodically met resistance from the Native Americans. Several treaties "settled" the disputes and allowed Pennsylvania to sell large tracts of lands to settlers and resource speculators. The first known settler to make a claim on lands within the watershed did so in 1794. Others followed slowly, as access to and within the watershed was difficult at best. Early settlers were primarily farmers, but as they cleared timber off the land, sawmills began processing the wood commercially. This was the beginning of the first major extractive industry within the watershed. By the mid-1850s, lumbering was common throughout the Kettle Creek watershed.

Along with the increasing numbers of settlers came the development of villages and towns. One of the more famous attempts at planned settlement was the Norwegian colony backed by the world-famous violinist, Ole Bull. The lands he had purchased for the new colony were difficult to farm, and in fact, many of the sites colonists developed were located on reservations outlined in the deed. Though his effort failed, Bull was and is commemorated in the establishment of the Ole Bull State Park. In the northern parts of the watershed, German immigrants settled the area now known as Germania, an area still dominated by agriculture. Growth of towns in the lower watershed (e.g., Cross Fork) was spurred by timbering, some forming from what were supposed to be temporary logging camps (e.g., Hammersley Fork). Toward the end of the 1800s, timbering activity increased greatly as railroads made their way into the watershed, facilitating the transport of logs to mills and lumber to markets. By about 1910, most of the timber had been cut and timber companies moved on to other North American forests. What had been a booming industry collapsed quickly, leading to the mass exodus of residents from the watershed.

In the late 1800s, mining for coal began another large extractive industry within the watershed, particulary in the lower reaches. By the beginning of the 1900s, coal mining was leading the formation of new towns, such as Bitumen (just west of the watershed's western boundary). Ethnic groups, such as Slovaks, moved into the watershed, in search of readily available jobs in the mines. By the late 1920s as market prices fell, much of the deep mining was abandoned, leaving only surface mining operations. These, too, ceased in the 1970s, leaving only the legacy of unreclaimed lands and acid mine drainage to reveal mining story.

As the timber companies removed the valuable timber and left the watershed, they abandoned their lands to the state. The Commonwealth claimed the lands and set about trying to restore the forests and to protect and preserve the rivers and streams. As a result, the Commonwealth now owns about 92% of the watershed as state forests and state parks. The forest, while not pristine, has recovered considerably over the past century. The Civilian Conservation Corps (CCC) played a large role in restoration and protection efforts during the 1930s. State forests include the Susquehannock, Sproul, Tioga, and a small portion of the Elk. The Kettle Creek State Park and the Ole Bull State Park are located within the watershed.

Today the watershed is sparsely populated and predominantly under state management. The primary industries are forestry (through the state forests), recreation and limited agriculture. Kettle Creek is a renowned trout stream, and the landscape is a popular destination for hunting as well. Small businesses have grown to support those activities.

Demography. There are ten townships and four counties that cover the Kettle Creek watershed. Population numbers in the watershed peaked at the urn of the 20th century, concurrent with logging and mining industries. Populations levels within the watershed have remained relatively stable since the 1930s.

The watershed population is generally older, as younger age groups decline in numbers. Few of the landowners within the watershed are actually permanent residents (< 20%). Most seasonal residents live within Pennsylvania, generally near Lancaster and Philadelphia.

Economy. The historical industries of agriculture and forestry still maintain a presence within the watershed, although mining is past. There have been some manufacturing industries within the watershed, but these have generally left the region over the past decade. The region has, on occasion, suffered some of the highest unemployment rates in the Commonwealth. Most watershed residents are not employed within the watershed itself, traveling as much as 25 minutes to work sites. The Kettle Creek Watershed Association is mostly nonresident.

Recreation. Recreation plays a large role in the watershed, especially as 92% of the watershed is state-owned and offers public access to forest and park environements. Numerous forest and water-based recreational activities occur year round. Popular activities include fishing, camping, hunting, boating, snowmobiling, and ice fishing. The state forests and parks are well-connected with a large network of hiking trails. Many small businesses have arisen to support recreational activities, thus providing a significant part of the economic base for the watershed residents.

Visual Assessment. The Kettle Creek watershed is a beautiful landscape. It maintains the rural character so typical of the central portion of Pennsylvania. Vast expanses of forests intertwined with the various streams provide an aesthetic found in few other locations throughout the state. Historic buildings still abound and help to remind us of the history of the watershed. Winding roads lead through the variety of landscapes contained along Kettle Creek and its tributaries. The roads also help to remind us of the history of the watershed, as we move from Westport north to Germania.

Natural Setting

Landuse. Landuse reflects the interaction of people and the landscape within the watershed. Broad uses have been reflected in the cultural development of the Kettle Creek watershed through agriculture, forestry, and mining. The current rural nature of the watershed lends itself largely to forest cover, a mix of industry, recreation, and preservation. Most of the land (92%) is under public ownership, though much is available for forestry activities. There are areas of the state forest, such as the Hammersley Wild Area, that are considered to be noncommercial forests, with values other than the timber. The Ole Bull and Kettle Creek state parks, though relatively small in size, contribute to the protected and recreational nature of landuse in the watershed. There are a variety of significant and sensitive natural areas within the region. There are a number of ecologically important sites as classified by the Pennsylvania Natural Diversity Inventory (PNDI). These areas may be geologically unique features, rare habitats, or home for rare and endangered species of plants and animals.

Private lands contribute a small percentage (8%) of the area of the watershed, but are located in some of the more ecologically sensitive regions, such as floodplains. Any future development of private lands into resorts, for example, has the potential to negatively impact ecologically sensitive areas.

Agriculture occupies a small proportion of the watershed (0.3%), but a significant 15% of private land use. These areas are primarily in the upper watershed; thus any impacts from sediment or chemicals could potentially be distributed through the entire watershed. In addition, if these areas are developed for other uses, such as resorts, then potential water quality impacts could also be noticed far downstream.

Wetlands occupy a small percentage of the area of the watershed (<1%), but their loss could have serious negative impacts for the quality of the stream network. Small wetlands, scattered throughout the watershed, serve a variety of roles, from water quality purification to flood storage. Though small in area, their impact on the overall quality of the Kettle Creek watershed is large. A larger proportion of the wetlands (37%) are on private lands.

The watershed is criss-crossed with many dirt and gravel roads. These roads, if not designed and maintained properly, have the potential to deliver excess loads of sediment into the tributaries and main stem of Kettle Creek. Sediment deposition can seriously impair wild trout production as well as impact upon stocked fishes.

Fisheries. Trout fishing holds a special place in the history of the Kettle Creek watershed, as well as the lives of its current residents. Kettle Creek has long been known as a special place for trout fishing, as far back as President Grant. There has been a documented decline in the brook trout fishery over decades, probably due to the introduction of brown trout. There has been a general decline in the fishing for both species as a result of thermal problems within Kettle Creek and its tributaries. Trout need clear and cold water to thrive yet many regions within the watershed indicate warming of the streams due to such things as siltation or a loss of riparian cover. Kettle Creek is one of the more heavily stocked streams in Pennsylvania, both by the Commonwealth itself as well as by private groups. Thus, it is considered very important to residents and seasonal visitors alike to maintain and improve the conditions for native and stocked trout within the watershed.

Habitat Assessment. Many groups have assessed stream habitat in the watershed over the years, using several different approaches. Most of the stream parameters measured are considered to be good, with the exception of areas where there were problems with substrate, sediment deposition, channel flow, bank cover, and the width of the riparian zone. It is important to have all tributaries assessed using a standard protocol such that regions can be compared.

Terrestrial Wildlife. Most of Pennsylvania's native wildlife species can be found throughout the Kettle Creek watershed. Notable species include restored populations of elk, river otter, and fisher. Almost 300 species of wildlife could be found within the watershed based on habitat opportunities. Highest species diversity appears to be along the riparian corridors. There are no State Games Lands within the watershed, although hunting is allowed in most of the state forest lands.

Water Quality. Water quality within the watershed is quite good, with the exception of areas in the lower watershed affected by acid mine drainage. All waters above the Alvin Bush dam are classified as Exceptional Value (EV) by the Pennsylvania's Department of Environmental Protection. This is reflected in the lack of problems noted by numerous water quality studies conducted over the years. Occasional problems have been found, but the water quality is good. Where AMD impacts are found, there are obvious problems with acidity and pH, aluminum, iron, and manganese.

One means of assessing water quality is to see what lives in the water. Macroinvertebrates are small organisms that indicate water quality conditions. For example, only certain organisms can live in very polluted water. Concurrent with chemical data, analysis of the macro-invertebrates shows the water quality in much of the watershed to be good. There are fair macro populations in some areas throughout the watershed. Populations drastically decline below the Alvin Bush Dam (even before AMD locations).

Non-point source pollution (pollution that enters the streams from diffuse sources) might be an issue to watch within the watershed. Runoff from dirt and gravel roads carries not only the excess sediment from the road, but any chemicals attached to that soil. Given the prevalence of dirt and gravel roads throughout the Kettle Creek watershed, care should be taken to ensure that road crossings of streams are well managed. There is also potential for excess nutrient and pesticide inflow into the streams from agricultural regions.

Atmospheric Deposition. Atmospheric deposition (also known as acid rain) has been an identified problem for the northern United States for many years. Pennsylvania lies squarely in the region of highest acidic deposition. With poorly buffered soils and streams in the watershed, it is possible for acidification to occur, damaging both forests and streams alike. If stream pH drops below 5, very little in the way of aquatic life can live in those waters. If forest soils are impacted by excess acids, tree regeneration is slowed and we might begin to lose the forest. There currently is no known data on acid precipitation from the Kettle Creek watershed, although there are measurement stations in nearby watersheds. The region is at high risk for problems.

Groundwater. Most of the drinking water in the Kettle Creek watershed comes from relatively shallow wells. It is important that the groundwater quality be maintained if drinking water supplies are to be protected. There was no clearly identified groundwater pollution problem when a model that evaluates groundwater pollution potential was applied. It is important to locate and protect those areas that serve as recharge points for groundwater. Any development on these sites could lead to introduction of pollutants (by paving) or a reduction in recharge, leading to supply problems.

C. Recommendations

Seven broad topics to be addressed for effective, long-term stewardship of Kettle Creek emerged from the assessment and problem analysis phase of the Keystone Project. Core issues were identified for each topic, goals were formulated to respond to those issues, and many specific actions, approaches, and strategies are offered as a range of alternatives recommended for consideration and implementation by the Kettle Creek Watershed Association and its partners.

Topic: Watershed Identity

The ecological and cultural features that distinguish and give identity unique to Kettle Creek as well as the connectivity of environmental conditions to internal, and external, social/political systems are key concepts imbedded in a successful "watershed approach". The goals defined for the watershed identity topic encompass: (1) a common future vision; (2) exploration and celebration of a rich history; (3) recognition of a strong visual quality derived from the forested mountain - valley landscape that is influenced by past and future land use and resource management; (4) protection of natural features related to residents' lifestyles and visitors' experiences; and (5) cooperative interactions to rally support for conservation initiatives.

Recommendations to broaden awareness and appreciation of identity focused on forming a committee charged with incorporating history components into watershed efforts in partnership with local, county, and state agencies. The intent is to develop and carry out projects portraying local history as a common bond among various stakeholders. Historical markers celebrating significant people, places, and events, interpretive modules linked to recreational opportunities such as logging rail beds, oral histories and photo documentation are among the suggested tools.

Conservation of the landscape expressing the Kettle Creek identity may most appropriately be implemented by voluntary, non-regulatory approaches. Mechanisms worthy of exploration include PA Scenic Rivers and/or Greenway designation of the PA Route 144 corridor and greatly expanded historic site interpretive signage. Proactive land use management ideas suggested would involve donated conservation easements or purchased development rights (PDR's) of unprotected critical areas (wetlands, floodplains, heritage attributes, visual amenities) identified and prioritized under the auspices of local planning programs.

The productive cooperative interactions the KCWA has forged with numerous partner agencies and institutions should be expanded and diversified to engage a larger support network. County planning/community development agencies, other watershed organizations in the West Branch, Susquehanna River, and Chesapeake Bay basins, and the Lumber Heritage Region are likely potential allies to leverage resources and support.

Topic: Education and Outreach

Kettle Creek stakeholders must have insights and knowledge of the relationship of sometimes technical, possibly unfamiliar, and seemingly irrelevant watershed stewardship matters to their personal values and interests and those of the community as a whole and to understand KCWA's mission if they are to become involved and supportive of the organization's goals. Since educating current members and reaching out to non-members is particularly important for the relatively newly formed KCWA to communicate its story, three issues framed the recommendations offered.

First, fundamental watershed management concepts, baseline knowledge of problems, and communication of KCWA's mission and achievements should be emphasized at this early stage. Maps of watershed boundaries displayed at public places, wide dissemination of annual reports/newsletters/project announcements to include consistent electronic and print media coverage and name recognition. Graphic thematic posters produced by the keystone team for school, church, club, retail locations or project sites may augment the traveling display.

Second, stakeholders need accurate, reliable information to constructively participate in decision-making discussions affecting resource policy on public lands or their individual actions to promote environmental stewardship. Formation of an Education/Outreach committee and use of an E/O coordinator, knowledgeable volunteers and specialists in various fields to deliver educational programs on current and upcoming topics is recommended. Numerous sources of technical and financial assistance, educational materials, pamphlets, fact sheets, web sites are available and referenced in the report.

Third, establishing a regional watershed education network in partnership with schools, conservation districts, watershed groups and others would stretch limited resources through sharing costs.

Topic: Community Capacity

KCWA's marshalling of external constituencies, such as non-resident anglers and state and federal agencies, to successfully implement ambitious stream habitat improvement and abandoned mine drainage remediation is widely recognized, well-established, and has gained much credibility for the association. Directing attention now to enhancing local capacity at the "community" level, strengthening ties with people in leadership positions, and investing in organizational development will pay similar dividends.

The issues framed dovetail with the preceding watershed identity and education and outreach functions: (1) increasing dialogue and working relationships between KCWA and local government, business, agricultural landowners, and other interests not currently engaged, including potentially conflicting viewpoints; (2) promoting inter-municipal collaboration; and (3) envisioning KCWA's broader, long-term mission and support base.

To increase dialogue and interaction, it is recommended that KCWA volunteers be appointed to attend municipal, school, county, service organization, clubs, Grange, and other meetings and to extend reciprocal invitations to KCWA meetings and events. Under-represented and nontraditional stakeholders should be systematically identified and non-confrontational forums developed to improve communications.

The need to build a viable organization for long-term stewardship would be addressed through periodic assessment of its mission, development of a five-year financial plan, membership recruitment and retention plan, and other ways and means.

Topic: Fisheries & Habitat

Habitat conditions are the primary determinants influencing the fisheries resources of the Kettle Creek main stem and important coldwater tributaries. The issue of coldwater habitat is a central theme and a driving force behind the Kettle Creek initiative. Warm water fisheries in the lower main stem should also be recognized and managed as a significant component of the watershed's recreational and biological assets.

Habitat recommendations are offered across a wide range. Bio-assessment techniques should be refined to better monitor conditions in streams of varying gradient following a protocol and data form developed for Kettle Creek. The KCWA habitat advisory committee can provide oversight and facilitation of expanded bio-assessment in the subwatersheds listed in the report.

Numerous stream reaches and subwatersheds are recommended for habitat improvement focused on five categories of habitat condition specific to the streams. The parameters used to evaluate and target habitat improvement needs are: (1) fish and invertebrate living conditions; (2) riffle and velocity-depth combinations; (3) sedimentation; (4) channel condition; and (5) bank condition. Techniques such as bank vegetation plantings, cross vanes and J-hooks, and live cribwalls typically used to address each type of habitat problem are referenced in the recommendations.

Angler surveys (last done in 1984) are recommended tools to monitor wild trout populations and establish management strategies, including hatchery trout stocking policies and potential modification of harvest regulations toward a goal of more self-sustaining wild trout populations.

Topic: Thermal Quality

Degradation of cold water ecosystems by elevated summer water temperatures is a long-standing concern in Kettle Creek. The problem is rooted in landscape scale change from historic logging and the resultant destabilization of stream channel morphology and riparian forest cover from which Kettle Creek has not yet, and may never, fully recover. Mitigation of thermal degradation to the extent possible in critical tributaries would be maximized utilizing data acquired though a watershed-wide thermal monitoring study and a prototype streamside canopy cover GIS assessment of the Long Run subwatershed initiated by the KCWA and the Keystone Project.

Recommendations are to continue the thermal study as presently installed. After one year, and annually thereafter, evaluation of results would permit relocation of equipment from unimpaired streams to new sites to acquire comprehensive data. The information would serve to prioritize on-going mitigation efforts in the most cost-effective manner and provide the greatest benefits. Thermal assessment is also recommended for the Alvin Bush Dam, small impoundments, headwater agricultural areas, and tributaries such as Hammersley Fork with channel alterations at the confluence of the main stem.

The Long Run streamside canopy assessment model should be extended to other subwatersheds and coordinated with the thermal data acquisition locations and findings to identify and prioritize future treatment sites to establish and improve riparian buffers of native trees, shrubs, and herbaceous plants.

Topic: Water Quality

Water quality, a primary indicator of watershed health, is remarkably good generally in Kettle Creek watershed but there are issues relating to several types of "non-point sources", including sediment from dirt and gravel roads and paved road runoff, acid mine drainage (AMD), acidic deposition, and agricultural runoff. Acquisition of reliable water quality and stream flow data is needed. The role of wetlands in protecting water quality is comparable to the wildlife habitat and biological diversity values of these important resources.

Nutrient reduction recommendations through Best Management Practices are focused on the upper watershed where agriculture is concentrated. Target watersheds, listed in rank order of priority are Long Run, Sliders Branch, Germania Branch, Cross Fork, and Little Kettle Creek. Educational programs on proper maintenance and installation of private wastewater treatment systems, demonstration systems at State Parks, and Bureau of Forestry upgrade programs at leased camps offer realistic alternatives.

High priority was assigned to the Dirt and Gravel Road program problem sites at Long Run, Cross Fork, upper Kettle Creek main stem, Sliders Branch, Germania Branch, and Little Kettle Creek. Pre- and post-construction monitoring of effectiveness should be done and a "road husbandry" program of community volunteers established to identify and refer candidate locations to municipal, county and state authorities as appropriate.

Training sessions sponsored by the state program would develop knowledge of volunteers.

Major abandoned mine drainage abatement has been initiated; collaboration with other nearby watershed groups (Beech Creek) on expensive sampling and monitoring would have mutual benefits. Establishing educational/research demonstration sites would attract universities and government-funded efforts which would promote construction of additional passive treatment systems.

Recommended data acquisition actions involved: a standard sampling protocol and sites; estimated flow measurement techniques; and relocation of the Water Quality Network (WQN) to the Cross Fork USGS stream gauge above the influence of Alvin Bush Dam.

Staff gauges and flow-rating curves are to be established by the thermal study research team by the end of summer 2001; on-going flow/temperature data collection by volunteers should continue at those locations.

The potential for acidic deposition impacts on water quality, and wild trout populations, in tributaries with poorly buffered bedrock geology of the Pottsville and Allegheny groups should be assessed during spring snowmelt or intense rain events. Sampling by portable pH meter and field kit tests for acidity/alkalinity would suffice to identify problem streams for more in-depth analysis of aluminum concentrations as a critical mortality factor for trout and other fish species.

Wetland occurrence modeling by the Keystone Project identified 472 acres of additional wetlands not previously inventoried by the National Wetlands Inventory (NWI). More precise delineation of the GIS database provided in the Keystone report by a university or DCNR-funded ground inventory should be performed. Management recommendations include a 25-foot buffer between identified wetlands and land development and a 2:1 mitigation ratio of disturbed wetlands, including a functional assessment after mitigation.

Purchased easement programs such as the USDA Wetland Reserve and other funding programs are available.

Topic: Landuse

Land conservation goals to maintain Kettle Creek's agricultural production base and heritage, the rural character and historic sites of the landscape, sensitive natural areas such as wetlands, floodplains, riparian corridors, scenic vistas, steep slopes, and unique biota or habitats are integral to a comprehensive watershed stewardship initiative.

The issue of declining agricultural production and increased economic value of land for even limited residential and commercial development in critical headwaters may be addressed by encouraging landowner participation in the county Farmland Preservation program. Perpetual agricultural land easements, Environmental Quality Incentives (EQIP), and Clean and Green provide economic incentives for voluntary land conservation. Prime farmland soils and those farming operations implementing Best Management Practices to protect watershed resources should receive preferential ranking and compensation though both private and public land conservation programs.

Baseline inventories and periodic updates of existing structures and potential development areas are needed. Voluntary land conservation techniques may be applied to maintain existing open space, low density villages, rural architectural identity and housing styles; good development that follows sustainable practices, links to existing infrastructure, and protects the watershed's rural character should be encouraged and recognized. Cluster development in environmentally suitable areas, avoiding floodplains, and poor wastewater treatment sites. Establish performance standards such as 50-foot buffers between buildings, utilities, and roads and natural features and zero storm water discharge for 25-year storm events.

A comprehensive inventory of natural areas is needed to promote awareness and to form the basis for proactive efforts to protect these cherished, high value assets. There is great potential for connectivity of large, contiguous natural systems, recreational values, and important watershed functions through collaboration of KCWA, Bureau of Forestry, local and county planners, and many other public agencies and private partners.

A watershed-wide land conservation initiative of this magnitude is clearly a substantial undertaking, exceeding the exemplary collaboration brought to bear on localized problems such as mine drainage abatement. The ability of the Kettle Creek community to meet the challenge will have a profound influence on the long term stewardship of the watershed.

THE PHYSICAL LANDSCAPE

The Kettle Creek watershed lies in the heart of the north central Pennsylvania mountain region. The stream carves its way, north to south, through the unglaciated Appalachian Plateau. The geology of the watershed and the region is characterized by layers of sedimentary rock, subdivided by narrow stream tributaries. The resultant terrain is moderately to extremely rugged, limiting intensive development.

Physical Setting

The watershed can be broadly divided into three geologic sections. The southern portion of the watershed is influenced by the highly resistant Pennsylvanian Sandstones of the Pottsville and Allegheny group (Geyer and Wilshusen 1982). In this section of the watershed, generally flat, broad ridges are broken by extremely steep valley sideslopes and narrow floodplains. The important coal seams of the Allegheny group have played a key role in the development, land-use, and water chemistry of this section. The central and northern sections of the watershed are underlain by Mississippian and Upper Devonian shale, siltstone and sandstone formations. This portion of the watershed has narrow to broad ridges and moderate to steep valley sideslopes interspersed by floodplains of various width. The rolling plateau and broad floodplains of these sections have allowed for some moderate development of agriculture and residential areas. The sedimentary layers of this portion of the watershed are being explored and developed for natural gas production and storage.

PHYSICAL
LANDSCAPE

Soils of the watershed are variable and are greatly dependent on the surface bedrock geology. Hazleton and Laidig soils are common in the coves of the tributary streams. Ungers and Meckesville soils occupy the sideslopes and Hustontown soils are often on the ridges. Many of the floodplains are composed of the Barbour and Craigsville soil series. A small section of glacially derived Lordstown soils occur on the extreme headwaters of the watershed. Soils can be classified based on their ability to infiltrate water. Kettle Creek has primarily B and C hydrologic soil groups. These soils are well drained to moderately drained, respectively. Most of the land-use limitations of soils on the watershed are due to slope and stoniness and subsequently much of the watershed is publicly owned as state forest.

The watershed contains 429 miles (690 km) of stream. Large streams have been broken into subwatersheds to assist in the description of key ecological and cultural processes (see map 1.2). Figure 1.3 is a summary of some of the physical characteristics of the subwatersheds of Kettle Creek.

Hydrology

Water is a large part of what makes the Kettle Creek watershed a special place. In order to appreciate the various processes and issues related to watershed health, we first attempt to discover the patterns and relationships of stream flow and climate. United States Geological Survey (USGS) stream gages at Cross Fork and Westport and precipitation measurements at the Alvin Bush Reservoir provide some of the data needed to assess the nature of the hydrologic cycle on Kettle Creek.

Stream flow on the Kettle Creek watershed is primarily dominated by rainfall inputs, although snowpack on the higher elevations of the watershed can influence water storage and runoff during the winter. In any region, rainfall amount and timing is uniquely distributed throughout the year. (See Figure 1.1: Alvin

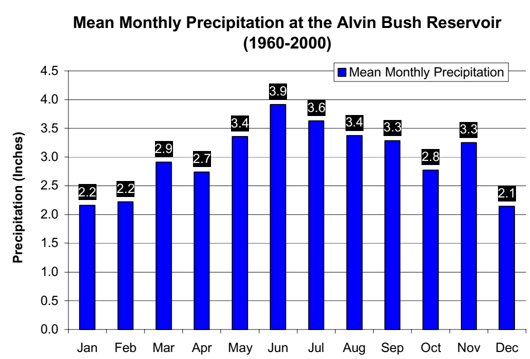


Figure 1.1 - This chart shows average monthly precipitation at Alvin Bush Reservoir. Average monthly rates of precipitation provide us with a "measuring stick" to judge unusual events.

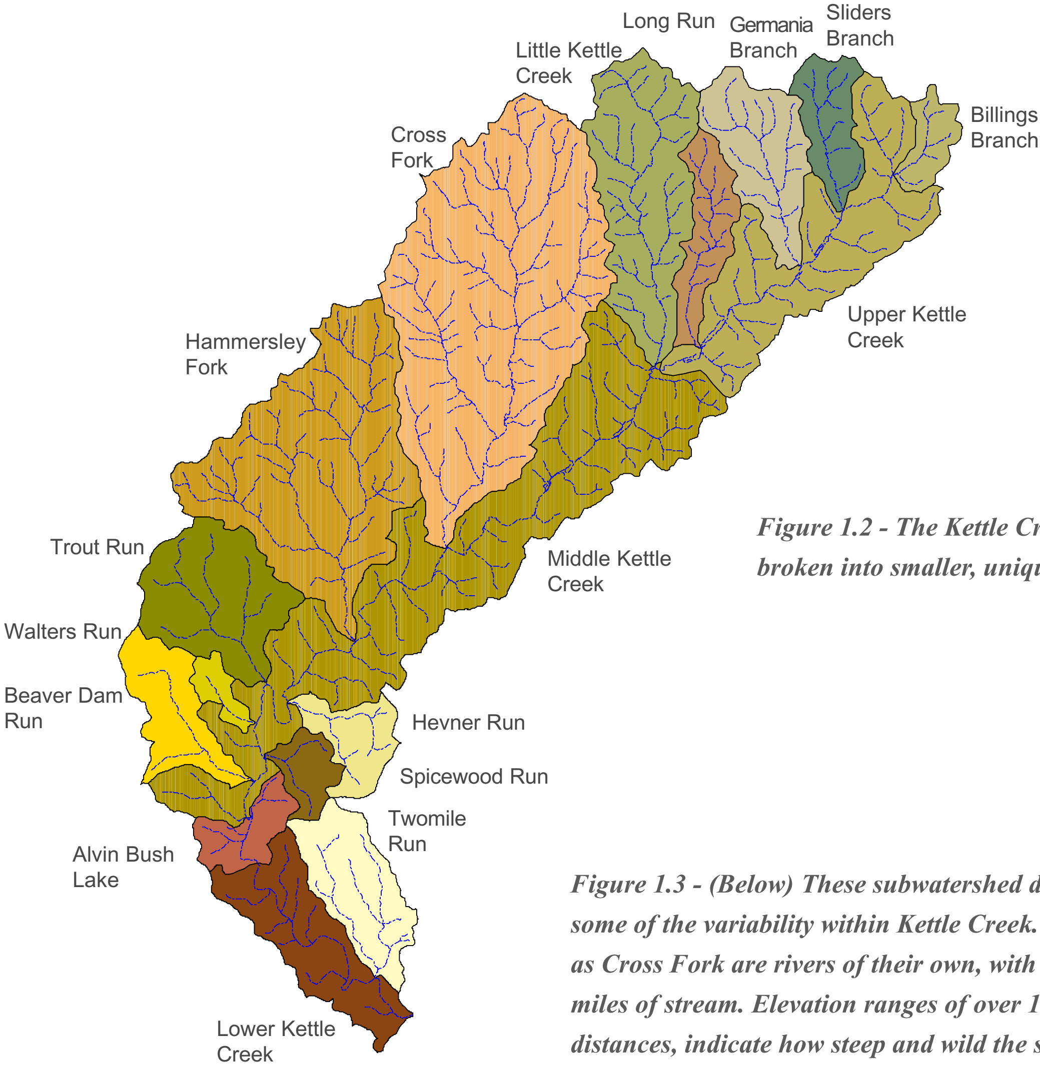


Figure 1.2 - The Kettle Creek watershed can be broken into smaller, unique sub-watersheds.

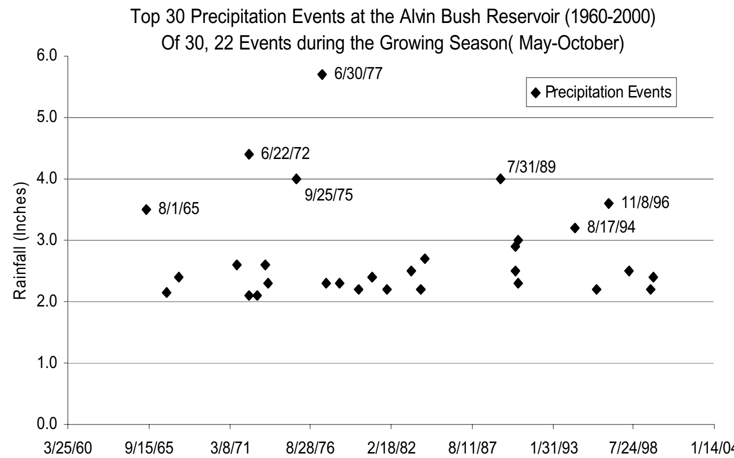
Figure 1.3 - (Below) These subwatershed descriptions indicate some of the variability within Kettle Creek. Subwatersheds such as Cross Fork are rivers of their own, with almost one-hundred miles of stream. Elevation ranges of over 1000', often over short distances, indicate how steep and wild the subwatersheds of Kettle Creek really are.

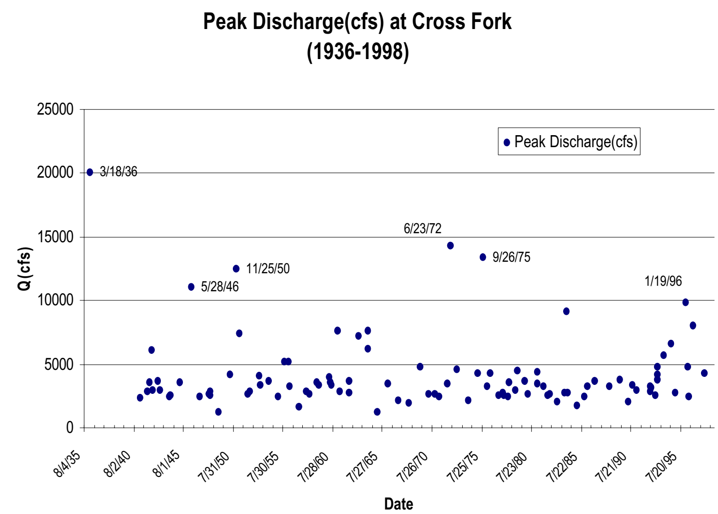
Subwatershed	Area(mi2)	Stream Length(mi)	Drainage Density (km/km^2)	Mean Basin Slope°	Elevation Range(ft)	Max. Elevation(ft)
Lower Kettle Creek	11.25	18.44	1.02	15.00	1499	2162
Twomile Run	9.15	13.74	0.93	8.32	1469	2204
Alvin Bush Lake	3.93	6.74	1.07	19.12	1348	2165
Middle Kettle Creek	45.29	79.73	1.09	16.78	1397	2237
Beaverdam Run	7.18	6.88	0.60	16.13	1437	2293
Spicewood Run	3.11	3.97	0.79	18.54	1348	2204
Walters Run	1.77	2.00	0.70	17.32	1269	2145
Trout Run	13.07	13.95	0.66	13.98	1401	2296
Hevner Run	4.81	7.57	0.98	14.87	1322	2240
Hammersley Fork	32.55	57.42	1.10	16.24	1374	2365
Cross Fork	49.92	94.70	1.18	14.65	1466	2512
Little Kettle Creek	18.25	36.23	1.23	13.84	1194	2437
Upper Kettle Creek	21.77	41.97	1.20	13.78	1210	2467
Long Run	6.01	13.19	1.36	12.31	1082	2388
Germania Branch	9.70	18.29	1.17	10.51	889	2388
Sliders Branch	5.54	9.74	1.09	11.51	813	2417
Billings Branch	3.01	5.35	1.10	9.18	686	2450
Total/Average	246.31	429.91	1.02	14.24	1247	2316

Bush Precipitation) The timing and intensity of precipitation will affect watershed functions, including fishing quality, flooding or the generation of pollution. An understanding of the timing and nature of precipitation can help us develop the best strategies for assessing water quality, fisheries productivity and habitat limitations. For example the majority of high flows occur on Kettle Creek in the spring, but the heaviest rain events are often in the summer (See Figure 1.4). These heavy summer rains are effective at creating erosive runoff events (Brooks and others 1997). If we are interested in monitoring stream sediment concentrations, it is advisable to sample in the summer during these large events. Alternatively, it may be best to sample for nutrient enrichment in the spring during high flows (See Figure 1.6).

During most years, the stream flows provide positive benefits to the Kettle Creek community, but at other times, Kettle Creek can react violently to unusual weather events. Stream gages on the watershed record these peak events and this information can be valuable for the prediction of the likelihood of future flood flows (See Figure 1.5). These peaks can have a dramatic effect on floodplain residents and will also influence the stream channel and fish habitat. While many of these "extreme" events have had negative consequences, it is the recurrence

RIGHT TOP AND MIDDLE: These charts illustrate a variety of hydrologic information. The top chart shows the peak storm events on record at Alvin Bush Reservoir. Most large storms occur in the summer, potentially contributing to erosive runoff. The middle chart shows peak stream flows at Cross Fork. Most high flows occur in the spring, but many of the largest events can occur in the growing season. It is likely that these flows are created by hurricanes.





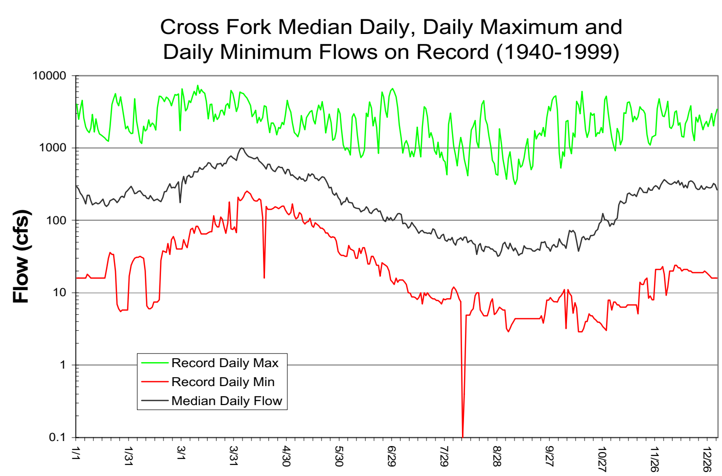


Figure 1.4,1.5,1.6 - The average maximum and minimum streamflows by date are indicated above.

of less-destructive, moderate flows called bankfull events, which shape and maintain the quality and character of Kettle Creek streams.

The size and frequency of these bankfull events are critically important in the design of fish habitat improvements and bank-erosion reduction projects (Rosgen 1994b). Based on field data around the U.S., bankfull events generally occur about every 1-1.5 years (See Figure 1.7). Bankfull flows at Cross Fork are probably about 2300 cfs. These are simply the probability of stormflows based on the historic flows. Future high water events may occur more or less frequently. The probability distribution was developed based on the Log-Pearson Type III distribution.

The Alvin Bush Reservoir, constructed in the late 1950's, has an influence on the hydrology of the Kettle Creek watershed. Built primarily as flood control for the town of Renovo, the dam limits peak flow events on lower Kettle Creek and distributes the flow over a longer period of time. Flow hydrographs provided by the

BANKFULL FLOWS

The term “bankfull flow” can be misleading. To a resident a bankfull event may involve the stream leaving its banks, but to a hydrologist or engineer the term “bankfull discharge” implies something slightly different. Any given stream has a particular flow that does the most "work". This "work" is the manipulation of streambed material. The movement of streambed material can create changes in stream slope, meander and habitat. These changes are all a natural part of a stream and can be extremely beneficial to stream organisms. The bankfull event is the flow that does the most work because of its frequency. Occurring on average every 1-1.5 years, these are generally our typical spring "high flows". Understanding bankfull events is critical in the design of stream restoration projects.

Average Return Interval (yr)	Flood Flow (cfs)
1.01	1359
1.05	1690
1.11	1940
1.25	2344
2	3617
5	6195
10	8588
20	11532
50	16528
100	21375
200	27385
500	37589

Figure 1.7 - (Above) This table shows how frequently high flows return at Cross Fork. Floods of the magnitude of Hurricane Agnes, are likely to occur every 50 years.

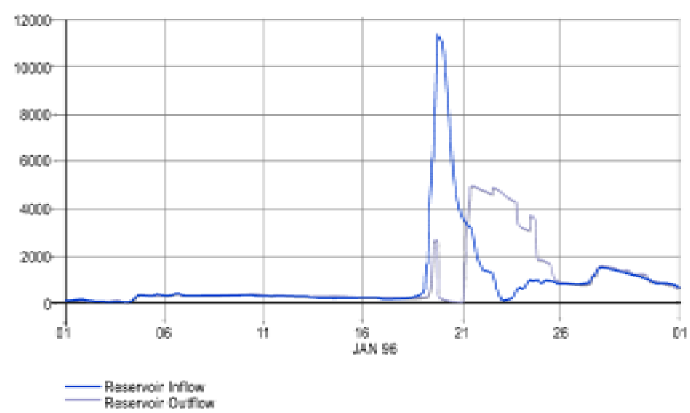


Figure 1.8 - This flow hydrograph shows the reduction of flood peaks by the Alvin Bush Reservoir. This is the flood of January 1996.

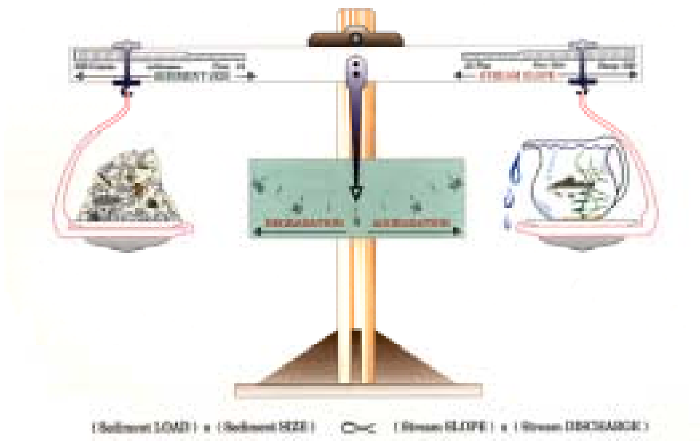


Figure 1.9 - Lane Scales (from Rosgen, 1994a). This image was developed in 1955 to illustrate the balance of watershed inputs and outputs. Any changes in the amount of streamflow or amount of sediment can affect the balance.

Class B stream channels have narrow floodplains that can be developed. Unfortunately, flooding in these areas is common.

Army Corps of Engineers illustrate these effects (See Figure 1.8). Peak flows at the USGS Westport stream gage are greatly restricted by the reservoir, making this gage station less valuable for hydrologic analysis. Unfortunately, the dam also provides a reservoir for sediment and will require periodic maintenance in order to maintain aesthetic quality.

The hydrologic properties of a watershed are often in a delicate balance. The Lane diagram helps to describe the relationship between inputs of water, sediment supply and stream slope. If we significantly change one of these values the others must compensate (Lane 1955). This balance of watershed inputs and outputs can help explain the changing character of Kettle Creek.

Stream Channel Classification

Stream channel classification helps to group stream sections according to their physical characteristics. Physical characteristics could include stream slope, streambed material sizes, cross-sectional area, or stream meandering. The classification system allows us to look at sections of the watershed as similarly functioning units. These units can provide a necessary framework for detailed habitat assessment, flood hazard areas, restoration design or bank erosion reduction.

The Rosgen stream classification system is the most common of these methods (Rosgen 1994a). This increasingly popular system of stream classification provides engineers, watershed managers and landowners a common "language" when discussing stream projects. Furthermore, the Rosgen classification system is based on the measurable physical characteristics of a stream segment. This approach allows a variety of observers to survey a stream reach, or section of stream, and come up with the same results. The Rosgen system was established to help river managers predict the re-

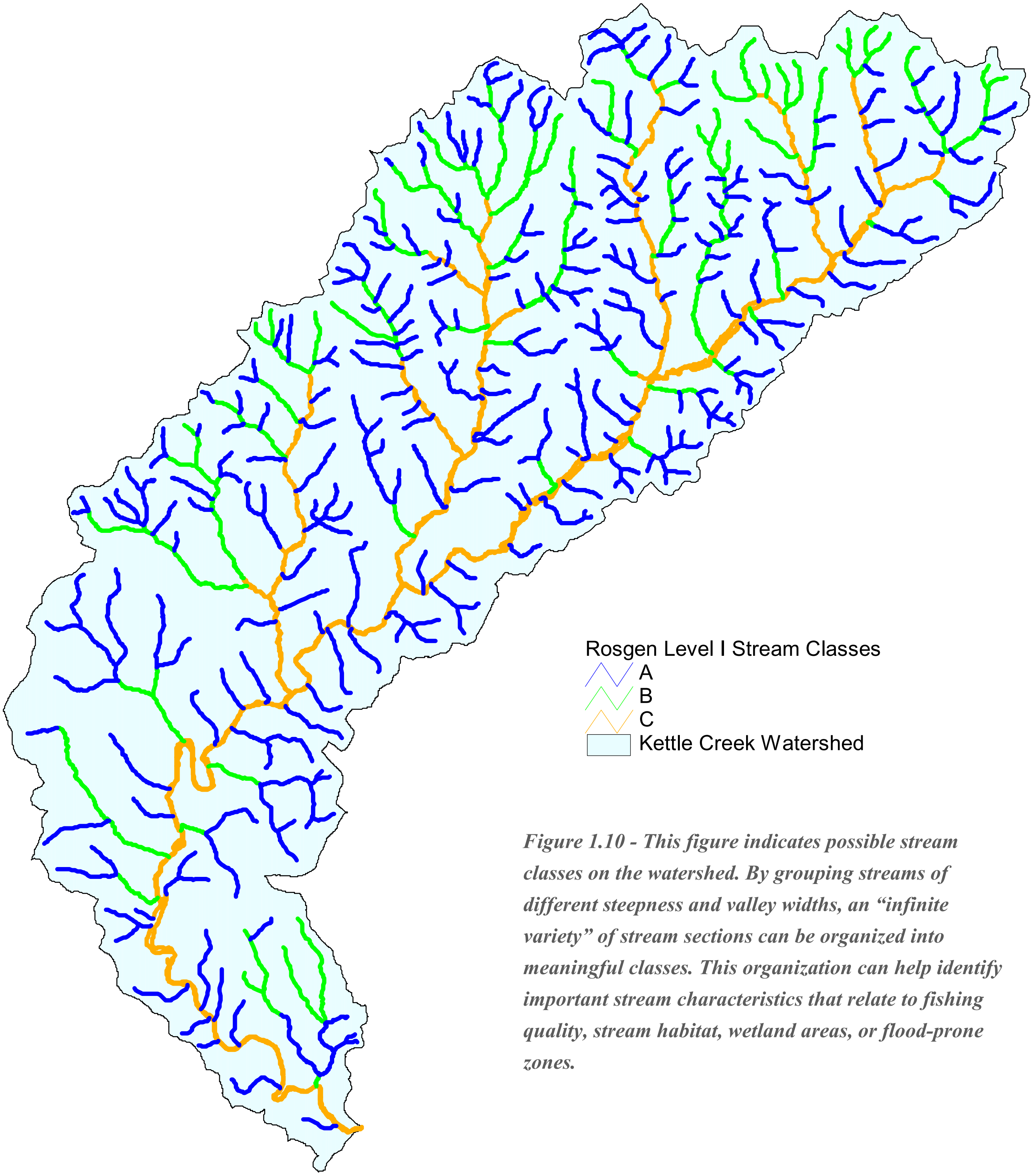
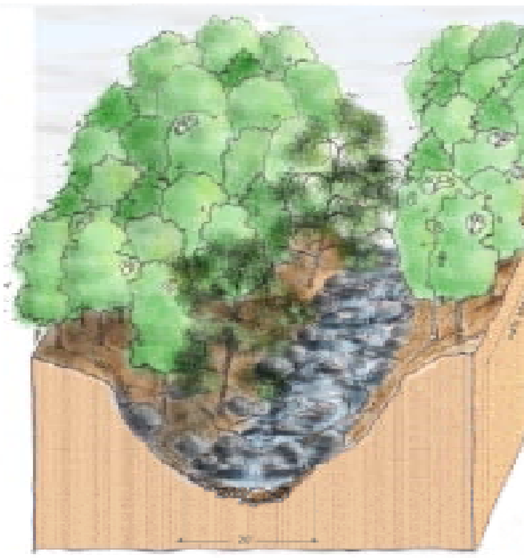


Figure 1.10 - This figure indicates possible stream classes on the watershed. By grouping streams of different steepness and valley widths, an "infinite variety" of stream sections can be organized into meaningful classes. This organization can help identify important stream characteristics that relate to fishing quality, stream habitat, wetland areas, or flood-prone zones.



>4% Slopes

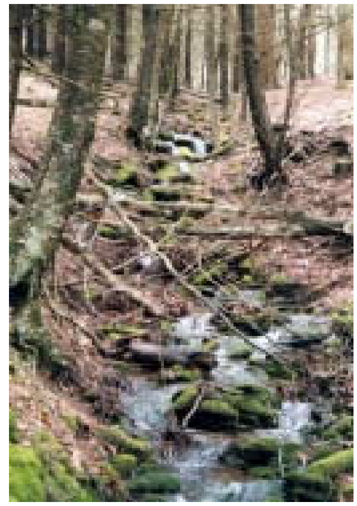
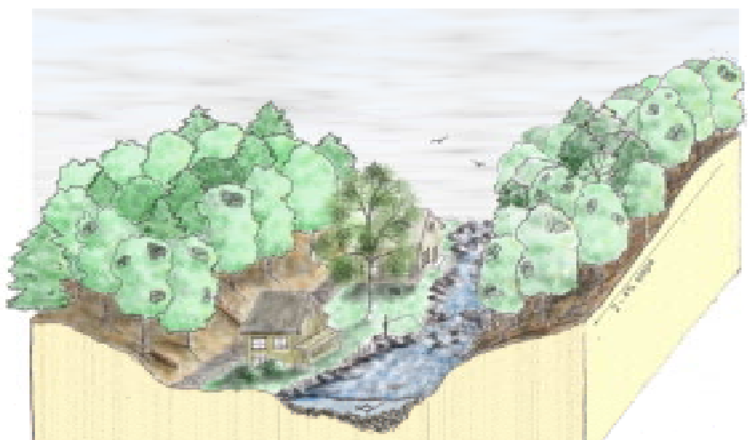


Figure 1.11 - Class A streams have steep slopes and narrow floodplains. These are often small headwater streams that act as sources of critical nutrients, sediment and food for downstream organisms.



2-4% Slopes

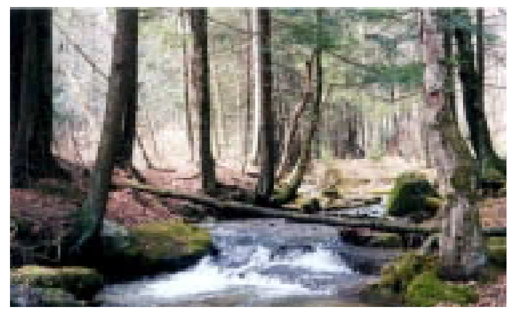
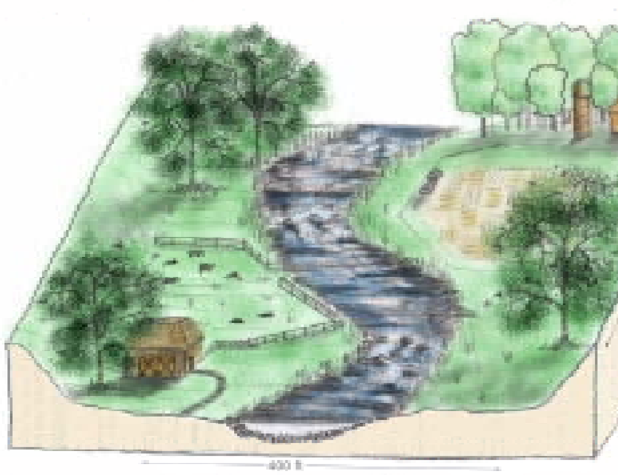


Figure 1.12 - Class B streams have moderate slopes and gravel and boulder streambeds. These streams are often the favored spawning grounds for wild trout.



<2% Slopes

Figure 1.13 - Class C streams have low slopes and wide valleys. These streams are valuable cool and warm water fisheries and are often developed for agriculture.

sponse of a river to human or natural changes. According to Rosgen (1994), a "natural stream channel stability is achieved by allowing the river to develop a stable dimension, pattern and profile over time." The ability to identify what such a "natural stable channel" should look like has greatly improved our ability to create effective stream restoration projects and improves our prediction of their influence to upstream and downstream reaches. Rosgen has established useful tables to predict the potential success of stream restoration projects based on stream class. Unfortunately, the accurate classification of stream reaches requires fairly extensive data collection within a watershed.

In order to begin to classify the streams of Kettle Creek, the Kettle Creek Keystone Projecct engaged in a Level I Classification of the watershed. This characterization was done largely from topographic maps and aerial photos. Stream reaches were grouped by similar slope class and valley confinement (the relationship of stream width to valley width). Stream slope provides a measure of stream energy, which is a dominant control on sediment transport and channel shape. Three stream classes are designated at this level of classification, Type A, B and C channels. (See Figures 1.11 - 1.13 Stream Class Illustrations) Type A channels have steep slopes and are often found in very narrow valleys. Type B channels have moderate slopes (2-4%) and Type C channels have low slopes (<2%) and are often found meandering through broad valleys. Most of the other channel types in the Rosgen Classification system relevant to this watershed would be variations of these three classes. It is probable that a variation of B channels occurs at the mouths of tributary streams and that variation of C channels occur in the larger floodplains. This initial classification provides a framework for the future prioritization of stream habitat assessments and restoration strategies. For example, habitat surveys performed on the Kettle Creek watershed are only partly representative of the stream types on the watersheds. Type A and B channels occupy over 66% of the watershed but are only represented in 25% of the habitat evaluations. Future habitat assessments should focus on these "less studied" stream reaches.

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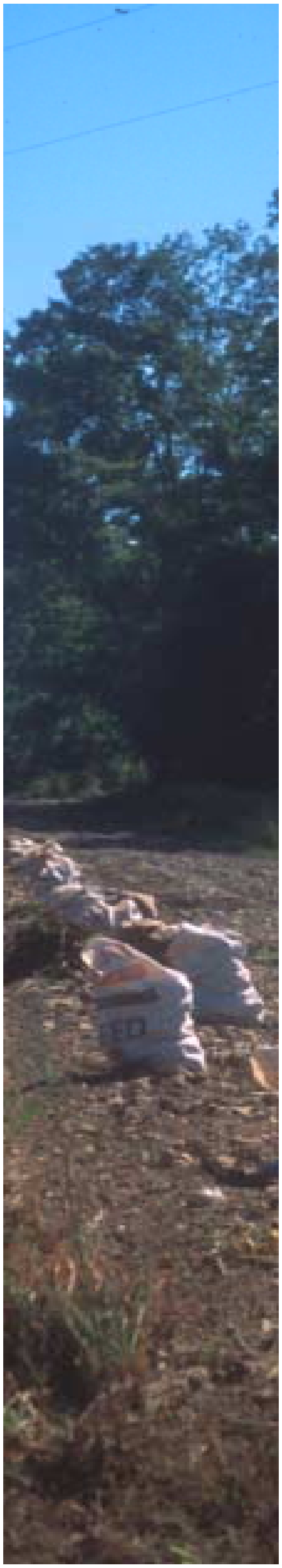


KETTLE CREEK
CULTURE

The rural and historically significant landscape defines the character and identity of Kettle Creek. The cultural history of the watershed portrays the evolution of the landscape and its resources. Social analysis, through demographics, economics and a discussion of the watershed association, illustrates specific trends in the population through time. The recreational and scenic value of the watershed landscape demonstrates contemporary values for natural resources and the overall environment, as defined by local residents and visitors alike.

The history of the Kettle Creek watershed is not unfamiliar. It incorporates the histories of Clinton, Potter and Tioga counties into a story about the people that have shared this landscape across time and relates local events, circumstances and conditions more directly to the landscape rather than editing it along socially constructed boundaries. It demonstrates the flexibility and resilience of the forest under human management, the distinct patterns of land settlement and speculation, and the shift from forest consumption to conservation that have occurred across the region and state. However, this history also includes visions of sustainable immigrant communities, natural gas extraction and storage, and the flooding of a small town that distinguish it from its surroundings. While life along Kettle Creek has seemed to pass without great change, the decisions made by residents and landowners have indeed transformed the landscape over time.

HISTORICAL LANDSCAPE

The evergreen plantations we see today resemble what the "Black Forest" of Pennsylvania once looked like.

Kettle Creek as Influenced by Native Americans

The watershed prior to human habitation was a mature, forested landscape of hemlock, pine, and oak. Hemlocks grew 100 to 150 feet (30 to 45 m) tall, the lower 40 to 50 feet (12 to 15 m) bare of branches from lack of sunlight (Beebe 1934). European explorers would later name the region "the Black Forest" of Pennsylvania, as the midday sun barely reached the forest floor. The pine and oak were tall, thick and straight.

Wildlife was also abundant from the air to the water. Passenger pigeons traveled the skyways and fed on native nuts. Elk roamed the Appalachian Plateau browsing the tender, woody vegetation. Wolves wandered the ridges in search of native deer, singing their wild melodies at nightfall. Beaver managed the waterways, building small dams throughout the headwaters. This landscape developed, and continues to develop, changing subtly each year, each season, each day.

Native Americans were the first known human inhabitants of the watershed. They lived as hunters, gatherers, farmers and fishermen in the then densely forested landscape. They inhabited large areas and moved seasonally throughout the landscape, actively managing natural resources of vegetation and wildlife for their sustenance. They burned forest patches to flush wildlife, to rejuvenate the native vegetation, and to cultivate orchards, cornfields and gardens. From the hides of animals, they tanned leather and from timber scraps, they sculpted woodcarvings. Their use and management of natural resources was efficient, productive, and sustainable[1].

As they moved through the landscape of the Northern Tier on their seasonal journey, they established regular routes of travel. The Kettle Creek Path connected the Cowanesque River to the West Branch of the Susquehanna by way of Kettle Creek. Native Americans may have camped along the creek while hunting and fishing in the region. Some believe that Kettle Creek was named for kettle cooking that occurred on a large boulder in the West Branch. Their theory describes how Native Americans would pour water into the depressions on the boulder's surface and then toss heated stones into the water to heat their kettles.

Several Native American tribes made their homes in the Mid-Atlantic region. Each tribe claimed large areas, though individual land ownership was unknown. The Iroquois and the Delaware tribes both claimed lands in what we now call Pennsylvania. The Iroquois lands were located in the north and west; the Delaware lands were in the south and east. The Iroquois were a community composed of several smaller tribes who claimed lands throughout present-day Pennsylvania and New York. Collectively, they were known as the Six Nations. The Seneca tribe used the region of the Northern Tier as hunting grounds for its people. The Delaware were also a composite community, including the Monsi (Munsi, Munsee, or Minisinks; meaning wolf) tribe and were incorporated with the Delaware Indians, and later with the Senecas, as their numbers declined.

European Exploration, Purchase, and Colonization of North America

Much of what is known about the early North American landscape and the people who lived here was first described in the travel diaries of European missionaries. David Zeisberger was a Moravian who traveled throughout the Mid-Atlantic region (Beebe 1934). Though his charge was to preach and baptize in the Christian doctrine, he spent much of his time learning Native American languages and culture. He wrote rich descriptions of Indian physique, folklore, and ways of life. He recorded their stories of creation and beliefs about the movement of the earth, sun, moon and stars. He described sacred rituals and beliefs in witchcraft and evil spirits. Insightfully, he noted that the Indian at peace was never in a hurry, "for they are everywhere at home, and whithersoever they wander they find the sustenance of the forest" (Wallace 1981).

> The American continent seemed to offer limitless resources to those who were only familiar with the cultivated European landscape. The sheer expanse and richness of the American frontier generated new commodities and professions for early Americans.

Other European explorers traveled the continent for its forest resources and traded European goods for Native American game. They recognized that the Native Americans were far better hunters of the native species and that they were eager to barter for tools and trinkets, such as brass kettles for which the creek may also have been named.

Interactions between Native Americans and Europeans were not always peaceful. As the Europeans attempted to colonize the region, the Native Americans attacked the new settlements. Though the Indians did not own the land in the way that Europeans defined ownership, they maintained their claims to inhabit it[2]. Colonists responded with devastating attacks on Indian settlements, such as the one led by Captains Patterson, Crawford, Sharp, and Laughlin in 1763 that destroyed a camp at the mouth of Kettle Creek (Linn 1883).

European persistence eventually led to treaties with the Six Nations that purchased the land for colonists. The boundaries of the agreements were generally natural features, such as streams and mountains. However, which stream the authors of the treaty meant was frequently unclear as Native American stream names were difficult for the European negotiators to understand. This led to frequent disputes over the land in question as both Native Americans and Europeans defended their claims. The Treaty of 1754, which opened a large part of western and northwestern Pennsylvania to settlement, was one whose agreed boundaries were adjusted after several years of ongoing disputes. An additional agreement in 1768 expanded the settlement area to include the previously disputed areas.

The 1784 Treaty at Fort Stanwick, in present-day New York, purchased much of Pennsylvania's Northern Tier, including the Kettle Creek watershed, from the Iroquois for $5,000 (Welfling 1949). Since Delaware and Wyandott Indians also claimed these lands, a second treaty and payment of $2000 was made. The following year, the Commonwealth opened the region to settlement, though Native Americans retained hunting rights for the next twenty years. For this reason, local governments in the Northern Tier were not organized until 1804.

The Division of Land for Private Sale

As a colony, Pennsylvania had been able to sell land without involvement from England. William Penn established the Pennsylvania Land Office to conduct initial land transactions. Once the colonies declared their independence, the Land Office was incorporated into the state government. To facilitate the division of land into parcels, and since surveying was highly inaccurate, the state adopted the use of rectilinear tracts to prevent boundary disputes.

The purchase of original land titles involved a 5-step process (Munger 1991). First, prospective landowners would file an application at the Pennsylvania Land Office, requesting a parcel of a specified size and location. The Land Office would then warrant the parcel, meaning it would order a survey to verify the boundaries and assess the resources within. Next, the survey was completed on the site and a diagram of the tract was made. A return of survey was then issued by the office, documenting that the survey process and monetary transactions were complete. Finally, a patent was issued, "passing ownership of the particular tract of land to its initial purchaser."

After the Revolutionary War, the new state government owed payments to military officers and to foreign investors, who had supported the colonies in their fight for independence. The Commonwealth offered land in lieu of cash payments to its military servicemen. Foreign investors were paid from revenue generated by land sales and resultant property taxes. William Bingham, a privateer from the West Indies, received large tracts of land throughout northern Pennsylvania and New York, for which he created the Bingham Land Company to parcel, survey, and sell (Currin 2001).

In order to generate revenue quickly and to establish American presence in the eyes of Native Americans, the remaining lands north and west of the Susquehanna River were parceled into lots as large as 1000 acres and offered for sale[3]. When high prices-$80.00 per 100 acres-failed to motivate buyers, the state reduced the price in 1788 (Beebe 1934) and again in 1792 to $13.33 per 100 acres (Welfling 1949). While this may seem inexpensive, few early Americans had the financial resources to purchase land and establish new homes on the frontier where the Commonwealth offered little service, support, or protection to rural residents. As prices fell, land was quickly bought up by speculators, most of whom were prominent businessmen in eastern cities. By 1817, most of the state's land, including the Kettle Creek watershed, had been sold but not occupied.

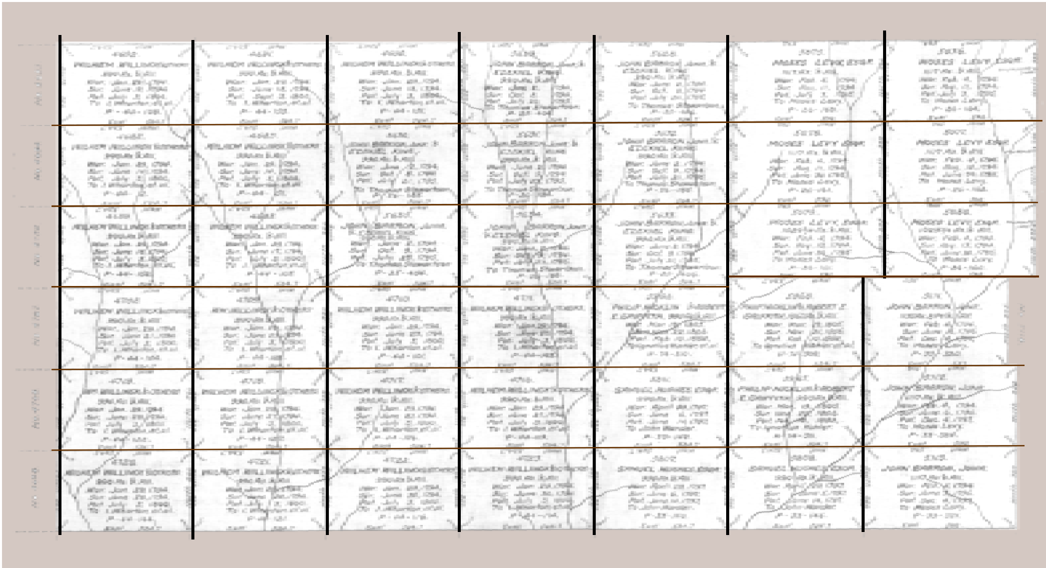


Figure 2.1 - Following the model of the Northwest Ordinance of 1787, much of the Northern Tier was divided and surveyed in a grid of rectangular, thousand acre tracts.

To further advertise the frontier land sales, surveyors and land companies were hired to explore the new region, to characterize the resources available and identify the best areas for farming and timber production, and to layout land tracts for purchase. As surveyors established tract boundaries, they divided much of the Northern Tier into a grid of 990 acre and 1100 acre tracts, making land purchases efficient. They witnessed these boundaries (or carved their initials) on trees, posts and stumps, including the American chestnut that was found throughout the forest during this time. Early surveyors included Henry Drinker for the German Land Company around 1792, Wilhem Willinck and the team of Nivklin and Griffith in 1805, whose names all appear on the original land warrant maps for Abbot and Stewardson Townships.

Ownership implied a responsibility to settle and improve the land, meaning clearing timber, planting crops and building a permanent home[4]. Speculators were able to avoid this requirement by way of a policy loophole. The prevention clause allowed owners to waive settlement responsibilities when relations with Native American proved threatening. When corporate owners wanted to avoid improvement costs, they reported grantees (real and fictitious individuals) that engaged the prevention clause and presented notarized certificates as proof of dangerous relations.

Land Speculation of Forest Values in Kettle Creek - Landowners by Purchase

During the 1790s as the land prices fell, several wealthy, urban businessmen bought multiple tracts in speculation of their resource value. Among them was Thomas Stewardson of Philadelphia, who purchased tracts throughout present-day southeastern Potter County and for whom Stewardson Township is named

Land speculation was popular, particularly with those in eastern business communities. As the Commonwealth reduced the price of land on the frontier in an effort to “civilize” the wilderness, these buyers purchased increasingly larger tracts of land.

(Heimel 1992). He probably intended to harvest the maturing white pine, commonly used for ship masts, and market it on the eastern seaboard or in Europe[5]. In 1851, George Stewardson and William Vaux sold portions of the property, to John F. Cowan, a Williamsport businessman (Heimel 1992). Within these tracts the Stewardson family reserved several parcels along the stream for their own use and development[6]. These reservations later became significant as Cowan sold the tracts to another, stipulating but not explaining the reservation held within its boundaries.

Other early speculators included surveyors from the land companies who bought up the most valuable tracts of land for themselves, as they knew firsthand of the resources found in the region. Wilhem Willinck, chief agent for the Holland Land Company, "bought over 1100 warrants in his own name and later purchased almost as many from other speculators" (Munger 1991).

Early American Settlers - Landowners by Claim

Richard Gilmore was the first European to stake a claim on the banks of Kettle Creek[7]. Though the territory was only opened for settlement six months after the Treaty of Fort Stanwix was signed, Gilmore had already chosen a site near the mouth of the creek on its northern bank (Linn 1883). A warrant dates his claim to July 21, 1794. But Gilmore must have abandoned his claim, since James Caldwell claimed the same site in 1807.

Simeon Pfoutz was the third European landowner in the watershed but the first known to develop his property, establishing his farm in 1813 (Lock Haven Express 1951). From Perry County, he traveled up the West Branch of the Susquehanna River and turned north into Kettle Creek. Finding a wide expanse of rich, alluvial soils at a bend in the stream, he cleared the land and built a log farmhouse. That same year, he returned home to prepare his wife, his daughter, and their possessions for the move north. The following year, together with a man named Paul Shade, the Pfoutz family traveled to Kettle Creek. Here, he and his wife, Susannah, raised nine children and built the first sawmill on Kettle Creek to process the timber on his farm. Pfoutz was a Pennsylvania Dutchman from Perry County and brought with him the Pennsylvania Dutch language and culture. His daughter, Martha, was the first-born and the first bride in the watershed. She married Isaac Summerson. Pfoutz died in 1856 and was buried in a small family cemetery located upstream from the Pfoutz home on north shore of Kettle Creek.

> Those who moved into the watershed brought with them their native landuage and social customs. The watershed's first family, the Pfoutz's, spoke Pennsylvania Dutch, but they were soon joined by English and Irish folk who spoke something close to our modern American English.

When Pfoutz and other early settlers first came to the region, there were no roads. They simply followed Indian paths and made narrow clearings where routes of travel were needed. One route that had already been established was Boone Road, used by Commodore Oliver Hazzard Perry and his fleet.

Roads that were first cleared for packhorse transport were later widened or "improved" for wagons. The Jersey Shore Road was one example. It opened in 1807, accommodating trade and early government travel from Jersey Shore to Coudersport. The route was funded by land speculators such as John Keating, Thomas Stewardson, and George Vaux (Beebe 1934). Work began in 1811 to widen the road and make it passable by wagon (Welfling 1949). John Cartee was one of the contractors hired to build a five-mile section of the road (Heimel 1992). He established a camp for his construction crew along Little Kettle Creek (now erroneously called Carter Camp). Other contractors included Ezra Hitchcock, Jonathon Edgecomb and Alvin Renells (Beebe 1934). Though few materials were needed, road improvements were nonetheless expensive. Upon completion of the route, a toll was implemented to generate revenue for loan repayment and the road was named the Coudersport and Jersey Shore Turnpike. The 12-cent toll, charged for each five-mile section traveled by a team and its wagon, continued until 1860 (Beebe 1934).

Even with improved transportation routes, population increased slowly in the Northern Tier and it was 1814 before the state government established county commissioners jointly for Potter and Tioga Counties (Welfling 1949). Over the next two decades, Potter County would gradually become independent of adjacent county politics.

Road improvements included not only clearing of the forest but also bridge construction where travelers frequently forded the streams. In 1815, a petition was submitted to build a bridge at Little Kettle Creek for the Coudersport and Jersey Shore Turnpike (Beebe 1934). The petition was approved and in 1816 the bridge was completed as part of the artificial road construction of the turnpike, also known as the Lycoming and Potter County Turnpike.

Improved roads were few and far between, crossing the watershed only in the northern regions. The common routes of early settlers along the lower part of the main stem directed continued development from the south. In 1822,

A monument for Simeon Pfoutz and his wife Susannah, the first permanent settlers on Kettle Creek, is located at the reservoir.

John Calhoun purchased land further upstream and built himself a home. He and his wife, Polly Daugherty, raised five sons and two daughters, several of whom settled close to home, beginning a long-standing Calhoun presence in the lower watershed. The Calhoun cemetery along Kettle Creek just north of Spicewood Run denotes a strong family presence in the Kettle Creek watershed.

In 1823, David Summerson moved from Renovo to the banks of Kettle Creek in present-day Leidy Township (Lock Haven Express: Kettle Creek). This Englishman built a home on the northeastern side of Beaver Dam Run in an area now known as Big Bottom, where the lower campground of Kettle Creek is found[8]. Although he and his wife had ten children, only two survived into adolescence. Summerson's presence in the watershed influenced the local language, changing the predominant language from Pfoutz's Pennsylvania Dutch to modern American English.

Early American settlers were necessarily independent and interdependent. They sustained themselves by clearing forest and cultivating the fertile soils. Initially, they grew Indian corn and buckwheat for themselves and their live-

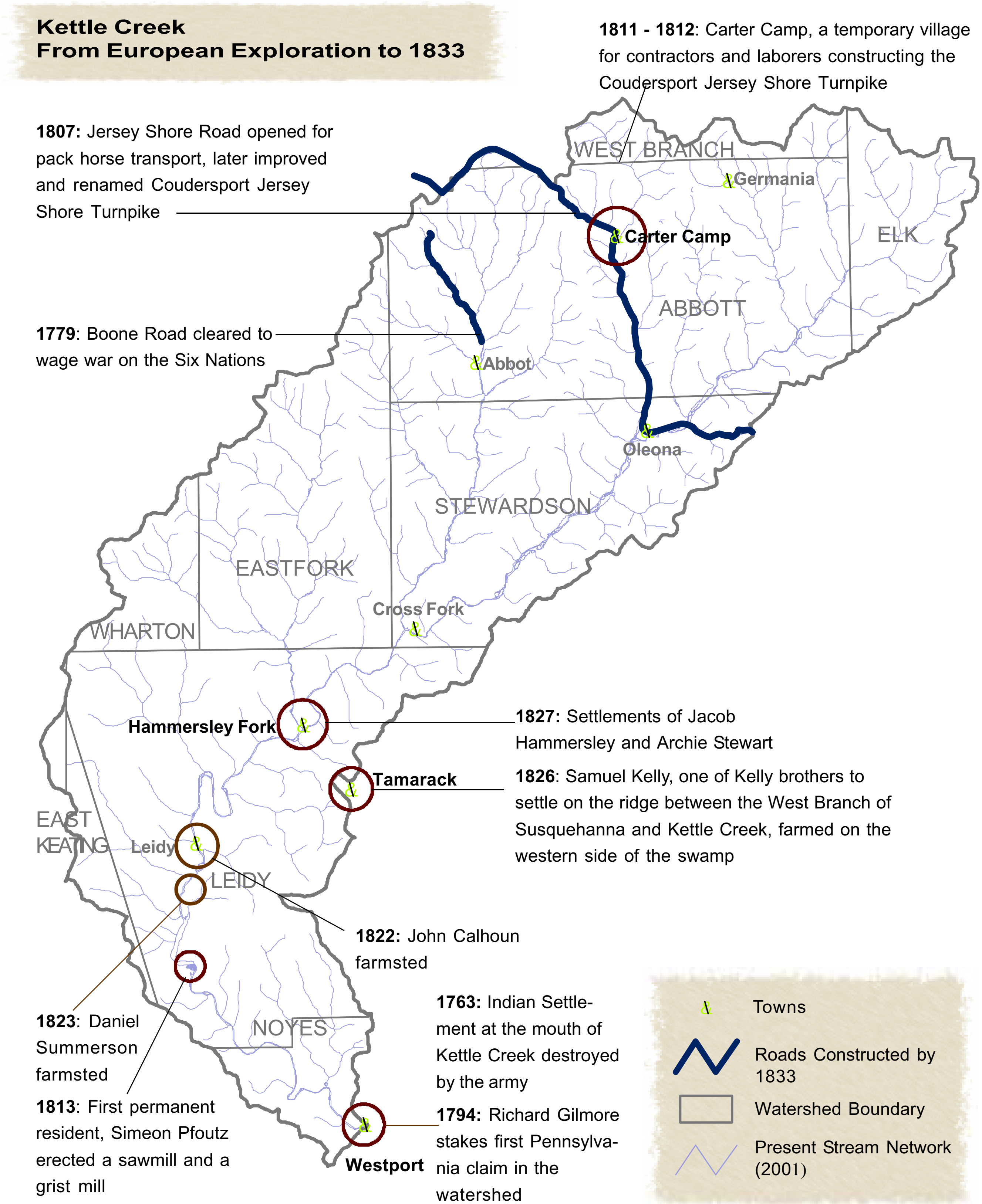


Figure 2.2 - Kettle Creek: From European exploration to 1833

stock. Few had any cash and instead traded their surplus of rye, corn and potato whiskey, venison, and maple syrup with others on the frontier. Since doctors were few and far between, whiskey was used as a medicinal treatment for many ailments. Cash was available from the state government for efforts to help tame the wilderness of the frontier. Bounties were offered for panthers and wolves and provided cash for purchasing household and agricultural equipment.

As residents harvested the dense forest, clearing the land for fields, they began to change the ecology of the watershed in subtle ways. This only foreshadowed the more dramatic change that would come with the onset of the lumber industry.

Through their desire to own personal property and to make the land properly productive, Pfoutz, Summerson, and other early settlers, such as John Moore, Thomas Brooks, Samuel Kepler, David McCoy, and Joseph and Marmaduke Summerson established agriculture as the predominant livelihood of the watershed[8]. Beginning with farming in the lower region, agriculture slowly moved north, following the creek and its fertile floodplain soils.

Due to the dense forest, settlers first had to fell and clear trees before they could begin constructing a home or plowing a field. Without a home to clean or children to tend, women contributed in this effort to help establish the family homestead as quickly as possible.

Agriculture and timber harvest went hand in hand as early settlers developed the frontier. While forestry is now practiced on public lands, agriculture continues as a private enterprise.

A few years later in 1827, Jacob Hammersley and Archie Stewart pushed the frontier upstream (Lock Haven Express 1947a). They selected the stream we now know as Hammersley Fork as the site of their homes-Hammersley on the eastern bank and Stewart on the west[9]. For several years, they carried sacks of flour from the river to their homes, traveling the Old Boone Road sixteen miles over the mountains. Tiring of this long journey, the two men built a gristmill on the western bank of the stream. "Old Jake" Hammersley and his wife, Jane Paine, "Granny Hammersley," raised a family of nine. The oldest son, Jacob P. Hammersley, was known for his skillful hunting even as a young boy.

Around the same time, the Kelly brothers, Alexander, Montgomery, George and Samuel, moved into the watershed from Ireland (Lock Haven Express: Kettle Creek). Samuel was the most widely known for his leadership in the Methodist Church that was established in 1831. The Kelly brothers settled on the western side of Tamarack Swamp, the first to establish a home on the uplands of the watershed, specifically between the West Branch and Kettle Creek.

With several families living, farming and milling along the main stem, a formal road was built around Oxbow Bend in 1834. Once completed, this route crossed the stream twenty-one times. A few years later, a road was completed from the West Branch to Cross Fork, then only a small, family settlement, via Paddy's Run and Stewart Hill. State Road, as it came be known, was the primary route for residents to reach southern commercial centers at Renovo and Lock Haven. (Mountain top routes on the western side of the watershed developed more than a decade later. In 1850, Butler Road was constructed along the ridge of the western watershed boundary from Westport to the headwaters of Sugar Camp Run and downstream to Kettle Creek (Lock Haven Express 1947i).

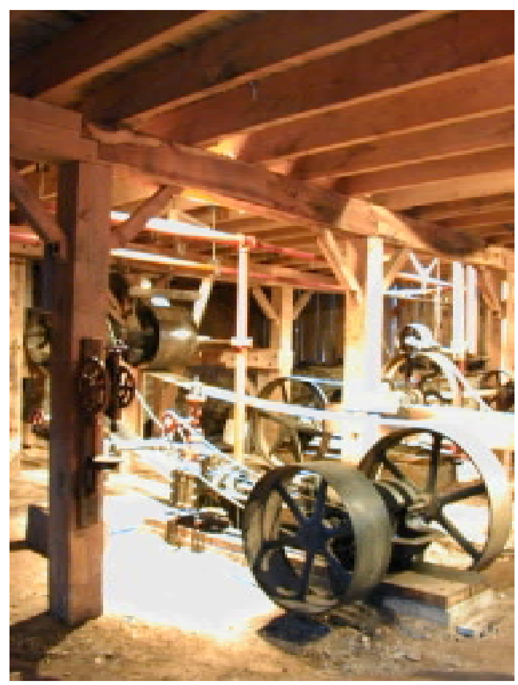
Miles Thompson moved into the watershed sometime after 1827 as well. He was named sheriff of Potter County-only the second to hold this position and the first to carry out a public hanging in the county in 1839 (Beebe 1932, Heimel 1992). He established the first known sawmill in the midsection of the watershed at Cross Fork in 1845 (Leeson 1890).

Frances French pressed the frontier of American settlement even further upstream when he settled at the confluence of Kettle and Little Kettle Creeks, what we know now as Oleona, in 1843 (Beebe 1932). Henry Andresen later bought his property in the mid 1850s, including the first hotel opened in the watershed. The building was merely a log house and was located in present day Oleona (Welfling 1952). Travelers were primarily mail carriers who delivered to rural post offices on a weekly basis.

Early Mills

Early farmers constructed sawmills to process the wood cleared for agricultural fields[10]. Later mills were built as commercial operations, first owned by individuals and later owned by large corporations. The white pine was harvested first, from the time of European exploration to the mid-1880s, and used for ship spars and large construction beams. Pitch and shortleaf pine were also common. The hemlock was removed around the same time and at first cut only for its bark, whose tannins were used in leather curing. Later, the hemlock was valued for its inner wood as well and used for wooden nails.

Miles Thompson's mill was the first of many constructed in the 1840s (Lock Haven Express 1947a). Three years earlier, in 1842, James Brook owned a small sawmill a short distance below Bearfield Run. Jacob Baugham and John L. Proctor also operated a sawmill, starting in 1848 or 1849. Their mill was profitable and after several years, they sold it along with several tracts of valuable timberland to Munson, Corbet & Company with some financial support from a man named Rumsey. This company built an-



Lumber mills, like this one, reconstructed at the Pennsylvania Lumber Museum, were built and operated across the watershed from the 1840s to the 1910s.

other sawmill about one mile below the Potter County line, which was later enlarged and converted into a gang mill. It was highly productive for a number of years, but eventually burned down. Edgar Munson was later known for clearing rocks from the stream to improve log rafting on the stream (Lock Haven Express). Sometime between 1840 and 1850, Michael Stout, his son, Franklin Stout, and Franklin Summerson purchased several tracts of timber on Hevner's Run and built a log gristmill and a sawmill about 825 feet (251 m) above the mouth of the stream.

Through the efforts of residents, the lumber industry continued to gain steady ground during the 1850s. By 1852, several small sawmills were run by Kettle Creek's waterpower. Hiram Meriman operated a water mill at Cross Fork. English gate mills were introduced and used a vertical sawing motion to cut 1000 board feet of lumber each day, a significant improvement over earlier methods. One of the first of these types was located at the mouth of Bearfield Run. Gang mills were also popular; Nathan Tuttle operated one on Hammersley Fork and the Goodman's owned another at Elm Camp.

But residents were not the only ones at work pursuing the local timber. Land speculators cashed in as lumber companies bought up large forested tracts, passing land ownership from one non-resident to another. As company holdings throughout the East were cleared, the Goodyear, Lackawanna, and Emporium Lumber companies moved into the region.

Political Organization for Population and Tax Assessments

Descriptions of the landscape during the 1840s can be found in documents related to the political formation of townships during this time. The lower portion of the watershed was described as having a very uneven surface, streams branching east and west, with deep hollows

While the lower portion of the watershed was generally unsuitable for farming, the upper portion was developed for its gentle slopes and fertile soils.

and narrow ridges, and few tracts suitable for farming. Stewardson Township was the first municipality to be established in 1844. Leidy Township was organized in 1847 (Linn 1883), Abbot Township in 1851 (Leeson 1890). Township lines were drawn and redrawn as new municipalties were organized.

As the region was further organized into county and township governments, assessments and surveys were made to describe the value and patterns of settlement in each municipality. These descriptions were early forms of census and recorded family names and property. The Stewardson Township Assessment of 1845, prepared by John Wolfe, listed the names English, Hall, Hazen, Herrod, Jekins, Pfoutz, Roundville, Stewardson, Thomas and Yoh in its record.

Just a few years later, tax records for Stewardson Township in 1849 indicate significant property improvement by several landowners (Heimel 1992). Two lumber mills were in operation - one owned and operated by Miles Thompson in Cross Fork and one by William Vaux and George Stewardson located in the upper parts of Kettle Creek near the home of Frances French. The Dodge brothers who operated a farm owned 14 oxen. And Ezra Pritchard, who lived near the mouth of Long Run, owned a patent leverwatch.

The first surveys of Abbot Township, not yet officially established, indicate that several families had settled in the northern region of the watershed. Thomas Abbot, Daniel Conway, George Wran, Peter Yochum, and Adam Yoh had all claimed or purchased land and built small homes. Official assessments of Abbot Township were completed in 1852, one year after its organization, and listed many more residents, including many Norwegian colonists.

Expansion of Infrastructure and Public Service for Rural Communities

Post offices were, and still are, few and far between. The first post office in the watershed was established at Westport in 1847. A. O. Caldwell was appointed postmaster and the office was named Kettle Creek. Residents from the mouth of Kettle Creek to at least the county line received mail at this office until another was instituted in Carter Camp in 1851 (Welfling 1952). Hubbard Starkweather served as postmaster here until the office closed in 1859. At some point, the Kettle Creek post office closed but a second was opened, again in Westport, in 1856. At that time, Sol Smith delivered mail twice a week from Lock Haven. As commercial centers developed at Cross Fork, Hammersley Village, and Bitumen, these towns also received regular mail delivery.

Settlements along the streams required connections with centers of commerce at Coudersport and Renovo. Through the development of roads, the headwaters of Kettle Creek were made more accessible to residents and regional travelers.

In 1852, the first bridge to span Kettle Creek was built at Westport. This bridge and other road improvements were integrated with the state's plan for expanding mail service. Postal delivery in rural Pennsylvania was quite limited up until this time. Mail pieces were held at the closest post office (still many miles away) for residents to pick-up while in town. Post offices and delivery schedules were established by the state based on the population of private residents and businesses. It was, in fact, an act of the Pennsylvania legislature in 1852 that enabled a future mail route from Westport to Cross Fork, since several road improvements and bridges were needed for the new route. The improved road was named Charter Road and opened later that year.

Other roads were cleared or constructed by private landowners. In 1856 Truman Goodman cleared a passage through Road Hollow on which he hauled logs to his sawmill. (In 1925, the road and its extension to the Potter County line became property of the state and were relocated to Five-mile camp, eliminating two particularly sharp turns. In 1936 after the March 18th flood (the largest on record), the road was again relocated, this time above the new high water mark of the stream.) The first railroad bridge to span the stream at Westport was built in 1859 just a few yards from the roadway crossing. Both bridges were swept away by the St. Patrick's Day flood of 1865.

Road, rail, and postal improvements during the 1850s were completed to support the rapidly expanding rural population. The mountains of central Pennsylvania attracted new residents for several reasons. The rural landscape provided an alternative to an ever more regimented society. It offered land ownership and independence to those who found it difficult to purchase property in the cities. The mountains compelled a sense of adventure in surviving and taming the wilderness. Others felt it provided a means to live peaceably with nature.

The Kettle Creek Landscape Offers Freedom and Resources for Immigrant Communities

The 1850s was a period planned for growth in the watershed - first by Norwegians and later by Germans. They envisioned the land as a place of freedom and opportunity, their vision enhanced by rich descriptions of the landscape and resources awaiting discovery. Ole Bull, a Norwegian musician envisioned an opportunity for his countrymen to escape the cultural oppression of Swedish rule; William Radde, an aspiring German developer, sought to create a cultural center, where German immigrants could be proud of their agricultural productivity rather than ashamed of their urban unemployment.

The Norwegian Colony

Ole Bull, a world-renown Norwegian violinist, traveled throughout the United States, playing in major cities and touring the American landscape. In the late 1840s and early 1850s, he traveled through Pennsylvania and was impressed by the upper reaches of the Susquehanna River Basin, as they reminded him of his homeland. Well aware of the political scene in Scandinavia, where Danish oppression had been defeated, only to be replaced by Swedish domination, Bull hoped to liberate his countrymen in the freedom offered by the United States. His interest in the upper reaches of the Susquehanna led him to John F. Cowan, a prominent businessman and social figure of Williamsport (McKnight 1905). A land transaction was arranged and Bull began to make plans to establish his new community. He purchased 11 warrants owned by Cowan for the price of $10,388.00 for the development of a Norwegian colony along Kettle Creek. The warrants lay in two blocks-the northern block along Little Kettle Creek and the southern block along the main stem (Welfling 1952). Within that purchase were three parcels, totaling 658 of the most tillable acres, reserved by the Stewardson

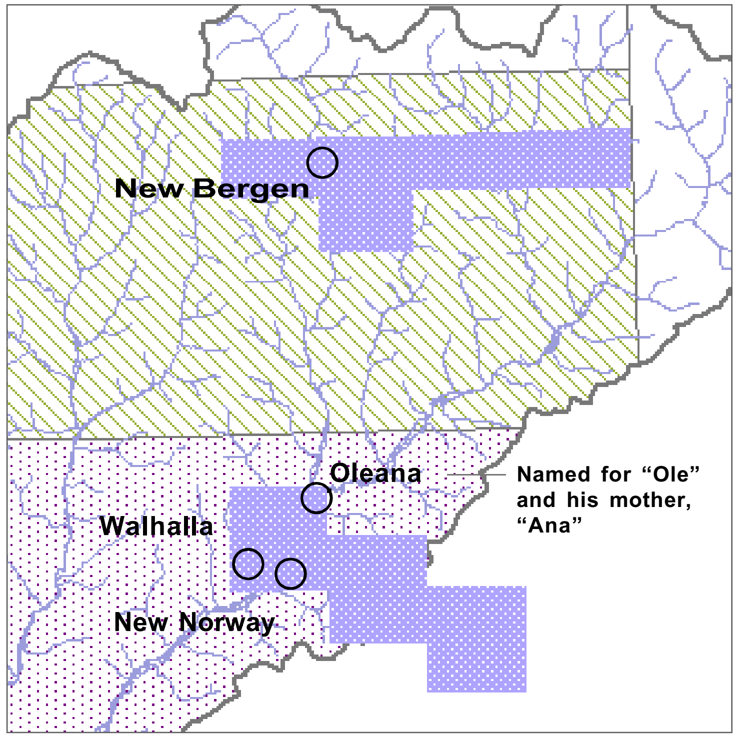


Figure 2.3 - Ole Bull planned four villages within the eleven warrants that he purchased in Abbot and Stewardson townships.

family adjacent to the stream and a small portion of the Coudersport and Jersey Shore Turnpike, the only improved road in the upper watershed (Myers 1983).

From descriptions of the landscape (Bull may not have seen the sites he would purchase), Bull envisioned an agricultural colony with village centers surrounded by fields and pastures. He planned four small villages: New Bergen,

> Apparent similarities between Kettle Creek's headwaters and the Norwegian landscape led Ole Bull to imagine that his fellow countrymen could find a prosperous life in Pennsylvania.

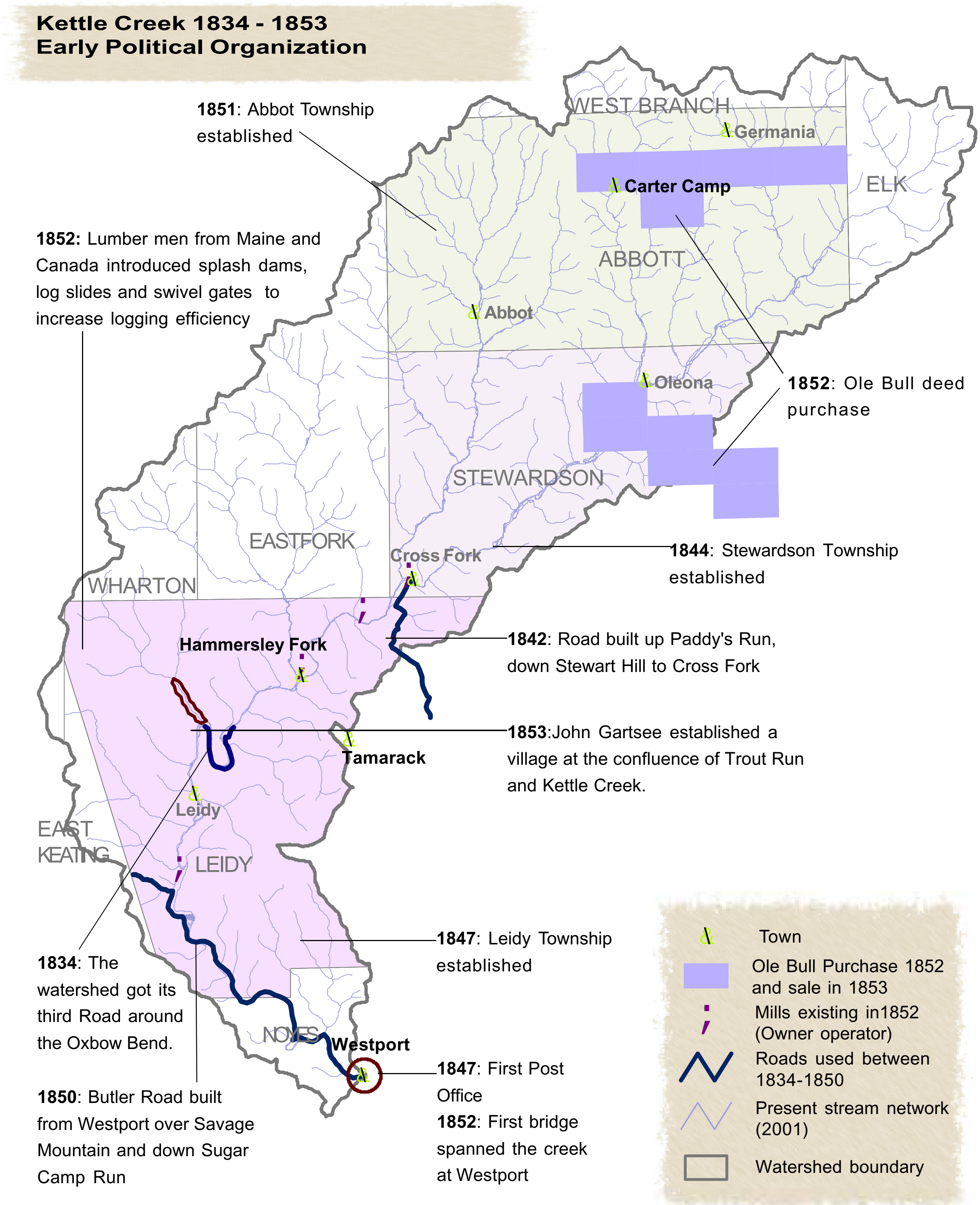


Figure 2.4 - Kettle Creek 1834 - 1853, Early Political Organization

Oleana, named for himself and his mother (and later known as Oleona), New Norway, and Walhalla (or Valhalla). With plans in mind, Bull purchased the properties and set about the promotion of his philanthropic venture.

In September of 1852, Bull traveled to the ports of New York City to gather a small group of men to begin construction of the new colony. He persuaded approximately 30 Norsemen, many of whom were skilled craftsmen, not to head for the Midwest but to help settle a new community in Pennsylvania (Heimel 1992). Bull paid for their travel, first by train to Wellsville, then by stage to Coudersport-the first of many subsidies for the colony's development. Their arrival in Coudersport drew the attention of local newspapers and was widely reported. Most of those who had already settled here did so quietly and individually. No one had taken such a corporate or development interest in the Northern region, so this was news.

From Coudersport, the group traveled on foot into the upper heart of watershed. They immediately began building homes for the future colonists and a school for the children. Merely 10 days later, Bull returned to New York to greet the first of those who had been lured across the ocean by stories of gold and mineral wealth, rich agricultural productivity, bountiful springs, and cheap, abundant land. Sailing upon the Incognito, over one hundred men, women, and children had dreamed of endless fields of oats, hay and corn, pastures of sheep and cattle, and profits to be made from sales in the big eastern markets (Heimel 1992).

Those first settlers were likely amazed by their first sights of the landscape. Their expectations of a farmable landscape with simply a few trees to clear were quickly replaced by the reality of steep, forested hillsides among narrow ridges and valleys. But their loyalty to Bull and his enthusiasm (and financial support) for newfound opportunities in America were not to be shaken and they set out to establish a new home. Bull paid the settlers for their labor ($.50 per day) to clear the land and provided food and shelter until they were self-sufficient (Heimel 1992). Colonists ate a simple diet of cow cabbage, nettles, leeks, fish and game and made clothes by hand when materials were available. Bull was not an on-site community developer, rather he appointed a staff of managers to oversee the development of the colony while he traveled the States, giving concerts whose proceeds benefited the colonists in wages and supplies.

Over the next several months, the colony grew at a modest pace. Colonists worked to clear the land of the dense forest by "grubbing," digging out the trees and roots by hand. Progress was slow but thorough - on the dense hillsides, two men could clear an acre per year. By January of 1853, construction of a sawmill, two watermills, a schoolhouse and several roads had commenced (Heimel 1992). As long as Bull continued to pay their wages, colonists were willing to work, though efforts dwindled as time wore on. Morale was also challenged by the winter of 1852 to 1853, when long periods of below zero temperatures discouraged work outdoors (Heimel 1992). But spring did come to the region and morale improved as the colony continued to grow and attention was directed toward Independence Day celebration.

Reports of the grand celebration planned at the Norwegian colony made newspaper headlines in New York City. They claimed that huge orders for lamps and wine kegs had been placed and that President Franklin Pierce and his Cabinet had been invited. Interestingly, there were few records of the actual celebration in comparison to those of its planning. One account suggests that more than 800 were in attendance, while another claims less than 300 participated. To date, there is no confirmation of President Pierce's attendance or that of Cassius Clay, a southern slave reformer who was also invited to the event (Welfling 1952).

Ole Bull's American home was to overlook the valley from this mountain top. All that remains of Ole Bull's "castle" today is its foundation and a collapsing stone wall on the mountain face.

Among other buildings constructed for the colony, Bull planned to build a home for himself at Walhalla, the "Royal Hall" or mythical resting place of slain heroes' souls. The building was portrayed as a castle in reports traveling back to Norway, since it was sited atop a steep cliff overlooking Kettle Creek. Bull reinforced this notion with the construction of a stonewall just below the house, giving it a regal appearance. The building itself, at least in as far as it was completed, was modest: a two story frame cottage 20' x 36', with hardwood floors, and porches skirting the sides. The interior, according to eyewitnesses, was much more lavish, decorated with imported fabrics and native hardwood panels.

Although the deed transaction had listed three reservations, Bull had never paid attention to their location until he read the deed in full. On May 25, 1853, he wrote to Cowan from Philadelphia, asking for an explanation of these holdings (Welfling 1952). Cowan replied that these parcels were indeed not part of the transaction and were, in fact, still owned by the Stewardson family.

Disappointed that all of his efforts and those of his colonists had been in error, Bull deeded back the properties to Cowan in mid September of 1853 (Welfling 1952). The settlers soon learned that Bull had never owned the land they had worked so hard to make their new home and that the true owners had little interest in supporting the colony (Heimel 1992). Colonists were offered the option of purchasing their plots, but few had the money to do so. Instead, most packed their belongings and returned to Wellsville to follow routes west to Iowa, Minnesota, Michigan, and Wisconsin or east to the port that would return them to Norway[11]. Bull continued to tour the concert halls of the East, sending profits when he could, but ultimately returned to Norway in 1860.

Norwegian settlers worked diligently to construct their new villages. But their timing and methods proved inadequate to establish a sustainable community before the challenges of topography and a particularly harsh winter took their toll on morale.

Henry Andresen was one of the few who were able to purchase land from Cowan. As Bull's personal secretary, he was well paid and able to afford the opportunity. He bought much of present-day Oleona and became a central figure-hotel proprietor, lumberman, merchant, grist miller, and postmaster-in the upper watershed (Heimel 1992).

Dr. Edward Joerg was another who purchased land from Cowan. Joerg, a physician, had been lured from Missouri to the region by Bull as a physician to oversee the management of a sanitarium (Welfling 1952). Bull's description led him to believe that the sanitarium was ready for operations and merely needed professional staffing. What he found upon arrival was a small log house with the barest of supplies. After the colony disbanded, Joerg purchased the 990-acre warrant, containing New Norway and Walhalla, and constructed a two story stone house from the remains of Bull's castle.

The Olson family also stayed in Kettle Creek after the break up of the colony. Martin Olson operated a blacksmith shop in 1853. His sons, Bert and Henry, operated a whetstone factory at Indian Run off Little Kettle. The whetstones they produced were twelve inches long and well known in the region. The sons eventually sold the operation to a man named Jordan and moved to New Zealand.

By 1882, thirty years after Ole Bull's purchase, several of the original buildings were still part of the community. A few homes, a hotel and a store still comprised Oleona and the post office at Carter Camp had become a multipurpose community hall. Dr. Joerg's home was still intact, as was the foundation of Bull's home. The Oleona cemetery had been established and would come to include many of the remaining Norwegian settlers.

Several of the Norwegians who remained in the watershed after the colony disbanded are buried in the Oleona cemetery.

Germania

The dust had barely settled on the upper watershed when two Germans began planning for another European community. Dr. Charles Meine and William Radde sought to establish not just a village but a full-fledged city for German immigrants under the freedom of the American flag.

> The original plans for Germania were modern for their time, including parks and fountains, industrial centers, and cultural amenities in the initial development proposal. However, they failed to consider how the ideas expressed on a sheet of paper would be constructed on the mountainous terrain.

Radde worked in New York as a publisher (Heimel 1992). News of the failed Norwegian colony passed through the city as colonists returned to Norway and Radde took advantage of the opportunity to acquire large tracts of land inexpensively. He bought out 15 of the remaining colonists to acquire east of the Norwegian colony and established the town of Germania. As part of the Pennsylvania Farm and Land Association, he planned to develop the town into a small urban center of factories, fountains, parks, and theatres, surrounded by agriculture. He envisioned each landowner having a downtown lot on which to build a home and a farmland plot for agriculture. He had a similar vision for a new city of Cross Fork, to be located at Oleona, though this plan never developed[12].

Radde sought industrious workers to help make his vision a reality. He sent descriptions of the new community home to Germany and to German neighborhoods of eastern American cities.

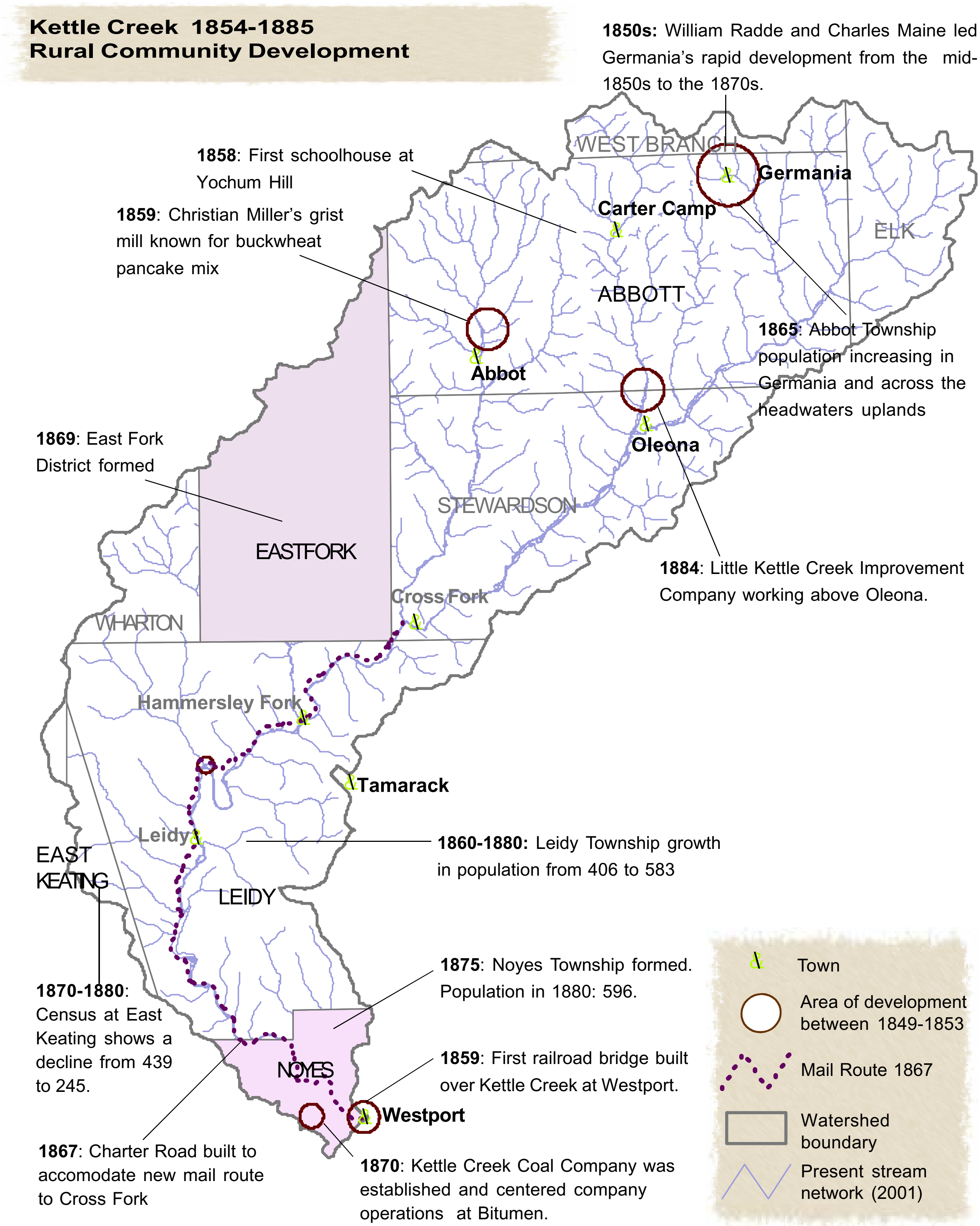


Figure 2.5 - Kettle Creek 1854-1885 Rural Community Development

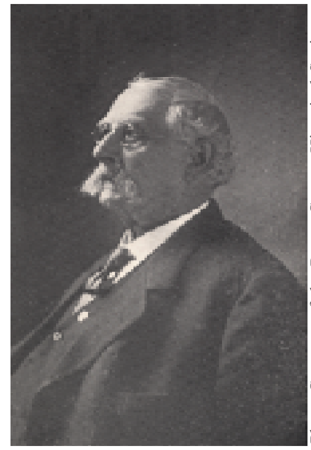
He claimed that it was better to be a poor, rural farmer than to be an unemployed urban worker.

In October 1855, Dr. Charles Meine moved to Germania. He represented the Pennsylvania Farm and land Association and oversaw the development of Germania for the state (Leeson 1890). He quickly built a log home in which to spend the winter and the next spring set about clearing land and building a sawmill, store, and several dwellings for future residents.

When the German settlers arrived, they were disappointed to find that the vivid descriptions of thriving agriculture that brought them to Germania were exaggerations. The plans for Germania had been beautiful on paper, however they were impossible to carry out on the steep topography of the Kettle Creek uplands. The plans were therefore scaled back to the bare necessities of a few streets and stores and adapted to the site.

The first stores opened as soon as buildings were constructed and stock was available. Fred T. Sahr and Christian Peterson opened the first store in Germania in the mid 1850s (Leeson 1890). The German community of course desired a steady supply of beer so Joseph Schwarzenbach opened a small brewery in 1858 (Leeson 1890). His business grew steadily over more than forty years and at the turn of the century, and he left Germania for Galeton where the railway could help distribute his product.

In 1859, Christian Miller opened a waterwheel-operated gristmill nearby to process grain for local farmers. Germania Roller Mills, owned by Frank Cizek and located between Germania and Carter Camp, was regionally renown for its pancake mix. The gristmill business was so profitable that when Cizek's mill was destroyed by fire, he replaced it with a larger mill in Germania to meet the local demand. Flour manufacture continued under Frank Cizek, Jr. until the beginning of the WWII when the Swiss silk used in the sifting process was unavailable and deer populations were severely damaging buckwheat crops. The mill continued to operate as a feed mill and farm supply store until 1976.



Dr. Charles Meine oversaw the development of Germania beginning in 1855

As wild fires were problematic in the region, Radde purchased a water pumper to protect his colony and residents. The thick forest yielded plenty of flammable, organic material that ignited easily when lightning touched the ground. Fires spread quickly through the forest and fields and often consumed entire villages as the wooden structures passed flames to adjacent buildings. Germania was the first community in Potter County to have fire protection.

The German settlers brought their Lutheran heritage with them. In 1859, as part of the July 4th celebration, the community placed the corner stone in the recently completed foundation of their new church.

By 1860, most of the households (51 of 75) in Abbot Township were German. Others remained from the Norwegian colony or had moved from other parts of the country. Only a few were native born Pennsylvanians. Many lived in and around Germania, but there were other settlements at Carter Camp and Yochum Hill as well as scattered homes along the headwaters streams. Most were farmers, raising cattle and buckwheat to sustain their existence, though the merchant market was steadily growing. By 1868, Germania was home to five locally-ownedbusinesses.

Children of the frontier were usually educated at home between chores on the family farm. In 1858 the first school was organized at Yochum Hill and met at the home of the teacher, Daniel Conway. By 1863, there were enough students to support a two-room schoolhouse in

A FEW CRAFTSMEN OF GERMANIA

Jacob von Allmen - harness and horse supplies

Joseph Breunig - blacksmith

Mr. Hensel - tinsmith

John H Hug - undertaker and funeral director

C.F. Martin - crafter of musical instruments

Lauir F Meissner - merchant general and agricultural tools

Frank Milde - merchant of general supplies and furniture

Paul Milde - cabinetmaker and spinning wheel crafter

Casper Neubauer and later John Bodler - shoe salesmen

William Schaar and George Shoemaker - blacksmith, wagonmaker

Germania. Over the course of time, the school became widely known for its excellent liberal curriculum. By 1880, there were five schools in Abbot Township educating 160 students at a cost of 90 cents per month per student. (At the peak of the lumbering industry, Abbot would host seven schools and as many teachers.)

For these families new to the frontier, social gatherings were particularly important part of community life. Around 1870, a social hall was added to the Sandbach Hotel and named the Schwarzenbach Hall. Local residents would gather here to dance and to take in the shows of traveling performers. As the community grew, additional facilities were needed and within a few years, Schwab Hall was constructed. By 1876, the local economy was comprised of two hotels, five retail stores, two meat markets, two shoe shops, a barber, a harness shop, two breweries and two blacksmiths.

While the Germans were a predominantly Protestant community, lumbering introduced other religions to the region. By the early 1870s, there were several Catholic families living in the watershed, mostly around Germania. At first, residents shared church facilities with other denominations and hosted ministers who traveled throughout the region. But in the early 1870s, a

Several structures in Germania have historic significance. The Germania Hotel hosted P. T. Barnum and Ole Bull and the Germania Store across the street has been in business since the early 1900s.

site was selected and construction began on a Catholic church (Lloyd 1921).

A third brewer moved to Germania in 1886. John Schmid found a welcome audience for his lager in this hardworking German settlement (Leeson 1890). When the county government proposed a prohibition amendment in 1889, Abbot Township overwhelmingly rejected the notion. Prohibition did limit the sale of alcohol in the upper watershed, but the Germans continued to enjoy their beer. Regulation prohibited the sale of beer in larger than gallon quantities but allowed beer service at restaurants, bars, and social clubs.

In addition to agriculture, many small businesses employed local residents and produced items for local and distant markets. As a center of agricultural commerce, several "smiths" and "makers" were located at Germania. Clothing, cabinets, food and farm supplies could all be found within a short walk downtown.

Businesses were also located in the more rural parts of the watershed. Hubbard Starkweather, postmaster as Carter Camp, found a sandstone ridge between Carter Camp and Kettle Creek that he thought would supply good material for whetstones. After purchasing the land, clearing a plot and building a house, he cutting and refining whetstones. In an effort to spark his new business, Starkweather produced several samples and distributed them to local residents. But the sandstones proved to be too soft for the metal implements the farmers needed to sharpen and Starkweather abandoned his operation. The clearing once provided a great campsite, as noted in several hiking guides.

In 1894, Dr. Meine helped organize the Schuetzen Verien, a fraternal club. Unsurprisingly, membership rose from 4 to 125 in its first four years. The organization constructed a clubhouse including a bowling alley, a shooting range, a ballroom, and a dining room and hosted regular local entertainment.

Germania grew steadily as a result of high grain and dairy production in the headwaters. In 1889, the Germania Land Company constructed a gristmill just east of town, possibly the largest gristmill in the watershed. Dairy farming was so productive that farmers found it increasingly difficult to sell their milk and sought ways to profit from the surplus. Around the turn of the century, two cheese factories were opened, one by Christian Schumaker in Germania, and the other, the Carter Camp Cheese Company, located near the Carter Camp Grange. The cheese business proved profitable, particularly during the lumbering era. But by 1916, most of the lumberjacks and their families had left the region and the factories were forced to close.

Just after the turn of the 20th century, John Cizek opened a heading factory in Germania. He realized that the abundant hardwoods that others were cutting for lumber could also be made into barrels heads. His factory employed 20 to 30 men involved in the cutting of timber for construction of his mill, the cutting and hauling of maple and beech logs, and the manufacturing various-sized barrel heads. His brother, Frank, operated a steam-powered traction engine to load logs onto the railroad cars. Once loaded, they were hauled to Germania where they were transferred to boxcars for shipment to eastern manufacturers.

As automobiles and gas-powered machinery became common throughout the Northern Tier, the town of Germania became a small hub of distribution, particularly for local farmers. During the 1920s and 1930s, there were as many as five pumps in town: David Gutgsell's woodworking shop, Herman Braun's store, the Germania Hotel, the Germania store, and Harold Beacker's garage.

Community Growth in the Lower Valley

While growth in the agricultural headwaters revolved around Germania, social and commercial life in the lower portion of the watershed centered on the town of Leidy. Theodore Leonard opened the first store in Leidy Township in 1856. After conducting the store for two years, he discontinued the business and left the region. Around 1860 Hamilton Fish engaged in a mercantile business. In 1862 Edgar Munson and Truxon Goodman became proprietors of the store, from which they managed a profit for eight or nine years.

The first schoolhouse erected in Leidy Township was built on the eastern bank of the creek. A man named Grimes was the first teacher employed. The next school was located on the western bank opposite where Boone road reached the stream.

The first mills were located along the main stem, where farms were located, but within a few years, mills were also constructed along the tributaries. By 1856, five saw mills were operating at Tamarack. Four other mills were also operating in the lower portion of the watershed. The mill at Bearfield Run was still running strong. A gang mill had been built below Trout Run. And two sawmills, one approximately 5 miles up Trout Run and another near Oxbow Bend, had been constructed. Meanwhile upstream, Thomas Bailey had constructed a sawmill near the mouth of Short Run, beginning its 30-year operation.

Agriculture made significant advances after the Civil War. Farmers of the lower watershed bought the first machines to improve the crop production. Hamilton Fish bought a reaper and a corn planter, and Dan Calhoun and David Summerson purchased threshing machines (Lock Haven Express 1947c). Productivity increased and easily supplied local residents and lumber camps with fresh crops. Apple harvests produced great surpluses that were shipped to New York markets. Apple season kept children busy peeling and drying the fruits for storage and sale. Livestock was a significant part of historic agriculture as well. During the 1860s 1400 cattle and 3500 sheep were pastured on the bottomlands and lower hillsides of the valley.

Railroads were slow to reach the watershed. There were few people to reach, few who could afford the fare, and the topography made railroad construction expensive. Only the profit to be made by getting lumber and hemlock bark to regional cities would truly make railroads worth the investment. In 1859, a railroad bridge was built across Kettle Creek at Westport. The railroad now continued along the northern bank of the West Branch toward lines delivering lumber from the mill at Austin.

Another village community was growing in Trout Run during the 1870s and 1880s. A church and cemetery had been established by 1876. Elizabeth Fish, wife of Hamilton, was the first buried here (Lock Haven Express: Kettle Creek). In 1883, John Gartsee established a hotel and a post office at the mouth of Trout Run (Lock Haven Express: Kettle Creek). Other residents saw opportunities to profit from the lumber companies working throughout the western reaches of the watershed and opened two general stores here as well, including one owned and operated by Clement Mills and Company. One mile above Trout Run, on the eastern side of the creek was a sawmill with its gangs of saw blades. Over the next forty years, the village at Trout Run would grow to include a general store, a wagon and blacksmith shop, a church, a shoe shop and a number of private dwellings.

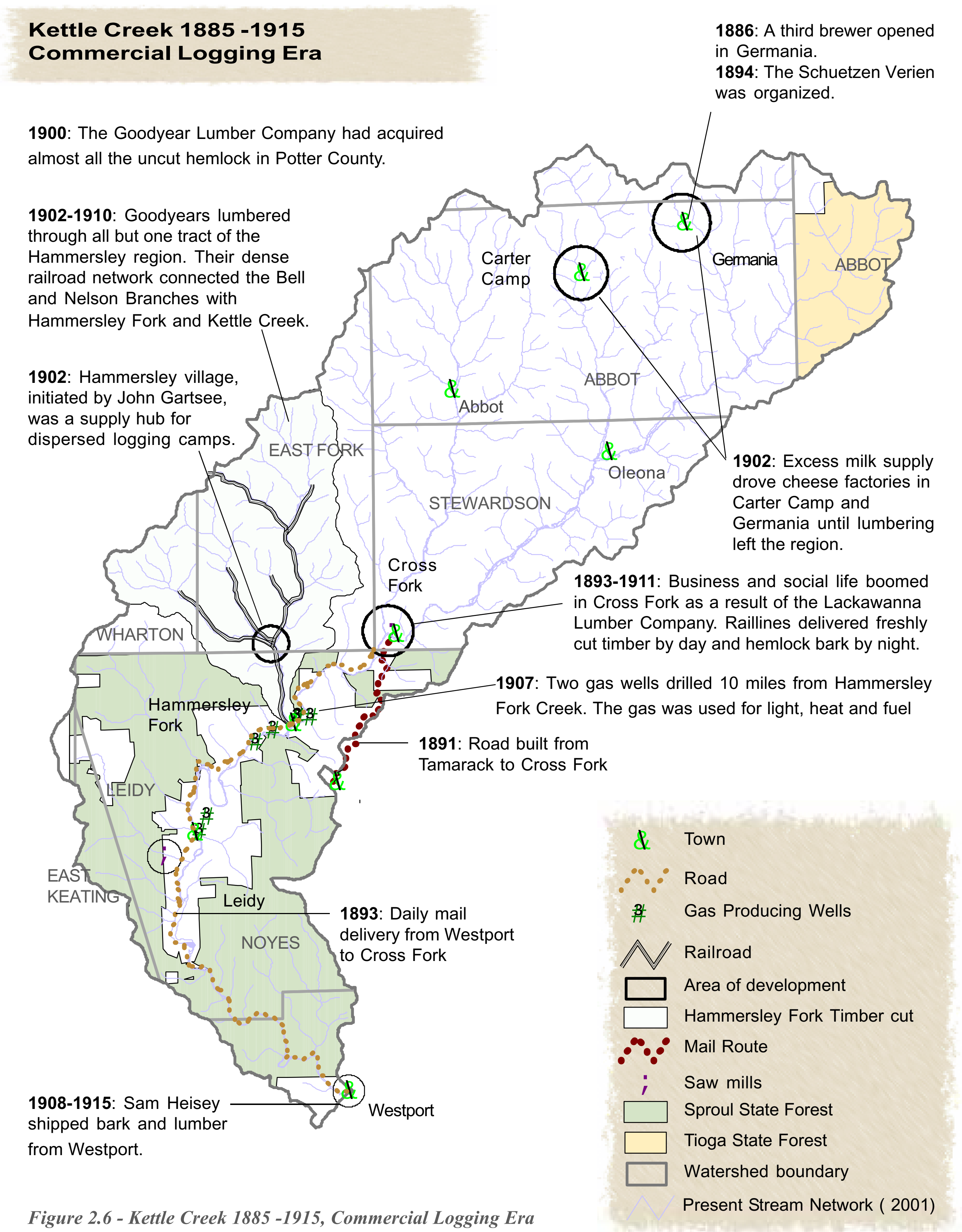


Figure 2.6 - Kettle Creek 1885 -1915, Commercial Logging Era

Tales and Legends in Kettle Creek

While agriculture and lumbering along Kettle Creek met most of life's necessities, people supplemented their diet and income with products from the natural environment (Lock Haven Express 1947c). The wildlife populations were abundant as a result of forest management by the Native Americans. The hooves of slaughtered animals were sold to glue factories. Wild pigeons were shot, barreled and shipped to eastern markets. Wild ginseng was gathered from the mountains and sold in local stores for 25 cents per pound.

Though hunting was a serious activity, tales of "the one that got away" or "the accidental trophy" were often shared in a lighter tone[13]. One such story is that of Ole Snyder, the firstborn child of the Ole Bull colony. While hunting with friends, Snyder strayed away from the group to pursue his own prize. Stumbling into another hunter's territory, he accidentally shot a stool pigeon. After a long apology, Snyder paid the owner for the damages and bought a few pigeons, for a generous payment, to imply his good aim. Before returning to his hunting troupe, he shot a few bullets into the birds to make his catch convincing.

Another story relates the density of deer in the late 1800s. At that time, deer seemed particularly abundant, because logging operations created forest openings where they could feed generously on tender new growth. Other areas, such as Impson Hollow, were known as deer runways, since they led to fresh water supplies. The story tells of Martin Joerg, who took aim at a deer, fired, and was disappointed to see it run from view. He was happily surprised, however, to see another deer a bit farther in the distance collapse from his shot. It seems hunting was quite easy in those days.

Another tale is that of the Klukey Family Deer Hunt. Confined to crutches by a broken leg, Charley Klukey managed to harvest deer near his property. With the help of his daughter to carry his rifle to his post, his wife to release the dog, and the dog to herd the deer within range, the family was able to have fresh meat throughout the summer.

One final story stars the deer that stole Ezra Pritchard's prize Winchester. Pritchard was quite proud of his rifle, taking great pains to clean and polish its parts. While hunting one day, Pritchard shot and the deer fell. But as Pritchard approached the body, the deer got up, snagging the rifle in its antler. Pritchard chased the deer for several yards before it fell to the ground again. He ran past the deer to retrieve his gun, as it rolled free from the antlers with only a minor scratch.

Lumbering Gains Momentum Across the Watershed

As lumber companies established thriving operations in Kettle Creek and surrounding watersheds, population records began to reflect the influx of lumbermen. Records for Leidy Township in 1860 show a ratio of almost 3 men to 2 women, indicating that lumbermen, mostly single or married but traveling alone, were moving to the area to take advantage of logging opportunities (Linn 1883). Those who preceded the logging operations were surveyors who looked for the best routes among the dense forest and rugged terrain. Those who traveled with the companies were the harvesters and haulers of the cut timber.

Because cutting sites moved so frequently, many lumbermen sought temporary housing in the watershed. Some rented rooms at hotels and boarding houses in the rural villages, while others built primitive shelters, designed to last for only a few months, for themselves and their families near their work sites. These homes were built of rough-hewn logs, chinked or sealed with mud and moss. Windows were covered with oiled paper and roofs were made of logs covered with moss-covered shingles. Homes only needed the most basic eating and sleeping facilities, since the workday of a logger was from dawn to dusk. A typical home had two bedrooms, a pantry, and a storeroom. Women spent their time cooking in the pantry or washing clothes in the creek. Furnishings were sparse, as well, since families moved frequently with the lumber camp to new timber tract locations.

Cutting camps were generally constructed at the center of the timber tract near a spring or stream, which provided fresh running water to the men and the teams. The tract was first cleared in the center to create openings for homes and camps buildings. Loggers continued to clear the trees toward the boundary until walking distance to the work site used precious company time, usually 2-3 miles, and the camp was moved.

For loggers and their families, life in the lumber camp was almost nomadic, moving every few months to cut a new tract. A saw miller's life was far more stationary, as his mill required the steady flows of the stream to drive his operation.

The process of logging a timber tract involved several steps. First the trees were felled and sawed into manageable lengths. Next the bark was peeled from the logs in 3' sections and the logs were skidded, or pulled by a team, to a stockpile at the crest of a slope. Logs were moved down the steep hillsides in slides or chutes and piled along the streambank. In the

Photo Courtesy of the Railroad Museum of Pennsylvania, Pennsylvania Historical and Museum Commission

This log hut was located close to south of Hammersley Village and had many wooden bunks and a wood stove.

Photo Courtesy of the Railroad Museum of Pennsylvania, Pennsylvania Historical and Museum Commission

Single lumbermen lived in the Hammersley Boarding House and ate in this dining room.

winter, ice and packed snow made the slides more slick and logs flew down the hills at great speeds. From the banks, logs were either rafted downstream or left waiting for spring flows to fill the splash dam reservoirs and carry them to the Susquehanna.

Early pine loggers were known for rafting their logs downstream-some as far as the Chesapeake Bay. They constructed small rafts from several logs and linked them together. On one of the rafts they would construct a shelter in which the crew would sleep on the journey. It took two or three days to reach Lock Haven, four or five to reach Williamsport, and several more to reach the Bay. Along the way, the rafters would stop for supplies, tying the raft to the riverbank and walking ashore to a local tavern. Whiskey was the popular drink, thought to cure any rafter's ailments. When the raft reached its destination, the crew disassembled the raft, piled the loose logs at the mill, and began the return trip to the camp on foot.

One after another, densely forested tracts of land were harvested for the valuable pine, hemlock, and hardwood species, leaving bare soils and empty habitats in their place.

Rafters wore spiked boots and carried can hooks to maneuver themselves and the logs on the busy river highways. Streams and rivers often became so dense with "log traffic" that the waterways became jammed and impassable. In order to restore the flow of valuable goods downstream, one of the rafters would walk across the tangled pile and attempt to loosen the clog. It was a very dangerous job for as soon as the clog was removed, the backup would come rushing forth. Many lives were lost as rafters were swept away in the current and crushed beneath the logs.

Other companies employed Mother Nature to drive the logs downstream. Amos Roberts, a lumberjack from Maine, built the first splash dam on Trout Run to float the logs downstream once spring rains had accumulated behind the dam. The dams were designed to hold back the logs until the dam was released, driving the logs to downstream mills. (Roberts also built the first log slide with a swivel gate to help move logs during the winter.) The splash dam quickly gained popularity, the second appearing on Nelson Fork in 1853. Since all of the cut timber floated downstream at once, each company or logger developed a mark or stamp that would identify the logs at the mill.

When spring rains were erratic, water levels could fall during a raft trip or log float. Without railroads or wagon trails to continue the journey, raft crews had to abandon their load and return to the camp. A later flood or high flow would carry the logs downstream, but these logs were at least temporarily lost profits for the lumber company.

Up until the 1870s, commercial mills were all located downstream. With the opening of a large commercial sawmill on the Woefel farm along Germania Branch, a transition to local lumber processing was begun. This mill processed some of the finest black cherry in the region. With lumber cut and dried, it could not be rafted or floated in the waterways, rather it needed to remain dry and stacked en route to eastern cities. The Goodyears were the first to invest in rail lines to connect their mills with existing rail networks to the north of the watershed.

At least one company continued to use the streams of Kettle Creek. During the 1880s, the Little Kettle Creek Improvement Company petitioned the state legislature to clear, widen, straighten and deepen Little Kettle Creek from its source to its mouth (Leeson 1890).

New and improved transportation routes were spreading across the watershed during the 1890s in order for farmers to reach each other and their local markets. In 1890 John Daugherty constructed a road from Indian Camp to Daugherty Run (Lock Haven Express 1947i). This was the first road in the watershed that did not ford a stream between the West Branch and the headwaters in Potter County. In 1891, a road was cleared from Tamarack to Cross Fork (Lock Haven Express 1947i).

Commercial interests in the lumber industry continued to develop throughout the 19th century. In 1890, several Williamsport businessmen joined together to profit from improved transportation of cut timber to downstream mills and markets (Linn 1883). They formed the Kettle Creek Railroad and began to develop a railroad network connecting lumbering activities on the West Branch with sawmills in Lock Haven and Williamsport. Lumber companies were also beginning to clear and maintain roads. In 1894, Frank H. Goodyear cleared a road from Galeton to Cross Fork in preparation for the Goodyear's lumbering activities in the watershed (Welfling 1949). Lumber companies made strategic purchases and developments over several years in order to access and transport their timber.

Kettle Creek Flourishes with Resource Extraction and Manufacturing Towns

When early prospectors realized the value of timber resources on their lands, they sold tract after tract to lumber companies working throughout the Northeast. One company would often buy numerous tracts in a region to consolidate harvest, milling, and transportation costs. Early companies were only interested in the pine that they knew how to work and they selectively cut it from the other species.

In 1893, the forests surrounding Cross Fork were thick with hemlock and hardwoods, rich habitat for wildlife. The pine had already been removed but the hemlock included some of the finest in the state. The area was home to just five or six families living in the valley, including the Thompsons, the Pollards, and the Knickerbockers. Their connection to the transportation and postal networks was limited. The booming lumber industry would soon demand improved mail delivery. As rail lines were installed, mail service was increased to three times per week. By 1893, mail delivery was upgraded to daily service to and from Westport.

The rich forest drew the interest not only of lumber companies but also of early developers. Emil Peltz purchased several acres north of the Cross Fork confluence in anticipation of lumbering activities and built a series of houses, calling his settlement Peltzonia (Currin 2001). By 1894, several buildings were complete only to be wiped out by a devastating flood. Peltz was undeterred, however, and he rebuilt with confidence.

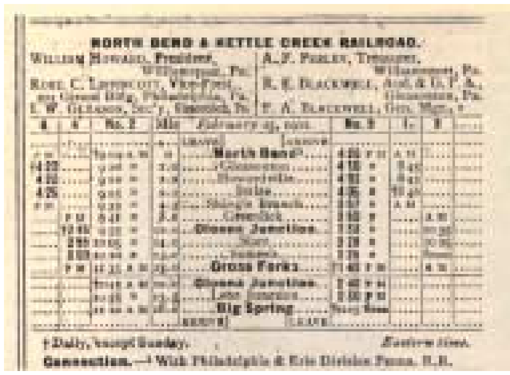
> Technological innovations allowed for larger mills that produced greater quantities of timber in ever-faster time. Companion industries took advantage of scrap lumber and fed shipping companies with barrels and barrelheads.

It was during 1893 that the Lackawanna Lumber Company began logging at the confluence of Cross Fork and Kettle Creek. With hundreds of acres under Lackawanna ownership, the company decided to invest in local milling operations, rather than floating logs downstream to operations in Williamsport. During that same year, the Lackawanna Lumber Company constructed its first sawmill in Cross Fork, one of the largest and most modern mills of the time,

RIGHT: Mileage cards were issued to travellers instead of tickets.

RIGHT-BELOW: 1901 Official Guide Timetable

BELOW: The Goodyear Lumber Company had a large network of railroads that connected Kettle Creek to its mill in Austin.



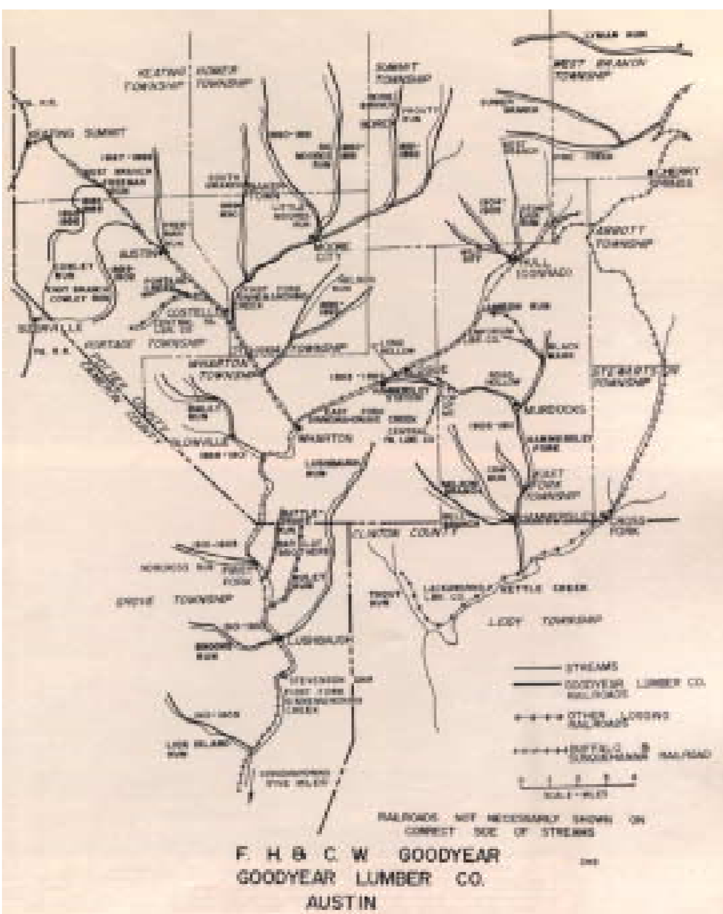


Photo Courtesy of the Railroad Museum of Pennsylvania, Pennsylvania Historical and Museum Commission

cutting as much as 75,000,000 board feet annually (Welfling 1949). The lumber supply seemed endless and soon several mills were open, making a variety of wood products. Since bulk materials, such as nails and bolts were shipped in wooden barrels, much of the smaller timber was used construct barrel parts. The Pennsylvania Stave Company, owned by Brooklyn Cooperage Company, operated a stave mill on the south side of the city, cutting the narrow strips that form the body of the barrel. Heading companies, those that made the disc-shaped barrel ends, also built two factories among the rising development at Cross Fork. In order to ship the processed lumber to markets throughout the East, Lackawanna purchased Buffalo & Susquehanna Railroad lines laid by the Goodyear Lumber Company that branched southward into the watershed from an east-west main near Cherry Springs. The interchange was known as Cross Fork Junction[14].

In 1895, the Lackawanna Lumber Company purchased the Joerg property along Kettle Creek for $28,000 (Heimel 1992). Over the course of the next fifteen years, Lackawanna would complete a small network of railroads to access its timber along Trout Run, Hevner's Run, and Turtle Point Run.

The Goodyear Lumber Company was primarily interested in hemlock and by 1902 it acquired almost all of the uncut hemlock in Potter County, including nearly all of the Hammersley Region (Taber 1971). The company chose a site at the mouth of Bell Branch along Hammersley Fork for Hammersley Village. The village was short-lived by present standards but did have a post office for several years, overseen by Mr. Hi Cranmer. The village was the terminus for the dense railroad network that was constructed alongside the stream network throughout the Hammersley Region and that joined the Buffalo and Susquehanna Line just south of Logue. This junction at the end of the line was known as Hammersley Station and was the scene of a whiskey robbery.

The Goodyears were the last of the lumber companies to set up true villages while they timbered the landscape. Their villages consisted of 75 to 200 men who stayed for several years while logging throughout the region. Later companies would set up temporary camps for their men and which moved frequently to avoid long distances between home and the work site.

The Goodyears continued lumbering into the early months of 1910, essentially clearing the landscape of mature hemlock. However, one stand, located along a Goodyear-Lackawanna border, was left untouched, as poor survey technology could not accurately determine its ownership. Neither company was willing to pay the penalty for cutting another's tract–three times the value of the timber. Rather than risking a dispute, both companies left the tract undisturbed. Today the tract is known as the Forest H. Dutlinger Natural Area.

Hemlock bark was peeled during spring and early summer when the ready flow of sap made peeling easier. The bark was hauled from the lumber camp by rail after dark to a central location in Cross Fork. From here, it was shipped north to tanneries in Galeton, Elkland, and beyond. The return trip was used to deliver food and supplies to Hammersley Village and to the lumber camps.

Once the hemlock was removed, the Goodyears headed west. The Emporium Lumber Company purchased the land and the railroad network and began to harvest the remaining hardwoods. The company expanded the network to reach B & S lines to the west that would deliver the raw timber to Austin and to markets along the Allegheny. The route through Long Hollow was steep, especially for an engine pulling fully loaded railcars. A small freight yard called Murdocks was constructed at the mouth of

Photo Courtesy of the Railroad Museum of Pennsylvania, Pennsylvania Historical and Museum Commission

Hammersley Fork: Steam engines pulled railroad carts of cut timber from the Hammersley Region. Small railway stations were located along the way to load logs and unload supplies.

Road Hollow so that the load could be delivered in two runs.

Emporium operated several engines in this region and each had its own speed for ascending the mountain. Due to these variable speeds and without phone lines, the train schedule was communicated through smoke signals.

In 1896, the Lackawanna sawmill burned, but there was so much timber available that the company quickly decided to rebuild. Its second

Cross Fork in 1904

Photo Courtesy of the Potter County Historical Society

The town of Cross Fork boomed under the leadership of the Lackawanna Lumber Company. Lumber, stave and heading operations brought rail and telephone service, more frequent and direct postal service, and electric lights to the interior of the watershed. Unfortunately, it relied so heavily on these industries that their absence brought rapid demise that was felt even in the headwaters.

Cross Fork lumber mill in 1908

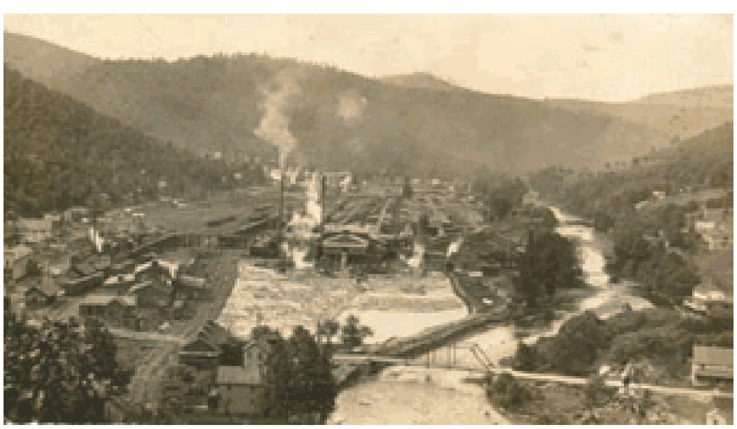


Photo Courtesy of the Railroad Museum of Pennsylvania, Pennsylvania Historical and Museum Commission

mill, completed in 1897, was significantly larger and therefore could process more lumber in a single day. Shortly thereafter, several companion industries opened shop in Cross Fork: a stave mill, a kindling mill, a shingle mill, a hub-factory, and a few machine shops to repair equipment. Things went smoothly for the next six years, until another fire in 1903 burned the mill again. Still, there was timber to be cut on Lackawanna lands, so a third mill was built that same year.

Lackawanna achieved its peak cut in January 1906. Stave and heading mills also reached peak production at this time. With hundred of thousands of board feet running through the mill, Lackawanna also supported a planing mill and a lath mill.

While Lackawanna was the prime operator in the Cross Fork region, other companies were had smaller holdings throughout the region. Without the financial resources to purchase rail lines, these companies had to float their logs downstream. In total, the lumber industry in the northcentral Pennsylvania region supported approximately 5000 lumberjacks annually.

Cross Fork - A Lumbering Hub

In the midst of a booming economy, Cross Fork became the commercial and social center for lumberjacks in the watershed. The Lackawanna Store was listed as the greatest trader in Potter County during the town's heyday, but not to the exclusion of other businesses. The dense rural population also supported five groceries, a farmer's market, a dry-goods shop, a millinery shop, two clothiers, a shoemaker, two medicine shops, a hardware store, a sporting goods store, and a few other retailers (Dana 1917). The Cross Fork post office even sold international money orders. Seven hotels were needed not only for business travelers, but also for men working in town, who opted to rent a room rather than buy or rent a house. In fact, many who came to Cross Fork for the abundant work opportunities left for lack of housing. In addition to the bars located in each hotel, residents and travelers could choose from three restaurants in town. Three doctors and a dentist provided medical services, while two undertakers offered burial services.

By the sheer presence of the lumber industry, residents received public services far in advance of neighboring areas. Two electric light systems, two water systems, and a sewerage system were all put into place by the lumber company and benefited local residents.

The resident population supported four churches, a chapter of the Women's Christian Temperance Union, a YMCA, lodges of Masons, Macabees and Odd-Fellows, a literary society, numerous card clubs, and an opera house. Other social organizations included the town band and baseball team, the Cross Fork Tigers, whose team members included professionals of the Lackawanna Lumber Company.

With many families living in and around Cross Fork, there were 250 children in need of formal education. A combined primary-secondary school with state-of-the-art laboratory equipment was built and staffed for this purpose.

Apparently the threat of fire was far worse than that of crime as Cross Fork's Hose Company was established during this time, but no police were employed.

For more than eight years, the town's own newspaper, The Cross Fork News, pursued its mission "to cheerfully report town happenings and to improve social and political conditions in the town and county"(Dana 1917). Among the articles published on March 30, 1906 was a report that a neighboring town was facing setbacks and would be closing its operations. Many read the article but no one thought the same might happen here.

By 1907, all of the timber in present-day Leidy Township had been cut with the exception of Beaver Dam Run (Lock Haven Express 1947b). (Here, Sam Heisey operated a small, portable mill, cutting and peeling hemlock and transporting it through Trout Run and downstream to Westport. His mill also processed lumber from a number of lumbering camps throughout the watershed until 1915.) But the end of the timber supply in this township failed to capture the attention of lumbermen and their families.

However, in April 1909, Lackawanna shut down its sawmill at Cross Fork. The company's lands had all been cut and what little remained was scrap wood by comparison. The logging industry had grown to a watershed scale by 1910. Nearly all of the virgin timber had been cut and exported. A network of railroads connected timber tracts to the mainline along Kettle Creek and to major routes to the north and south. But the logging industry as it was practiced in the late 19th century was not sustainable and timber was growing scarce. Companies began closing their operations along Kettle Creek and moving to western regions. Lackawanna moved its operations to West Virginia and parts of New Mexico, leaving the town devastated in its absence.

Fires took several buildings that summer, including two hotels. Remaining residents were more concerned with collecting valuables than in protecting vacant buildings. By fall, the railroad station had burned down and the "exodus (was) in full swing." The following year, fire destroyed an entire block. While fires were very common at the time, arson is suspected to have been the cause in an attempt to collect from the insurance companies.

Businesses and services closed without the underlying support from the lumber company. By 1913, the population of Cross Fork had dropped to less than 200 (Welfling 1949). With declining timber traffic and passenger travel, the railroad was forced to close.

> The end of the lumbering industry came suddenly and surprisingly to rural communities that had come to rely on the seemingly endless abundance of a single resource.

The population in 1914 was recorded as 61 and by 1923, only 40 people would call Cross Fork home (Zorichak 1923). Real estate values had dropped from $896.862 in 1904 to $18.815 in 1914 and tax rates to 2 1/2 cents per acre. Aware of the devastation that these people were facing, the state offered financial assistance to prevent bankruptcy.

In 1917, all that remained was one hotel, three stores, and a high school. The school, in fact, was for sale with all of its equipment including two organs.

Today, the schoolhouse remains as a reminder of the booming lumbering hub at Cross Fork.

As Lackawanna finished cutting operations on its individual tracts, it had sold these to the state as early as 1909 (Heimel 1992). The lands were then allocated to management under the Department of Forest and Waters[15]. Once milling operations were closed at Cross Fork, the company sold all lands back to the state, at a rate of $3 to $4 dollars per acre. Public land ownership was at first not welcomed by the few remaining residents, but efforts to reclaim the landscape and support this rural community, and the employment these activities offered, were appreciated. The Department worked to restore the landscape by tearing down remaining vacant buildings, filling in excavation, and draining the millponds, often employing remaining residents. In addition, the state also provided water system repairs and maintenance for the hose company.

When the lumber industry moved into the watershed with full force, many farmers attempted to earn a living in both forest and field. As a result, many farms were neglected. Buildings and fences were not maintained and livestock were left to roam and graze the landscape. When the lumber companies moved west, these men returned to their properties to face the expense of repair but with little money to do so. Farmers had never truly left their land but had been overshadowed and distracted by the scale and impact of the logging industry. The land had always been fertile along the main stem with plentiful wildlife to supplement crop and livestock production (Zorichak 1923). Some species were, in fact, so numerous that they were problematic for farmers. News articles from the Lock Haven Express suggest that farming certain crops was difficult due to the high deer populations in the local forests.

Since the 1920s, Cross Fork has remained a small rural town. Many returned to agriculture as a way of life after Lackawanna's departure. Recreational interest throughout the watershed grew as a result of abundant fish and wildlife populations and the leasing of state forest lands for private cabins. As automobile ownership increased, fishermen traveled to Kettle Creek for the chance of a good catch. By 1963, the combination of small stores, local motels, and rental cabins showed that residents supported recreational tourism in their economy.

Today, few families live in the town of Cross Fork, but many rural landowners claim it as their home. Hotels and restaurants cater to a wide range of visitors–hikers, hunters, fishermen, and snowmobilers–who pass through town. Cross Fork has also become the home of an annual Snake Hunt, drawing people from across the state and the nation to this rural community.

Coal Mining

As coal began to compete with timber in fuel markets, investors and speculators hired prospectors to explore the Northern Tier, in search of coal seams known to underlay the region. Joseph Russell and David Bly were mineral prospectors who discovered coal resources atop the mountains aside Kettle Creek (Parucha 1986). By the mid 1870s, coal mining was underway in the watershed.

Without machines to remove the surface layers, miners dug vertical shafts to access the coal deposits. Underground tunnels left the surface essentially undisturbed. Miners used pick axes to chip pieces of the coal from the tunnel walls and loaded them into carts that were trucked back to the mineshaft. A total of 16 mines were operated throughout the lower watershed, extracting bituminous or soft coal from the Lower Kittanning coal seam (Klimkos 2000). The Kettle Creek Coal Mining Company operated 6 of those mines between the years of 1874 and 1929 and supported the village community of Bitumen (Klimkos 2000).

The Kettle Creek Coal Mining Company was formed by a group of investors but managed by civil engineer, George Miller. Miller was the superintendent, hiring mine employees, opening mines, building new houses and founding a company store that included US postal service (Parucha 1986). He would also serve as mayor and judge of the Bitumen community. Eisenhower, Miller's strong-armed constable, fiercely protected the interests of the company by keeping close track of those entering or leaving Bitumen.

Wages prior to unionization were paid by the ton, for which a miner received thirty cents per ton for mining and loading (Parucha 1986). Many discrepancies arose from the weight measured and paid by the weighmaster and that determined by the miner. Each miner had to furnish his own tools, powder and dynamite, as well as oil for lantern and carbide for the lamp on his cap. A monthly fee was deducted from each worker's earning for the sharpening of his tools by the company blacksmith. Coal for cooking and heat was free, but workers had to mine and load on their on time and were charged one dollar for their hauling labor.

As the market boomed and mines produced mass quantities, coal was taken off the mountain by cable cars. The cars were guided along a track on an incline plane to a tipple at Cooks Run, where the coal was weighed and loaded into Pennsylvania Railroad Cars for shipment to Williamsport and Eastern markets.

Mining was no less dangerous than logging. A mine explosion killed eighteen miners and injured several more in the fall of 1888. The following year, flooding washed out the tipple at Cooks Run and several company houses. Those who survived the tragedies were quick to leave, abandoning their jobs and homes for safer vocations. Despite setbacks in the labor force, mining resumed in full force when Slovaks were hired in 1890 (Parucha, 1986).

Kettle Creek: 1915 to present
Conservation, Recreation, and Rural Living

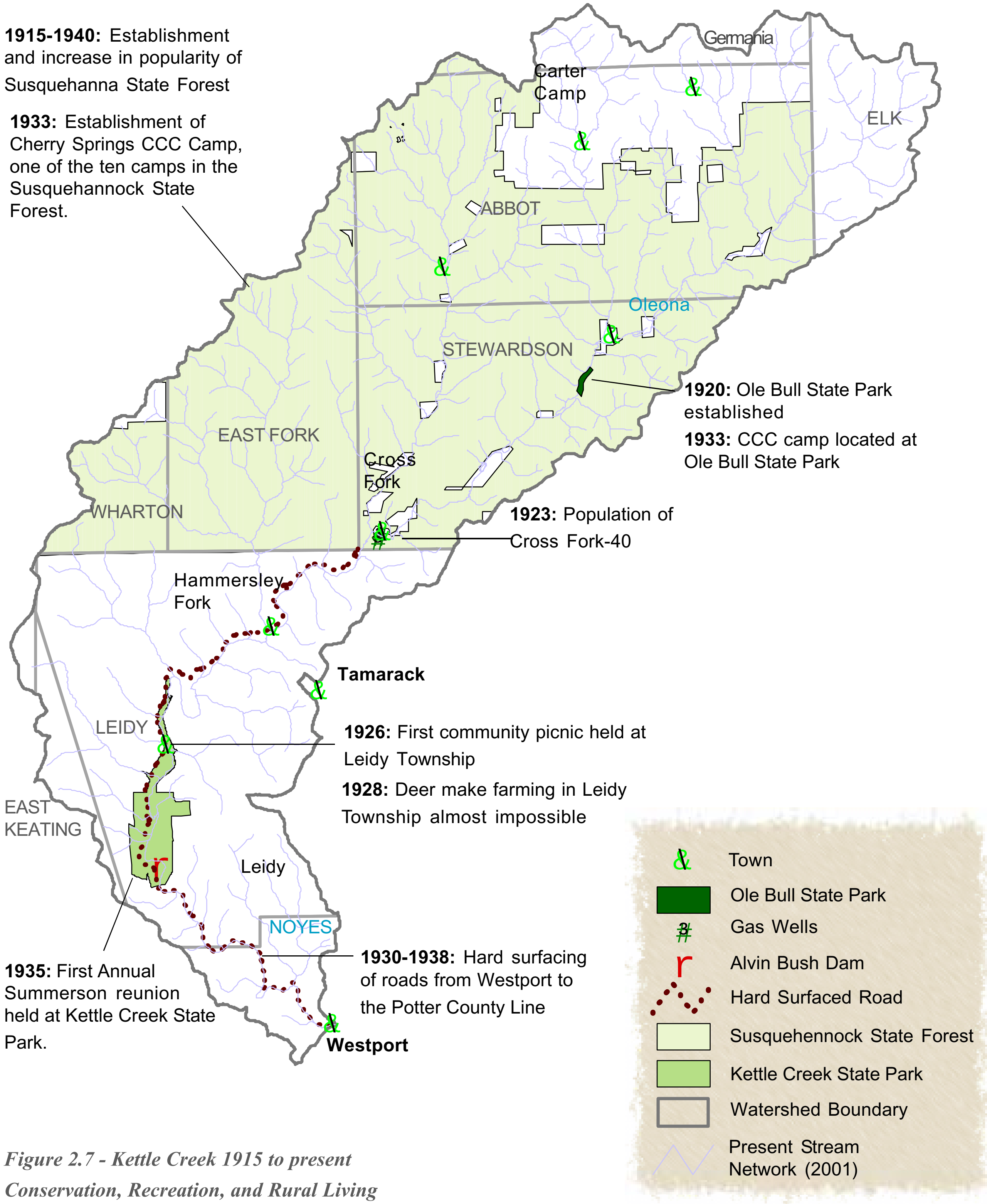


Figure 2.7 - Kettle Creek 1915 to present Conservation, Recreation, and Rural Living

Bitumen - A Mining Town

While Germania was a hub of agricultural activity and Cross Fork was the locus of the lumbering community, Bitumen was the center of coal mining in the Kettle Creek watershed. As a self-contained, company-supported community, it had an influential impact on the industrial and cultural heritage of north central Pennsylvania. The Kettle Creek Coal Company offered both employment and public services to its employees, thriving as a predominantly immigrant community between 1890 and 1930. Initially, the mine workers were American, but soon these men sought safer, higher-paying jobs in other parts of the region. Though the work was dangerous and hard, the jobs were abundant and steady for willing workers.

In need of a hard working labor force, the mine operators turned to the industrial cities of the east where they found several stout Slovaks and offered them company housing and medical care in exchange for their labor. The men and their families wrote of their newfound prosperity in Bitumen to friends and family in Eastern Europe, inviting them to immigrate and take advantage of American opportunities. From the 1890s to the early 1920s, Czechs, Poles, Russians, Ukraines, and Yugoslavs immigrated to America, willing to work for the offered wages in exchange for a new life of opportunities. Along with their work ethic, the Slovaks brought with them their social culture. They brought their Catholic and Greek Orthodox religions, their ethnic foods, their thirst for whiskey and wine, their festive dances and songs.

Residents lived in company owned houses and shopped in the company store. Miners' houses were plain, two-story, four room plank structures. Since there was no indoor plumbing, water was piped from a mountain reservoir to taps along the streets from which residents filled their buckets and carried them home. Coal for cooking and heating was free, but the miners had to mine it themselves on their own time and load it on the wagon themselves.

While the company store met all the basic needs of the residents, the arrangement also kept miners in debt. The company prohibited purchases from other towns and catalogs, so families were forced to pay the prices set by the store operator.

The company also provided medical services to miners and their families. The doctor was a salaried employee of Kettle Creek Coal Company, but he accepted and perhaps even encouraged additional payments of produce, livestock, and poultry.

> During the era of deep coal mines, Bitumen's economy and social culture thrived, independent of its neighboring communities. The Kettle Creek Coal Mining Company met the miner's every need from home to health.

Since working conditions were difficult, miners were quite interested in union organizers who passed through the region. The company, of course, discouraged, even prohibited, meetings with union representatives on company property, but miners skirted this issue by meeting elsewhere. Despite further company obstacles, the miners were able to organize to influence wages and safety through the union.

In 1897 the first Catholic Slovak Union (Jednota), Immaculate Conception Slovak Roman Church, was built to serve the immigrant's spiritual needs. Religion ran deep in the Slovak community, as even the baseball team consulted the priest before games. The Church was moved several times due to the constant expansion of the Kettle Creek Coal Company to where it finally stands today. The Church also started a school for its children. Studies in grammar, mathematics and history were combined with religious instructions. Slovak language was also taught to the children, as it was one of the main languages spoken here. Subsequently a local school was added and this was beneficial to the residents who could not afford the small tuition charged for the Catholic School.

As was customary in Slovak communities, holy days were reserved for spending time with family and friends. A marching band accompanied parades in the street. Dancing was an important social function and the town eventually constructed two dance halls to host special events. Baseball games were popular, as were picnics and long walks after the Sunday meal. Recreation in Bitumen was fun and free.

Over time, the Church would become a community landmark, a special place in the memories of past and present residents. By 1969 members of the Church and new residents of Bitumen had organized to preserve the church, as a historical part of Bitumen. Thus the Bitumen Shrine Corporation was founded to protect and maintain the church and its cemetery. Through donations, the church was renovated. Today the church is totally dependent upon continued financial support from external sources for its upkeep and maintenance. An annual reunion, held during the 4th of July weekend, reaffirms the commitment to and relationships surrounding the Immaculate Conception Shrine at Bitumen.

The children of Bitumen enjoyed the outdoors. After completing schoolwork and household chores, the young boys would leave their homes for games of baseball, rounder (and its many variations), and sling shot. They learned to whittle. In the summer months, they visited the swimming hole at the shoots in Cooks Run, skinny dipping in the cool waters and fishing along the banks. When they wanted to catch larger fish, they walked to Kettle Creek.

The girls' lives were more focused on household responsibility. They too had chores and spent time learning reading, writing and math skills. When these tasks were complete, they were allowed to skip rope, play hopscotch and jacks, and sing with their neighbors and friends. Occasionally a few would follow the boys to the swimming hole to catch a glimpse of bare skin.

Technological innovations changed mining procedures. By 1909, the mines were electrified, providing power and eliminating the need for mules to pull carts through the mine tunnels. But such improvements were not able to remove the risks of mine operations. On December 16, 1910, the brake shoe on a cable shattered, releasing the cart down the incline plane. Two miners were killed and two others were injured in this unfortunate accident.

The population of Bitumen peaked at 1200 that year. Over five hundred male residents were employed in the mines and the balance represented their families. The total number of people supported by mining activity was actually much higher, since some workers lived outside of Bitumen.

The town continued to expand during World War I. As demand for coal fell after the war, the company began to cut workers' wages. Union members went on strike to protest the decrease and in 1929, as contracts expired, mines across the state were closed. Workers who lived in company housing were given 30 days to vacate their homes or face eviction. Many miners enlisted in military service to provide a small but steady income for their families. Service also offered the immigrants access to American citizenship. Others decided to leave Bitumen for Trenton, New Jersey, where the abundance of goods and textile companies promised immigrants many benefits over the economic monopoly in Bitumen. The remaining miners refused to accept the wage rate offered by the coal companies, despite union efforts to reach an agreement. It was two years before an agreement was finally reached in 1921 and mines reopened but on a much smaller scale.

By 1929, nearly all of the deep mines had been abandoned. With each passing month more and more families left Bitumen. Company houses stood empty for several years though some were torn down by 1930. Mining companies closed their operations and left their lands to the Commonwealth by defaulting on property taxes. The Commonwealth then allocated the properties to the Department of Forests and Waters who became responsible for reclamation efforts. The Work Projects Administration, one of the programs of Roosevelt's New Deal, provided funds to seal many of the deep mine openings in an attempt to protect streams from sulphuric acid[16].

In contrast to the logging era that lasted as long as the timber supply, coal mining ended when local companies were unable to compete in the national economy.

While underground mining resulted in minimal surface disturbance, it did cause other environmental hazards. Mine shafts allowed air and water to interact, physically and chemically, with deep geologic layers. This interaction resulted in the release of toxic gases into the air and chemical pollutants into the water that eventually discharged at the surface. Gases were an immediate work hazard at the time of mining activity, but water pollution developed over many years and was exacerbated by the surface mining that followed. Liming machines were employed along Whiskey Springs to mediate the acidic drainage from mining sites.

During the 1960s, the Commonwealth leased lands in Sproul State Forest to D.G Wertz Coal Company and the Kettle Creek Corporation for surface mining, or strip-mining, of the Lower and Middle Kittanning seams. (Surface mining removes large areas of the vegetation, soil and bedrock layers above the coal seam to access the coal from above, rather than from within[17]. This technique ravaged large areas in the lower portion of the watershed that caused increased amounts of sediment pollution in Cooks Run and Kettle Creek.) In addition to surface access, mining required a site permit issued by the Department of Mine and Mine Inspection, the first of which was issued in 1960. Permits authorized the mining activities according to state regulations. Records from DEP, the follow-up agency to DM&MI, indicate that a total of 10 permits were issued between 1960 and 1969. D.G Wertz operated 4 sites in the early 1960s: the Westport mine (under 3 separate permits), the Crowley mine, the Wertz mine and the Cattaragus Road East mine. The Kettle Creek Corporation operated its 4 mines in the later 1960s, one each at Short Bend Run, Crowley Run, Bitumen, and Batschelett.

The mines closed as demand for bituminous coal fell or the coal was completely extracted. Most mines were abandoned, leaving the pit and the spoil to nature (or the state) for restoration. In 1977, the Surface Mining Control and Reclamation Act required mining companies to restore or reclaim their sites to a more natural condition. The Kettle Creek Corporation followed through and reclaimed some of their mines before closing their lease.

Natural Gas

Natural gas was first discovered while drilling water wells at Indian Camp in 1902 (Zorichak 1923). The gas was considered a nuisance because it hampered drilling with frequent, lasting fires, since it ignited easily and burned slowly. It was only five years before its physical and chemical properties were well understood, and at that point, energy suppliers would begin to take an interest in the region for the clean, inexpensive energy that the gas could provide. In 1907, two gas wells were drilled ten miles from Hammersley Fork (Zorichak 1923), providing light, heat, and fuel for local residents.

Though its properties were understood, its location in the bedrock was not. Around 1920, two more wells were drilled south of Cross Fork. One was 3500 feet (1067 m) deep, the other just over 2500 feet (762 m) deep, and both were dry. But within three years, a number of successful wells were installed and the Kettle Creek gas field was established. The wells were concentrated in the north-central part of Leidy Township but extended three quarters of a mile north of the mouth of Hammersley Fork. The Clinton Natural Gas Company, headquartered in Williamsport, extracted the gas and distributed it as far east as Philadelphia and New York.

The natural gas pipelines impact both the environmental integrity and the scenic quality of the watershedby cutting through the forested hillsides.

The area was heavily drilled from 1954 to 1958, a period locally known as the Gas Bowl. The demand for gas was high due to rapidly expanding suburban development and its relative low cost. By 1958, many of the gas wells were empty and those who had come to rely on the Kettle Creek supply were forced to buy gas from other regions or find alternative fuels. Daily supply exceeded daily demand in southern drilling regions and companies soon looked for storage facilities. Empty wells in Kettle Creek offered inexpensive storage and in 1960, the wells were refilled.

> While natural gas was extracted faster than timber or coal, its subsurface voids have been effieciently reused as natural storage facilities for these same regional markets.

Natural gas offered inexpensive energy for light and heat but came with environmental costs. More than once local residents had to evacuate their homes because gas pressure in storage wells threatened to blow out gas lines leading into the building. In 1966, a sludge pond above Bunnel Bridge broke under the pressure of stormwater, spilling tailings from the drilling operation and industrial and maintenance wastes into the main stem of Kettle Creek. The spill contaminated the stream with minerals and soils extracted by the rig during the drilling operation, diesel fuel, garbage, oil, grease, and caustic soda and aqua gel from the drill bit, killing most of the aquatic species for more than a mile. Yearly hatching cycles of aquatic insects, which were rather predictable before the spill, are just now returning to form.

Environmental Impacts Inspire State Efforts Toward Conservation: Forests, Parks, and Flood Control

The environmental impacts of logging across northern Pennsylvania were expressed from the small streams to the Susquehanna River. Increased flows and flood damage, sediment-laden waters and eroded streambank property, increased water temperatures, and nutrient loading angered property owners and forced the state to engage in forest and water resource conservation to protect the health and well-being of it citizens.

Under the leadership of conservationists such as James Trimble Rothrock, Mira Dock and Gifford Pinchot, the Commonwealth purchased denuded properties for $3 to $4 dollars per acre and established a Division of Forestry to manage them for conservation and recreation. The fact that lumber companies bought forested land in large tracts enabled the agency to expand the state forest in sizeable and often contiguous parcels.

By 1909, Lackawanna had cut all of the timber from the Joerg property. The Commonwealth purchased the tract and managed it as part of the Cross Fork State Forest Reserve within the State Forest system. The Joerg house, constructed in the 1850s, was retained and became as the residence of the forest ranger under the State system.

Representing the Department of Forests and Waters (and the first woman appointed to a state commission), Mira Dock visited the watershed in October 1911. Accompanied by District Forester Walter Mumma, Forester Emerick, and Ranger Bennett, she toured Trout Run and the Hammersley Region en route to Germania, Galeton and Coudersport, assessing the value of lands available for state purchase. While Dock's surveying was usually done on horseback, Mumma had a car arranged for this trip from Renovo to Coudersport and Galeton[18].

Though pipeline management requires open corridors, these areas hold great habitat potential.

In addition to conservation and recreation, the State Forest also provided a means of employment for residents during the early 20th century. A district forester and ranger were generally hired from a forestry school, but they in turn hired men to make road repairs, construct new roads, and plant seedlings of Norway spruce, white pine and Carolina poplar. They fought fires on both state and private lands. Their wages were far short of regional pay, and the district forester made multiple requests to raise their pay.

Fires threatened not only local residences but also the regeneration of a diverse, native forest. Several fires were particularly devastating: in the Hammersley Region in 1907, from Tamarack to Spicewood in 1909, and in the western portion of the Hammersley Region in 1913. Some areas were particularly fire-prone, such as Turtle Point, where thickets of huckleberry seemed to ignite with the suggestion of a spark. An extensive network of fire trails and access roads was developed and maintained to protect the State Forest (Zorichak 1923).

The district forester was in a sense a surveyor for the state system. With thoughts of potential timber harvest in the recovering forest, Mumma reported that lack of transportation made the resource commercially unavailable.

In 1912, the State Forest sold seven miles of pipeline right-of-way to the Clinton Natural Gas Company. initially, foresters did not require restoration of pipeline corridors, but instead called for revegetation that would enhance habitat for wildlife.

Conserving the Wilderness for Recreation

Recreation on public lands was growing more popular every year with increased ownership of automobiles and social movement to escape the polluted, industrial city. As a result, the Commonwealth established a state park system at the turn of the 20th century. Two parks were later created along the Kettle Creek. Kettle Creek State Park was located at the mouth of Summerson Run and Ole Bull State Park was sited just below Oleona in 1920. The parks were open to the public for picnicking, camping, fishing, and hiking. Increased recreational facilities may have been one factor in the anecdotal references to the early 1900s as the creek's prime fishing era.

Through the Pennsylvania Administrative Code of 1929, state forests were permitted to lease small parcels, generally 1/4 acre lots, to Pennsylvania citizens for healthful outdoor recreational use. In addition to promoting recreation, leases generated revenue for the state forest. The lessee agreed to pay for any improvements, e.g. buildings, built these to meet state forest regulations. Leases were renewed every 10 years, at which point new regulations were enforced. Leases could be sold, transferred, or assigned if the lessee no longer wanted to maintain the site. (The state forest now desires to reacquire these parcels.) In 1970, the state forest stopped issuing new leases. The Kettle Creek watershed hosts approximately 100 camps in each of the Sproul and Susquehannock state forests.

Anglers from across the state visit Kettle Creek and its tributaries for their exceptional angling opportunities.

Road construction throughout the watershed continued as the public demanded greater access to the State Forest lands and as forest fires persisted in the North Central Region. With little money to make road improvements for increased volume and new modes of transportation, i.e. the automobile, townships asked the Commonwealth for financial aid. From 1925 to 1938, the Commonwealth helped fund several road projects, including road surfacing of Route 144 along Drury's Run to Tamarack (Lock Haven Express). Other projects improved drainage of road surfaces and replaced small bridges that were insufficient for modern transportation. Charter Road from Westport to the Potter County line received its first hard surface in the 1930s. The Forestry Department

The lower campground of Kettle Creek State Park offers a shady site for summer campers.

also continued to develop new access routes from Trout Run to Wharton and along Sugar Camp Run.

In 1951, it was discovered that William Penn still owned approximately 73 acres of land among the gas fields of Kettle Creek (Lock Haven Express 1951). The land had never been warranted and therefore still belonged to the original proprietor, William Penn. Nearly surrounded by state lands, the Commonwealth assumed ownership and placed the tract under management of the state forest.

Civilian Conservation Corps Camps along Kettle Creek

While the Great Depression of the 1930s significantly impaired economic investments, it had a positive effect on recreational development and landscape conservation across the nation. The need for job training for abundant male youth population, reforestation of harvested lands, and improved recreational facilities for an increasingly mobile society led Franklin D. Roosevelt to establish the Civilian Conservation Corps in 1933. Young men, particularly from urban areas, were employed by the government to build state park facilities, clear state forest roads, and plant tree seedlings. In addition to their work, the men took academic and vocational courses. Each young man was paid a weekly wage, a small portion of which was given directly to him while the rest was delivered to his home address. The small amount received was used to maintain a clean uniform and to pay for snacks and weekend ventures. Meals and lodging were provided at each camp.

There were four CCC camps located in the Kettle Creek watershed during the 1930s and early 1940s, one each at Hammersley Fork, Ole Bull, Windfall Run, and Two Mile Run. (Camps were also located at the Dyer Farm, Cherry Springs, and Lyman Run and may have completed projects within the watershed.) The Camp at Hammersley Fork, S-133, opened in 1933 and was closed by 1938. Captain G. Millholland commanded and Loring H. Grant of Galeton was Camp Superintendent (PCCCC 1983). Camp S-87 at Ole Bull operated from 1933 to 1941. The Ole Bull Camp was established under the leadership of Captain C.C. Griffin,

Camp Ole Bull was one of four Civilian Conservation Corps camps located in the Kettle Creek watershed in the 1930s. Its servicemen constructed picnic shelters, dammed the creek for swimming, and assisted local foresters in fire control and reforestation of state lands.

Captain Gomer L. Coble, and Lieutenant R. Ware (PCCCC 1983). Captain Joseph S. Hoffman and Lieutenant Herman W. Schweizer arrived in the fall of 1933 to lead the camp for the following several years (PCHS 2000). Camp S-137 at Windfall Run operated from 1933 to early 1936 under the leadership of Captain C.M. Lyons and James D. Glover (PCCCC 1983). The camp at Windfall Run reportedly reopened to assist in recovery and rebuilding in the Renovo community after the late spring flood of 1936.

The first tour of men to serve at Camp S-87 at Ole Bull had intended to go to Windfall Run but inclement weather hindered their travel they requested to stop at Ole Bull State Park. Amid downpours and puddles, they immediately erected tents for temp lodging. Within the first days, they built officers quarters at the foot of the eastern mountain and by fall had constructed permanent barracks below. A kitchen, mess hall, and recreation room were constructed in a U-shape to create a small courtyard or drill field for quasi-military exercises The buildings were heated by wood stove and lit by oil lamps.

Over the eight years that Camp S-87 was open, the servicemen built a dam to form a swimming area for the park, planted evergreens in the valley, and blazed and maintained fire trails throughout the recovering forest. In addition to conservations projects, they also helped local residents. After severe rain or snowstorms, the CCC men would clear the roads so that doctors and farmers could reach their destinations. In their spare time, servicemen tended the camp gardens, played games in the recreation hall, watched movies in the recreation room, and spent weekends in Coudersport or Galeton, maybe Renovo. Through weekend encounters (mostly positive), several men came to know the local residents, including the young women, and chose to marry and settle where they had invested their time and efforts.

Taming the Waters

In 1936, spring rains caused particularly heavy flows in Kettle Creek and throughout the headwaters of the Susquehanna. As waters from Kettle Creek and adjacent watersheds converged in the West Branch, flood volumes and resulting damage dramatically increased. News of the damage in Renovo was reported throughout the region. Many residents from Kettle Creek were involved in recovery efforts, including servicemen from several CCC camps.

Concern for the safety of residents and property generated widespread interest in developing flood control mechanisms. The State responded with a plan to construct four dams to control floodwaters of the West Branch. Some suspected the government had ulterior motives, such as water purification, in mind for the dam operation. In 1957, the Army Corps of Engineers constructed the Alvin R Bush Dam to detain the floodwaters of Kettle Creek. This 165-foot earthen dam would create a pool 1300 feet (390 km) long, 4.5 miles (7.2 km) of shoreline, providing extensive recreational opportunities in addition to flood control.

The construction of the dam and reservoir permanently flooded the town of Leidy. Residents were forced to relocate, and due to family history in the valley, many chose to remain in the local area. Kettle Creek Valley Road that passed through the center of town was relocated along the western hill slope of the valley.

While flooding was controlled in downstream communities by the Bush Dam, it continued to impact the main stem of Kettle Creek. The heavy flows caused by Hurricane Agnes in 1972 and storms in 1975 caused significant changes in the shape of the channel. Sandy soils were easily eroded, destabilizing the bank vegetation, widening the channel, and decreasing average channel depth once flows subsided. Shallow channels resulted in warmer waters and changes in fish habitat and population. In Potter County, many camps were flooded out and Hammersley Fork was heavily impacted.

Recent Watershed History

While Victor Beebe, Michael Leeson, William McKnight and John Linn have gathered and analyzed historical data available at the turn of the 20th century, recent historical events and personalities have not been assessed in any comprehensive manner. News articles have reported local events as they happened, but no summary or analysis of these happenings has occurred to date. Points of interest for future analysis include: the development of state forests and parks, CCC activities throughout the watershed, the flooding of Leidy, seasonal camps at Ole Bull State Park, such as summer programs by Keystone Boys Club and music festivals organized by Inez Bull, the Cross Fork Snake Hunt, the fall Leek Festival held in Germania, and the reintroduction of elk in the region. Local personalities include Harry Kinney, the "Mountain Boy," and Preston

The Alvin R. Bush Dam was designed to control floodwaters in the West Branch and created this reservoir in Kettle Creek State Park.

"Slim" Croyle, who was known for calling deer from the mountains by name to hand-feed them. In addition, the birth and achievements of the Kettle Creek Watershed Association deserve documentation.

The logging industry of north-central Pennsylvania has not been forgotten. The Woodsmen's Show was organized in 1952 at Cherry Springs State Park to celebrate the history and culture of Pennsylvania's lumbermen. In 1975, the first Bark Peeler's Convention took place to revive the annual meeting of "woodhicks and bark peelers" each 4th of July weekend. The event was held at the Pennsylvania Lumber Museum, where a sawmill, log holding pond, and village smith shops provided the background for contests, such as log rolling and tobacco-spitting. While these annual events commemorate the regional logging history, they do not express the unique contributions of the local landscape.

In addition to cultural developments, the landscape had continued to change since the early 1900s. Local residents tell of swimming holes filling in with sediment, inhibited trout migration, warmer waters that are changing fish populations, stocked fish out-competing the young wild ones, and the extinction of native species and introduction of non-natives. Streams getting wider and shallower and changes in species composition from pine and hemlock to oak dominated forests are indeed environmental changes, resulting from short-term and long-term impacts of land management across the entire watershed.

Conclusions

Over the course of history, residents and visitors have come to the watershed, particularly its valley and uplands for the productive soils that it offers for crop and dairy, and forest production. They have come for the immediate access to a high quality, natural and recreational environment. (President U.S. Grant was perhaps the most notable political figure to visit the watershed, as a guest of Colonel A.C. Noyes of Westport.) They have also come for the freedom and privacy that rural living offers and the self-reliance that it demands. Whether for short-term visits or long-term residency, people expect to find low-density development and high-density "nature."

Euro-American settlement and speculation led to two distinct forms of land ownership in the Kettle Creek watershed. Frontier settlers selected their sites based on stream and landform patterns that would support agriculture for many years and therefore explored the landscape to find suitable sites. Speculators chose their tracts geometrically, according to land surveys, and based on the mature condition of the timber that would turn a quick profit as soon as harvesting began.

Since the introduction of European-style land ownership, a large percentage of the watershed has always been managed by nonresidents. Speculators purchased large areas and would have proportionally large impacts on the environmental quality of the watershed. Once harvested, the land was sold or defaulted to another non-resident land manager, the state, who now attempts to conserve the land and water resources at the same scale as its degradation.

The abundant natural resources and the small-scale development define the Kettle Creek watershed as a frontier landscape. As with many rural watersheds, natural resources such as a maturing forest, tillable soils, and coal and gas deposits have been the engine of local economy. During their individual heydays, the lumber and coal mining industries fueled growth and sustained communities of up to 2000, many of whom were immigrants following the prosperity of company investors. But as resources were extracted faster than they were naturally replenished, these industries faced local decline, and those who relied on them were forced to leave or find other vocations to support themselves and their families.

As a result of natural and human factors, Kettle Creek has provided abundant fish and game for sustenance and sport for hundreds of years. The opportunities it holds engage residents and visitors alike in an intimate experience with nature and its waters.

With the passing of land ownership from lumber companies to the state, a shift from forest consumption to forest conservation occurred. Like the lumber companies, the state profits from its land management but not in private ways. Rather, the benefits are found in the increased health and well-being of all Pennsylvania citizens.

The Kettle Creek watershed shares in the regional lumbering history of the northcentral Pennsylvania region, but it also has a distinct history that separates it from the surrounding region. The Ole Bull colony, the planned community of Germania, and the combination of timber, coal, and gas resources all contribute to this distinction and the unique identity of the watershed.

In addition to the story of the Kettle Creek watershed, there are a number of historic sites and structures that can be seen throughout the landscape. As a result of settlement patterns, many of these are located in the valley along the main stem of the creek. These landmarks in the community could be used to share the history with watershed visitors.

Changes in the landscape and the water were most noticeable during and after the logging and mining eras, but change also occurred as each farmer cleared the forest for field and pasture, as roads were cleared, constructed, and improved, and as plantations were established throughout the valley. With each personal, corporate, and government decision about the use and management of land, both land and water resources were impacted.

GOAL: HISTORY

WI 1.2 Goal: Explore and celebrate the rich cultural history of the watershed as a community and for visitors.

Notes

1. Although we commonly think of the American frontier as a pristine landscape, Native Americans had actively, sensitively, and sustainably managed its resources for centuries.

2. Native Americans and immigrant Europeans had very different ideas about land ownership. Living in tribal societies, Native Americans treated the land and its resources as community property. Immigrants, on the other hand, were rebelling against European authorities and social systems and sought personal property as an expression of their independence.

3. The Northwest Ordinance of 1787 used this same process of divide, survey, and sell to organize and establish ownership of United States territories across the country.

4. Settling on the land implied converting the acres of forest into fields of cultivated crops, making nature more "productive," yet unaware of the impacts such conversion would have on the environment.

5. Timber values changed over time. Pine was familiar and easy to work-"the Lord's wood." Hemlock, in comparison, was "full of hell, fire, and knots," but over time, its strengths were understood. After the evergreens were gone and primary needs of shelter were met, Americans found the hardwoods to be valuable for interiors and furniture.

6. Within the right to own land, Americans assumed the right to profit from it. As land was bought and sold, the most valuable tracts were often reserved or exempted from the transaction, leaving the spoils in the hands of the original landowner.

7. Since streams provided fresh water for people and livestock, early farms were located along the banks.

8. The Summerson family, descendants of David, Joseph, and Marmaduke, maintained a close connection with the watershed landscape and in 1935 held the First Annual Summerson Reunion at Kettle Creek State Park (Lock Haven Express: Kettle Creek). Their connection ran so deep, in fact, that they petitioned the Department of Forests and Waters to change the name of the park to Summerson Run Park.

9. Streams, and the hollows from which they came, were commonly named for the family living at or near the mouth.

10. Mill owners also took advantage of these sites, finding inexpensive transportation for lumber and shingles during much of the year.

11. Discouraged by the slow development of their settlement, its accidental location on another's property, and the steep topography, many Norwegians faced the choice of pursuing freedom in the Midwest or returning to their native land. Since Bull personally funded the colony from its infancy with profits from his concert tours, only a few were able to afford the cost of purchasing the land they had cultivated from the Stewardsons. But those who did became significant members of the Kettle Creek community.

12. Once it became clear that the elaborate plans for German settlements were not appropriate for the steep terrain, plans for a new city of Cross Fork were abandoned and development efforts focused on a revised site design for Germania. The German population grew steadily supporting a wide variety of businesses and several social organizations.

13. These tales were documented by W. W. Thompson in Historical Sketches of Potter County: Hunting and Fishing Stories, Legends.

14. The lumber industry influenced rural life in several positive ways-it brought more frequent and more direct postal service, introduced telephone and passenger rail service, and produced electricity for rural towns.

15. Out of concern for flooding and water quality at turn of the 20th century, the Department of Forests and Waters began replanting the lower hillsides with evergreen species. The trees were not meant to replace the native forest but it was thought that they would prevent erosion and downstream sedimentation.

16. Deep mining has had lasting impacts on the watershed. While many mines were sealed through reclamation efforts of the late 1930s and early 1940s, seepage through fractures still impairs water quality in lower reaches and the main stem.

17. Surface mines not only disturbed the vegetation and surface soils that buffer the impacts of rain events, but they also exacerbated acid mine drainage from deep mine seeps by exposing more fractures at the surface.

18. Automobiles first became a regular site in the watershed as the United States Postal Service expanded and improved delivery to rural areas. By 1921, automobiles were in use to deliver mail from Renovo. A decade later, mail service was still based in Renovo but traveled first to Westport, north to Cross Fork and returned via Tamarack.

DEMOGRAPHIC TRENDS

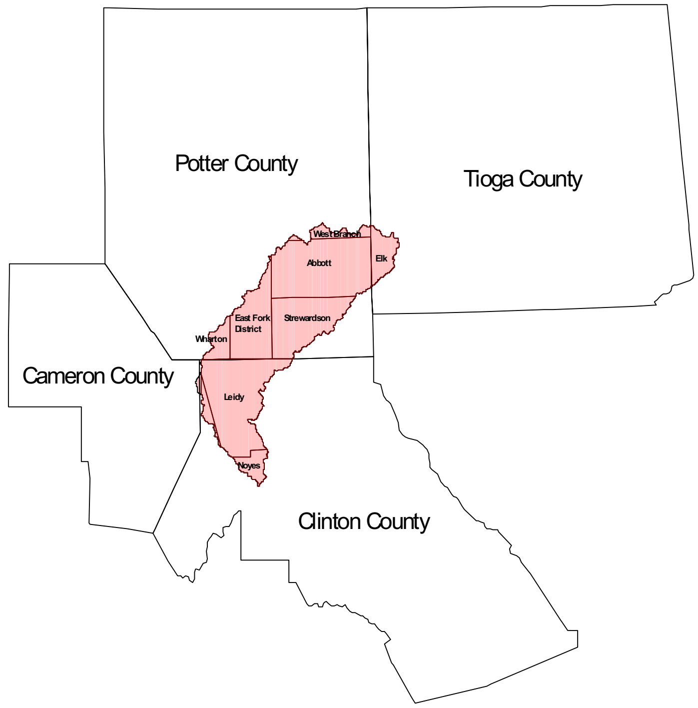


Figure 2.8 - Watershed boundaries often overlap into multiple municipalities. As shown above, 4 counties and 10 townships fall within the boundaries of Kettle Creek.

Introduction

Demographic trends - or changes in population characteristics over time - provide valuable insight into the social character of a community. Demography analyzes the experiences of people such as birth, marriage, death, employment and aging and can be used to pinpoint the causes and consequences of population changes over time. Demography can reveal trends in social change and the impact of this change on the natural environment. While biological analysis - for instance water quality analysis - provides insight into the health and state of natural resources, demographic analysis reveals information about the people who use and enjoy these natural resources.

The overlap between natural watershed boundaries and political municipal boundaries results in multiple municipal districts that lie within and overlap multiple watersheds. This presents a challenge for demographic analysis in watershed planning as data collected generally follows municipal township, county and state rather than watershed boundaries.

Gathering information for Kettle Creek watershed was no exception to this challenge. Demographic data were collected for the watershed at the county and township level as it allowed for the greatest historical depth of inquiry while still maintaining boundaries close to those of the watershed. The degree of relative homogeneity in the Kettle Creek landscape - a largely rural forested landscape - relative to its context within Clinton, Potter, Cameron and Tioga Counties led to some assumptions in the gathering of data; it was assumed that data collected at the township level would represent trends and patterns in the community both within and across the watershed boundary. Because the vast majority of land - specifically populated land - lies within Clinton and Potter County, data were collected for these counties. The numbers discussed below reflect an accumulation of townships in Clinton and Potter County that overlap into the watershed.

Political Boundaries In the Watershed

The political boundaries within Kettle Creek include portions of 7 census blocks, 10 townships and 4 counties (See Figure 2.8: county and municipal divisions in Kettle Creek). Population trends within these municipalities reveal a potential for development of private lands in the watershed due to a rising population and increasing market value of private lands.

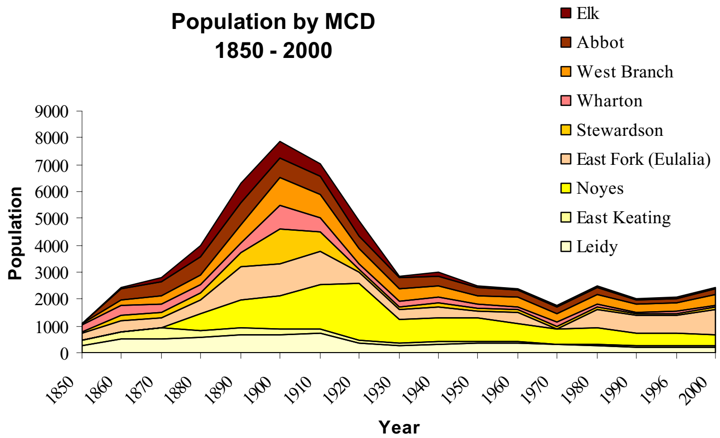


Figure 2.9 - Population values skyrocketed between 1880 and 1920 due to a peak in timber and other extractive industry; this trend was typical across much of the state. Following this period of population increase, distinct population fluctuations followed changes in the economy as people moved to and from the city, in search of jobs (Miller et al 1995).

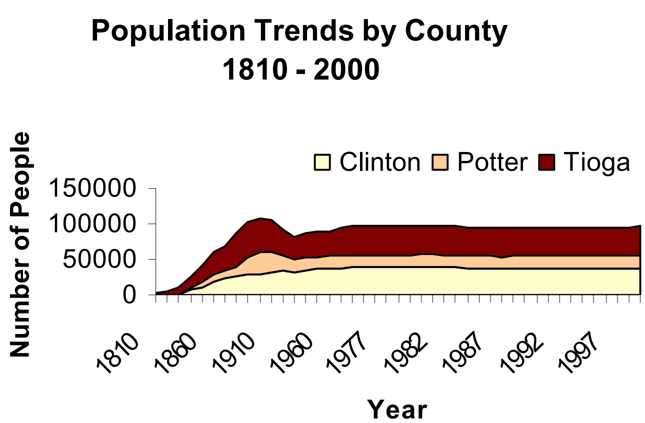
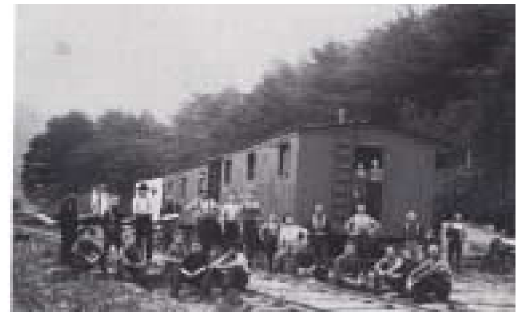


Figure 2.10 - Population trends as seen at the township level can also be seen at the county level. This is due to the relatively homogenous -- rural, low density development -- landscape of Kettle Creek.



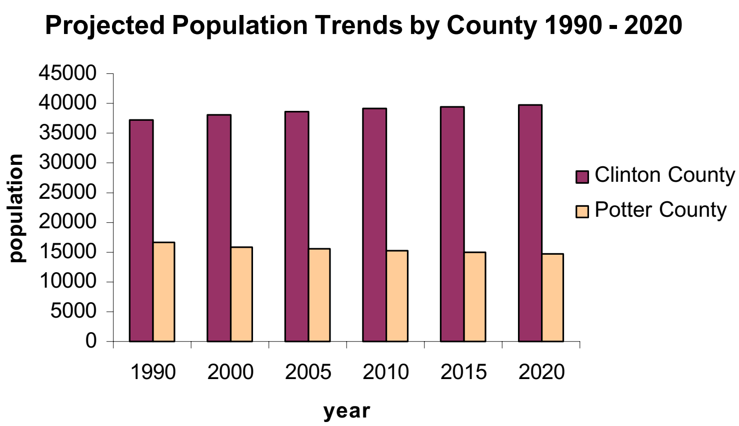
Historical Population Trends

Throughout the past two centuries, the population trends in Kettle Creek have experienced dramatic transformations due to a shift in the economy from industrial resource extraction to service based industry. From the organization of the earliest townships in the early 19th century, the watershed population experienced slow, steady growth. In Potter county, the first commercial pine timber industry opened in 1837; during this time, timber was sent downstream to be cut, processed, marketed and sold and did not provide direct significant economic benefit to the local economy. By the 1880's the Goodyear Lumber Company had begun the first local cutting mills stimulating the local Kettle Creek economy and encouraging an influx of residents in search of employment to the watershed (Clinton County Data Book 1990). The rapid growth of steam power further intensified the efficiency of both timber production and in turn timber consumption further stimulating the local economy; a sharp increase in population occurred as a result of this.

The boom in the logging industry paralleled that of the population. Populations in Kettle Creek watershed increased exponentially during the period of 1890- 1910; however this boom was short-lived. The timber industry had effectively cleared the once rich, forested landscape. As the last hemlocks and hardwoods were cut, and as the mechanization of agricultural production resulted in fewer avail-

Percent Change in Population: 1980 - 2000		% change 1980 - 1990	% change 1990 - 2000
Clinton	Leidy	-18.63%	7.01%
	East Keating	-33.33%	9.09%
	Noyes	-26.62%	-9.50%
Potter	East Fork	-97.74%	-6.67%
	Stewardson	-45.45%	12.12%
	Wharton	-32.69%	30.00%
	West Branch	-23.73%	37.06%
	Abbot	-27.92%	30.64%
Tioga	Elk	-8.70%	21.43%

LEFT Figures 2.11 & 2.12 - 2000 census data revealed a dramatic increase in population within and accross the boundaries of the watershed despite 1990 census projection numbers that suggested a general decline in population (see figure below).



LEFT Figure 2.12 - 1990 Census projection data suggested a general decline in population in Potter County and a subtle increase in population in Clinton County.

able jobs, unemployed settlers were forced to follow lumber operations westward or move back to the cities. Between 1900 and 1930 the Kettle Creek population declined rapidly at the township and county level leaving behind a barren and economically stagnant landscape. Many settlers flocked to the cities where there was a strong wartime demand for factory production (Miller 1995). Others followed lumber operations westward and south.

Limited available jobs during the depression in the late 1920's and through the early 1930's reversed this migration pattern outside of the rural areas. During this time, a small increase in population can be seen in Kettle Creek. While the overall population trends decline, another minor population peaks occurred circa 1960 during the post-war baby boom (Miller 1995). (figures 2.9 & 2.10).

While a trend towards population decline continued up through 1996, the 2000 census data revealed a population increase by as much as 38% in Kettle Creek townships (See Figure 2.12 - percent population change). In light of the census population project numbers that projected Potter County to decline in population through the year 2020, this increase is quite a surprise. (See Figure 2.11 & 2.12: 1990 county projection data & percent change in population 1990 - 2000). (Bureau of Census 1990).

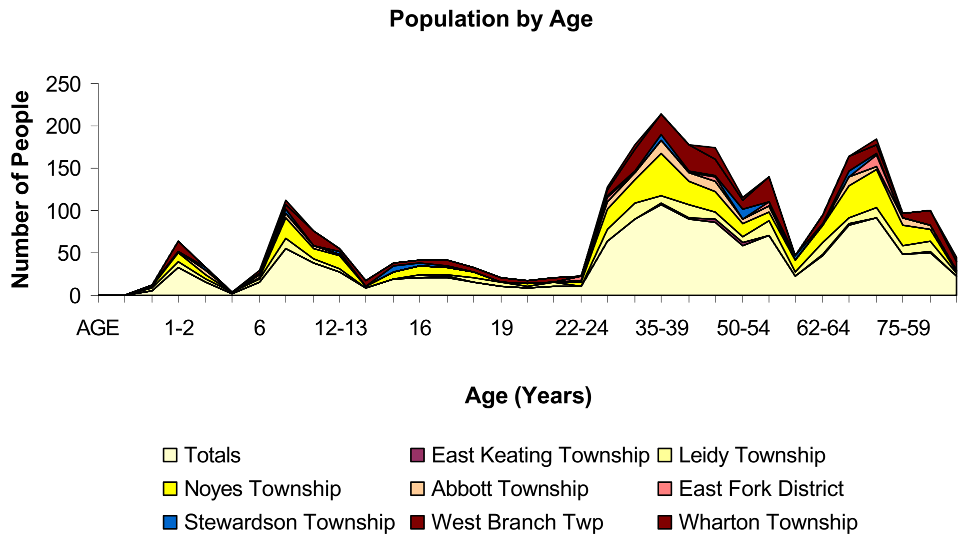


Figure 2.13 - Following 1990 census data, the majority age group was between 30 and 40. This age distribution can be attributed to the post-WWII 'baby boom' and associated period of American affluence.

Population and age trends

Following trends across the state of Pennsylvania, the watershed population is aging. The majority of residents in the watershed are between the ages of 30 and 40. From 1980 - 1990 the average township population age increased from 29 to 33 years old. Similarly, county and township populations within the watershed have experienced declines in the younger generation ages 18 and under (See Figure: 2.13) in conjunction with an increase in people over the age of 65 (See Figure: 2.14 - change in population by age, 1990; See Figure 2.13 - distribution of population by age 1990). These trends are common across the state as people today simply live longer today (Miller 1992). However this trend is occurring for a different reason in Potter and Clinton County. Positive birth to death rations in these counties suggest that the birth rate exceeds the death rate. Housing occupancy numbers that show two-person households as an average for the watershed further supports this. Thus, the decline in population can be largely attributed to younger generations leaving the watershed in search of more diverse employment opportunities (Clinton County Comprehensive Plan, 1992). (Figure 2.14)

Change in Population by Age Group 1980 - 1990

	Under 18	65 & Older
Clinton County	-16.60%	25.90%
Potter County	-17.30%	19.70%

Figure 2.14 - While the younger population is declining in the watershed, the older population is increasing. This can be attributed, in part, to a decline in available local jobs.

Land-ownership and Housing Occupancy

Land Ownership

Less than 18% of all landowners in Kettle Creek are permanent, year-round residents. Based upon the mailing addresses of the 2,063 landowners in Kettle Creek watershed, nearly 82% can be considered seasonal residents as their permanent mailing is listed outside of the watershed (See Figure 2.15 - residency and land ownership). While the majority of seasonal residents reside in the Commonwealth of Pennsylvania, some come from as far as Minnesota and California. Within the state, a strong majority reside in the southeastern and south central areas of Lancaster and Philadelphia. (See Figure 2.16: Place of residence by state).

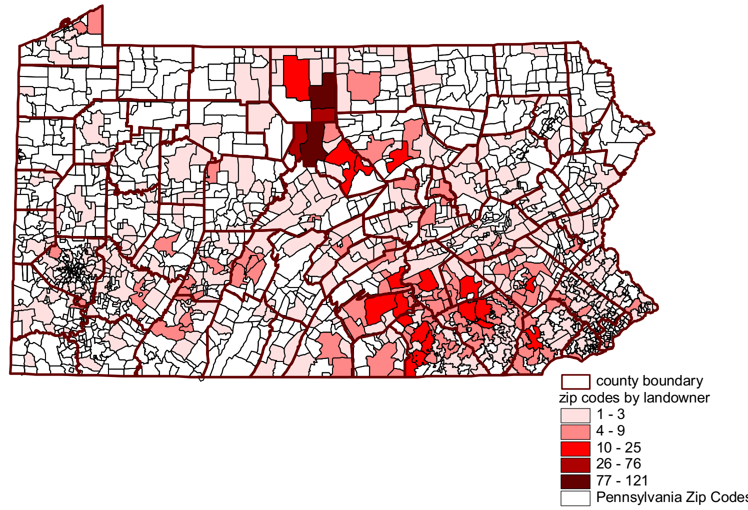


Figure 2.15 - This map illustrates where watershed landowners permanently reside. Recreational opportunities attract seasonal residents to the watershed from all over the state .

Housing Occupancy

Much of the housing that stands in the watershed today was constructed prior to 1939. The fact that a majority of housing today is seasonally used, suggests that much of this early housing has been since transformed into seasonal housing or service industry establishments such as hotels and stores. Further research and inventory of the existing housing in the watershed could serve to clarify this.

From 1940 to 1980 seasonal housing doubled (and in some instances tripled) in number (See Figure 2.18: percent increase in seasonal housing over time). This increase can be accounted for, in part, by New Deal programs that sought to revitalize the country's economy and resulted in a post-war surge in recreational use of the landscape (Miller 1995: See page 71 for a discussion of recreation today).

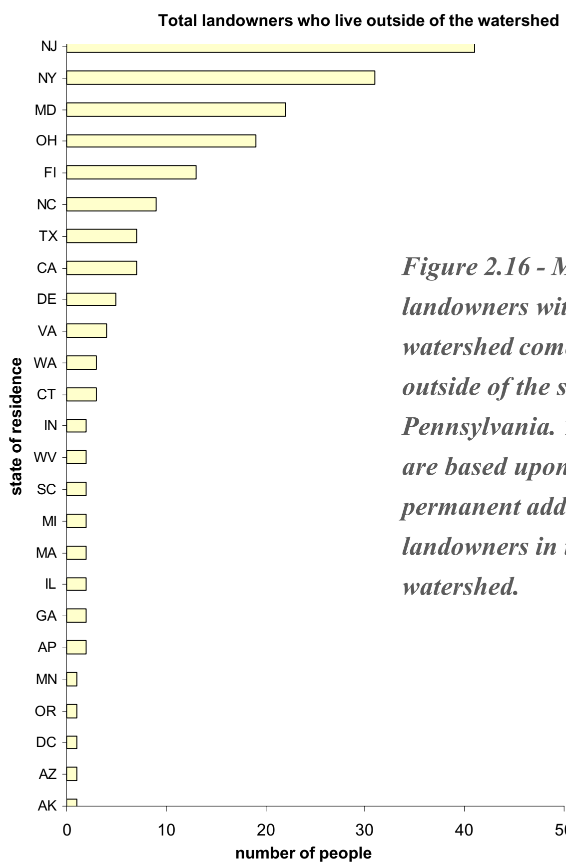


Figure 2.16 - Many of the landowners within the watershed come from outside of the state of Pennsylvania. These data are based upon permanent addresses of landowners in the watershed.

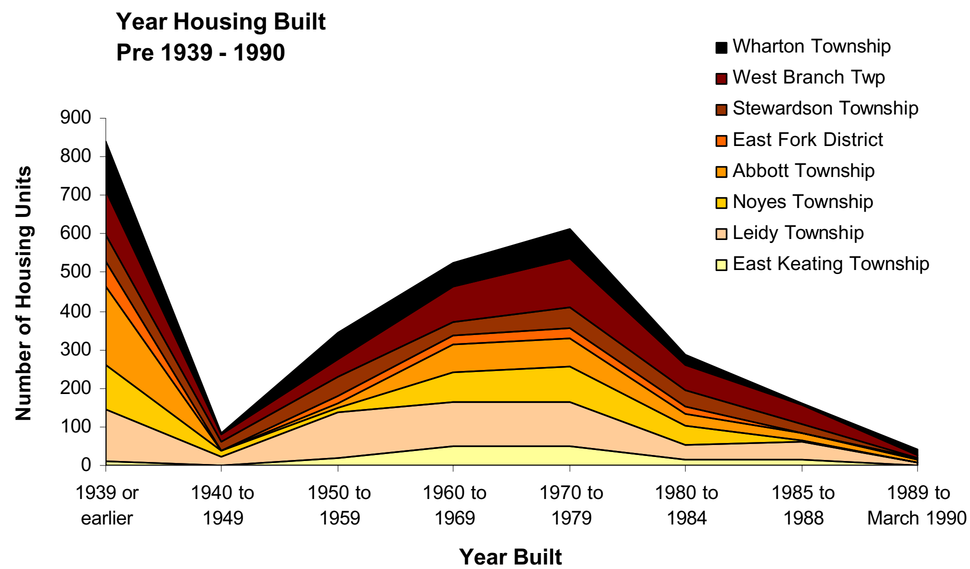


Figure 2.17 - Housing in the watershed according to the year it was built. A large portion of the housing in the watershed was constructured during early twentieth century logging boom.

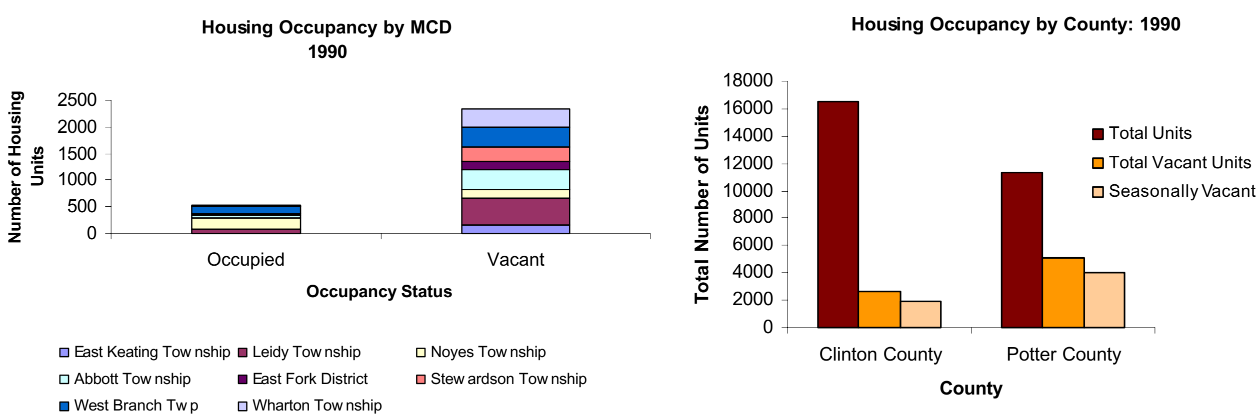


Figure 2.18 - The preponderance of seasonal residents accounts for the high housing vacancy rates wtithin the watershed.Compared to the housing occupancy by MCD, county trends reveal similar trends in high seasonal vacancy rates.

Introduction

Historically, logging, mining, agriculture and natural gas have supported the economy of Kettle Creek. The early twentieth century marked the end of the logging boom. While gas, agriculture and manufacturing have since declined in importance to the watershed, the timber industry still thrives within the state forests. The decline in manufacturing has also brought about a seasonally based economy that is driven by the heavy recreational use of the watershed.

Industry Trends Today

Following the early twentieth century logging boom, the watershed economy became strongly seasonal following hunting, fishing and recreational uses. Jobs available to the community and dollars spent within the community became limited to these high use seasons and thus unstable. During the nationwide recession of the 1980's, several key manufacturing industries left the local area resulting in an economic low point for the watershed in 1983. During this time, Clinton and Potter Counties documented unprecedented unemployment rates -- as high as 18%. Economic instability left the watershed ten years behind the rest of the country in recouping from this recession (Clinton County Comprehensive Plan, 1992). Recently, the International Paper Company, located outside of the watershed and one of the largest job providers in Clinton County left. As the job base continues to decline, the younger generation will continue to leave the watershed.

Today, the economy in the Kettle Creek watershed is supported predominantly by recreation. Seasonally-based establishments that accommodate the needs of recreational watershed user, such as food services and lodging businesses dominate the economy. This seasonal economy yields instability in that available jobs are limited to particular times of the year. (Clinton County Comprehensive Plan 1992). While manufacturing has provided a strong economic base to the watershed throughout the mid twentieth century, (See pages 27 & 37 for further information on the economy in Germania and Crossfork), the watershed has experienced a shift towards a service-based economy in the past two decades. During the 1980's, a sharp decline in the manufacturing industry occurred; as large manufacturing industries left, hotels, and other service industries increased by as much as 43%. This trend continues even today.

Employment and Unemployment

Employment rates in the watershed are just beginning to align with those of the state following the 1980 recession. As long as employment opportunities continue to decline, the decline in working class resident population will continue. In light of this township and county condition, state and county programs have been developed to attempt to rejuvenate the declining economies.

ECONOMIC ANALYSIS

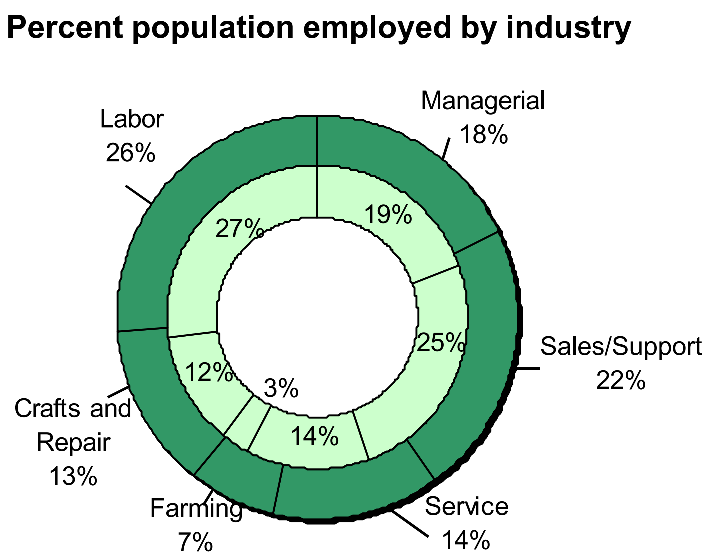


Figure 2.19 - Today, available jobs in sales, managerial and other service based industries greatly outnumber those in the labor (manufacturing industry). Above: the dark green represents Potter County while the light green represents Clinton County.

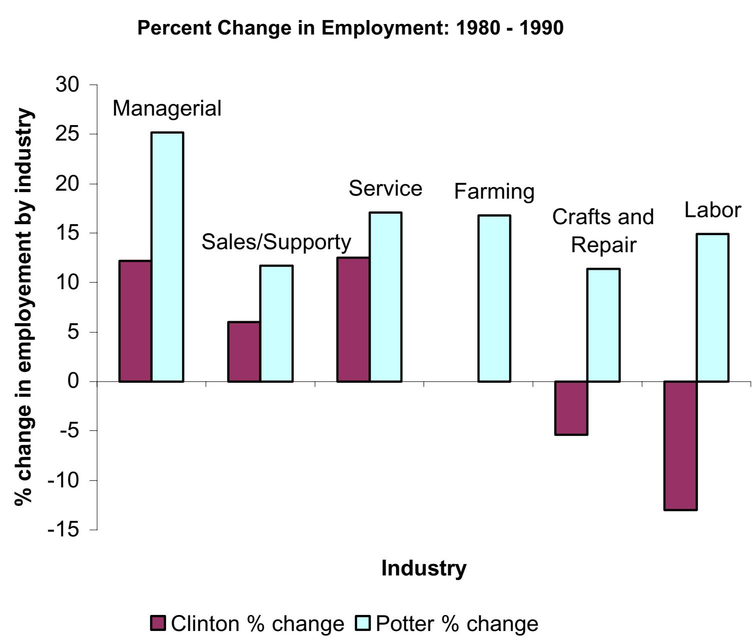
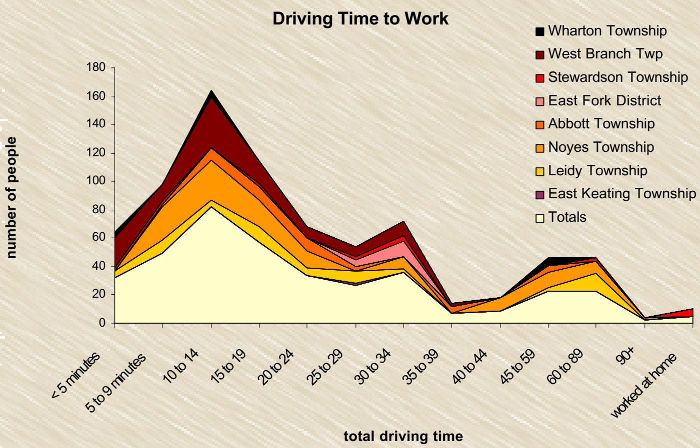
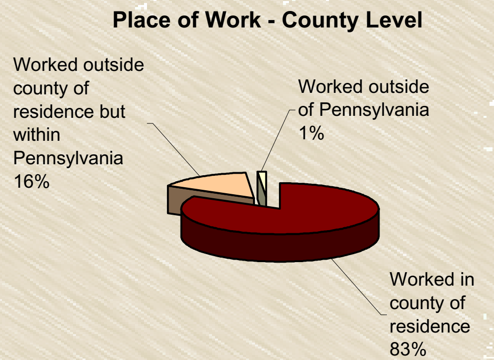


Figure 2.20 - Employment trends reveal a shift towards the service based industries such as hotels and restaurants. This is a direct result of major manufacturing companies leaving the area in the past few decades. Seasonality has yielded instability in the economy.





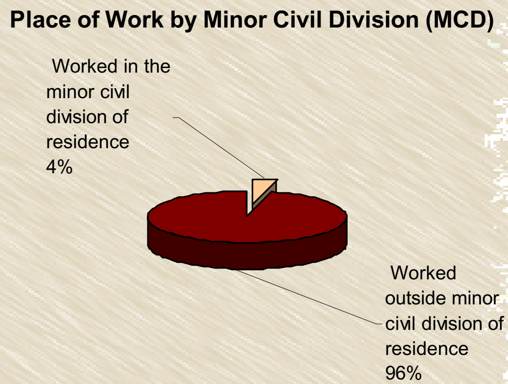


Figure 2.21 - The majority of residents within the watershed do not work within their home municipality. As the last major manufacturing establishments have left the watershed, residents have been forced to either leave the watershed or seek employment in other areas.

Employment in and Around the Watershed

The major employers that support residents within the watershed include large manufacturing companies and state, county and local governments. Because few of these industries are located specifically within the watershed, residents, particularly young people, are forced to seek employment elsewhere, commuting long distances or relocating. (See Figure 2.21: commuting time to work). Few Kettle Creek residents work within the boundaries of the watershed. Most commute 10-25 minutes to work on average. While 83% of residents work within the county in which they reside, 96% of working residents do not work within their township of residence. (See Figure 2.21 - place of work by county / MCD). This is mainly due to large, industrial employers in the watershed who have left taking with them a potentially strong job base. The loss of the International Paper Company in Clinton County, left the Woolrich Company as one of the only remaining large manufacturing companies supporting the watershed. Lack of economic development in the watershed can account, in part, for the continued decline in population. Specifically, Leidy, Noyes and East Keating townships, (all of which rest within the boundary of Kettle Creek watershed), have some of the lowest development rates in Clinton county.

CCC timber plantations in Potter County.

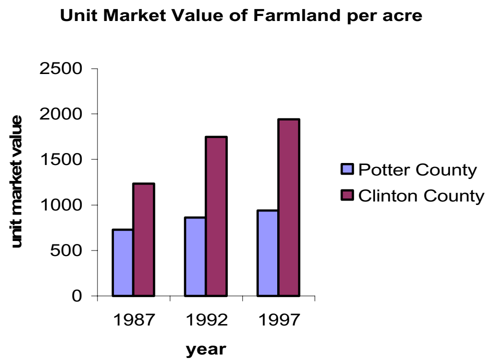
Susquehannock State Forest..

Timber Resources and the Economy

Forestry is a large part of the natural and economic heritage of Pennsylvania and likewise in Kettle Creek. While over 92% of the watershed is state forest land, a significant portion of this is commercially viable timber stands. These stands are abundant with valuable hardwoods such as black cherry and red oak and could provide extra revenue to the townships to support conservation efforts such as easement acquisition within sensitive headwaters areas in the watershed.

Timber in the state forests is managed by the DCNR Bureau of Forestry and all cutting practices must be environmentally certified. Ten percent of the revenue earned from timber harvesting is designated to a statewide forest regeneration fund to be redistributed to state forest districts. This money provides resources for forest regeneration such as saplings, tree shelters and deer exclosures. The remaining 90% of this income is distributed through the main office in Harrisburg, through a timber augmentation fund, to support Bureau district operations. DCNR also pays in lieu of taxes split three ways between the county, township and school districts at a rate of 1.20$ per acre. Noyes Township, located in the watershed, received the highest in lieu of payments in the state of Pennsylvania last year.

Among other changes to the 1996-2000 DCNR State Forest Management Plan, the 2001-2005 State Forest Management plan recommended a higher allocation of funds from Timber Harvesting to the local municipalities. This change, if made, could provide municipalities with fiscal resources to implement landuse conservation measures.



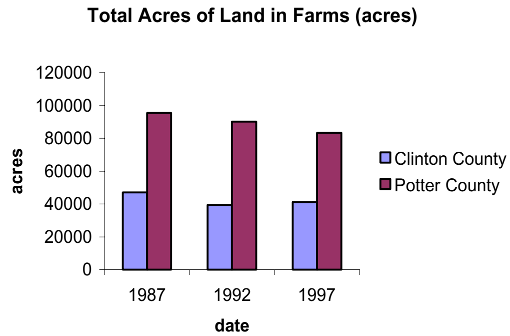


Figure 2.22 - While smaller-scale farmland production might not be as profitable as it once was, the market value of these lands is quickly rising. Declining farmland acreage accross the watershed, county and state is often a result of this land being purchased by development groups.

Agriculture and the Economy

Agriculture is an important source of income and jobs to the economy of north central Pennsylvania. Historically, in Kettle Creek, the agricultural landscape was a strong component of the economy and social system. Yet in recent years, the number of farms and total acreage of farmland has declined throughout the region and the state. Specifically, total farmland declined by over 12% in both Clinton and Potter County between 1987 and 1997 (Agricultural Census) (See Figure: 2.22 - Total acres in farmland and increase in market value of farmland over time). This loss of farmland can be attributed to large-scale agricultural industries that out compete smaller farmers - a trend that is occuring across the state and the nation. In turn, agricultural lands are generally clear and flat making them prime property for development. Thus, as agricultural production continues to decline, the market value of farmland is increasing by as much 57% (See Figure 2.22). This increase in turn encourages small-scale farmers who are losing profit on their land to sell their valuable property for commercial and residential development. (For more information on agriculture in Kettle Creek, see landuse, page 109).

Across the state, a decrease in the total number of farms relative to the farmland acreage suggests a transition towards larger scale agricultural production in the past 15 years. (Agricultural Census of the United States 1997). As these large-scale agricultural establishments out compete smaller family operations, farmers are forced to sell off valuable lands - often to developers.

Agriculture in Potter County.

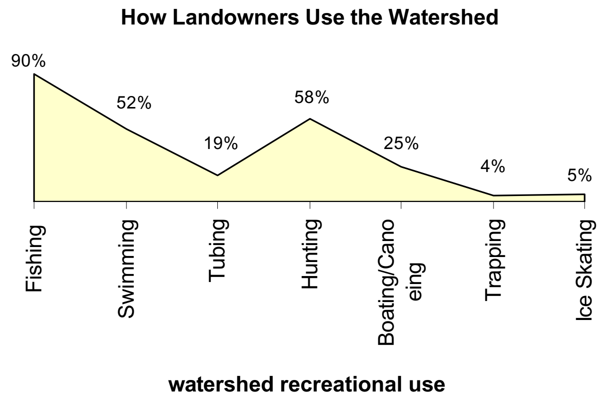


Figure 2.23 - 'How landowners use the watershed', results of the 2000 survey conducted by the Clinton and Potter County Conservation Districts.

KCWA DEMOGRAPHICS

The Power of Community Participation

At the heart of a cohesive, effective community watershed association are those people who live in the watershed - those people that perhaps value the landscape most - resident stakeholders. Included in this group are not only resident landowners, but also local township, county and state officials who are most familiar with the needs and desires of the community. The collaboration between and among these stakeholders not only ensures that decisions made regarding landuse in their watershed reflect their resident values, but also empowers a watershed association and in many cases, betters the long-term success of the group. Yet collaboration among stakeholders is but one piece of the puzzle.

While the efforts of the watershed association have successfully lead to numerous projects completed, further funding has its limits. Furthermore, increased local participation might assist the watershed association in its efforts to conserve the valuable lands of Kettle Creek. Key characteristics that could facilitate the long-term success of the association include: strong resident support of the association; resident and stakeholder participation in the association and its activities and efforts; uniform resident knowledge of problems and issues in the watershed; and finally partnerships developed with other local organizations, groups, businesses and municipal officials.

Association Membership Strong Resident Support

In the year 2000, Kettle Creek Watershed Association was supported by a healthy membership of 131 people. Considering the relative youth of the watershed association, this degree of membership is not only commendable, but also illustrates a broad interest in the health of the watershed and its association. However, only a small minority of resident landowners in the watershed are actively participating in the watershed association. Of the total membership from the year 2000, 3% were local watershed residents (a total of 4 people). Outreach, particularly to local residents of the watershed, might help the association target its efforts towards the desires of the local community. Local participation could potentially strengthen the long-term sustainability of the association.

KETTLE CREEK WATERSHED ASSOCIATION
ENHANCE PRESERVE MONITOR PROTECT

Knowledge of Issues & Problems

A survey conducted in the Spring of 2000 by the Conservation Districts in association with the Kettle Creek Watershed Association received broad response from seasonal residents who owned camps or businesses in the watershed. Further survey of residents to identify trends in opinions about issues in the watershed might assist the association in its education and outreach strategies.

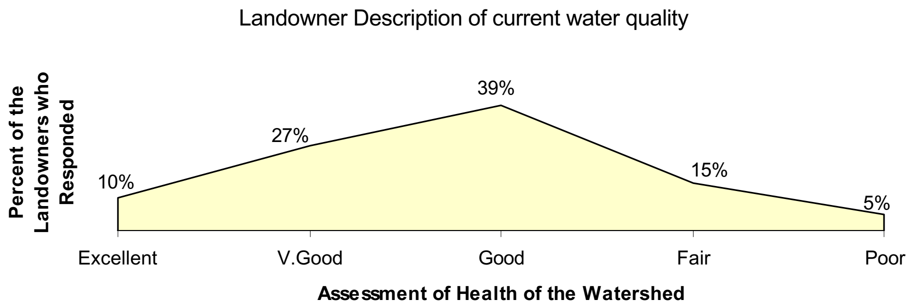


Figure 2.24 - Landowner assessment of water quality in the watershed was highly varied. This suggests a need for information regarding water quality in the watershed. Further survey of the community could serve to identify education and outreach strategies that could be used to spread valuable information about the 'state of the watershed'. (Graph Data: Clinton & Potter County Conservation District 2000)

A strong baseline understanding of watershed issues and the clear dissemination of information by the watershed association are identified strategies for an effective watershed association . Following the Clinton and Potter County Conservation District survey, the question regarding the overall watershed 'health' suggested that landowners in the watershed are not uniformly aware of basic watershed issues. While 13% thought it had improved, the rest were unsure or suggested it had declined (See Figure 2.24). While it might not be a realistic goal to seek community consensus on this question, response rates suggest that educational programs that emphasize the basic 'state of the watershed' information could be beneficial to the efforts of the association. For example: are Kettle Creek and its tributaries 'healthy'? What are the greatest issues or challenges that face the watershed and its residents concerning natural resources? What can be done about these issues individually? As a group? In addition to informing stakeholders about issues in the watershed (both positive and negative) this could also foster the establishment of a clear watershed based association mission which community members can understand and support.

Partnerships

Partnerships with other watershed and conservation organizations, municipalities and government officials and representative resident stakeholder groups could further strengthen the efforts of the watershed association. Similar collaborative efforts have begun in other areas and have achieved great success in other states (Michaels 1999). Not only would it provide additional financial, technical and human resources to the association but also it could foster the development of a cohesive watershed community. Municipal partnerships could facilitate landuse conservation strategies at a scale that bridges conventional municipal boundaries. Partnerships with state forests and parks could serve to promote and revive the economy via recreational and interpretation opportunities. (See Community Capacity Recommendations, page 225).

Conclusions: What does this mean for Kettle Creek?

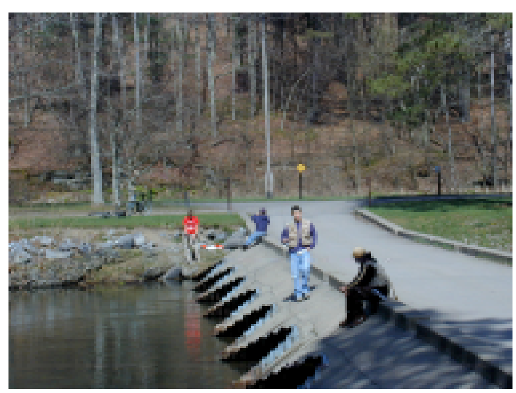
Trends in development today suggest an overall decline in population in larger cities in addition to a redistribution of population towards recreational and amenity areas such as the Poconos (Miller 1992). Following the increasing market value of land, the heavy recreational use of the watershed and the recent increase in watershed resident population, the private lands in Kettle Creek could become vulnerable to development that does not maintain the rural character that makes Kettle Creek such a unique place (see page 106 for more information about private lands and development in Kettle Creek). The continued monitoring of new development within private lands in the area could bring light to future development pressures before they occur. A comprehensive building inventory that identifies historic and current structures throughout the watershed could facilitate this monitoring. Finally, the implementation of future development guidelines could encourage development that maintains the current, low density development character of the watershed.

Collaboration between the county planners and Township Supervisors could facilitate the monitoring of overall development trends within the watershed. This would further assist in the alignment of township municipal code with county comprehensive plans. Careful guidance of the future development of Kettle Creek in addition to the conservation of the rural agricultural and industrial character of the watershed.

GOALS: SOCIAL

LU 2.1 Monitor growth and development in the watershed

CC 2.2 Increase the dialogue with people and other community organizations in the watershed, counties, and region.



RECREATION
IN THE WATERSHED

Introduction

Recreational opportunities within the Kettle Creek watershed are well established, well connected, and well documented. The abundance of publicly owned land, estimated at 92% (including 82% of streamside land), establishes easy access to forest- and water-based recreation for watershed residents and visitors alike. Numerous trail connections allow people to move throughout the watershed's recreational areas and the larger region with ease. Both public land managers and private interest groups have made recreational location, use, and regulation information available through brochures, guidebooks, and on-line resources. In addition to the destinations and activities found here, the watershed community further supports recreation with food, lodging, and supply services from its small business sector.

This recreational analysis will identify the role recreation and leisure activities play within the Kettle Creek watershed. It begins with a brief discussion of the role of recreation in our personal and community lives. This is followed by a summary of the types of recreation and leisure opportunities available in the watershed, and the analysis concludes with a discussion of possible, future opportunities and/or roles for recreation and leisure in the Kettle Creek watershed both as a means of enjoyment and as an industry.

The Role of Recreation and Leisure in American Society

According to Dr. Robert W. Douglass (1999) of the Ohio State University, "There has been an increasing trend in outdoor recreation and nature-based tourism participation from the time that record keeping began." He adds that, throughout the history of the United States in particular, "good and bad economic times seem to have direct changes in [recreational] style, but increases in involvement in outdoor recreation have accompanied both of them." Statistics generated by numerous agencies monitoring recreational activity seem to support such assertions. For example, a recent study by the National Survey on Recreation and the Environment found that, in 1995, approximately 95% of Americans (age 16 and older) participated in outdoor recreation and that the popularity of recreation and the activity in recreation related industries were growing faster than the general population (Driver 1999; Douglass 1999). In other words, our society has repeatedly demonstrated a preference for outdoor recreation regardless of broader economic conditions (growth or recession) and social contexts (depression, war), and the continued acceleration of this "recreation" trend has become more noticeable over time.

These hikers are preparing for a day's walk from Cross Fork.

Many would argue that this growing demand for recreational amenities is related to the increasing urbanization of our society. While the urban environment supports industrial efficiency and socio-cultural diversity, in most cases it fails to connect us with the natural environment that has traditionally and still, strongly, influences our national identity. Established as a nation on the frontier of civilization, we have become "an urban society that

As many residents of (and visitors to) the watershed know, Kettle Creek is a renowned trout fishing destination. Recently the Creek was featured on Trout Unlimited's National TV Program - TUTV

still clings to the concepts of the great outdoors and self reliance" (Douglass, 1999). Thus, as Americans continue to migrate toward urban areas, they will also demand continued public access to the undeveloped regions in order to preserve a part of their heritage. Recreation also provides many modern American citizens with their most intimate contact with our nation's natural resources and, for this reason, it can play both direct and indirect roles in the evolving concept of how America's lands should be cared for, used, and valued (Douglass 1999).

Subsequently, shifting social and community priorities of the last decade have seen changes in outdoor recreation and its management. Many community stakeholders are continually demanding increased involvement in environmental decision-making processes that directly affect the biophysical qualities of (and recreation on) both public and private lands (Driver 1999). This can be attributed to the recognition that informed, local changes in environmental and recreation policy can have noticeable, positive impacts on one's own recreation experience as well as a community's economic, social, and environmental well-being. Consequently, many American communities and local governments (chambers of commerce, regional planning offices) have taken a more critical look of the quality of life they offer. Their analyses have led to the allocation of additional resources for improving or enhancing their quality of life including the provision and proper management of open space and recreation resources.

Given this increased focus on recreation as a vehicle for improving quality of life, researchers and professionals tasked with documenting the growing importance of recreation and leisure in the U.S. have brought a number of other interesting recreation-related issues to light. These include the identification of benefits to individual and community health associated with recreation and leisure activities and a more specific analysis of the economic opportunities presented by the recreation and leisure industry.

While most of us accept recreation as "good for us," we rarely consider the range of benefits that recreation provides. According to Barry L. Driver, USDA Forest Service, (1999) the benefits of recreation and outdoor leisure activities for individuals and communities "pervade practically all aspects of [human] behavior and performance: mental and physical health, family and community relations, self-concept, personal value clarification, perceived personal freedom, sense of fitting in, pride in one's community and nation, performance in school and at work, ethnic identity, formation of social networks and systems of social support, spiritual renewal, involvement in community affairs, environmental stewardship, and economic growth, development, and stability." Driver's comments reflect the fact that recreation is not strictly a physical activity but a social and psychological one as well. Regardless of the type of activity-bicycling, bird watching, fishing, or sports-recreation can offer the participants or groups of participants fulfillment in a variety of ways. His statement also implies that recreational participation often incorporates travel costs and/or equipment investments that both directly and indirectly benefit local economies.

Recreation and leisure related industries have repeatedly been identified as one of the top five industries in the U.S. and often rank in the top three economic sectors as revenue generators for most states (Driver 1999). A watershed with many recreation opportunities, like Kettle Creek watershed, is a prime example of the ways in which economic activity can be generated by the recreation industry. Land values in northern Potter County have been rising steadily as more and more people throughout the state of Pennsylvania relocate their homes or build second homes closer to the tranquil setting and recreation opportunities found within northern and central Pennsylvania. Several small businesses have been established for some time to meet the needs of recreationists in the watershed and, as recently as 1990, the services industry in and around the Kettle Creek watershed accounted for 26% of watershed resident employment (Look to the Demographics and Economics Sections of this document for more related information). Service establishments like tackle shops, snack shops, motels, and rental cabins all support and depend upon the recreational quality of the local environment.

In conclusion, recreation and leisure opportunities are vital to a healthy community or region like the Kettle Creek watershed. In addition, and because of continued accelerating nation-wide growth trends in the recreation industry, Kettle Creek stands to offer many opportunities for health, well-being, and resource appreciation to future generations of Pennsylvanians. It is very important to recognize the central role of recreation and recreation planning in maintaining the quality of life, its role in bringing people to Kettle Creek, and it role in fostering resource stewardship in the watershed. With a proper perspective, the future of (and for) recreation in the Kettle Creek watershed could be quite positive.

The tackle shop, pictured above, is just one example of a local business supported by the recreation industry.

Recreational Opportunities Within Kettle Creek Watershed

Recreational and leisure activities supported and/or provided within the Kettle Creek watershed include boating, camping, fishing, horseback riding, hunting, hiking, biking (trail and roadway riding), swimming, picnicking, ATVing, environmental education and interpretation, sledding, tobogganing, ice fishing, ice skating, snowmobiling, skiing, scenic driving, and several others. In some instances, these activities can be pursued on privately owned landholdings, but the majority of these activities are supported on the 92% of watershed land under public and institutional management.

As stated above, the watershed's public lands are very well connected. A vast network of trails (e.g. hiking, snowmobiling) and roads within each of the parks and forests allows access to many remote parts of the watershed. Two, larger regional trail systems (The Donut Hole and Susquehannock Trail Systems) connect recreational destinations within the watershed with many more recreational sites beyond the watershed boundary for most of the year. For example, Cherry Springs State Park,

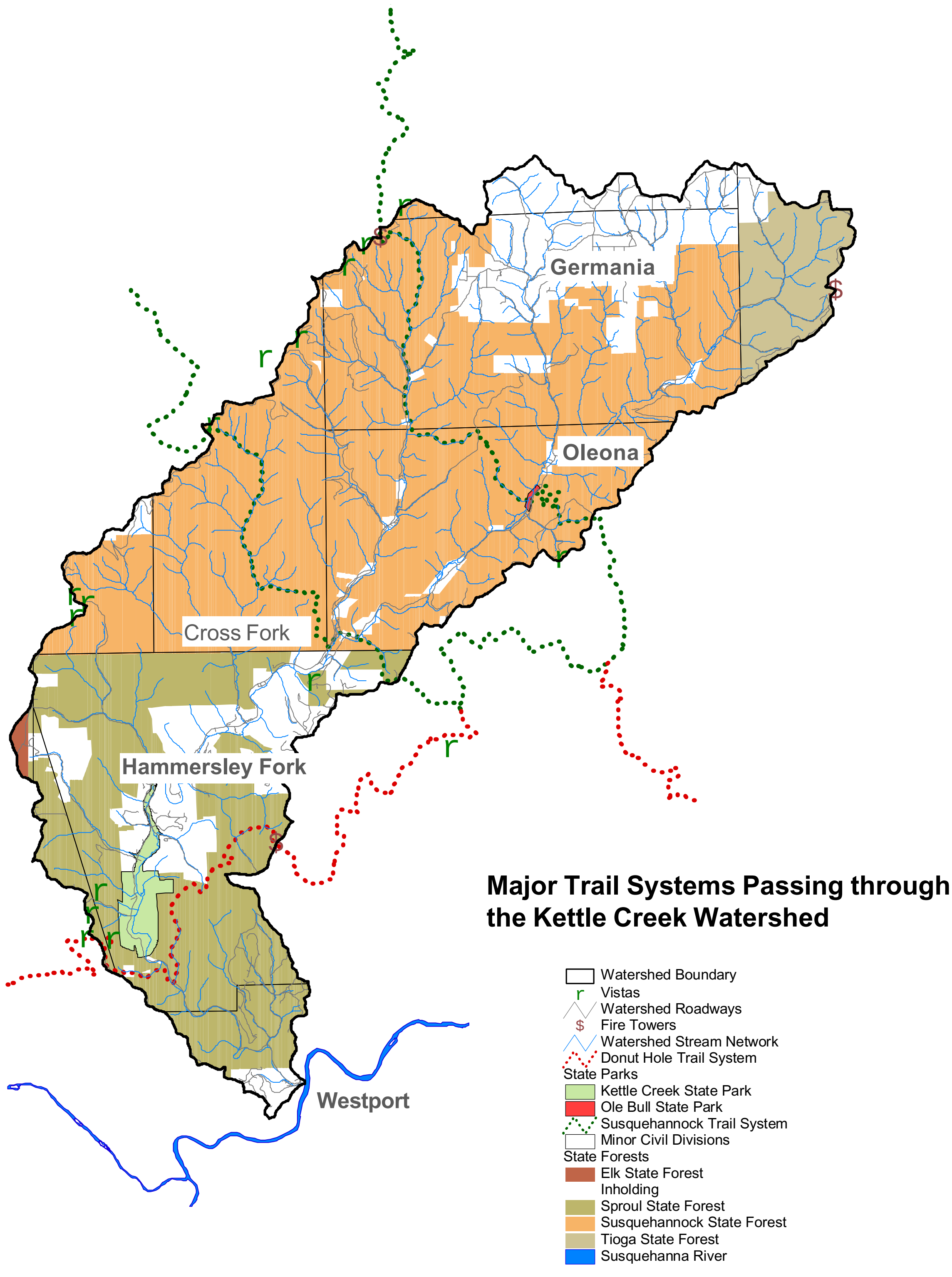


Figure 2.25 - Major Trail Systems Passing Through the Kettle Creek Watershed

Denton Hill Ski Area, and Lyman Run State Park can be reached via the Susquehannock Trail System. Other destinations, like Bucktail State Park and Natural Area, Elk State Forest and State Park, Hyner Run State Park, Johnson Run Natural Area, and Sinnemahoning State Park can be reached via the Donut Hole Trail. (See Figure 2.25 - Trail Systems). In the winter months, alternative travel routes and destinations become available as many township roads and trails open for snowmobile use (See Figure 2.26 - Snowmobile Trails).

The following paragraphs provide a brief summary of the Kettle Creek watershed's public lands (parks and forests) and the services provided by their managing agencies.

State Parks

In the years following the establishment of Valley Forge State Park in 1893, Pennsylvania has developed one of the nation's largest parks systems with over 116 outdoor recreational areas. The PA Bureau of State Parks was formed in 1929 "to provide outdoor recreation facilities in a natural setting, to preserve park areas and to provide environmental education opportunities" (PADCNR 2001). Since that time the state parks system has grown consistently, with the largest growth occurring under former Department of Environmental Resources Secretary Maurice K. Goddard (1955-1970).

During his administration, Goddard strove to establish a state park within roughly 25 miles (40.2km) of every Pennsylvanian, to insure that all citizens would have ample access to outdoor recreation opportunities. Goddard would most likely be pleased with the state parks system of today (now managed by the PA Department of Conservation and Natural Resources), which offers recreational, educational, and leisure opportunities to everyone with relatively short travel times. The system includes two state parks, Kettle Creek State Park and Ole Bull State Park, within Kettle Creek watershed. Elk State Park lies outside the watershed boundary on the western side of Elk County but is linked to the state parks within the watershed through regional trail systems.

The reservoir created by the Alvin Bush Dam supports boating and a warm water fishery in the summer months. In the winter, it is an excellent ice fishing destination.

Kettle Creek State Park: Kettle Creek State Park encompasses 1793 acres (725.6 ha) along the main stem of Kettle Creek in western Clinton County. The focus of the park is the 1300 foot (396m) long reservoir and the resultant 4.5 miles (7.2km) of shoreline. The reservoir, created by the Alvin R. Bush Dam in 1962, arose from a joint flood control project with the U.S. Army Corps of Engineers and the former Pennsylvania Department of Environmental Resources (DER).

The reservoir offers warm water fishing and seasonal swimming, non-powered and electric boating, ice fishing and ice skating. Land-based activities within the park include camping (tent or trailer), picnicking, environmental education and interpretation, horseback riding, hiking, mountain biking, and winter sports (sledding, tobogganing, snowmobiling, and cross country skiing).

More information about Kettle Creek State Park can be obtained on-line at http://www.dcnr.state.pa.us/stateparks/parks/kettle.htm or by contacting the park office.

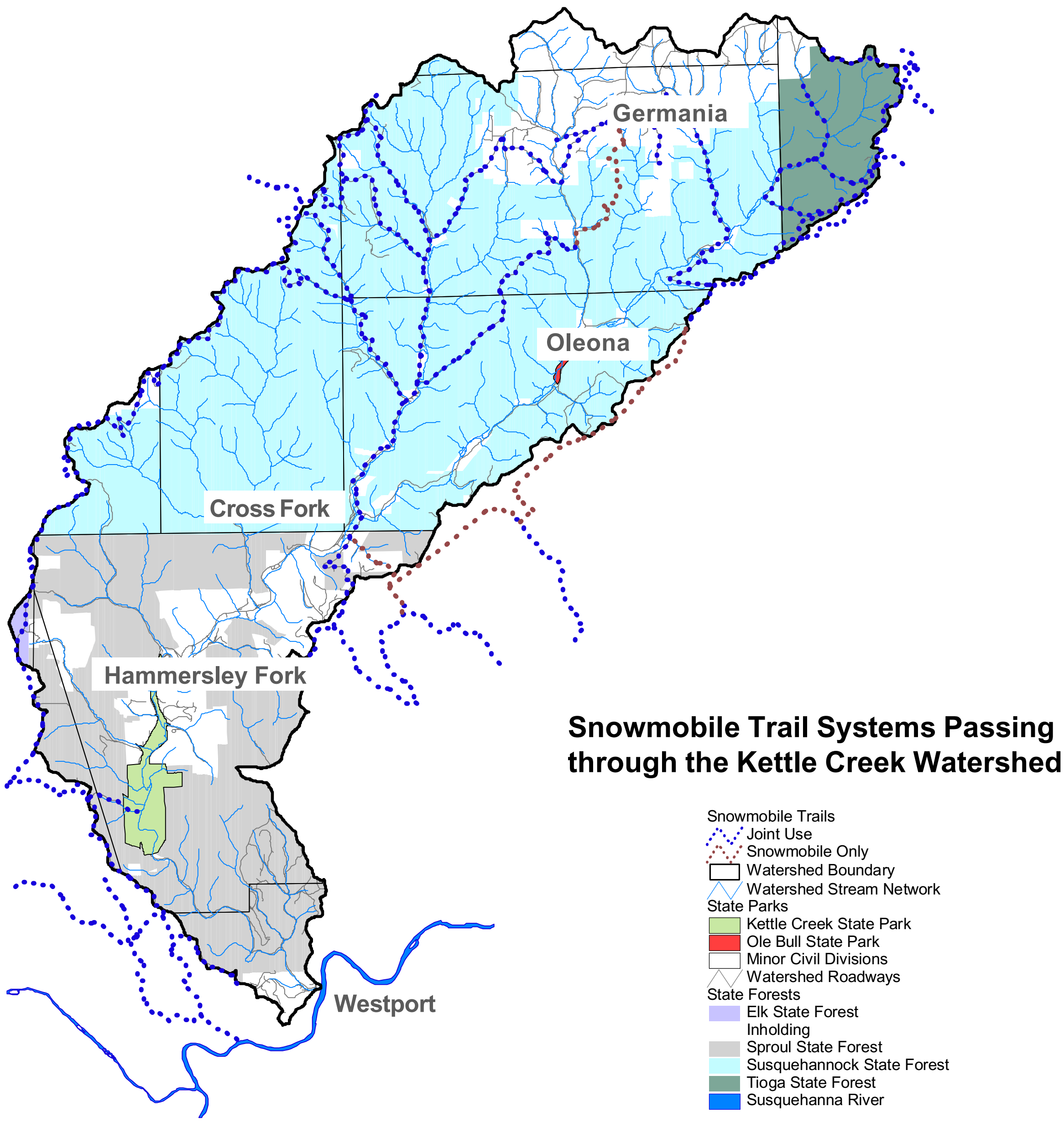


Figure 2.26 - Snowmobile Trail Systems Passing Through the Kettle Creek Watershed

Ole Bull State Park: Located in southern Potter County, Ole Bull State Park is named for Ole Bornemann Bull-a famous Norwegian violinist who attempted to settle a Norwegian colony in the area in 1852. The land that now comprises the park was purchased from timber companies between 1909 and 1925. Civilian Conservation Corps (CCC) Camp S-87, which was located within the park, built most of the current park facilities in the 1930's.

Recreational opportunities at Ole Bull State Park include camping in both fields and forest areas, vacationing in the Ole Bull Cabin, environmental education and interpretation through provided programs and the self-guided Beaver Dam Nature Trail, swimming, fishing in both standard stocking and special regulation areas, picnicking, hunting, hiking, and winter sports (cross country skiing, snowshoeing, and snowmobiling).

More information about Ole Bull State Park can be obtained on-line at http://www.dcnr.state.pa.us/stateparks/parks/ole.htm or by contacting the park office.

The beach at Ole Bull State Park

A portion of the Ole Bull Castle's foundation in Ole Bull State Park.

State Forests

Following the industrial boom of the late 19th century, Pennsylvania, or "Penn's Woods," was virtually devoid of forest cover. Many of the trees were taken for lumber and wood products or to fuel the furnaces of the state's early iron and steel industries. However, it was under the guidance of Dr. Joseph Trimball Rothrock (a Civil War veteran, a professor of botany, human anatomy, and physiology, the first President of the Pennsylvania Forestry Association, and the first commissioner of PA's Division of Forestry in the Department of Agriculture, which would later become the Bureau of Forestry) that the state began to purchase abandoned timberland in 1895. The purchases were made with the intent of reclaiming the woodland for forest and water conservation. Consequently, Pennsylvania has seen many of its once vast forests rejuvenated. Today, there are roughly 4.3 million acres (1.7 million ha) of publicly owned forests and approximately 17 million acres (6.9 million ha) of forested land (both publicly and privately owned) within the state today.

Snowmobiling is both a popular recreation activity and a mode of transportation in the winter..

Of these 4.3 million acres (1.7 million ha) under public management, 2.1 million acres (849,843 ha) are under the stewardship of 20 separate state forest districts. Pennsylvania's state forests are managed to provide some of the world's most valuable timber, clean water for the state's streams, and recreation opportunities for all Pennsylvanians. Three of Pennsylvania's state forests have significant holdings on the Kettle Creek watershed: Susquehannock, Sproul, and Tioga State Forests. A fourth, Elk State Forest, covers only a small portion of the western part of the watershed and is not discussed here in detail.

Susquehannock State Forest: The Susquehannock State Forest derives its name from the Native American tribe that once inhabited much of northern and central Pennsylvania. It encompasses 262,000 acres (105,000 ha) in Clinton, McKean, and Potter Counties, 82,645 acres (33,445 ha) of which lie in the Kettle Creek watershed. Recreational opportunities in the Susquehannock State Forest include sight-seeing from trails and roadside vistas, hiking (89 trail miles, or 142 km, are actively maintained with signs), hunting, fishing, ATVing and snowmobiling (in designated areas), and cross country skiing.

The Hammersley Wild Area can also be found within the Susquehannock State Forest along the Hammersley Fork tributary of Kettle Creek. The Bureau of Forestry manages this tract of land as a wild area, though private mineral and gas rights in a portion of the area prevent its full designation. The Hammersley Wild Area is officially closed to motorized vehicles and possesses the last of the "old growth" hemlock trees in the watershed in the Forest H. Duttlinger Natural Area. The significance of the Duttlinger Natural area is recognized throughout the state of Pennsylvania.

More information about Susquehannock State Forest can be obtained on-line at http://www.dcnr.state.pa.us/forestry/forests/susuq.htm or by contacting the district forester's office at Coudersport, PA.

Sproul State Forest: At 290,000 acres (117359 ha), Sproul State Forest is the largest state forest in Pennsylvania. Roughly 31,470 of those acres (13000 ha) are in the Kettle Creek watershed. Because of its size, the Sproul State Forest offers a variety of both forest and streamside settings and opportunities for recreation. Possible activities include hunting, fishing on 400 miles of freestone and cold water streams with 12 reaches designated as Wilderness Trout Streams (two of which are located in the Kettle Creek watershed-John Summerson Run and the upper portion of Hammersley Fork), hiking with connections to both the Chuck Keiper and Donut Hole Trails, horseback riding, canoeing, bicycling, scenic driving, ATVing and snowmobiling in designated areas, and cross country skiing.

More information on Sproul State Forest can be found on-line at http://www.dcnr.state.pa.us/forestry/forests/sproul.htm or by contacting the district forester's office in Renovo, PA.

Tioga State Forest: Tioga State Forest derives its name from the Native American word "tyoga," meaning "two rivers," in recognition of the Seneca tribe who once owned much of the land that is today's state forest. Tioga State Forest encompasses 160,000 acres (64,750 ha) in Tioga and Bradford Counties, including less than/roughly 7357 acres (2977 ha) in the Kettle Creek watershed. Much of the land in the Tioga State Forest was former property of timber and land holding companies and, thus, the landscape within the forest is reflective of past resource extraction through the composition of existing timber stands. Much of the parks forest's present infrastructure was developed and built by the Civilian Conservation Corps when the land became property of the state of Pennsylvania.

More information on Tioga State Forest can be obtained on-line at http://www.dcnr.state.pa.us/forestry/forests/tioga.htm or by contacting the district forester's office in Wellsboro, PA.

Recreation and Cultural history

The contemporary Kettle Creek landscape, which supports such a diverse recreational environment, is the result of many historical actions taken by the landowners and residents of the watershed. Previous attitudes toward commercial resource extraction, land management, and the importance of providing outdoor recreation opportunities are apparent in the mosaic of existing forest communities, patterns of current land development, and the location of existing recreation facilities. Consequently, many sites of culturally and/or historic significance lay within (or adjacent to) public park and forest holdings. In addition, Kettle Creek's parks and forests contain artifacts (structures, structural foundations, bridge abutments, rail beds) that reveal the watershed's unique history.

While the most actively supported recreation and leisure activities in the watershed are physically challenging, forest- and water-based activities, historic interpretation and heritage tourism offer yet other possible avenues for public and private land management. The Pennsylvania Heritage Tourism Study, completed in 1999, reported that heritage tourism represented 12% of the tourist population and 25% of the state's tourism revenue in 1997 (Shifflet 1999), generating jobs, income, and tax revenue for local economies. With the potential for increased local revenue, heritage tourism has been used as both the lead and supporting components of economic revitalization projects in other Pennsylvania counties (for example, Bucks County) and has been supported by a wide range of community interest groups.

At its core, heritage tourism serves two purposes: commemoration and education. It has economic and recreational factors as well, but fundamentally it is about honoring historic people, places and events by sharing their significance with current generations. In the case of Kettle Creek, the interpretation of historical sites that overlap the existing recreational network could compliment a strong recreation industry. Historic interpretation and recreation destinations have already been intertwoven in the form of the sign at the castle vista at Ole Bull State Park-allowing for an initial understanding of the colony. This state park was also logged by the Lackawanna Lumber Company, leaving a changed forest and a narrow railroad grade that rides the lower slope of the mountain. The park later benefited from the work of the Civilian Conservation Corps, Camp

A snow covered foundation of a cabin built by the Civilian Conservation Corps Camp S-87 in Ole Bull State Park.

S-87, from 1933 to 1941 in the planting of trees across the degraded logging lands, construction of picnic and swimming facilities, and trailblazing for recreation and fire control. These historical occurrences are also evident in the landscape in many ways and present their own interpretation opportunities.

Ole Bull State Park is one of many sites in the Kettle Creek watershed that subtly express the repeated use of the landscape by various people and could enhance the recreational network with additional interpretation. Sites relevant to resource extraction are found throughout the state forests, since logging and mining occurred on such a large scale. Still others are located along the main stem corridor, where the stream network provided fertile soils for early Kettle Creek farms and mills. (See Scenic and Visual Analysis for more details on history along the main stem.) These sites offer opportunities to share, celebrate, and promote rich cultural and environmental history of Kettle Creek through the recreational network.

Recreation and Cultural Events

Recreation in the Kettle Creek watershed also includes several cultural events hosted within the watershed boundary and regional and events for which Kettle Creek businesses and institutions offer lodging and food services. Of course, Kettle Creek is always a popular destination for the first days of trout season, but many other events offer enjoyable opportunities to the both watershed residents and visitors alike. Ole Bull State Park has hosted an early summer music festival in recent years, and the Cross Fork Snake Hunt bring visitors from across the country to Kettle Creek each June. The Barkpeeler's Convention and the Woodsman Show are also held each summer at the Pennsylvania Lumber Museum and nearby Cherry Springs State Park, respectively. Late autumn draws seasonal residents and visitors to public and private camps for the first days of buck and bear season.

These events represent the culture of Kettle Creek and its surrounding region. They provide opportunities for learning about the condition and use of the environment and about others in the watershed community. They also contribute to the identity of the watershed as a high quality natural environment that both past and present generations value.

Future Recreation Possibilities for the Kettle Creek Watershed

Recreation indeed plays a significant role in the lives of watershed residents and other members of the watershed community. There are abundant and diverse activities enjoyed throughout the watershed and the year, and the popularity of these activities supports camps, stores, and restaurants owned and operated by watershed residents. But it is still important to note that at the core of recreation is the quality of Kettle Creek's natural resources, for it is the natural environment that provides the quality of life that residents desire and that visitors enjoy.

Consequently, maintaining a high quality of life will require the conservation of natural resources and recreational opportunities in the Kettle Creek watershed. With such a high percentage of public land, an active and open dialogue with state park and state forest management is vital to the future of recreation in this watershed. Private landowners can also contribute and expand the collective knowledge of watershed history and culture by through their voluntary participation in interpretive and conservation projects-thus improving the quality of the resources under their ownership as well. Finally, visitors and non-residents interested in the quality of natural resources may supply conservation projects with knowledge, funding, and manpower. Together, the collective management and support of both natural and cultural resources and programs can maintain and enhance both recreational opportunities and the existing character of the watershed.

It is important to note that there are programs and land management initiatives available to collaborative resource managers, communities, and other stakeholders that are intended to recognize, promote, and protect outstanding regional natural resources, recreational opportunities, or culturally significant open space networks. Greenways are one of the more popular types of these initiatives (others include conservation easements and transfers of development rights). A greenway, by definition, is a linear overland corridor established along a natural feature or transportation corridor which may be established to meet a variety of needs. To learn more about greenways as a possible alternative for preserving and enhancing many of the positive aspects that support recreation and a high quality of life, see the greenways appendix on page 267.

GOALS: RECREATION

LU3.2 Designate and protect high value areas. Encourage the protection of these areas through buffers and the promotion of natural areas or recreational open spaces.

- Greenways

WI1.4 Recognize tand protect the unique natural features of the watershed that have influenced resident life and visitor attendance.

WI1.2 Explore and celebrate the rich cultural history of the watershed as acommunity and for visitors.

- Continue to integrate local history with recreational opportunities.

These photographs illustrate the pastoral character of the northern watershed landscape.

VISUAL ASSESSMENT

Introduction

There are several reasons for undertaking a visual assessment within the Kettle Creek watershed. They include the need to recognize the existing scenic quality within the watershed, to qualitatively characterize that scenic quality so that it can be more accurately promoted and conserved, and to establish a baseline to evaluate future change in the watershed landscape.

This visual assessment is composed of three parts. The first part is a broad categorization of the scenic qualities of the watershed. Kettle Creek is truly beautiful for a number of quite specific reasons. This section will characterize the current state of the landscape in both words and images in the hopes that these qualities may be preserved for future reference and analysis in the face of landscape change.

The second part of this visual study identifies the unique character, nature, and importance of the central travel corridor through the watershed, namely the roadway along the main stem of Kettle Creek (from Westport to Oleona) and Rt. 144N along Little Kettle Creek to Germania. This "roadway study" is intended to recognize 1) the visual character, spatial character, and value of the several Kettle Creek watershed roadways as "scenic driving routes," 2) the visible historical significance of some parts of their alignments and adjacent historical sites, 3) the visual significance of Kettle Creek, itself, from the roadway, and 4) the ability of these roads to speak of the character of the watershed to motorists "through the windshield."

The third, and final, part of this particular study is dedicated to Kettle Creek's potential for inclusion in Pennsylvania's Scenic Rivers System, a product of the Pennsylvania Scenic Rivers Act. The PA Scenic Rivers Act was enacted to recognize the outstanding recreational and aesthetic values of many of the state's waterways and adjacent land areas. This chapter will include a brief summary of the Scenic Rivers Program, more information about the Scenic Rivers program as it may, potentially, apply to Kettle Creek can be found in the appendices at the end of this report.

Visual Condition of Kettle Creek watershed

As many residents of Kettle Creek have stated, the watershed landscape is beautiful. The truth of this statement is rooted in our unique American values for the qualities of rural landscapes: their wildness juxtaposed by their visible pastoral and agricultural heritage, their field, woodland, and wildlife productivity, and their similar appearance to the landscapes on which our founding fathers lived-composed of lush forests, rich fields, flowing streams, idyllic farms, and small, personable villages.

In each of these rural qualities, we find a myriad of colors, textures, forms, and spaces appearing across the landscape that draw our admiration again and again, throughout seasonal changes. The watershed's many acres of hardwood forest display lush green foliage in late spring and crisp colors in autumn. Its fields and meadows roll across the gentle slopes of the valley floor and the headwaters uplands. Its riffling waters mask distant sound and still pools mirror the changes in the vegetation as well as the ever-changing sky above. Residences are also scattered throughout the landscape. Some are clustered in small villages, while others are situated among the fields, woodlands, and springs. Many, however, are constructed from local materials and styles and appear as if they, too, were grown from this very landscape.

Together, they comprise our view of the watershed from the road, from the ridge, and from the stream. The roads allow glimpses of the stream through the streamside vegetation and draw attention to the mountainous terrain through their course. From the ridges we can see into the valleys, patterned with forest, plantation, and clearing, and across the rolling uplands of a cultivated landscape. From the stream, the views are cast through the stream corridor itself and contained within the adjacent streamside forests.

In addition to patterns we see in the natural environment, there are patterns or trends in the design and placement of structures that we see today. Residences are typically two-story buildings, while camps are generally only one-story. Many residences were likely built before 1900, while camps have flourished since the 1920s. In the valley, structures are built at the foot of the mountain, nestled into a hollow, or sited on a knoll. Along the ridges, buildings are typically sited for views across the landscape, rather than within it. Buildings in the villages closely line the road, while others are set back several yards, at least. In addition, there may also be patterns in the placement of porches or windows. These characteristics give a sense of coherence and a consistent character to the Kettle Creek watershed.

One of the best ways to understand and preserve the appearance of the watershed is through photography. Current digital imaging applications allow us to create realistic images of land use applications, proposed develop-

Undisturbed woodland and stream environments exhibit the intrinsic beauty of north central Pennsylvania.

ABOUT VISUAL ASSESSMENTS

This study is filled with images of the watershed in its current condition; both residents and visitors can contribute to this collection with relative ease. These watershed images can serve as both a baseline indicator for the current quality of the watershed landscape and as a tool to evaluate future change.

This evaluation process can also be done by hand cutting and pasting several photographs (of the same size and scale) together. One image (the base image) is typically a photograph of the landscape in question. The other images (from which objects are cut) are of typical development (homes, offices, and so on). These objects are then pasted onto the landscape (base) image to better visualize what the landscape could look like if it is developed.

These images (taken from Sinking Valley in central PA) demonstrate the capabilities of digital photo editing for evaluating landscape change. (Photos by R. Binkowski, A. Feldman, and M. Little; PSU Dept. of LArch)

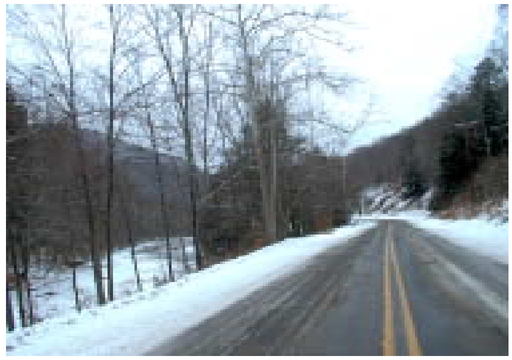
ment, or forestry practices in order to evaluate the visible landscape change. These composite images are often more easily understood by a general audience, who can then discuss and vote for or against the proposal with a more comprehensive understanding of the impact of development.

In short, it is necessary to recognize the outstanding visual quality of the Kettle Creek watershed and to identify the significant visual components (for example, open fields, forested hillsides, or works of architecture) of that quality in order to conserve the watershed character that so many enjoy. These components, when identified and analyzed, can then be used to guide development that contributes to, rather than significantly alters or degrades, the watershed character.

The Kettle Creek Corridor Roadway Study

When was the last time you drove a truly beautiful route? What made it beautiful? Was it the focal points or objects in view? Was it a dramatic background? Was it the constantly changing composition that you saw through the windshield? Or was it the sense or rhythm of motion imparted by the turns in the road? Each of these factors can contribute to a positive travel experience, and many of them can be found along major routes through the Kettle Creek watershed.

In The View from the Road, Donald Appleyard (1964) writes, "Those who are alarmed by the ugliness of our roadways emphasize the repression of vice rather than the encouragement of virtue." He believes that it is possible to emphasize the potential beauty of roadways rather than to accept them as "one more price of civilization." In truth, we Americans spend an overwhelming amount of time in our cars as a captive audience-our eyes fixed on the scene framed by windshield during our daily commutes and many of our other travels. Travelers



These views from the roadway corridor between Westport and Germania illustrate the dramatic scenic quality of the landscape: a sinuous valley; forested hillsides of pine, hemlock, and hardwoods; pastoral headwaters; and a stream that seems to braid with the road and riparian vegetation.

in the Kettle Creek watershed (both residents and visitors) are no exception.

Throughout our daily, weekly, and monthly travels we observe far too many "ugly" roadways and too few visually engaging routes. This roadway study contends that the roadway corridor from Westport to Oleona and along Little Kettle Creek to Germania is not an ugly roadway. Rather, it is a rare, attractive roadway that engages the viewer with both eye-catching sites and a unique sense of motion. Therefore, it deserves to be recognized for many of the positive qualities that it possesses.

The overall goal of this roadway study is to raise awareness for the driving experience in the Kettle Creek watershed. As Appleyard proposes, "road watching could be a delight ... a dramatic display of space and motion, or light and texture, all on a new scale" (1964). Travel along the corridor from Westport to Oleona to the headwaters of Little Kettle Creek could be both a kinesthetic and rich visual experience in which motorists knowingly feel the turns and the rise and fall of the road across the landform and anticipate the views found around each bend.

In addition to the moving and visual experience, roadside historical and natural sites in the Kettle Creek watershed can also be included as educational and enlightening sidelights because of their significance and their proximity to the roadway. The drive from Westport to Germania along the main-stem and Little Kettle Creek could in fact tell the cultural history of the watershed through a series of interpreted locations, including the settlement at Westport, the three Civilian Conservation Corps camp sites and their plantations, the Summerson farm (the lower campground of the Kettle Creek State Park), the local gas supply for light and heat, the village of Cross Fork, once a booming lumbering town, the (rebuilt) home of Dr. Edward Joerg and the Henry Andresen farm (both of the Norwegian colony), Carter Camp (and its role in road construction, the Norwegian colony and cheese production), farms of distinctly historic character, and their historic business and social center, Germania.

There are yet other benefits to completing a scenic roadway study. The first of which is a "snapshot" in time which documents the current qualities that make an attractive roadway corridor and identifies areas for possible future enhancement. A second benefit is that a completed roadway analysis may help examine alternatives for improving existing roadways that are short of constructing or reconstructing them-saving both time and money. For example, a confusing or dangerous stretch of roadway or intersection could be improved by removing excess vegetation to improve visibility and through the provision of additional signage in places that the driver's eye is most likely be drawn. A third and final benefit is the identification of areas, frequently seen by travelers in the watershed, that posses valuable or unique characteristics (i.e. exceptional vistas) that may face significant pressures (i.e. development or infrastructure and utility installation) and should therefore be identified as possible preservation efforts to preserve the visual quality and the popular identity of the watershed.

Before discussing the scenic roadway study graphic(s) (on pages 281 and 283) included in the appendix, it is important to note several factors associated with automobile travel. Appleyard argues that the modern car interposes a "filter" between the driver and the world he or she is experiencing and that our senses of sound, smell, and touch are all subordinated to our sight, which is, in turn, framed by the windshield due to our relative inactivity. Thus, this study focuses mostly on the visual aspect of driving.

It is also important to note that two people rarely have the exact same experience while driving and that they rarely travel the very same route from start to finish at any given time. The highway experience is both "reversible" (we can travel in the opposite direction on the same segment of road and sometimes see things in an entirely different manner), and "interruptible" (drivers frequently start and stop at different points) (Appleyard 1964). For the purposes of this study, however, it was necessary to establish a single study route.

The corridor beginning in Westport, traveling through Oleona, and traveling portions of Rt. 144N to the northern border of the watershed, was selected for its consistent use by residents and watershed visitors. It encompasses not only the most heavily traveled road segments in the watershed (according to the Pennsylvania Department of Transportation), but also the particular routes used by many Pennsylvanians (arriving from PA Routes. 80, 220, 144, 120) to access recreational sites at both Kettle Creek and Ole Bull State Parks. The roadway along Little Kettle Creek, which passes through Germania, was also selected because of its serpentine nature, the fact that it passes through a beautiful part of the pastoral northern reaches of the watershed, and because it serves as a link to destinations north of the watershed like those on PA Route 6 in Potter County.

The following paragraphs are also intended to aid in interpreting the diagrams in the appendices, on pages 281 and 283. A GIS generated map has also been provided as a reference for locating areas of interest on the diagrams. The composition of the visual roadway analysis diagrams, is as follows: Photographs taken at one mile intervals along the study route are located in the column at the far left to provide orientation on the sheet. Profiles of the roadway which indicate the relative position of the roadway, the stream and the ridgelines are located in the next column (a fine line has been

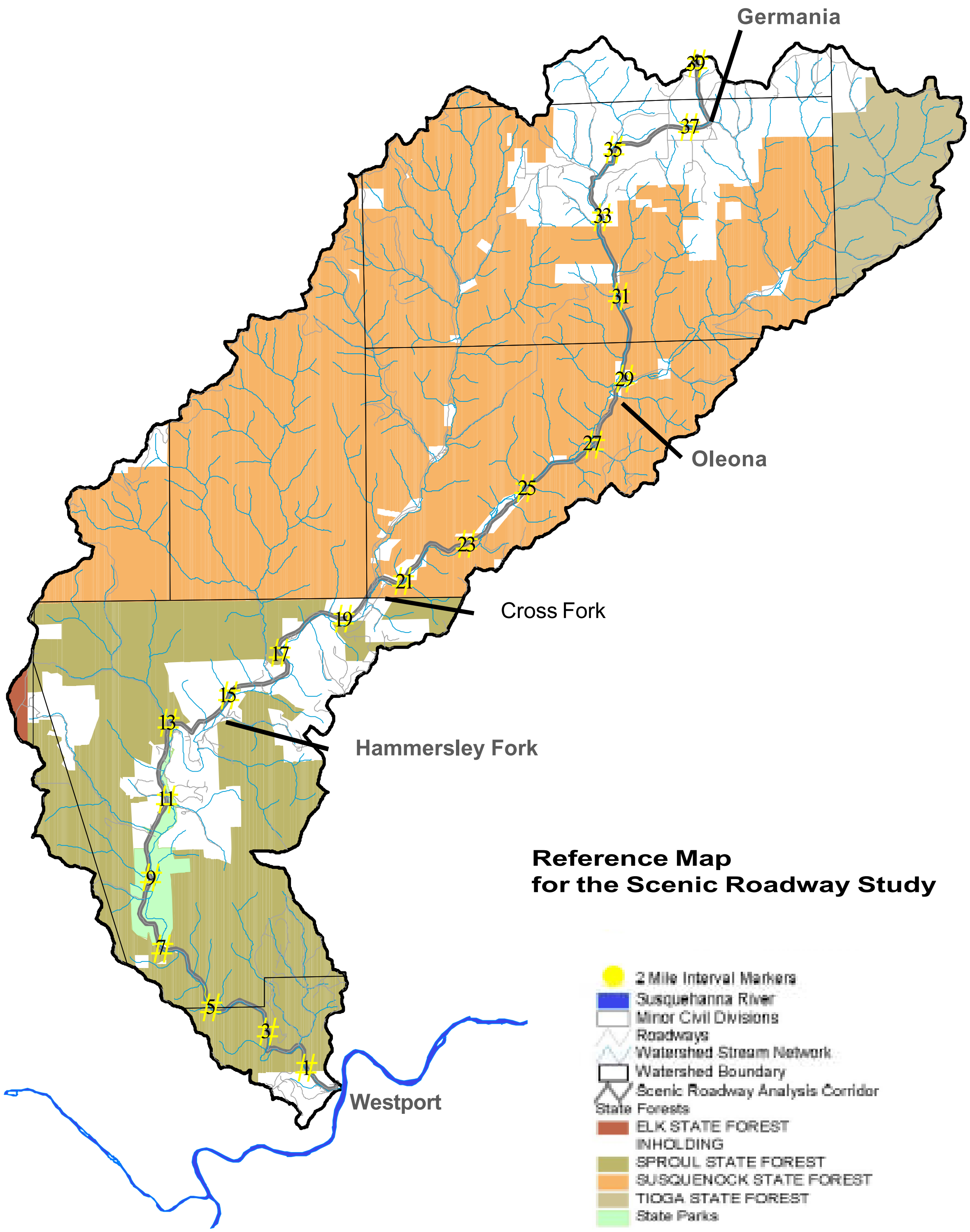


Figure 2.27 - Reference map for the scenic roadway study

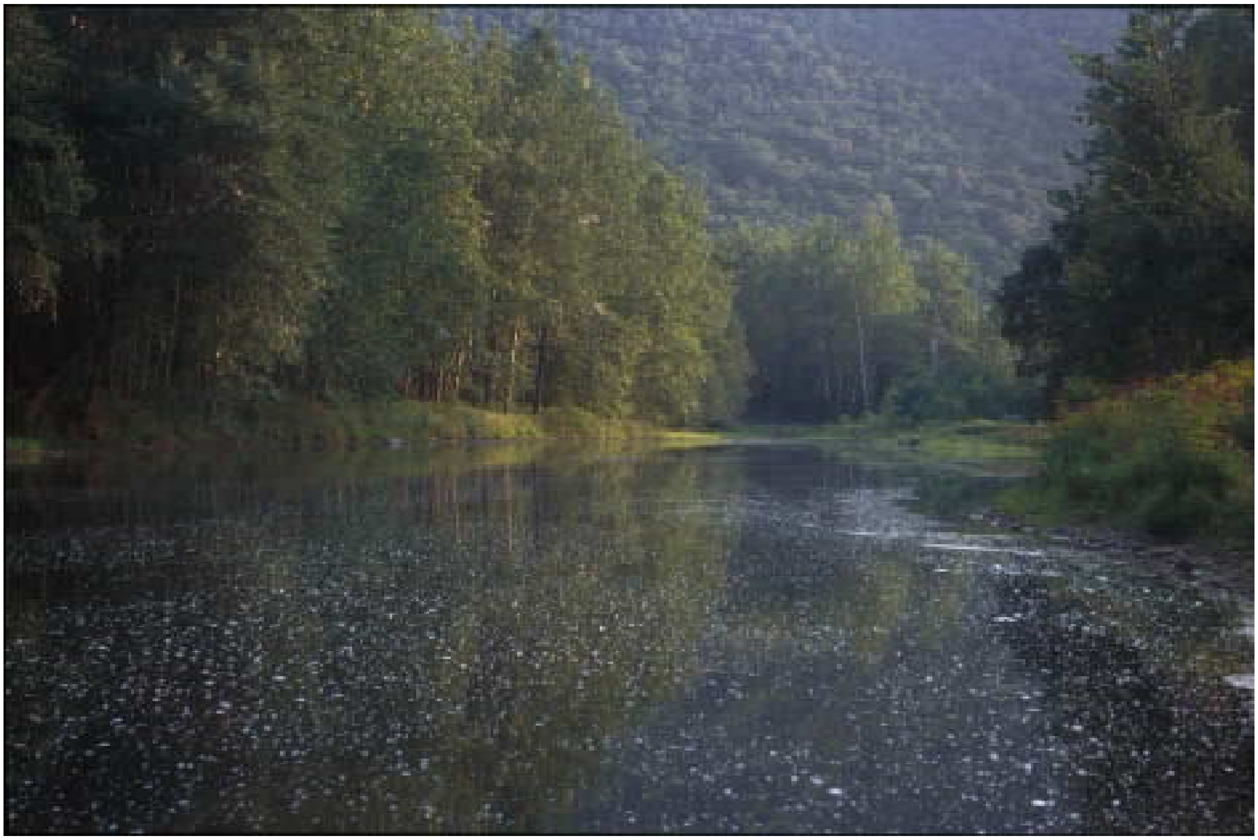
included on these sections to indicate the relative position of the roadway centerline).

The third column contains an interpretive diagram which relates both the spatial character (the degree of enclosure) and the sense of directional change one experiences when traveling the route. The notation used in these diagrams is relatively simple. The relative width of the blocks located along the (dashed) roadway centerline indicates the relative enclosure of the roadway (in the valley and, in cases, within vegetation which enhances the sense of enclosure). The relative curvature of those same blocks is intended to portray the degree which the roadway curves as one travels along it. In locations where there is a break between blocks, this indicates a change in the character of the roadway. For example, such a break is located at mile marker six, where the narrow, densely vegetated experience of the roadway from Westport gives way to the open expanses near Alvin Bush Dam.

The diagrams, themselves, are intended to show how the relationship between the road, the landscape, and the stream changes constantly along the route from Westport to Germania and to identify important sites along that same route (i.e. sites of historical significance, desirable views). At times viewers are more aware of their proximity to the stream than to the ridges that define the valley, or vice versa. As the road climbs and descends the mountain slopes, travelers sense changes in their vertical distance from the streambed. As the stream meanders back and forth along the valley floor, travelers may sense their horizontal separation from the water, always knowing approximately where the stream lies, but not exactly as camps, meadows, and forest obstruct their view. At particular times, viewers may have a strong sense of feeling enclosed in the landscape or riding gently on the landscape. They can take notice of spatial enclosure provided by the mountains-how it helps anticipate the direction the roads will take and directs views to mountainside fall color displays. The roadside vegetation also provides enclosure, opening and closing views to the stream. Depending on the direction of travel, these views may be cast upstream, downstream, or across the stream. The evergreen vegetation creates dark tunnels within the lightly filtered hardwood forest. Where roads pass along or through pine and spruce plantations, viewers may notice the highly ordered planting in contrast with the organically ordered forests.

Kettle Creek and the Pennsylvania Scenic Rivers System

As was indicated in earlier parts of this document, the pressures of increasing land values and development both in and around the Kettle Creek watershed (see Land Use, Economics, Demographics, and Recreation) present almost definite future changes and possible negative visual impacts within the watershed landscape. The PA Scenic Rivers designation is yet another tool available for the preservation of land and water resources in the face of development in the Kettle Creek



Kettle Creek, near the confluence with Hammersley Fork.

watershed where no other measures exist (for example, public land ownership, zoning regulations that regulate development, conservation easements, or transferred development rights).

In certain locations, a Scenic Rivers designation may also reinforce already existing protections. Therefore, this introduction to the PA Scenic Rivers Program has been included to familiarize watershed stakeholders with the opportunities, benefits, and process of the Scenic Rivers Program.

The Pennsylvania Scenic Rivers Act (#283) was passed in order to preserve the outstanding aesthetic and recreational value of many of the state's rivers and adjacent land areas for the potential benefit of Pennsylvania citizens. The Scenic Rivers system is comprised of free-flowing rivers, streams, or tributaries thereof, that are recognized in five categories (wild, scenic, pastoral, recreational, or modified rivers) by the Department of Conservation of Natural Resources and are authorized for inclusion by law. Today, there are approximately 500 miles of Pennsylvania's streams and rivers included in this program.

While many river corridors are often referred to as "blueways," many terrestrial corridors are referred to as "greenways". To learn more about blueways and greenways, refer to the previous discussion of recreation and the greenway appendix (page 267).

There are many benefits associated with river conservation and protection as provided by the PA Scenic Rivers Act. Healthy, free-flowing rivers are increasingly seen as assets to healthy communities. Throughout history, rivers have been the threads of the landscape connecting our communities and providing water, transportation, and recreation opportunities. In addition to these social benefits, these rivers are also ecological corridors (often referred to as "blueways") that link many fragmented terrestrial habitats and are vital to the function of many of our ecosystems within the state of Pennsylvania.

GOALS: SCENIC

LU 3.2 Designate and protect high values areas. Encourage the protection of these areas through large buffer and the promotion of natural areas or recreational open spaces.

- Scenic by-ways or corridors

WI 1.2 Explore and celebrate the rich cultural history of the watershed as a community and for visitors.

WI 1.3 Recognize that the current visual quality of the watershed is characterized by forested slopes and ridges.

WI 1.4 Recognize and protect the unique natural features of the watershed that have influenced resident life and visitor attendance.

In many cases, Scenic Rivers designations work to preserve the existing, outstanding qualities of Pennsylvania's rivers and other waterways (as well as adjacent lands) by recognizing their present outstanding qualities and their exceptional natural and cultural heritage. Scenic rivers designation is intended to generate greater public recognition of a waterway and, in some cases, to benefit the social, cultural, economic, and environmental conditions surrounding it (17 PA § Code 41.2). A Scenic Rivers designation can also help to prevent further degradation of the waterway through the inhibition of dredging and mining operations and through the preservation of critical habitats, e.g. wetlands (25 PA § Code 11.5, 25 PA Code § 86.102, and 25 PA Code § 105.17). Under Pennsylvania Scenic Rivers designations, any such activities that may present potential negative impacts for a scenic river must first be evaluated and obtain proper permitting (Allegheny Watershed Network 1999). It is important to note that a Scenic Rivers designation and subsequent policies/requirements are not intended to override local or municipal land use ordinances where they exist. Instead, Scenic Rivers protection is meant to function as a supplement to local land preservation strategies and/or a measure of protection where no other means (i.e. desired ownership, zoning, conservation easements, or transferred development rights) are currently established. In either case, community participation in the application process is entirely voluntary.

Please refer to the recommendations section (page 255) of this document for a more complete explanation of the Pennsylvania Scenic Rivers System process and a sample eligibility study applied to the main stem of Kettle Creek.

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LANDUSE & LANDCOVER

Human interaction with the natural landscape determines the ecological health of the watershed; it also contributes to the character and identity of the region. While the watershed is predominately comprised of public land, each landowner contributes to the watershed health and identity. As one of Pennsylvania's most heavily stocked and naturally productive coldwater fisheries, Kettle Creek also attracts visitors from across the state, who value its rich angling opportunities and its historic, rural character. This chapter discusses both the public and private management of various landuse types found throughout the watershed.

Introduction

Landuse, or the way in which people use and depend upon natural resources, is simply a relationship between people and the landscape. It sculpts the character of the places in which we live and it also has profound impacts on the natural resources upon which we depend. Kettle Creek exemplifies this intimate relationship. Historically, its timber and coal supported a thriving industrial watershed economy. Agriculture, throughout the northern watershed and along the main stem valley, allowed people to live directly off of the land. Today, the rural, forested watershed is cherished for vast expanses of contiguous forest, thriving coldwater fisheries and recreational opportunities. Whether it is remnants of the watershed's industrial heritage or its thriving present day forest, all of these characteristics make Kettle Creek a unique place to live and visit. On a larger scale these characteristics contribute collectively to the character and identity of both Kettle Creek and the north central Pennsylvania region.

Just as landuse defines character, it also carries the potential to impact the natural areas around it and, in turn, the people who depend upon these natural resources. For instance, infrastructure that facilitates access to the watershed, such as roads and utilities, becomes a source of sediment and nutrient problems to the streams. This in turn affects both adjacent and downstream stream water quality. Fish and other wildlife that depend upon these clean waters also are affected. Yet as extensively as landuse affects the natural landscape, it also affects the people who drink that water and fish in those streams.

As long as people continue to live in and visit the watershed, the landscape will continue to change. Identification and conservation - by the residents of Kettle Creek - of the lands that are most valued by the community is the first step towards conserving the cherished Kettle Creek watershed identity as it is today.

Classification of Landuse Types

A categorization of landuse type by ownership could help to identify potential partners in the implementation of conservation measures. Forested lands are predominately state owned and managed by the Bureau of Forestry. Natural and sensitive lands, including wetlands, springs and seeps, span across private and public boundaries throughout the watershed and thus become a management issue for a host of stakeholders. Privately owned residential and agricultural lands are regulated by the municipalities. Each of these landuse types and its associated issues is broadly outlined below. This chapter will provide a framework for the inventory and assessment of high value lands in the watershed. While management recommendations are outlined at the end of this chapter, it is left to the Kettle Creek watershed residents and the association to prioritize conservation measures based upon what elements are most important to them.

Kettle Creek is 92% public land that is managed and supervised by the Commonwealth of Pennsylvania. Included within the watershed are four state forests and two state parks.

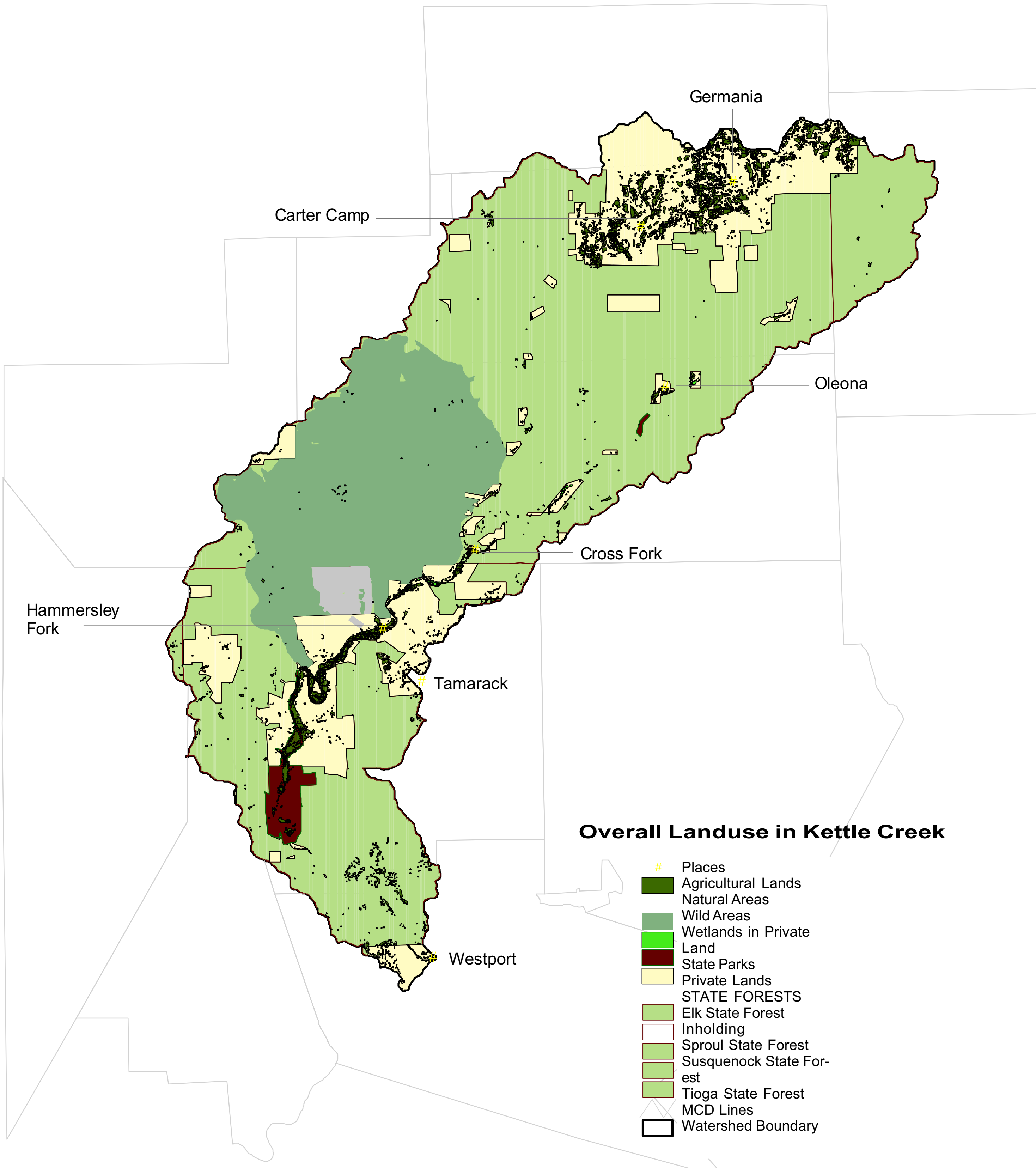


Figure 3.1 - Overall landuse in KettleCreek

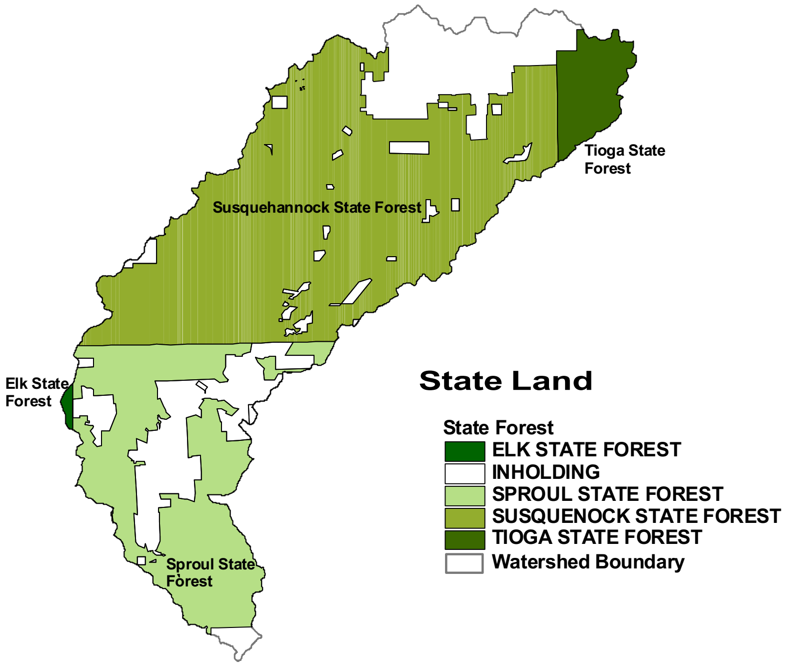


Figure 3.2 - Commercial timber lands within the state forests bring in revenue to the DCNR and the local municipalities.

All state forest lands are managed by the DCNR under a state forest management plan. This comprehensive plan, revisited every 5 years, prescribes forest stewardship principles for the management of cutting, natural areas, historical areas, sensitive areas and recreational areas. The 2001-2005 plan is currently being revised.

Public Lands

STATE OWNED

LANDS

State Forest Land

Elk, Sproul, Susquehannock and Tioga state forests make up approximately 92% of the watershed. The forests offer not only abundant hardwood timber, fish and game, and a rich history but also comprise some of the largest expanses of contiguous forest in the state. These tracts of contiguous forest provide viable wildlife corridors and support a uniquely diverse plant and animal habitat. (For more information on Wildlife see page 147). These large expanses of forest also maintain the exceptional value waters of Kettle Creek and its tributaries. The dense forest floor absorbs and filters nutrients and sediment emanating from adjacent roads and development. It also absorbs excess storm water, moderating flow and flood events in the stream.

State forest lands are designated and managed by the DCNR Bureau of Forestry under a State Forest Management Plan. Commercial timberlands, generally areas with high value timber stands, are managed for sustainable cutting and provide revenue to both the state and the local municipalities. Noncommercial lands are often economically unsuitable for cutting and are typically managed as environmentally sensitive areas (See Figure 3.3 - State forest timber stands).

Commercial Timber

State Forest commercial timberlands are dominant in Potter County, particularly around Kettle Creek's mainstem and the tributaries and mainstem of Cross Fork. They are managed for sustainable timber production. In addition the State Forest Management Plan prescribes the careful management of environmentally sensitive areas, including erosion-prone steep slopes (greater than 20%), ridgelines, headwaters and rock outcroppings, to moderate both the economic costs and the environmental impact of cutting in these areas. (For a discussion of headwaters see page 110).

The state forests generate economic resources for both the state and municipalities. While revenue from timber harvesting supports the

Forested areas in the watershed are predominately composed of Northern Hardwood tree species (approximately 50%); other species include Mixed Oak (Quercus sp. 29%) Red Maple (Acer rubrum 4%), Aspen (Populus sp.) and Gray Birch (Betula populifolia 3%), Coniferous Plantations of Virginia Pine (Pinus virginiana) and other conifers 1%), White Pine (Pinus strobus) and Hemlock (Tsuga canadensis 1%).

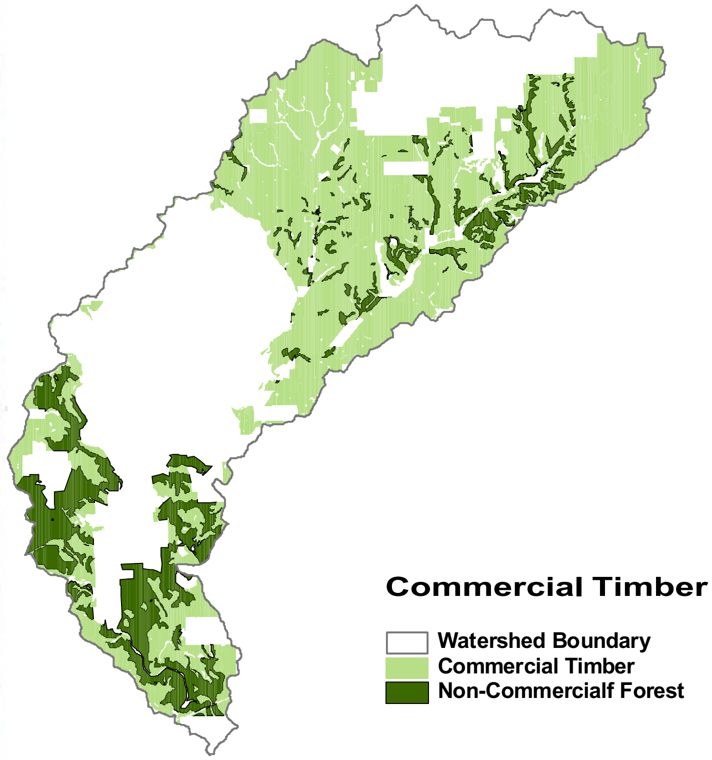


Figure 3.3 - Commercial timber lands within the state forests provide revenue to the DCNR and the local municipalities.

Bureau of Forestry, municipalities also benefit from in lieu taxes. The 2001 - 2005 State Forest Management Plan draft further proposes an increase in revenue allotted to the municipalities. Support of this plan could provide additional revenue to the townships, bringing with it the opportunity to implement municipal improvement projects.

Non-Commercial Timber

Noncommercial state forest timber areas are generally found in rugged terrain that presents a financial barrier to timber harvesting in areas with relatively low value timber stands. These areas are widely dispersed throughout the watershed although a large percentage falls generally in the southern part of the watershed (See Figure 3.3).

Lack of development within noncommercial forest lands provides the opportunity to link to adjacent tracts of forest. These links, would create tracts of contiguous forest corridors

State forest lands offer rich & diverse wildlife habitat and enhance the visual quality of the watershed.

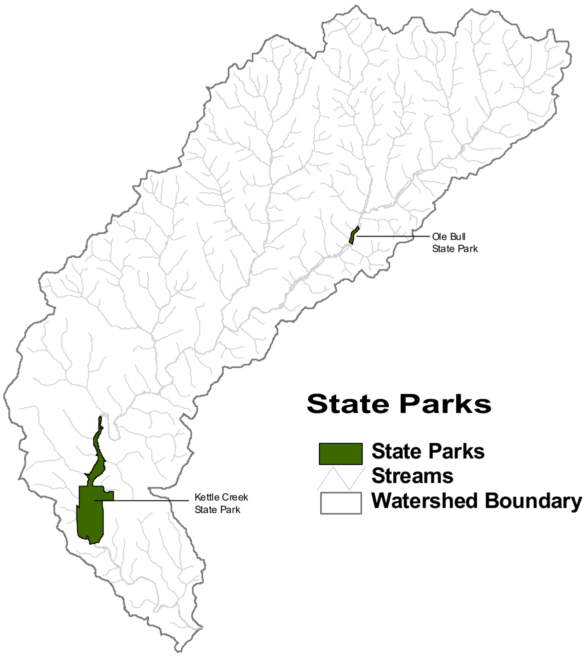
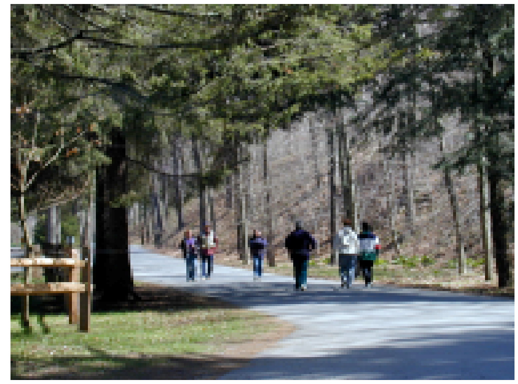


Figure 3.4 - Two state parks along the mainstem of Kettle Creek draw visitors from across the state each year.



People participating in outdoor activities at Ole Bull State Park

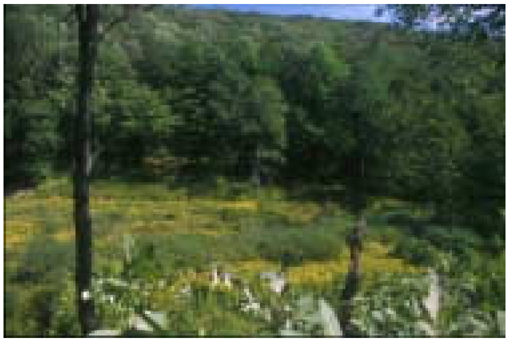
State Parks offer opportunities for both outdoor recreation and environmental, historical and cultural education and interpretation.

which would thus enhance the potential for wildlife diversity. These areas could further foster forest connectivity with the riparian streamside forests; in turn this would provide valuable wildlife corridors promoting greater species diversity in the watershed.

State Parks

There are two state parks in the Kettle Creek watershed that offer opportunities for many outdoor recreational activities (See Figure 3.4). Kettle Creek State Park rests on 1,793 acres in the lower branch of Kettle Creek in western Clinton County (See figure 3.4). Ole Bull State Park, situated along the Kettle Creek Valley in Potter County, is 125 acres. The state parks, while relatively small in area, play a large role in the watershed identity. Both parks offer abundant recreational opportunities (For more information on Recreation and State Parks see page 75). They also seek to provide environmental, historical and cultural education and interpretation. They attract a wealth of visitors to the watershed and contribute to the income provided by local businesses.

The parks strive to promote a strong land stewardship ethic through the conservation of the area's natural, historic, scenic, aesthetic and cultural heritage. The management of natural resources within the state parks is focused on recreation and scenic value. Fishing and hunting are regulated by the PA Fish and Boat Commission (PA FBC), the PA Game Commission and the DCNR.



Inherently beautiful natural areas provide rich and diverse wildlife habitat.

Wildlife & Natural Areas

Natural and sensitive areas include wetlands, floodplains, forested areas and other areas that are particularly vulnerable to landuse impacts. Hammersley Natural and Wild Areas, located in the subwatersheds of Hammersley Fork and Trout Run, are two such designated areas. Natural areas not only enrich the landscape through the provision of habitat for an abundance of plant and animal species, but also perform key ecological processes such as floodwater storage and nutrient filtration. Connectivity between these ecosystems enables habitat diversity.

Natural Areas

Natural areas within Kettle Creek have a unique opportunity to survive and thrive. The rural, largely undeveloped landscape provides the opportunity for a diverse plant and animal habitat. A distinctive geography, situated at the junction of the five physiographic provinces, at the edge of the glaciated and unglaciated sections of the state and between the northern hardwood-conifer forest communities of northern Pennsylvania and the mesic (or moderately moist) central forest communities to the south and west, fosters a greater diversity of unique plant and animal communities.

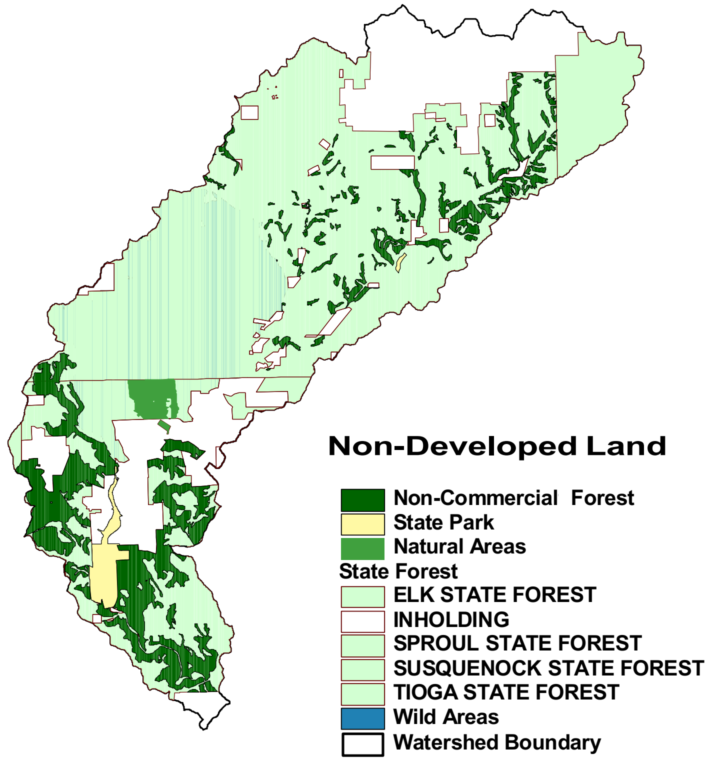


Figure 3.5 - Non-developed land occupies 92% of the total watershed area covering many natural and sensitive areas in Kettle Creek watershed.

PA Natural Diversity Index

NATURAL
& SENSITIVE AREAS

A significant inventory of natural areas in Kettle Creek is available for Clinton County through Pennsylvania Natural Diversity Index (PNDI) developed separately by various counties. (See figure 3.6 - designated conservation areas in Kettle Creek) The PNDI is equivalent to the national Natural Heritage Inventory (NHI) program that seeks to recognize, document and understand species biodiversity at state, national and global levels. PNDI was established in 1982 to document not only rare and endangered species, as well as historic areas across the state. It is conducted through partnerships between The Nature Conservancy (TNC), the Bureau of For-

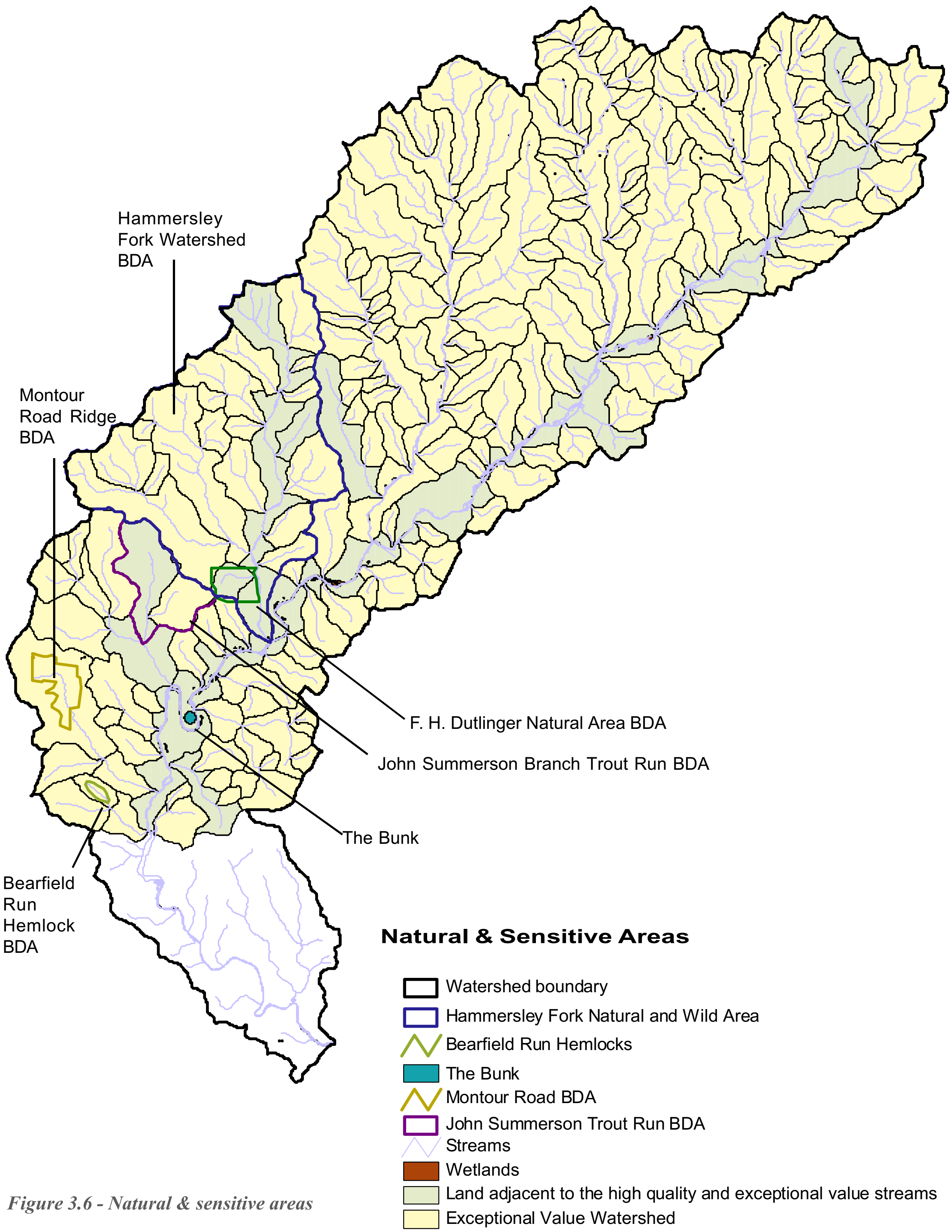


Figure 3.6 - Natural & sensitive areas

estry and the Western Pennsylvania Conservancy. Specifically in Clinton County, the inventory is a joint effort between the Pennsylvania Department of Community Affairs, the Clinton County Planning Commission, and the Western Pennsylvania Conservancy. The PNDI only assesses and ranks high quality, sizable natural communities. It includes pristine natural areas are those areas that are ecologically disturbed. In addition, it considers present conditions as well as potential future conditions for conservation management.

Following the Clinton County PNDI designations, specific areas within the watershed could be managed as sensitive areas (For more information on PNDI designations- see Appendix D, pg 286). These designated lands are a mixture of farmland, federal flood protection land, state parks, state forests, villages and residential lands. They are designated at the larger scale to connect significant natural heritage areas within the watershed. Much of land around Hicks Hollow, above the Alvin Bush dam through Hammersley Fork, is a designated PNDI conservation area. Hammersley Fork and Trout Run, tributaries that provide 1/6 of Kettle Creek's flow, are classified as "exceptional value". These areas support thriving populations of fresh water mollusks, brook trout, king fishers, osprey, bald eagles and other animals that depend upon moderate to large freshwater riverine systems.

PNDI DESIGNATED AREAS

The PNDI designated areas by municipality are listed below. (For more information on the PNDI program, see the Appendix G, page 309).

East Keating Township:

The Montour Road Ridge Biological Diversity Areas (BDA)

Historically, Kettle Creek has been heavily impacted by agriculture, logging and mining of coal and natural gas. This resource extraction dramatically changed the composition and structure of the watershed's biological communities. The southern portion of the watershed along Two-Mile Run is a prime example of a stream so affected by mining that few species can survive in the area. Some communities, such as those in the Hammersley Fork Natural Area, remain vibrant and should be protected.

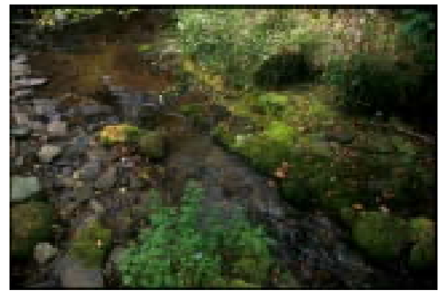
Situated in the Hammersley Fork Quadrangle, Montour Road Ridge is a likely site for a species of special concern and its primary food source.

Leidy Township

Bearfield Run Hemlocks BDA

Located within the Hammersley Fork Quadrangle, Bearfield Run is a PNDI high significance area. On the northeastern slope of the ridge separating the right and left forks of Bearfield Run, is an exemplary old growth Northern Conifer Forest dominated by eastern hemlock. Designated as Bearfield Run BDA, this 30+ acre area shows traces of early logging and selective cutting that ended around 1904 with the closing of the last Bearfield Hollow logging camp. Presently Bearfield Run supports a thriving old growth forest of hemlock (*Tsuga canadensis*), yellow birch (*Betula lenta*), sugar maple (*Acer saccharum*) and





Natural areas are visible in every part of the watershed and lend it a unique character and identity. These areas should be protected for their visual and natural qualities.

PNDI designated sensitive areas often are classified by the presence of rare and endangered species. However, identification of these species or their exact locations is never revealed for their protection.

Beech (*Fagus sp.*). A newly widened access road that runs along the lower boundary of the area fragments the otherwise connected forest. This road, if relocated before it became a part of a larger trail system, could encourage greater connectivity within the site.

F. H. Dutlinger Natural Area (BDA)

The Dutlinger Natural Area lies within the Hammersley Fork Quadrangle in the proposed Hammersley Wild Area. Classified as exceptional significance, it is situated adjacent to and west of the flood plain where Hammersley Fork meets Kettle Creek; it includes all of Beech Bottom Hollow watershed. The Natural Area is an example of a PNDI designated area that is managed by the Bureau of Forestry. Dutlinger Natural Area is home to approximately 35 acres of Northern Conifer forest types dominated by old growth eastern hemlock in addition to a northern conifer swamp. It also houses old growth hardwood species including yellow and black birch (*Betula alleghaniensis* and *Betula lenta*), american beech (*Fagus grandifolia*) and sugar maple. The lower valley and slopes of Beech Bottom Hollow support a Mesic Central forest type dominated by beech, maple (*Acer sp.*), white oak (*Quercus alba*), white ash (*Fraxinus americana*) and cucumber magnolia (*Magnolia acuminata*).

John Summerson Branch Trout Run Watershed (BDA)

Located in the Hammersley Fork Quadrangle, the John Summerson Branch Trout Run watershed is classified as exceptional significance. It has two unique wetland communities: a Broadleaf Conifer Swamp and a Mixed Graminiod Marsh. Although the wetland area shows little evidence of recent disturbance, the area immediately adjacent to the north reveals a history of logging. Scattered old growth white pine stumps from the early logging days and hardwood stumps from subsequent cuttings cover an open area that is now colonized by young woodland growth such as quaking aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*). Sedimentation accelerated by early logging has attributed to significant changes in wildlife species composition and stream and wetland morphology.

Spicewood Saddle Wetland BDA
Located in the Hammersley Fork Quadrangle, Spicewood Saddle Wetland is classified as high significance because of a small natural pool that rests on the saddle at the top of the Spiceood Run watershed. A diversity of grasses, sedges and aquatic mosses flourish within this minimally disturbed wetland. It also supports a plant in the Lily family that is a primary food source for an animal of special concern in Pennsylvania.

Hammersley Fork Watershed BDA
Situated in the Hammersley Fork Quadrangle, the Hammersley Fork watershed, classified as exceptional significance, is a PNDI Biological Diversity Area. Hammersley Fork, a high gradient stream, is also classified as exceptional value by the PA DEP. Its expansive floodplains support rare forest communities.

Natural Geologic Site
Several miles above the Alvin Bush Dam, Kettle Creek makes two 180-degree turns before continuing south. It is probable that the oxbow formed at this site will eventually create an oxbow lake at the junction of the bottom parts of the loop. Known as the "Bunk", this area is recognized as a natural geologic site. (Geyers and Bolles 1979 & 1987).

NOYES TOWNSHIP MANAGED AREAS

Sproul State Forest, Susquehannock State Forest, Hammersley wild Area, F. H. Dutlinger Natural Area, Kettle Creek State Park, Elk State Forest

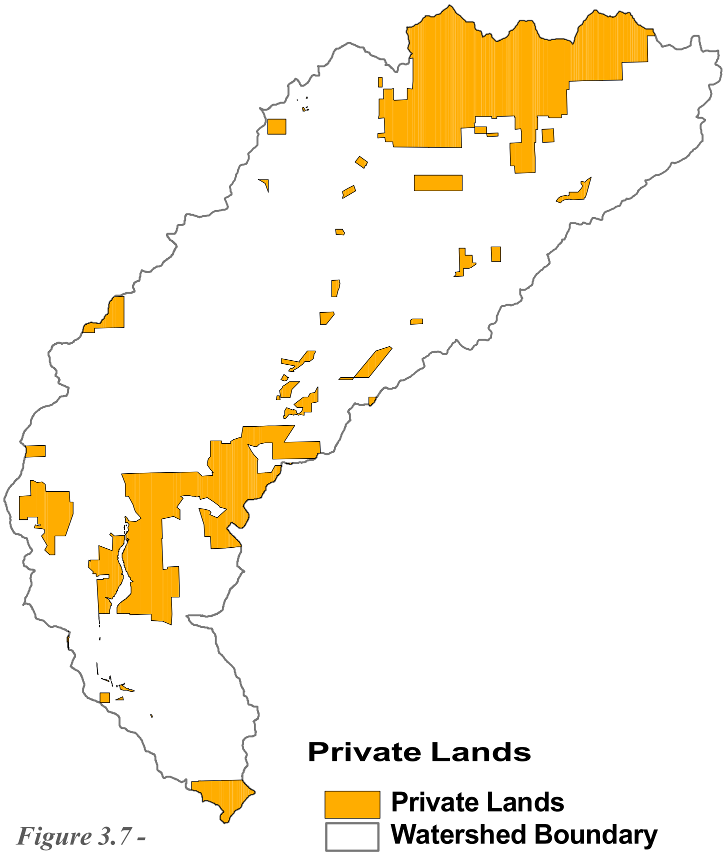


Figure 3.7 - While only 8% of the watershed is private land, these lands are located in ecologically critical areas such as headwaters and floodplains.

PRIVATE LANDS

Introduction

The sparsely populated, rural and agricultural landscape of Kettle Creek is highly valued by residents. Rural residential and agricultural lands make up a large portion of the private lands in the watershed. They furthermore contribute to the local and regional watershed character and identity. As suburban sprawl has consumed much of the open space in other watersheds, Kettle Creek has held on to its rural values. Today, in light of rising market values of land, the watershed has an even greater opportunity through the use of future landuse planning.

Private lands also have an impact on the integrity of the waters and wildlife habitat in the watershed. While only a small percentage of the watershed is privately owned (less than 10%), the majority of this private land is situated on environmentally sensitive areas such as floodplains, wetlands and headwaters. These areas provide habitat for a host of plant and animal species in addition to maintaining the high quality streams that support the thriving fisheries of Kettle Creek. These ecosystems also tend to be the most sensitive to disturbance. Managing the potential for future development or redevelopment of private lands today could serve an important role in not only maintaining the rural, agricultural character of the watershed, but also conserving the high quality waters and wildlife habitat for perpetuity.

Private Residential Lands

Rural villages of Kettle Creek watershed include Westport, Cross Fork, Oleona, Carter Camp and Germania (See Figure 3.1). Residential areas are commonly clustered around a small town center that houses a post office, fire hall, community store, local restaurant and hotel; single-family homes are common and generally house 2 people (Census Bureau 1990). Limited infrastructure such as paved roads or municipal water, power or sewage exists within the watershed.

The rural watershed village communities of Kettle Creek are closely knit. Residents know each other in these towns and congregate around the local stores, bars and community buildings. These villages foster a strong sense of community rare in other places. Homes, which date back to the beginning of the twentieth century in some cases, carry their own unique history.

Yet, just as rural development contributes positively to the character of the watershed, as discussed earlier, it also has an impact on its natural resources. Development, particularly along the floodplains, limits the amount of riparian vegetation available to filter sediment and nutrients from runoff. Infrastructure such

The local Germania store: Rural commercial development contributes to the overall character of the watershed.

A local residence in Cross Fork.

as roads, and sewage utilities create sources of sediment and nutrients to the streams (For more information on dirt and gravel roads see page 178). It is up to the community to decide how important their water quality is to them. And in Kettle Creek, the opportunity exists to carefully manage the future development, and

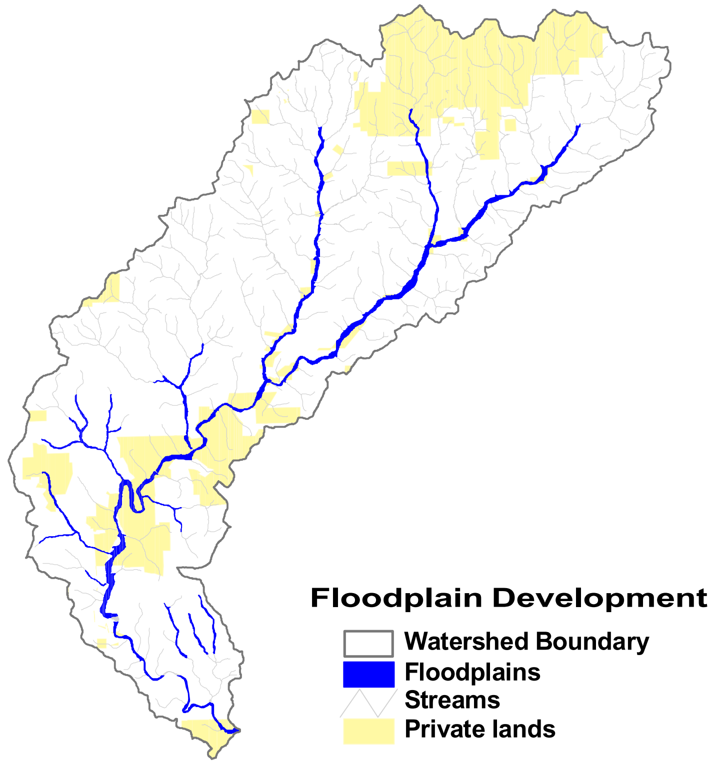


Figure 3.8 - A majority of private lands are located within the floodplain and are developed for residential and agricultural uses. This arrangement creates potential for damaging flood events.

redevelopment of private lands, in a way that ensures high water quality.

Floodplain Development

Floodplain development is common throughout the watershed. While private residential land amounts to less than 8 percent of the total landcover in Kettle Creek, a majority of this private land is within the floodplain.

Historically in Kettle Creek, and throughout the country, floodplains have been developed for residential and agricultural use. Low-gradient topography in riparian floodplains facilitates transportation networks and building construction; a readily available water supply in addition to direct visual access to the stream has invited many to call the floodplains their home. Yet this development is vulnerable to flood damage and furthermore creates a greater potential for damaging flood events.

A picturesque view of the agricultural landscape in Potter County

Pennsylvania, specifically the north central region, is known for rolling hills and vast open fields of grains and vegetables; it is a state devoted to agriculture. However, today, commercialized, large-scale farming is out-competing smaller scale, family-owned farms. While agricultural lands are quickly declining, the market values for these lands is on the rise (Agricultural Census 1996). Smaller scale farmers are often economically driven to sell their land to developers.

Flood plains serve as an extension to a stream channel bed. During times of high stream flows, they accommodate and retain channel overflow. Vegetation roots in riparian forested areas retain soil along the stream banks limiting bank erosion and stream sedimentation. Wetlands along the stream corridor have an even greater capacity to retain and absorb excess stream flows and stormwater runoff. Development in these areas can disrupt these natural water filtration and retention processes and in turn can lead to degraded water quality and stream corridor habitat over time. Development can also have profound impacts on the overall morphology, or shape, of the stream (For more on stream morphology, see page 6)

Dirt and gravel roads, particularly those located in close proximity to the stream corridor, deliver a tremendous amount of sediment to the streams and wetlands (For a discussion of dirt and gravel roads see page 178). This results in wide, shallow streams that are vulnerable to thermal warming (For more information on thermal conditions in the watershed see page 158). Local residences and camps, while maintaining a low impact to the watershed now, if rebuilt, could infringe further into the floodplain and cause further erosion and sedimentation throughout the watershed.

Development also can increase the occurrence of flooding and the frequency of high, intense stream flows. Impervious surfaces such as paved roads - or those surfaces that do not have the ability to absorb water - limit the amount of stormwater that can infiltrate the ground; in addition they increase the speed in which water flows off into streams resulting in high velocity, short duration stream flows. This in turn leads to sporadic flooding and increased erosion and sedimentation. (To learn about stormwater, see page 177).

Private Agricultural Areas

Through time, Pennsylvania has been known for its agricultural landscapes. Portions of Kettle Creek were once agriculturally productive. Through the years, rugged topography has limited the economic viability of agriculture. Today, agricultural lands in Kettle Creek, approximately 456 acres, makeup about only 0.3% of the entire watershed area but comprise about 15% of the total private lands.

This 15% of the total private lands contributes significantly to the agricultural character and identity of both Kettle Creek and the north Central Pennsylvania region. Agricultural lands maintain available open space yet agricultural lands are declining across the watershed and the state. Smaller scale agricultural production can no longer compete with large, industrialized production. (For further information on agriculture and economy, see page 67). As farmers struggle to produce, market land values of these highly developable, flat areas are increasing. The result is farmland that is sold to commercial developers, or in some cases, such as the Poconos, resort development.

> Roughly 4% of the population resides on smaller-scale farms. Common crops include corn, seed and a variety of grains such as wheat and oats.

The Farmland Preservation Program, and Agricultural Security Areas are two programs that respond to this problem of declining agricultural character. For a discussion of these programs, see page 262 in the landuse recommendations.

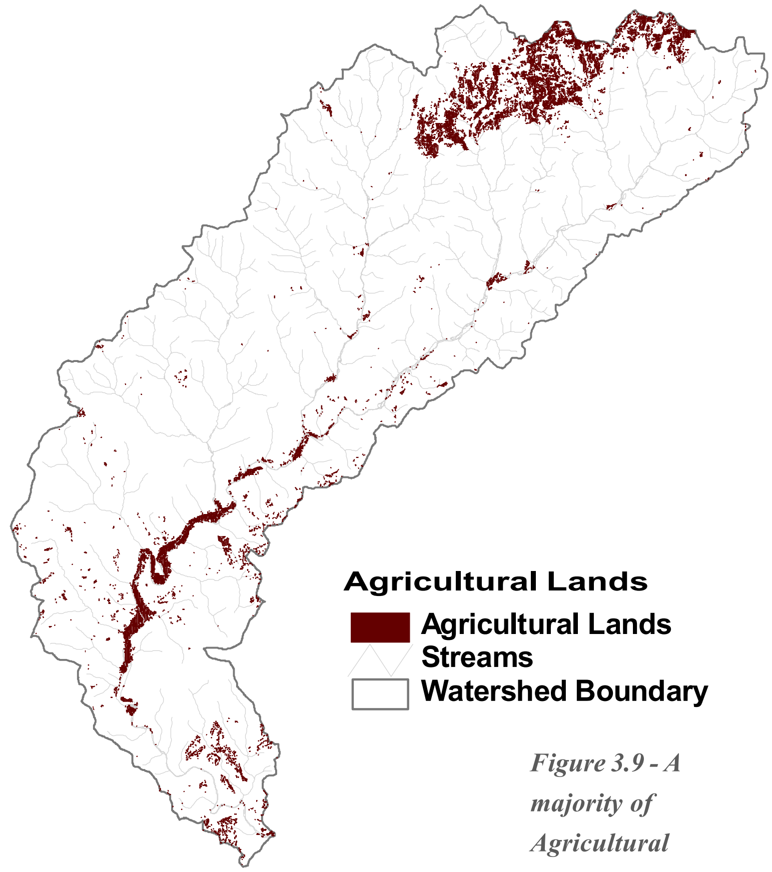


Figure 3.9 - A majority of Agricultural areas are located in the headwaters and some are also distributed along the main stem Kettle Creek.

While the majority of this land lies in the headwaters around Little Kettle Creek, Germania Branch and Sliders Branch, some is also concentrated along the mainstem of Kettle Creek and along Hammersley Fork. Much of this land is farmed for corn, oats, potatoes, hay & alfalfa and livestock (For more information on agricuture and economy see page 67).

In addition to the loss of agricultural character, a majority of the agricultural lands lie in the headwaters of Kettle Creek. As agricultural production continue to decline and the market values continue to rise, these lands carry a strong potential to be developed. These trends, combined with limited landuse protection in the northern portion of the watershed leave the headwaters of Kettle Creek vul-

The northern headwaters of Kettle Creek. The open, relatively flat rolling character of agricultural lands make them prime for development. As land market values continue to rise in these areas, the conservation of these lands, could preserve the agricultural character and identity of this area. It could also protect the integrity of this sensitive headwaters system.

nerable to industrial, residential or commercial development.

The Impact of Headwaters Development

Headwaters provide cool, clean water to a stream network. Germania Branch is an example of a headwater stream that feeds the mainstem of Kettle Creek. Kettle Creek, in turn, is a headwaters watershed of the Susquehanna River basin that ultimately flows into the Chesapeake Bay. The ecological integrity of headwaters is critical, as stream impacts in these areas will inevitably affect water quality in the subsequent tributaries downstream.

The geological context of headwater streams in addition to their function make them perhaps the most sensitive areas within the watershed stream network. Headwaters are often located in areas with shallow ground water supplies that feed water to the streams. This shallow water supply has a high potential of exposure to pollutants such as nutrients from fertilizers or livestock wastes. The low flow of water in headwater tributaries leaves them susceptible to the smallest amounts of pollution. In headwaters areas, there is a high probability of wetlands that are easily impacted by adjacent landuse. (For more on wetlands, see page 112).

The Potential For Future Development

While development pressures today are limited in the watershed, an impending increase in land value within Kettle Creek (For more information on land value see page 67) suggests a strong potential for future development - particularly in the northern portion of the watershed. Limited landuse protection further encourages commercial, residential or industrial development if sold or rebuilt. Finally, a turnover in resident population could invite new landowners with intent to rebuild or redevelop their newly acquired land.

Future development could bring with it additional roads and utility lines, impervious surfaces and other infrastructure that would infringe upon the high quality wildlife habitat and waterways within the watershed. The careful management of this development could serve to maintain the high quality watershed. (See recommendations, page 254 for a discussion of right of ways and development).

What elements in Kettle Creek are important? Is it the industrial history? The streams and abundant fishing opportunities? The rural architecture and character? Or perhaps the abundance of forest and natural areas? This decision concerning the prioritization of land conservation is left to the people and the municipalities within Kettle. Anticipating and planning for potential future development and redevelopment can effectively conserve the natural, rural landscape that Kettle Creek is today. Landuse planning can furthermore empower a community to decide what types of development occurs in their watershed.

Municipal collaboration could allow for the successful implementation of landuse planning at the watershed level. While county comprehensive plans often seek to promote valuable land stewardship principles, these principles hold little weight without the implementation of landuse planning practices at the township level. (For more information on township authority, see page 57). While county comprehensive plans might seek to moderate future development, township and county officials must collaborate to implement this at the township level. The KCWA could become a discussion forum for this dialogue surrounding watershed wide issues and objectives. As a non-regulatory group, the association could facilitate the establishment of inter-township development guidelines that would protect the existing natural and cultural resources that are cherished in the watershed; these guidelines in turn could encourage positive growth to occur in suitable areas.

GOALS: LANDUSE

LU 1.1 Identify and prioritize high value agricultural lands for conservation.

LU 1.2 Develop and encourage the use of Best Management Practices (BMPs) on Agricultural Production lands to minimize impacts on adjacent natural resources.

LU 2.1 Monitor growth and development in the watershed.

LU 2.2 Encourage positive future residential and commercial development that not only maintains the rural architectural identity of the watershed but which also follows sustainable 'BMP' development.

LU 2.3 Encourage development in environmentally suitable areas (site suitability) and cluster new development around existing infrastructure.

LU 3.2 Designate and protect high value areas. Encourage the protection of these areas through large buffers and the promotion of natural areas or recreational open spaces.

LU 2.5 Encourage coordination between the county comprehensive plan and the township zoning ordinances.

Emergent wetlands have developed upstream of the splash dam on the upper main stem of Kettle Creek

Wetlands

Overview of Wetlands

Wetlands bring many images to mind including cattail dominated marshes, beaver ponds, and flooded timber. These places are obvious wetlands. The less obvious wetlands are the seeps and springs on hillsides or vegetated side channels away from the mainstem of a stream. All of those places are wetlands and they have similar features, such as wet soils and plants adapted to live in wet conditions. Wetlands also need a source of water such as precipitation, stream flooding, groundwater or a combination of the three.

WETLANDS

Wetlands are legally defined in the United States as:

Those areas that are saturated or inundated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (ACOE 1987 Delineation Manual).

A technical definition is used to classify wetlands, but it boils down to three parameters. They are the presence of plants adapted to wet soil conditions (hydrophytes), hydric soils (or soils that have a high capacity to hold water) and a source of water. Wetland soils are unique because they often fluctuate between conditions with or without oxygen. The fluctuation has an effect on plant assemblages.

> Hydric soils are wet or saturated during the growing season with anaerobic conditions in the root zone (Wetland Soils 2001).

Wetlands are often referred to as marshes, wet meadows, shallow ponds, swamps and bogs (PADEP Fact Sheet). Wetlands provide many functions to the watershed including habitat for wildlife, cold water discharge to the streams, and water purification. The vegetation in wetlands is capable of collecting sediments and nutrients from upland sources. The nutrients become plant food and the sediments become wetland soils. Wetlands do have a pollution threshold and once exceeded, wetlands can be degraded or destroyed, as such, wetlands need to be protected. Regulations exist to protect wetlands and their functions. Several agencies including the PADEP and the United States Environmental Protection Agency (EPA) have developed rules and procedures to define and protect wetlands.

Historical Wetland Use

Historically, humans have viewed wetlands as an ecosystem with little value or function. The soils were too wet to support agriculture without hydrologic manipulation. Travel was difficult in wetlands because the soils would not support wheeled vehicles and the standing water was often too shallow to float a boat that could carry significant cargo. Wetlands also were the haunts of mythical swamp things and mud monsters. The solution to the unproductive land "problems" was to fill, drain, or dredge a wetland so that it provided a practical anthropocentric use.

Agriculture has been the predominate force in wetland loss. The Swamplands Act (1849-1860) granted wetlands to citizens if these areas were drained for agricultural or mosquito control. The USDA inventories from 1906, 1922, 1940, and 1953 indicate that an average of 30.25 million ha (74.7 million acres) could be drained for agricultural production. Wetland losses attributed to agriculture began to decline in the 1960s. However, the newest threat to wetlands is urban development. Wetlands drained for agricultural use have the potential to be restored; however wetlands lost to urban development seldom have that same potential.

The estimated wetland acreage for the contiguous US in the late 1700s. was 89 million ha. Current estimates suggest that there are approximately 42 million ha remaining, a computed loss of 53% (Mitsch and Gosselink 1993). The federal government under the first Bush administration, circa 1990, to protect the remaining wetlands adopted a "no-net-loss" policy. No-net-loss refers both to size and function of wetlands

NWI Wetlands

The National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service produces information on the characteristics, extent, and status of the Nation's wetlands and deepwater habitats. NWI mapping initiated in 1986 using aerial photographs to demarcated wetlands which are transferred onto topographic quad sheets or digital files. Wetland scientists recognize that NWI maps do not identify a large portion of wetlands due to aerial identification methods. Wetlands that are under a tree canopy are often missed when developing NWI maps (Cole, personal communication). A wetland prediction model was developed to identify potential wetlands missed by the NWI maps by using local geology, slope, and proximity to streams.

This is a palustrine emergent wetland near Cross Fork representing plant diversity typical of wetland communities.

The wetlands potential map was ground verified in the upper portion of the watershed near Carter Camp, Dry Hollow/Leetonia Road, and Sliders branch. The pixels representing very high probability on the map were within 50 meters of wetlands occurring on ground. The model predicts an additional 472 acres of wetlands not identified by NWI inventories (814 acres) resulting in a 58% potential increase in wetland acreage (1286 acres) in the watershed. The potential acreage was calculated from the number of pixels from the Wetlands Potential map having a very high value. Each pixel is 900 m^2, during field checking some wetlands were found to be less than 900 m^2 meaning the model could overestimate the potential wetland acreage.

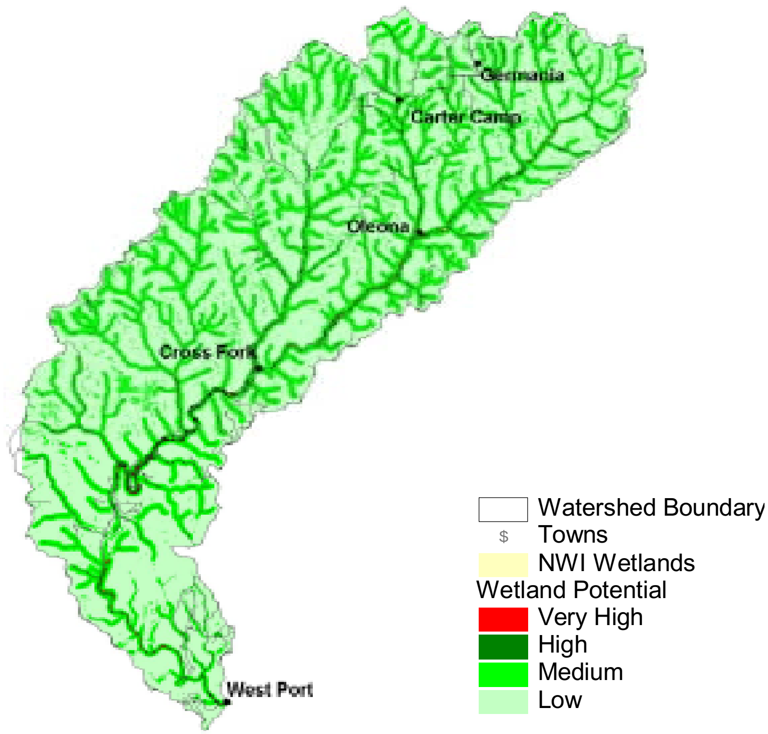


Figure 3.10 - The figure shows the high wetland potential along the main stem.

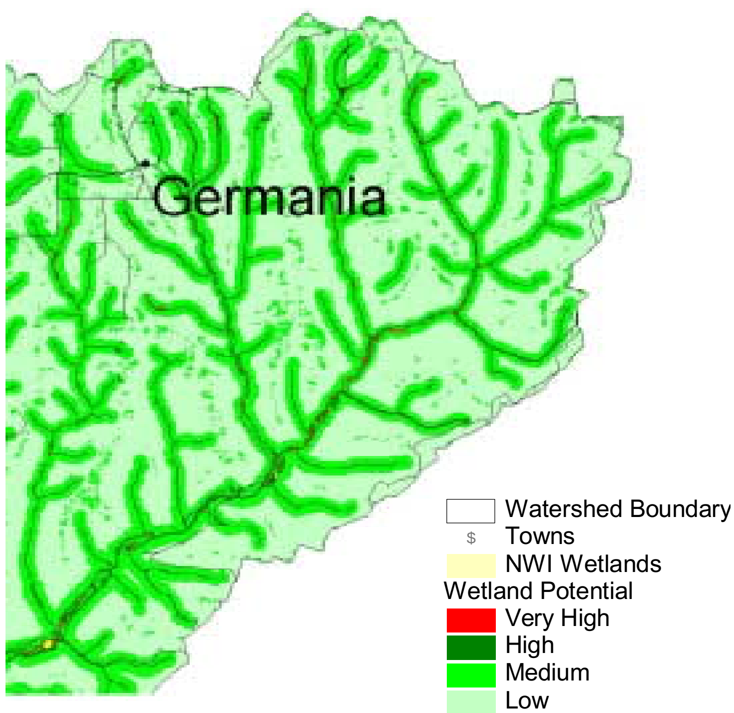


Figure 3.11 - The red pixels show the areas of highest wetland probability in the upper watershed.

Extensive ground verification is needed to validate percentage of wetlands contained in each pixel to more accurately estimate the potential wetland acreage. The model is an indicator of potential wetland resources. Because wetlands are important to water quality, it is important to consider the potential impact to water quality if broad scale landuse changes occur that impact wetlands. The streams in the upper watershed are classified as riverine wetlands by the Cowardin classification system. The streams were not included in the calculation because they have already been identified by NWI and USGS maps. The images on the following page are a watershed view and an enlarged view of the Wetland Potential map. Notice the red pixels (very high potential) in the Germania view are located adjacent to NWI wetlands denoted by yellow pixels. The high potential areas are also located adjacent to tributaries similar to NWI wetland locations in the lower watershed. (For more information on Wetland Potential Model see appendix, page 293)

Kettle Creek Wetlands

The wetlands found in the Kettle Creek watershed have been impacted by draining for agriculture, filling for road or railroad construction, and flooding when the Alvin Bush Dam was constructed. Stream channel manipulation often decreases flooding, but it also deprives riparian wetlands of flood water. Most of the wetlands identified by the National Wetland Inventory (NWI) are found adjacent to the main stem of Kettle Creek and its major tributaries. The NWI maps have been used to inventory the wetlands in the watershed and the following paragraphs will discuss the results.

The digital NWI maps have demarcated 816 acres of wetlands in the watershed. NWI maps identify wetlands based on a hierarchy starting with a general hydrologic regime i.e., rivers, lakes, or marshes (Cowardin et al. 1979). The hierarchy then classifies wetlands by vegetation, and then physical characteristics of the plants or system type. A typical Cowardin classified wetland is a Palustrine Emergent (PEM) wetland or a freshwater marsh. The NWI maps identify three types of wetland systems in Kettle Creek watershed: palustrine (marsh), riverine (stream) and lacustrine (lake).

Palustrine Wetlands

Palustrine Emergent (PEM) wetlands are generally covered with herbaceous plants with small areas of standing water and a soft muddy soil surface. An observer would often be able to walk across this type of wetland, but might sink in the mud as they crossed. These types of wetlands are often found around seeps and springs and low spots in fields. These types of wetlands can be found above Cross Forks on the western side of the stream with cattails as a good indicator. Palustrine wetlands cover 299 acres in the watershed (See Figure 3.12). The palustrine wetlands break out into four categories emergent (113 acres), scrub/shrub (55 acres), forested (88 acres), and unconsolidated (43 acres). Most of the palustrine wetlands in the watershed are found on the floodplain of the main stem of Kettle Creek. The wetlands are closely associated with the stream because the source of water is the over bank flooding of the stream. The floodplain is also flat which results in poor drainage and the development of wetlands. Beavers are prevalent in the watershed and construct dams on abandoned stream channels and on tributaries that flow across the floodplain. The beavers create wetland complexes that persist after beavers abandon the dams.

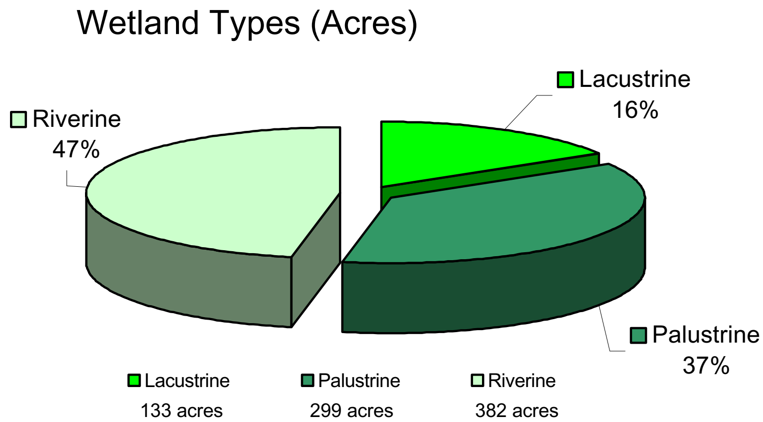


Figure 3.12 - Distribution of major wetland types in the watershed. Riverine wetlands are the major component because all streams in the watershed are considered wetlands.

Palustrine emergent / openwater wetland (PEM/POW) near Carter Camp created by a beaver dam. This site was ground verified using the wetland probability model and found to have very high potential of wetland occurrence.

Lacustrine wetland at the confluence of Kettle Creek mainstem and the Kettle Creek Lake. Lacustrine wetlands remove nutrients from the water, provide fish habitat, and stabilize sediments.

EXCEPTIONAL

VALUE WETLANDS

EV wetlands definition EV wetlands are those associated with habitat for threatened and endangered species, EV and wild trout streams, wild and scenic rivers, state designated wild or natural areas, and public or private water supplies. See the wetlands appendix on page 289 for more detailed information.

A functioning riverine wetland

Lacustrine Wetlands

The second largest wetland category is lacustrine with 133 acres. The Kettle Creek lake is considered a wetland because portions of it are shallow enough to support aquatic vegetation and the soils are saturated. However, area with water depths greater than 6 feet (2 meters) do not support rooted aquatic vegetation and are therefore not considered wetlands. The inlet of the reservoir does have a thriving wetland community. The water lillies and cattails are examples of hydrophytes.

Riverine Wetlands

Riverine wetlands are the most prevalent type in the watershed, covering 383 acres. The figure is misleading because the entire stream channel on the mainstem is considered wetlands. The stream does have saturated soils and a source of water but the majority of the flowing sections of the streams are not vegetated. Unconsolidated wetlands are abandoned stream channels and large gravel bars.

Exceptional Value Wetlands

The wetlands occurring above the Alvin Bush Dam are considered exceptional value (EV) wetlands because the streams in that part of the watershed have been classified EV. (For more information on EV streams see appendix pa. 287) . Wetlands with the EV designation are more protected because of the association with the EV stream. EV wetlands maintain the exceptional value of the adjacent streams by providing habitat for baitfish and macroinvertebrates, removing sediments, removing excess nutrients, and mitigating flood flows.

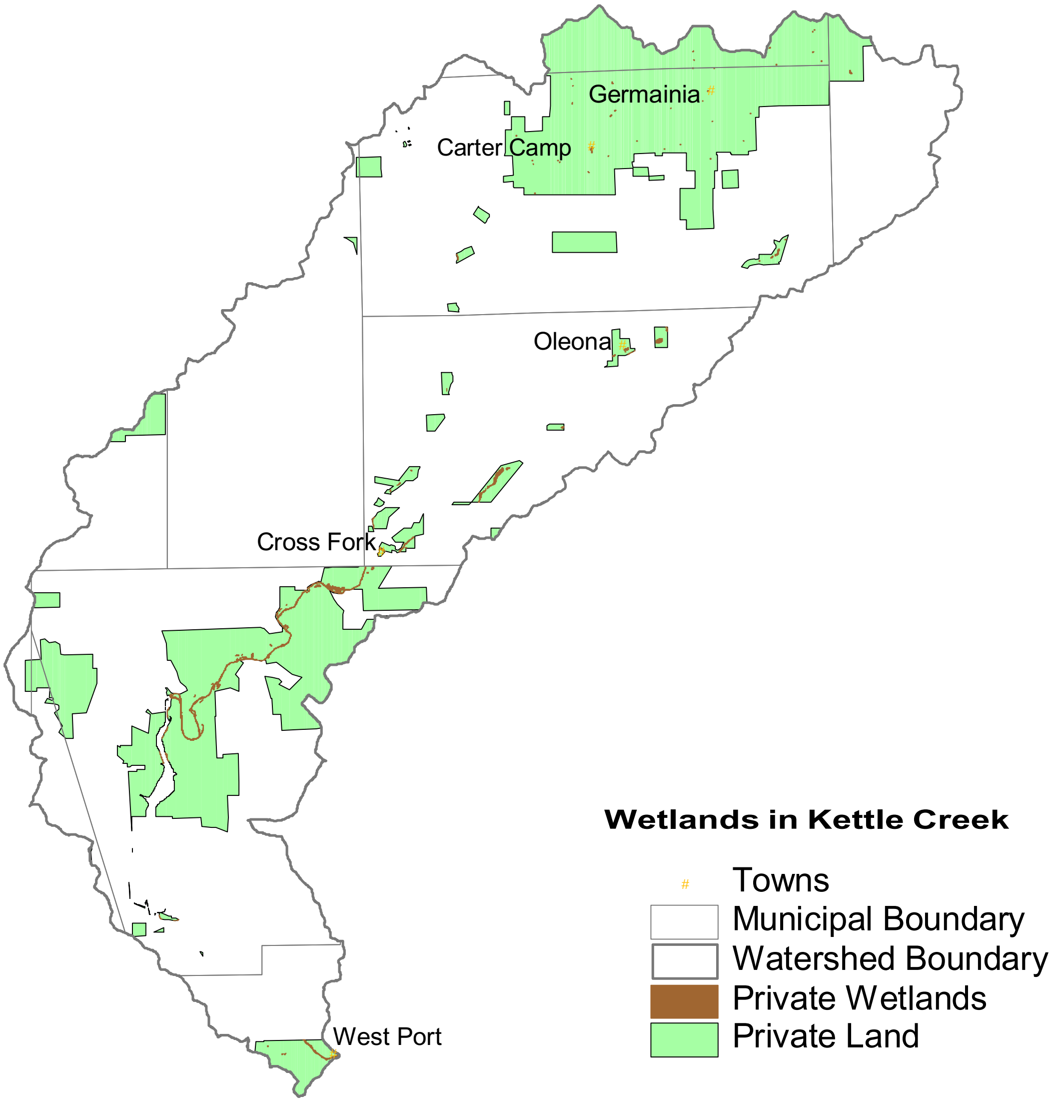


Figure 3.13 - Wetlands in Kettle Creek

Private Wetlands

The final issue regarding wetlands is the prevalence of wetlands in private ownership. Thirty-seven percent (or 297 acres) of the wetlands within the watershed are located on private lands. Wetlands found on public property are considered to be protected. Historically, privately owned wetlands are at a higher risk of degradation. Currently, the wetlands on private land are being protected and conserved and landowners are commended for these actions. Land-use policies and education activities addressing wetlands are two of the best tools available to conserve wetlands located on private lands. Private landowners can preserve and protect wetlands by not filing or draining wet areas and buffering wetland areas when developing a site. A 25 foot (8 meter) vegetated buffer would significantly protect a wetland from small to moderate disturbances on a site. Refer to the Private Wetlands map, green tinted areas are privately owned proper-

GOALS: WETLANDS

WQ 4.1 Identify wetland resource in the watershed WQ 4.2 Protect wetland resources in the watershed

WQ 5.2 Preserve and protect surface water.

LU 3.1 Educate local residents, municipal officials and business representatives about the value of wetlands.

ties and the brown shapes with in those areas are wetlands. Privately owned property makes up 8 % of the watershed, but 20 % (1410 acres) of the private property in located on the flood-plain where most wetlands occur.

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WILDLIFE & FISHERIES

Wildlife and fisheries refers to all mammal, bird, amphibian, snake, turtle, fish, and invertebrate species. These species are an integral part of many recreational activities in the watershed including fishing, hunting, viewing, and photography and are renewable resources when given the proper habitat conditions. Ecologically, these species comprise a distinct biological community within Pennsylvania. The following chapter reviews the fisheries, physical habitat, and wildlife resource attributes of the Kettle Creek watershed.

Fishery Management Anthology

A fishery is a system composed of three interacting elements: habitat (the environment, including both living and non-living components); biota (the living organisms in a ecosystems, including fishes, plankton, aquatic insects, birds, mammals); and humans, who are both users of fishery resources (for example recreational anglers) and competitors for water. Fishery management is the manipulation of the three interacting elements in a fishery to meet intended and desirable objectives (Murphy and Willis 1996). This section summarizes the management strategies on Kettle Creek by the Pennsylvania Fish and Boat Commission (PFBC) from past to present and the current surface water protection designations given by the Department of Environmental Protection (DEP).

PLANKTON are free-floating microscopic organisms, including algae, plants, and animals that cannot swim against a current

BUFFERING CAPACITY is the ability of a stream to maintain the water pH within a narrow range.

INDIGENOUS refers to an organism that is native to a geographic region.

FISHERIES MANAGEMENT

Kettle Creek is a freestone stream, originating in a forest region of Elk Township, western Tioga County, near the Potter-Tioga County line. A freestone stream is one with very little buffering capacity having little to no limestone along with low alkalinity. The majority of the watershed is forested. Rolling farmlands cover the rim of the upper basin and the U-shaped valley is relatively undeveloped forest. A large portion of the drainage area is in the Susquehannock and Sproul state forests. Human habitation and development along the stream valley are limited to scattered hunting camps and small settlements with few permanent residents. Three state park impoundments (Ole Bull Dam, Kettle Creek Lake and Kettle Creek Recreation Dam) are present on Kettle Creek. The Ole Bull Dam and Kettle Creek Dam are small in height, 12-15 ft (4.2-4.6 meters), and the impoundments are used primarily for recreation. The Alvin R. Bush Dam, which forms Kettle Creek Lake, is 165 ft (50.3 m) in height and provides flood control and recreation. Kettle Creek becomes impacted by mine drainage about three miles (4.8 km) below the dam. Six miles (9.6 km) below the dam, where Two Mile Run enters Kettle Creek, is no longer suitable for stocking and maintaining trout populations.

Pennsylvania Fish and Boat Commission Kettle Creek access sign

The Department of Environmental Protection (DEP) designates the waters from the Alvin R. Bush Dam to the confluence of the Susquehanna River as a Trout Stocking Fishery (TSF). TSF requires the protected water use to be maintained with stocked trout from February 15 to July 31 and the maintenance and propagation of fish species and additional plants and animals, which are indigenous to warm water habitats. The DEP also designated the waters from the inlet of Kettle Creek Reservoir to Alvin R. Bush Dam as a High Quality- Trout Stocking Fishery (HQ-TSF). For waters to qualify as High Quality (HQ) the surface water must meet certain criteria. This section of Kettle Creek qualified to receive the HQ designation because of its Class A wild trout stream designation given by the PFBC. All waters above the reservoir pool elevation received the DEP designation of Exceptional Value Water (EV), in which the surface waters meet the criteria for HQ waters as well as more stringent criteria (Figures 4.4 and 4.5). The conditions that qualify Kettle Creek for EV status are 1) the majority of surface water is located in state park natural areas and state forest natural areas, 2) plus some of the water is labeled as exceptional recreational value and 3) that a portion of water is designated as "wilderness trout stream" by the PFBC (Department of Environmental Protection 1999).

Extensive logging occurred in the Kettle Creek watershed between 1890 and 1920. Whole tributary watersheds would be cut at one time after rail lines were installed to transport lumber to the mills (Taber 1972). Some lumber companies would transport their timber to downstream mills by binding the logs together and rafting them to the mill, while others built splash dams along the tributaries that retained the flows of natural springs and streams. The release of the water behind these dams would then carry the logs to the mainstem. Uncontrolled fires and poor logging practices used during this period were detrimental to the fishery resources; however, fishing was reported to have been best in the early 1900s (Watts and others 1942). Reasons for this apparent inconsistency are unclear. Timber removal produced increased water yields in the watershed for up to ten years, which may have kept stream temperatures low. Stream temperature is an important factor that influences the types of species and fish communities able to survive and reproduce in that environment. In turn, the increased water yield helped to flush the high amount of siltation produced by the lack of erosion control methods during logging (Hollender and others 1983).

Photo Courtesy of Railroad Museum of Pennsylvania, Pannsylvania Historical and Museum Commission

Poor logging practices at Hammersley railway station in the early 1900s

Historically there has been a decline in the brook trout (*Salvelinus fontinalis*) fishery, which may have been due to the introduction of brown trout (*Salmo trutta*) into the watershed (Watts and Harvey 1946). Brown trout were first released in Cross Fork Creek in the 1920's because of their ability to reach larger sizes and survive at slightly higher temperatures than brook trout. Brown trout became well established throughout the drainage by the 1940s. Increased angling pressure or harvesting on Kettle Creek may also have lead to the demise of the brook trout fishery, since brook trout are more susceptible to angling pressures than brown trout (Watts and others 1942). Brook and brown trout were stocked during the 1930s and trout stocking has continued to the present. Rainbow trout have also been stocked since 1936 in the Clinton County portion of Kettle Creek and since 1946 in the Potter County portion. Smallmouth bass (*Micropterus dolomieu*), catfish (*Ictalurus spp.*), and yellow perch (*Perca flavescens*) were stocked in the lower reaches during the mid 1930's to early 1940's (Hollender and others 1983). In addition to Kettle Creek, stocking included Kettle Creek Recreation Dam, Kettle Creek Lake, Cross Fork Creek, Little Kettle Creek, Germania Branch, Trout Run, and Hammersley Fork. Local cooperative nurseries also made additional stockings. While brook trout are dominant in the headwaters, they are quickly replaced downstream by brown trout, which yield to smallmouth bass near Kettle Creek Lake.

Not all management strategies have worked, even though they may be done with the best intentions. The addition of the Alvin R. Bush dam allowed for the waters below it to increase temperatures enough to negatively impact the trout fishery below the dam. The PFBC and Army Corps of Engineer cooperated in establishing a coldwater release to promote a coldwater tailwater fishery downstream from the dam to Owl Hollow; unfortunately this alteration did not improve conditions as much as intended (B. Hollender, PFBC, personal communication 2001).

Kettle Creek is managed chiefly for a catchable trout fishery. The Pennsylvania Fish and Boat Commission (PFBC) classify trout streams from A through D according to fish abundance or biomass (the combined weight of a group of fish usually expressed by unit area or volume pounds per acre/kilograms per hectare) (Figure 4.1). Other stream categories defined by the PFBC are low density trout population (L) and warm water fishery (WWF) (Figure 4.2). Currently, of the 430 stream miles (694 km) of Kettle Creek and its tributaries, 73% are not classified (NC). Of the remaining 27%, class A dominates with 60 miles (97 km) or 14% of streams. Class B, C, L, and WWF are represented by a very

Photo:Tim Stecko

Yellow perch (Perca flavescens)

Combined Trout Stream Classificatior		
Class	lbs/acre	Total biomass kg/ha
A	36 lbs/a	at least 40 kg/ha
B	18 lbs/a	at least 20 kg/ha
C	9 lbs/a	at least 10 kg/ha
D	< 9 lbs/a	less than 10 kg/ha

Figure 4.1 - Trout Stream Classification

Management Classifications			
Class	miles	km	%
A	60.1	96.9	14
B	7.9	12.7	1.9
C	7.6	12.3	1.7
D	27.1	43.7	6.3
NC	315.2	508.4	73.8
L	4.2	6.8	1
WWF	5.8	9.3	1.3

Figure 4.2 - Management Classification

small percentage or number of miles, while class D streams encompass 27 miles (44 km) of Kettle Creek. The PFBC stocks approximately 26 miles (43 km) of Kettle Creek and its tributaries in streams classified as B, C, D, or L indicated by an (S) following the classification. There is a stream section below the Alvin R. Bush Dam that contains no trout due to poor water quality caused by acid mine drainage which is indicated by (MD). The PFBC manages 16 miles (27 km) of either Class A or B waters under the Heritage angling program or Wilderness Trout stream program indicated by a (H) or (W) respectively following the biomass classification (Figure 4.3). Drastic declines in the wild brown trout populations were recorded during the 1996 inventory on the section of Cross Fork Creek, managed under the Heritage Angling Program. These declines appear to have been the result of severe climatic events during the summer of 1995, during which a drought occurred, followed by an early winter flood of 1996.

Kettle Creek is one of the most intensively stocked streams in the Commonwealth. Currently, it is managed chiefly for catchable trout fishery under statewide angling regulations except for specially regulated areas. Two of these special areas are reserved for use by children under 12 and disabled persons and are located at Cross Fork and Ole Bull State Park. Cross Fork Creek; from Bear Trap Lodge downstream to the weed property encompassing 5.4 miles (9 km), is managed under the Heritage Trout Angling program for catch-and-release fishing with barbless artificial flies. The Delayed Harvest Fly-Fishing-Only area (formerly Fish-for-Fun) was purchased in 1971 by the Pennsylvania Fish and Boat Commission (PFBC) and is on the main-stem of Kettle Creek; from 500 feet (152 m) downstream of SR 0144 bridge upstream for a distance of 1.7 miles (2.8 km).

Class A wild trout water is a surface water classification by the PFBC, based on species-specific biomass standards, that says a stream must support a population of naturally produced trout of sufficient size and abundance to support a long-term and rewarding sport fishery.

ANGLING PRESSURE is the amount of fishing that takes place in a specific area over a period of time; it is usually measured in angler-hours or angler-trips.

The John Summerson Branch, a tributary of Trout Run and the upper section of Hammersley Fork, a tributary of Kettle Creek are managed under the Wilderness Trout Stream program, which is a surface water designation by the PFBC to protect and promote native trout fisheries and maintain and enhance wilderness aesthetics and ecological requirements necessary for the natural reproduction of trout (See Figure 4.3.). Kettle Creek Lake is a part of the Select Trout Stocked Lake Program, which allows anglers to fish the lake for trout during March when most stocked waters are closed to fishing. Kettle Creek Lake and a part of the main-stem from the Potter/Clinton county line to Owl Hollow are also classified as "approved trout waters", which means they meet the PFBC criteria to be stocked with trout (Pennsylvania Fish and Boat Commission 2001). At the present time no other fish are stocked in Kettle Creek or its tributaries except trout. Cooperative stocking is still occurring but varies every year.

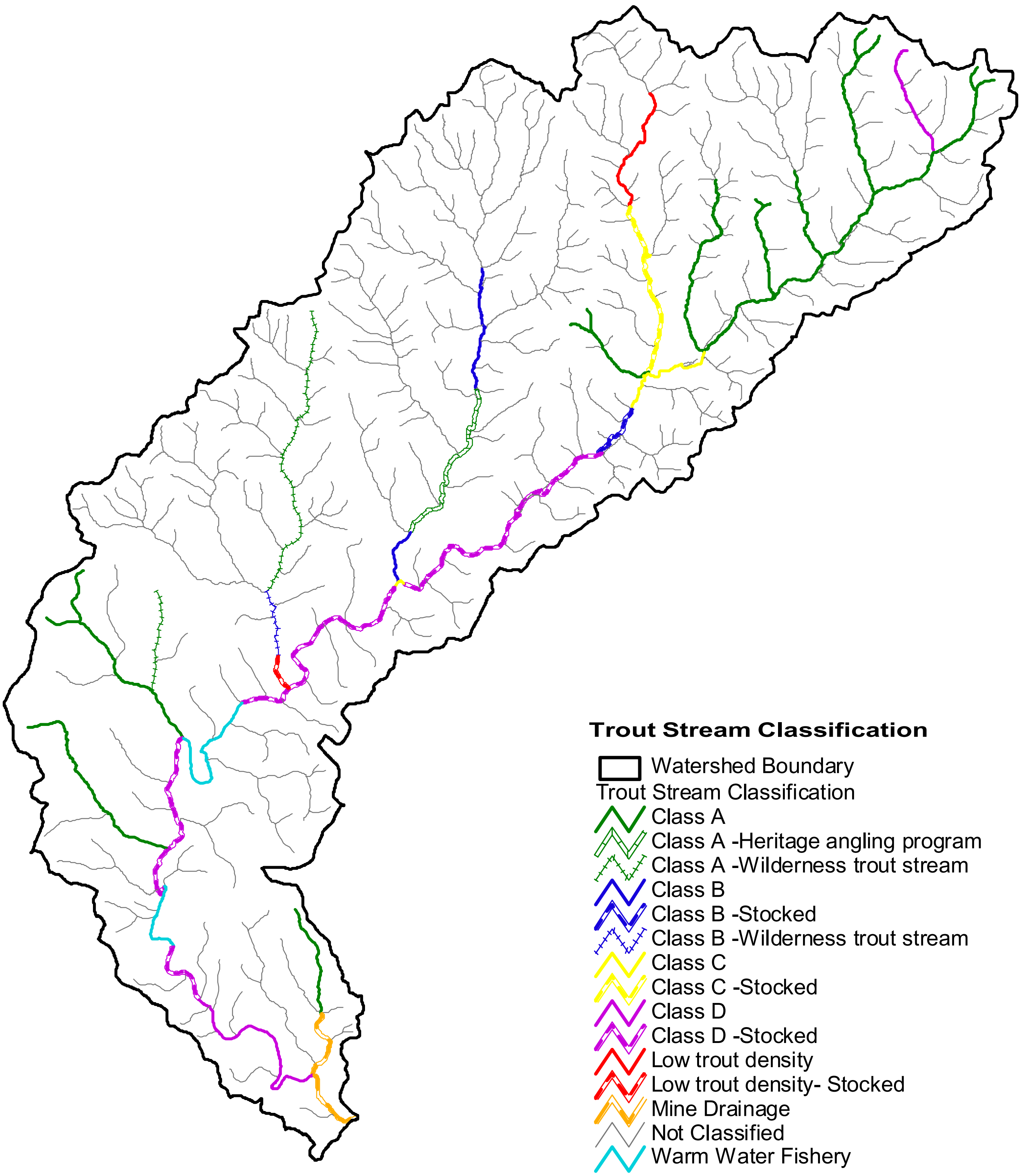


Figure 4.3 - Trout biomass and management programs

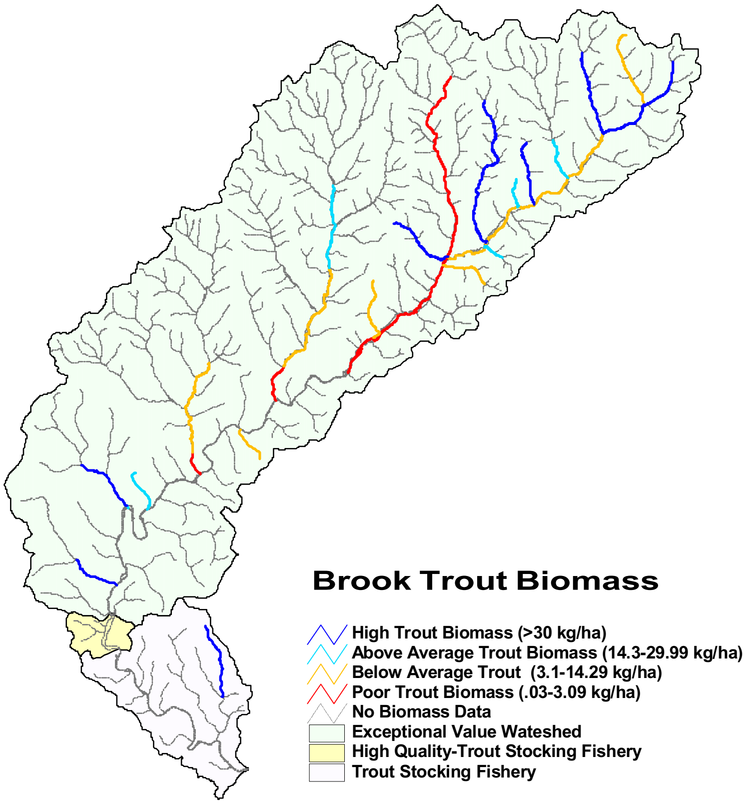


Figure 4.4 - Brook Trout Biomass

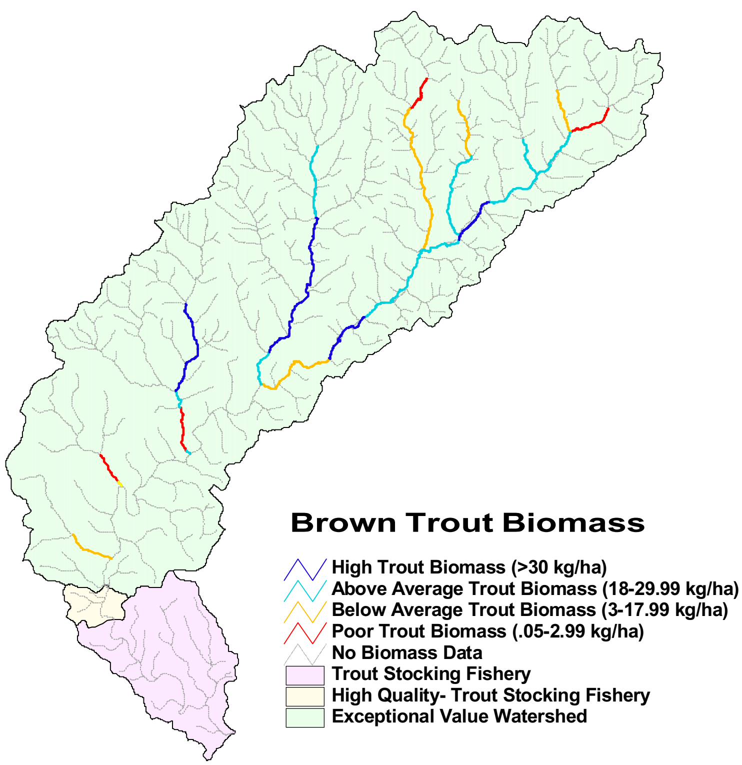


Figure 4.5 - Brown Trout Biomass

Photo:Tim Stecko

Brook trout (Salvelinus fontinalis) - male in breeding coloration.

Photo:Tim Stecko

Brown trout (Salmo trutta)

Photo:Tim Stecko

Rainbow trout (Oncorhynchus mykiss)

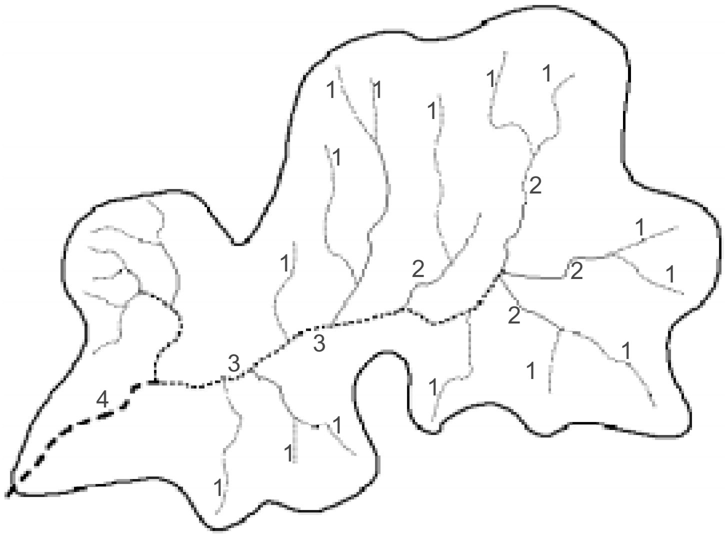


Figure 4.6 - Stream order ranking modified from Murphy and Willis (1996).

STREAM ORDER is the ranking of relative sizes of streams within a watershed based on the nature of their tributaries. A first-order stream receives no defined tributaries; a second-order stream results from the confluence of two first-order streams and so on.

In 2000, West Clinton Sportsman's Association stocked 1,237 trout in Kettle Creek. In both Clinton County and Potter County angler clubs stocked 3,976 trout in the Clinton County sections plus 11,143 in the Potter County portion.

Upper Kettle Creek provides anglers with a diverse quality trout fishing in an aesthetically pleasing natural environment. Water quality in upper Kettle Creek is affected by seasonally high water temperatures, which limits the wild trout populations (Figures 4.4 and 4.5). Channels that have scoured and shifted overtime may have reduced potential trout habitat. Anglers willing to walk to remote areas may be rewarded by sections of stream that support excellent wild brook and naturalized brown trout populations. Despite the rather sparse human population, angling pressure is comparatively heavy because many anglers travel to the area from other parts of Pennsylvania and surrounding states. Overall, trout stocking appears to be a sensible management strategy on Kettle Creek.

Trout: Biology

Many members of the trout family are highly valued game and sport fish, supporting important fisheries in coldwater ecosystems. The wide distribution of these species reflects, in part, historical popularity of trout transplants and stocking. Brook trout are native to eastern North America, from Canada to the southern Appalachians in Georgia and west to Minnesota, and have been introduced into many coldwater ecosystems in western regions. Rainbow trout (*Oncorhynchus mykiss*) are native to western North America, although they have been widely stocked throughout north central and northeastern America. Brown trout are native to Europe and western Asia but were transplanted to the United States in 1883 and now occur in coldwater ecosystems throughout Canada and the northern United States (Hocutt and Wiley 1986).

All trout prefer clear, cool, well-oxygenated lakes and streams. Brook trout occur most commonly in small first-order or headwater streams (Figure 4.6) and lakes, often at high elevations. The brook trout is able to survive in very cold conditions with a short growing season and are relatively intolerant of warm water, seeking out temperatures below 68°F (20°C) in the summer. Rainbow trout are usually found in cool lakes and streams with adequate shallows and vegetation to support good food production. They are most successful in habitats with temperatures of 70°F (21°C) or slightly lower. Brown trout can remain active and can thrive at slightly higher temperatures than brook trout, but otherwise have similar habitat requirements. The optimum temperature range for brown trout is 65-70°F (18-21°C) (Willers 1981).

For streams and lakes to support self-sustaining trout populations, habitat suitable for spawning and survival of eggs and fry must be available. Brook, rainbow, and brown trout all spawn over gravel beds in small streams. Mature fish may travel upstream to reach suitable spawning streams. Brook and brown trout can also spawn on gravel shallows in lakes, although brook trout require groundwater upwelling and moderate current for successful reproduction. Brook and brown trout are both fall spawners. Brook trout eggs are deposited in late summer in northern regions and brown trout spawn in late autumn to early winter, at a temperature of 48-51°F (9-10°C). For both species, eggs hatch in mid-winter and fry emerge from the gravel in very early spring, just before ice breakup. Rainbow trout are primarily spring spawners and begin to spawn between temperatures 50-60°F (10-16°C). Eggs incubate for four to seven weeks before hatching and fry emerge from the gravel after another five days or two weeks (US EPA 1993). All species spawn in nests, referred to as "redds", prepared primarily by the female. The female clears away debris and silt from the redd by turning sideways and beating the bottom substrate using a series of rapid fanning movements of the tail. When the spawning process is completed, the female covers the redd with loose gravel using a similar motion. No further parental care or protection is provided. Trout do not die after spawning and generally spawn in multiple years.

Photo:Tim Stecko

Blacknose dace (Rhynichthys atractulutus)- male in breeding coloration

Photo:Tim Stecko

Creek chub (Semotilus atromaculatus)- a common cold water fish species

Photo:Tim Stecko

Fall fish (Semotilus corporalis)-a common cold water fish species

Brook, rainbow, and brown trout are carnivorous feeding on a wide variety of organisms, including aquatic and terrestrial insects, crayfish, leeches, mollusks, frogs, small fish, and

MANAGEMENT CONCERNS FOR TROUT FISHERIES

In general, trout fisheries require more intensive management than do many warm or cool water fisheries. Management problems and concerns could include the following:

HABITAT DEGRADATION

Poor land use practices can lead to siltation of spawning areas. Trout can reproduce successfully only in clean gravel substrate; egg and fry survival can be decreased dramatically by even small to moderate silt loads. Land clearing can also increase water temperatures, which in turn depletes oxygen levels, eliminating suitable habitat for trout during the summer.

ANGLER PRESSURE

Trout, in general, are highly catchable and susceptible to over-fishing during some seasons of the year. Brook trout in particular, tend to occur in small unproductive streams that support relatively few fish; therefore populations can be easily depleted. Remedies used for reducing angler pressure include fishing regulations and stocking. Slow-growing, late-maturing populations may require relatively large minimum size regulations to sustain adequate numbers of sexually mature, reproducing fish.

INADEQUATE NATURAL REPRODUCTION

Suitable spawning areas or habitat may be unavailable. Migrations into spawning streams may be blocked by beaver dams, or construction of dams or roads. Reproductive success may also be low as a result of fish predation on trout eggs, fry and juveniles. Often, populations with insufficient reproduction are supplemented or supported by stocking.

Excessive predators or competitors - Young trout are highly susceptible to predators, such as pickerel, or fish-eating water birds. Yellow perch may compete with juvenile trout and also potentially feed on trout eggs. Different species that utilize the same resources may also be a source competition (i.e. brown vs. brook trout).

large zooplankton (animal species only). In general, fish play a less important role in the diets of these species than for most other important game fish, such as bass. Brown trout and rainbow trout tend to reach larger sizes than the brook trout. Fish and crayfish figure more prominently in the diet of very large brown and rainbow trout (Kendall 1978).

Fish Species Composition and Species Diversity

Diversity simply refers to the number of different species in a given area. The fish diversity of Kettle Creek, in terms of those living species that are known and have been collected, is given in Figure 4.7. Many factors work together to determine the composition of a fish community in a given stream or lake. Small streams often receive much of their organic energy input from the terrestrial community in the forms of insects, leaves or pine needles. Aquatic primary production is usually low because small streams tend to be shaded. The leaves are processed by aquatic insects, which in turn are eaten by fishes and other predators. As streams become larger and broader, more sunlight and plant nutrients reach the water, and balance shifts to greater primary production. Algae attached to rock surfaces are the major source of food for insect species that scrape such surfaces and are eaten by fishes. As streams become still larger, turbidity may reduce the amount of light available for primary production.

Fish communities change from small streams, where most fish are feeding on insects and invertebrate leaf processors, to more complex communities that include fish that feed on a variety of sources such as plants, large invertebrates and other fish species. Fish species that occur in streams or lakes have naturally moved into these water bodies or historically been introduced (accidentally or on purpose) by human activities. Figure 4.7 also indicates whether a species is natively found in the Kettle Creek watershed (indigenous) or introduced to the watershed by accident or on purpose (nonindigenous). Natural patterns of fish species distribution tend to follow major drainage systems. Habitat characteristics and biotic interactions determine the actual species composition and relative species abundance. For a species to persist, the stream or lake must provide suitable habitat for reproduction, survival and growth. The greater the variety of habitats in an area the more fish species that area can support (Magnuson 1991).

Photo:Tim Stecko

Redbreast sunfish (Lepomis auritus)- a common warm water fish species.

Small streams are very susceptible to alterations of their environment. Habitat losses can occur from alterations such as channelization from erosion and flood control, siltation, agricultural runoff, and wastewater discharges. In most regions there are fish species that are especially sensitive or intolerant to human disturbance.

PRIMARY PRODUCTIVITY is the rate at which algae and other plants convert light, water, and carbon dioxide to sugar in plant cells.

Kettle Creek Species Composition		Temperature Preference	Range	Tolerance to human disturbances
		Coldwater= C = 50-60°F(10-16°C)	Indigenous = I	R = Rare Intolerant
		Coolwater= K = 68-77°F(20-25°C)	Nonindigenous = N	I = Common Intolerant
		Warmwater= W = 77-86°F(25-30°C)		M = Moderately Intolerant
				T = Highly Tolerant
				P = Moderately Tolerant
Common Name	Genus species	C / K / W	I / N	R / I / M / T / P
Central Stoneroller	*Campostoma anomalum*	-	I	-
Cutlips Minnow	*Exoglossum maxillingua*	-	I	-
Bluntnose Minnow	*Pimephales notatus*	-	I	T
Common Shiner	*Luxilus cornutus*	K	I	-
Golden Shiner	*Notemigonus crysoleucas*	K	I	T
Rosyface Shiner	*Notropis rubellus*	-	I	I
Blacknose Dace	*Rhinichthys atratulus*	C	I	T
Longnose Dace	*Rhinichthys cataractae*	C	I	R
Pearl Dace	*Margariscus margarita*	-	I	-
Creek Chub	*Semotilus atromaculatus*	C	I	T
Fallfish	*Semotilus corporalis*	C	I	-
River Chub	*Nocomis micropogon*	C	I	I
White Sucker	*Catostomus commersoni*	K	I	T
Northern Hog Sucker	*Hypentelium nigricans*	W	I	M
Margined Madtom	*Noturus insignis*	W	I	-
Brown Bullhead	*Ameiurus nebulosus*	W	I	T
Slimy Sculpin	*Cottus cognatus*	C	I	-
Shield Darter	*Percina peltata*	-	I	-
Greenside Darter	*Etheostoma blennioides*	-	I	M
Tessellated Darter	*Etheostoma olmstedi*	-	I	-
Brown Trout	*Salmo trutta*	C	N	-
Rainbow Trout	*Oncorhynchus mykiss*	C	N	-
Brook Trout	*Salvelinus fontinalis*	C	I	-
Tiger Trout	*Salvelinus fontinalis x Salmo trutta*	C	N	-
Pumpkinseed Sunfish	*Lepomis gibbosus*	W	N	P
Redbreast Sunfish	*Lepomis auritus*	W	N	-
Bluegill Sunfish	*Lepomis macrochirus*	W	N	P
Smallmouth Bass	*Micropterus dolomieu*	K	N	M
Largemouth Bass	*Micropterus salmoides*	W	N	-
Rock Bass	*Ambloplites rupestris*	W	N	-
Black Crappie	*Pomoxis nigromaculatus*	-	N	-
Yellow Perch	*Perca flavescens*	K	N	-
Redfin Pickerel	*Esox americanus americanus*	K	N	-
Northern Pike	*Esox lucius*	-	N	P
Tiger Musky	*Esox lucius x Esox masquinongy*	-	N	P

Figure 4.7 - Temperature and Tolerance Classification of Kettle Creek Fish Species

These disturbances involve a wide variety of environmental disturbances including water quality and habitat degradation (Karr 1991). For example, intolerance to siltation is common but other types of intolerance may also be present. The Kettle Creek fish species composition list (Figure 4.7) indicates the species in the watershed that fall into a tolerance category (Ohio Environmental Protection Agency 1988). The categoriesof intolerance pertaining to the Kettle Creek fish species composition include rare intolerant (R), common intolerant (I), and moderately intolerant (M) and the levels of tolerant include highly tolerant (T) and moderately tolerant (P). Young fish tend to be much more sensitive or intolerant to all environmental stresses than older fish.

Competition is another ecological interaction involved in the composition of fish species. Taub (1989) acknowledges competition as one of the major controlling mechanisms of species dominance. Streams and lakes typically have several species that compete for limited resources and the species most successful in capturing the resource will increase at the expense of the less successful. Fish using the same resources do not necessarily compete if the resource is so abundant that its use by some species does not distress others. Competition can be most severe among fish that use the same resources in the same way. This has been demonstrated in Kettle Creek when the introduction of the brown trout occurred in the late 1800's. The nonindigenous brown trout established itself in the watershed and eventually displaced the indigenous brook in many areas (Watts and others 1942). Often, however two species can coexist if predation, angling, or other forces prevent them from becoming extremely abundant. Fish can even change their feeding areas or types of food when competing with or being preyed upon by other fishes.

An important physical factor influencing the composition of fish species in a watershed is

Photo:Tim Stecko

White sucker (Catostomus commersoni) - a cool water species.

temperature. The temperature of the surrounding environment determines their body temperature. Thus, temperature directly influences fish growth rates, activity levels, reproduction, and most other aspects of fish biology. Different streams and different locations within a stream can exhibit very different thermal regimes or temperature ranges. These regimes have a critical influence on the fish that a site can support. Some streams remain very cold throughout hot summer months if they have groundwater inputs or have extensive shading, while others that are exposed to the sun and have relatively little groundwater contribution can come close to ambient air temperatures (Stoneman and Jones 1996). Freshwater fish are known to be able to detect small differences in water temperature (Eaton and others 1995) and to seek cooler water if it is available under conditions of heat stress (Headrick and Carline 1993). Different fish can tolerate different ranges of temperature, some can survive in a wide range of temperature and some can survive in a very narrow range of temperature. Every stream or lake has its own thermal regime and temperature variation that is an important factor which influences the types of species and fish communities able to survive and reproduce in that environment.

Photo:Tim Stecko

Golden shiner (Notemigonus crysoleucas)- a cool water fish species

Fish species prefer to live at different temperatures. They are often classified as coldwater, coolwater, and warmwater fish, depending on their preferred water temperature (Figure 4.7). Coldwater fish require the approximate midpoint of water temperature to be 50-60°F (10-16°C), but in general less than 70°F (21°C) to grow and reproduce. Coolwater fish prefer their approximate midpoint for temperatures to be 68-77°F (20-25°C), or generally higher than 65°F (18°C) but less than 75°F (24°C). Warmwater fish require an approximate midpoint of 77-86°F (25-30°C), but usually higher than 75°F (24°C) to grow and reproduce (Magnuson and others 1979).

Many researchers have monitored species composition in Kettle Creek over the last 30 years. Argent and others (1997) constructed a geographical information database for Pennsylvania that shows fish collections completed by state agencies (e.g. universities, Pennsylvania Fish and Boat Commission (PFBC)), which can be linked to tables of data that contain information on the species composition and date of capture. Fish species collections on the mainstem of Kettle Creek were pooled together from Argent and others (1997) database ranging from the late 1960's to the end of the century. The PFBC has, by far, done the most extensive sampling in the watershed, due to its intensive management role. The other recorded investigator is Dr. Ed Cooper, an ichthyology professor from the Pennsylvania State University (PSU). The species composition in Kettle Creek did not change drastically over time from the pooled databases although noticeable changes occurred at a few collections sites. For instance, in 1967, Cooper sampled the confluence of Twomile Run with the mainstem of Kettle Creek, an area impacted by mine drainage, and collected no fish species. Thirty years later in 1997, the PFBC sampled the same area and collected two species of fish, the white sucker (*Catostomus commersoni*) that is highly tolerant to human disturbances, and the smallmouth bass (*Micropterus dolomieu*) that is moderately intolerant to human disturbances. Finding these fish could be an indication of a slight improvement in water quality. By far the most intensively sampled area by the PFBC for the longest duration (1978-present) is along the mainstem of Kettle Creek, just above the confluence of Cross Fork upstream to the confluence of Little Kettle Creek. Species composition has averaged 15 per sample, thus indicating a diversity of habitats that can support a variety of fish species. Collections upstream of the confluence with Germania Branch along the mainstem of Kettle Creek by the PFBC and Cooper from 1964 to the present are indicative of cold and cool water species as no warm water fish species have been recorded.

Another way to look at potential species composition in Kettle Creek is the Gap Analysis Project (GAP) (For more information on GAP, refer to page 151). The GAP analysis for Kettle Creek predicts potential habitat for 37 fish species (Appendix G, page 305), while fish species collection in the watershed totaled 35 (Figure 4.7). Out of the potential 37 fish species listed on the GAP analysis, 24 coincide with the actual species collected on the watershed. Eleven fish species actually collected in Kettle Creek watershed were not listed on the GAP fish species list for potential habitat.

Historical Pollution of Kettle Creek Fisheries

Summary of reports written by the Pennsylvania Fish Commission, 1966.

On Sunday September 4, 1966 near the town of Cross Fork, Potter County, Pa, Kettle Creek was severely damaged by pollution originating on State Forest lands in the vicinity of Clarks Hollow. The source of the pollution was a gas well drilling operation. The upstream limit of pollution was one mile below Bunnell Bridge on Route 144 and the downstream limit was the Alvin Bush Dam. Immediately below the point of entry, all aquatic invertebrates were killed. The absence of aquatic invertebrates persisted for approximately two miles (3.2 km), where very few organisms were found. Crayfish were extremely sensitive to the toxic material and were killed in large numbers, even in areas where other invertebrates survived. The crayfish appeared to be annihilated from the point of entry to at least the Leidy Bridge. The pollution depressed the fish population from Clark Hollow downstream to the area where Hogstock Run enters Kettle Creek. In this four mile (6.4 km) section, the only fish species that survived in any appreciable numbers was the margined madtom, a small non-game fish. The fish kill began on September 4th and reached the top of the Alvin Bush Dam by September 6th.

The estimated number of fish killed was 185,642, including species of trout, bass, suckers, fallfish, minnows, and chubs. Large numbers of juvenile bluegills and smallmouth bass were killed at the upper end of the lake where the stream first enters the lake; however, the kill did not extend far into the lake, apparently offset by dilution. The pollution also caused heavy siltation and an oily smelling, sandy material was reported to have completely covered the bottom of all pools for about two miles below the point of entry. Below this, siltation was still noticeable but became less pronounced.

Figure 4.8 - Historical Pollution in Kettle Creek.

Water in the damaged areas was brown in color and some areas were coated with clay deposits. By the time the water reached the backwaters of the lake, it resembled a colloidal suspension of clay in color, similar to cardboard. Some shoreline vegetation and soils were also damaged by oil, that collected at edges of the stream.

In conclusion, 4 miles (6.4 km) of Kettle Creek were so severely polluted as to be virtually devoid of aquatic invertebrates and desirable game fishes. Half this distance was so badly silted that it became esthetically unattractive to anglers and very poor habitat for most aquatic organisms. As the pollution progressed downstream, the toxicity decreased until it was neutralized in the backwaters of Kettle Creek Lake. The greatest damage downstream from Hammersley Fork was to the fish life. Overall, approximately 15 to 17 miles (24 to 27 km) of Kettle Creek suffered damage (Figure 4.8). At the present day, no visual effects of this pollution are present and the stream has appeared to recover from the pollution.

GOALS: FISHERIES

FH 1.1 Improve and develop habitat assessments.

FH 1.2 Improve stream habitat focusing on flow, substrate, and riparian areas.

FH 1.3 Monitor habitat to attain more self-sustaining wild trout populations.

FH 2.1 Recognize values and opportunities in Kettle Creek watershed.

Photo:Tim Stecko

Central stoneroller (Campostoma anomalum)

Photo:Rob Criswell

Shield darter (Percina peltata)

Photo:Tim Stecko

Bluntnose minnow(Pimephales notatus)

Photo:Tim Stecko

Rosyface Shiner (Notropis rubellus)

Photo:Tim Stecko

Pumpkinseed sunfish (Lepomis gibbosus)

Photo:Tim Stecko

Norther Hog sucker Hypentelium nigricans)

Introduction

Habitat assessments are defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour and others 1996). Habitat assessments encompass many different aspects of the stream in order to provide a method of measuring the rating of the habitat. Assessments are usually conducted on a 328-foot (100 meter) section of the stream. There are many different categories upon which one obtains a score, based on a habitat assessment data sheet. Once complete, the score is totaled to acquire an overall habitat score and rating. There are two types of data forms for the habitat assessments already conducted in the Kettle Creek watershed. Both are versions adapted from the Environmental Protection Agency (EPA) rapid bioassessment protocol (EPA, 2001); copies are available in the Appendix.

The first form is used and distributed by the Pennsylvania Fish and Boat Commission (PFBC) (Appendix F - Page 295-296). The PFBC form includes ten categories: Epifaunal Substrate/Available Cover (subcategories of fish and macroinvertebrates); Riffle Quality; Embeddedness; Channel Alteration; Sediment Deposition; Frequency of Riffles (or bends)/ Velocity-Depth Combinations; Channel Flow Status; Bank Vegetative Protection (each bank scored separately); Bank Stability (each bank scored separately); and Riparian Vegetative Zone Width (each bank riparian zone scored separately). In this section, the groups that used this data sheet are Mansfield University (MU), Lock Haven University (LHU), and the Center for Watershed Stewardship at Penn State University (CWS) (Figure 4.9).

The second form is used and distributed by the Pennsylvania Department of Environmental Protection (PA DEP) (Appendix F - Page 297-8). The DEP form includes 12 categories that are similar to the categories listed previously. The differences between the two forms are as follows. The first category is labeled Instream Cover (fish only). This is similar to the Epifaunal Substrate/Available Cover PFBC category except that it does not consider macroinvertebrate habitat. The second DEP category is labeled Epifaunal Substrate and is exactly the same as the PFBC category of Riffle Quality. Another difference is the DEP habitat assessment data sheet separates the PFBC Frequency of Riffles /Velocity-Depth Combinations category into two separate categories (labeled Frequency of Riffles and Velocity-Depth Combinations). The DEP form also adds another category labeled Grazing or Other Disruptive Pressure. The remaining categories are consistent with the PFBC form except when scoring banks or zones, the DEP form does not score each bank separately. In this section, the samplers that used this data sheet are Lock Haven University (LHU) and the DEP (Figure 4.9).

HABITAT ASSESSMENT

In the Kettle Creek watershed, overall, the majority of the sites assessed rated Optimal or Suboptimal with a few Marginal ratings. In this section, the overall score was not discussed. Instead, the category ratings are used in order to pinpoint potential problems in the watershed. Each category will also be described in this section.

PFBC Epifaunal Substrate/Available Cover or DEP Instream Cover

Rating is determined by the amount of fish cover, logs, boulder, cobble, undercut banks or other substrate favorable to fish colonization. The PFBC forms also rates amount of macroinvertebrate habitat present. Good measures of fish habitat would include undercut banks, logs, pools and the presence of fish. Good measures of macroinvertebrate habitat

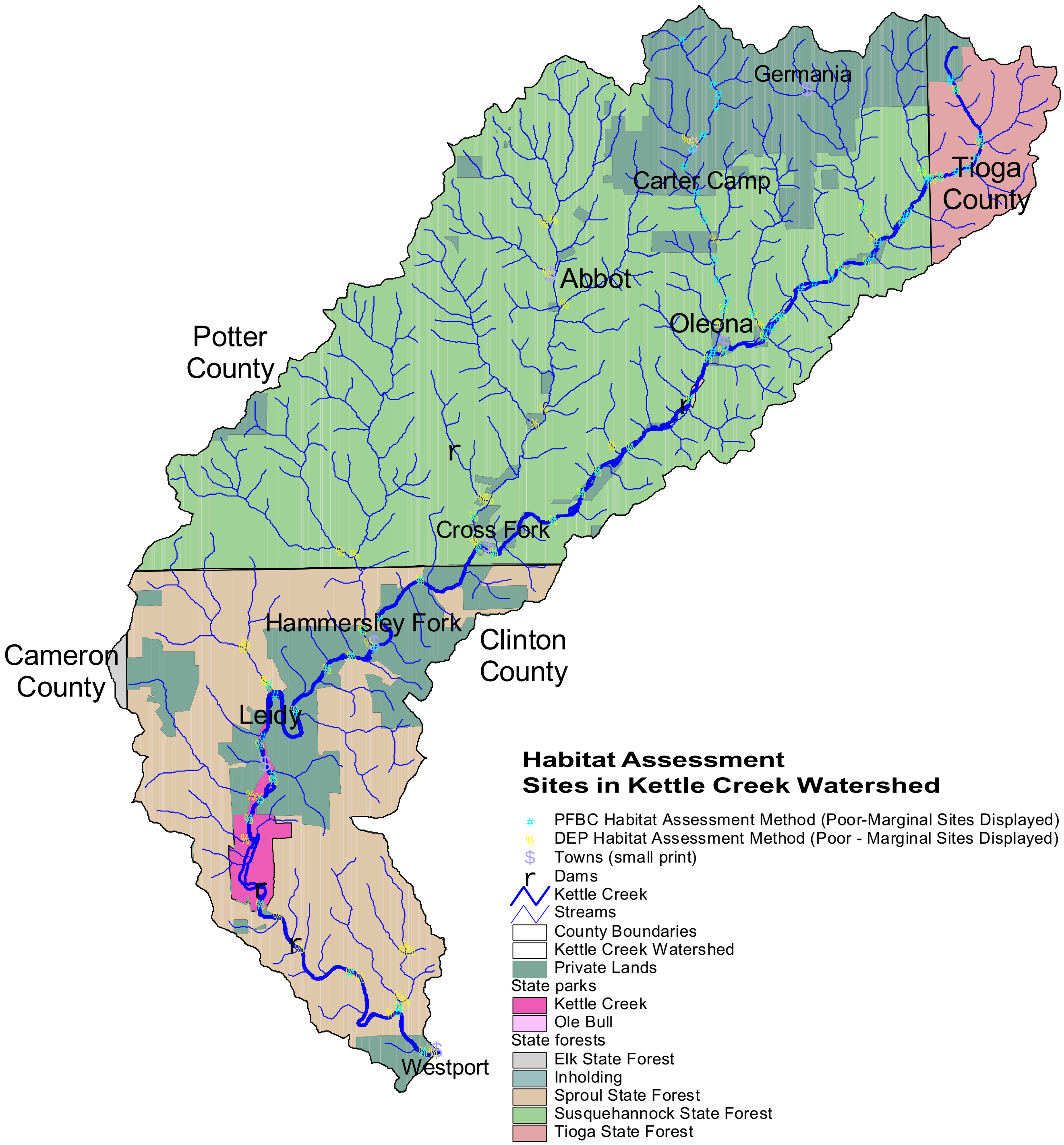


Figure 4.9 - Habitat assessment sites in the Kettle Creek watershed.

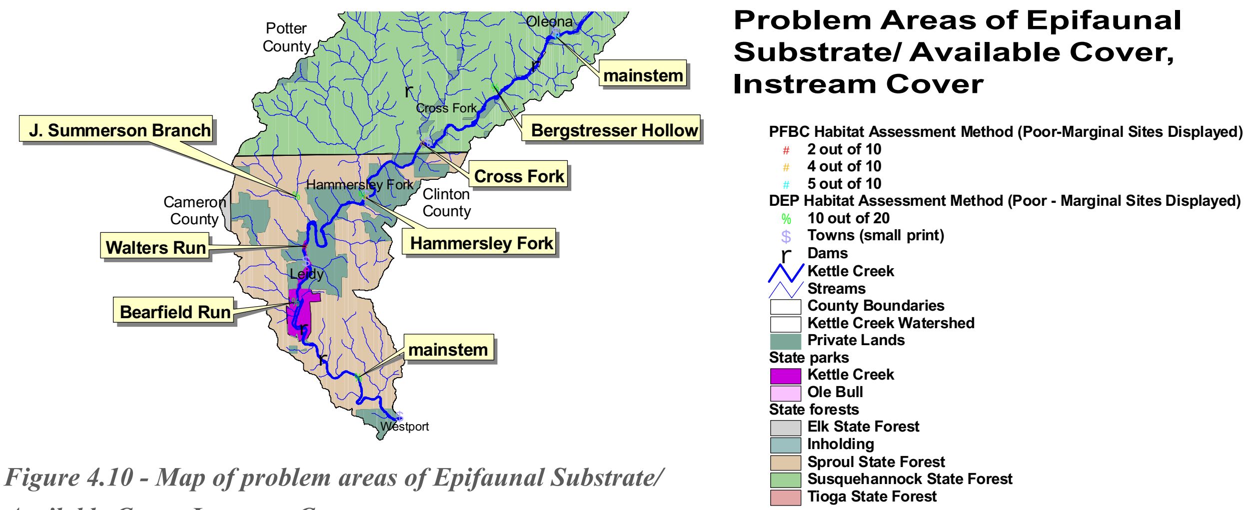


Figure 4.10 - Map of problem areas of Epifaunal Substrate/ Available Cover, Instream Cover.

would include boulders, cobbles, submerged logs, riffles and the presence of macroinvertebrates. Sections of stream that scored marginal - poor from the habitat assessment previously conducted in the Kettle Creek watershed are Bergstressor Hollow, Hammersley Fork, John Summerson Branch, Bearfield Run, Cross Fork, Walters Run, and two locations on the mainstem of Kettle Creek (one upstream of the USGS gauge at Cross Fork, and the other upstream of Little Kettle Creek). Locations of these sites can be seen on the map in Figure 4.10. Macroinvertebrate habitat was found to be suboptimal - optimal throughout the watershed.

PFBC Riffle Quality or DEP Epifaunal Substrate

An optimal rating is determined by area containing well-developed riffles and runs and abundance of cobble. An optimal riffle is as wide as the stream itself and as long as twice the width of the stream. Abundant bedrock would cause a decrease in riffles and would score low in this category. A better quality riffle will inhabit a diverse population of fish and macroinvertebrates. Sections of streams in the Kettle Creek watershed that scored marginal - poor in this category are Billings Branch, Hammersley Fork, Cross Fork, and Walters Run. Locations of these sites can be seen on the map in Figure 4.11.

PFBC and DEP Embeddedness

Embeddedness was rated by the amount of fine sediment surrounding the gravel, boulder, and cobble particles. A stream section with an optimal rating in embeddedness has a small percentage of gravel and cobble surrounded by fine sediment. The particles in the stream are easily moved with your hands. Embeddedness is important to macroinvertebrates because the more embedded a rock is, the less area there is for the macroinvertebrate to live on. If a stream bottom has high embeddedness, fish have difficulty in locating areas to lay eggs. Areas in the Kettle Creek watershed that may need some improvements because of a marginal - poor rating are sections of Little Kettle Creek, Twomile Run, Huling Branch, and two locations on the mainstem (at the mouth and upstream of the USGS gauge at Cross Fork). Locations of these sites can be seen on the map in Figure 4.12.

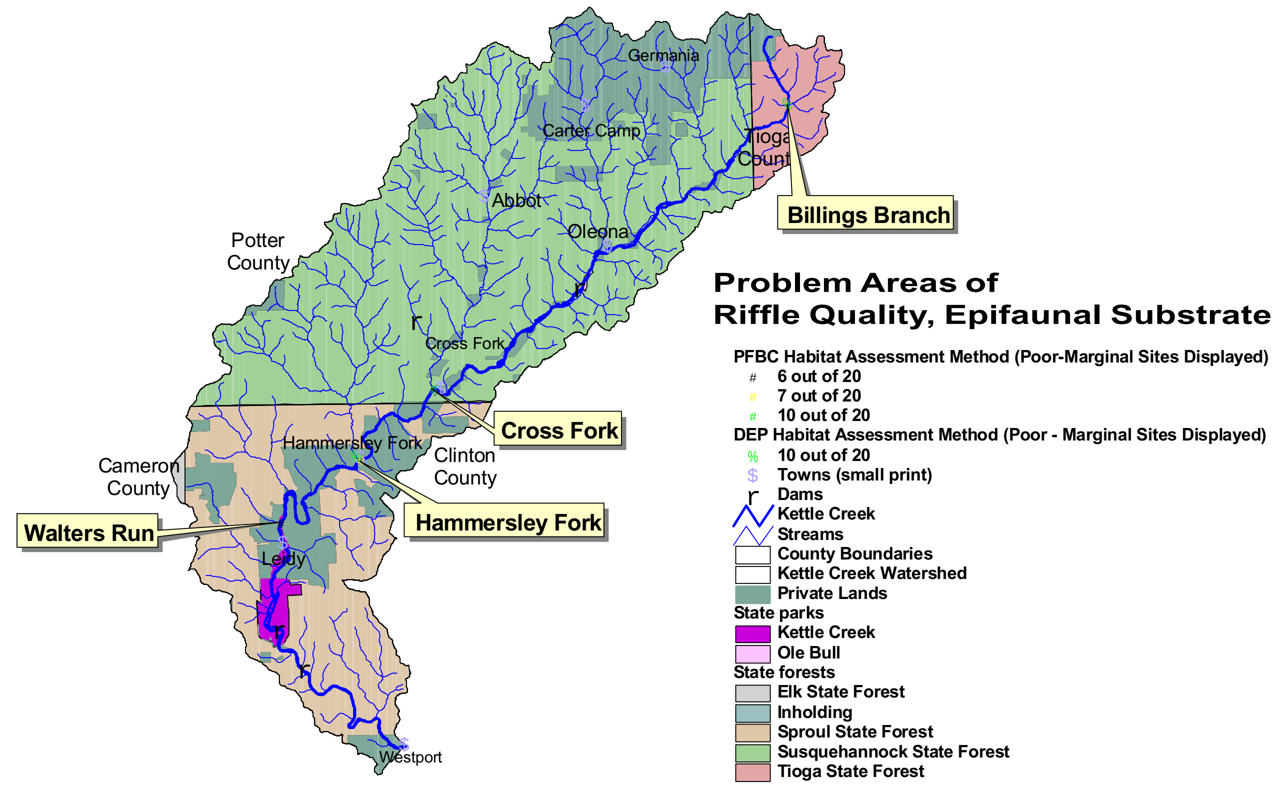


Figure 4.11 - Map of problem areas of Riffle Quality, Epifaunal Substrate.

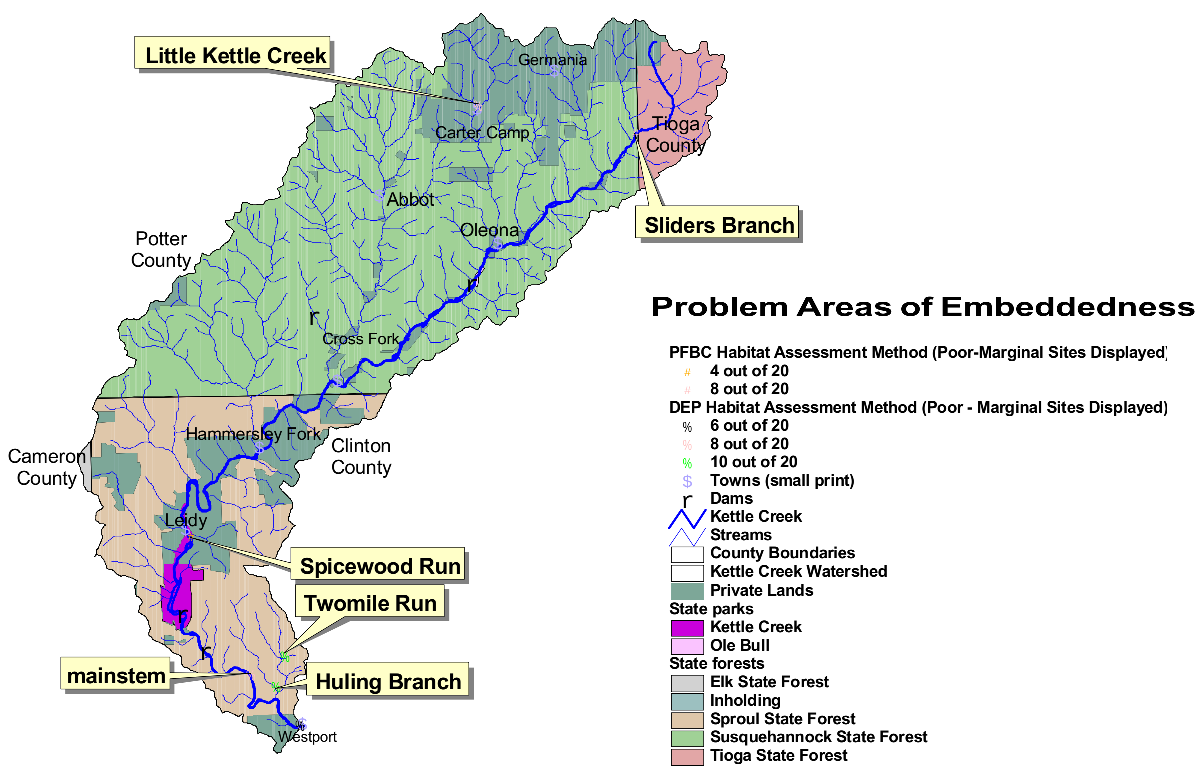


Figure 4.12 - Map of problem areas of Embeddedness

PFBC and DEP Channel Alteration

Channel alteration indicates the occurrence and amount of unnatural channelization or dredging within the stream section. An optimal score has minimal or no channelization or dredging. Channelization and dredging causes problems for fish and macroinvertebrates because it results in far less natural habitats than naturally meandering streams. According to the habitat assessments conducted, there was only one area within the Kettle Creek watershed where there was extensive channelization. The location of this site was on Hammersley Fork, just upstream of the confluence with Kettle Creek (Figure 4.13).

PFBC and DEP Sediment Deposition

Sediment Deposition is rated by observing the number of sediment bars or island formations. Sediment deposition can restrict the presence of pools and reduce available surface area of boulders and cobbles, which can degrade fish and macroinvertebrate habitat. Little or no enlargement of islands and point bars would receive an optimal rating in this category. Marginal - poor areas in the Kettle Creek watershed are sections of Ives Hollow Run, Little Kettle Creek, Twomile Run, Huling Branch, Sliders Branch, Beaverdam Branch, and two sites on the mainstem of Kettle Creek (one upstream of the USGS gauging station and the other on the mainstem between Sliders and Germania Branch). The location of these sites can be seen in Figure 4.14.

PFBC and DEP Frequency of Riffles and/or Velocity-Depth Combinations

Frequency of Riffles refers to the quantity of riffles in the stream study section. According to both the PFBC and DEP data sheets, the distance between riffles divided by the width of the stream is an indicator of riffle quantity. An optimal riffle quantity indicator would be five to seven. A variety of habitat is also important in these categories. Velocity-Depth Combinations refers to four types of velocity-depth regimes (slow-deep, slow-shallow, fast-deep, and fast-shallow). Optimal streams will have all four velocity-depth combinations present. Macroinvertebrates prefer shallow combinations while fish prefer deeper combinations. As previously mentioned, the PFBC data sheet combines these two categories into one. Marginal - poor ratings within the Kettle Creek watershed occurred in sections of Cross Fork (velocity-depth good, but frequency of riffles low), Ives Hollow Run (velocity-depth low, but frequency of riffles good), Boone Run (velocity-depth low, but frequency of riffles good), Trout Run (velocity-depth low, but frequency of

An example of channel alteration at Hammersley Fork.

BANK DESIGNATION: Left and right bank is determined by facing downstream.

CHANNELIZATION is a man-made alteration to the natural pathway of the stream

DREDGING is a process in which the natural channel of the stream has been deepened or widened by human activities

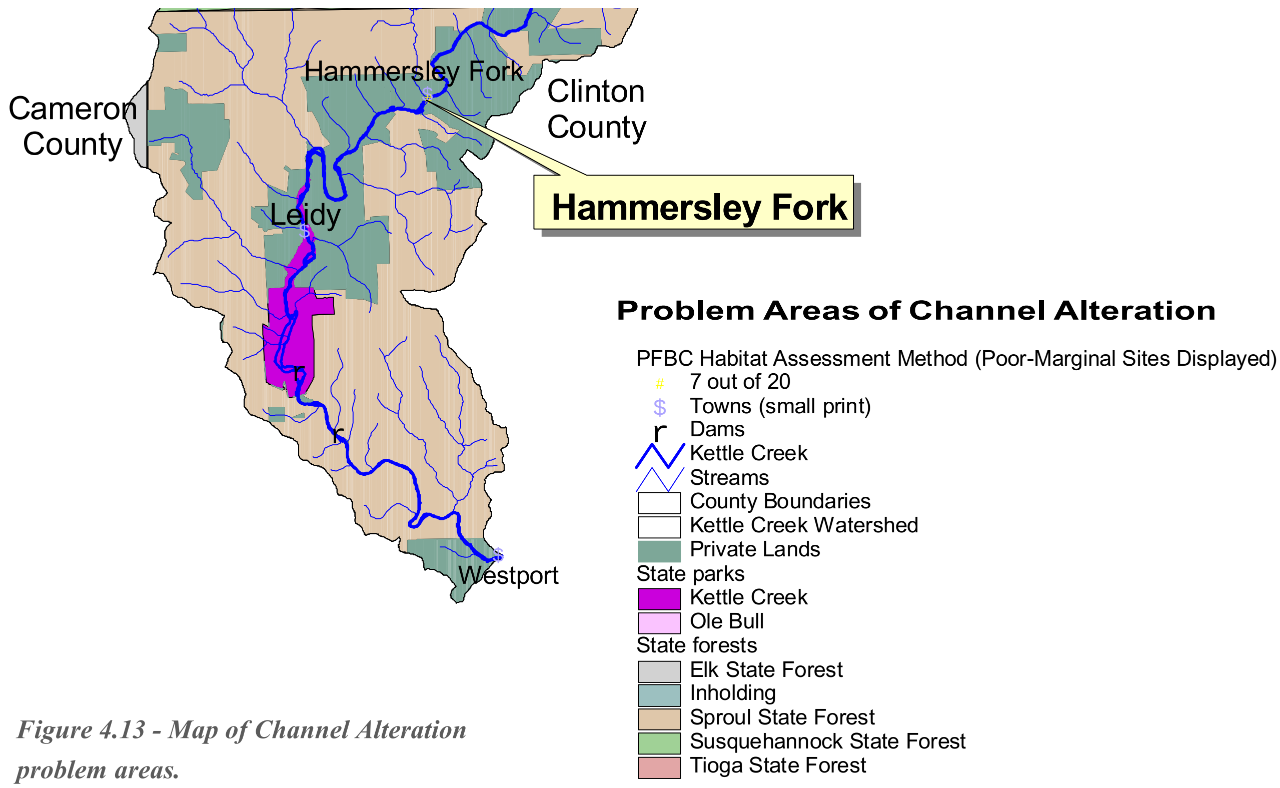


Figure 4.13 - Map of Channel Alteration problem areas.

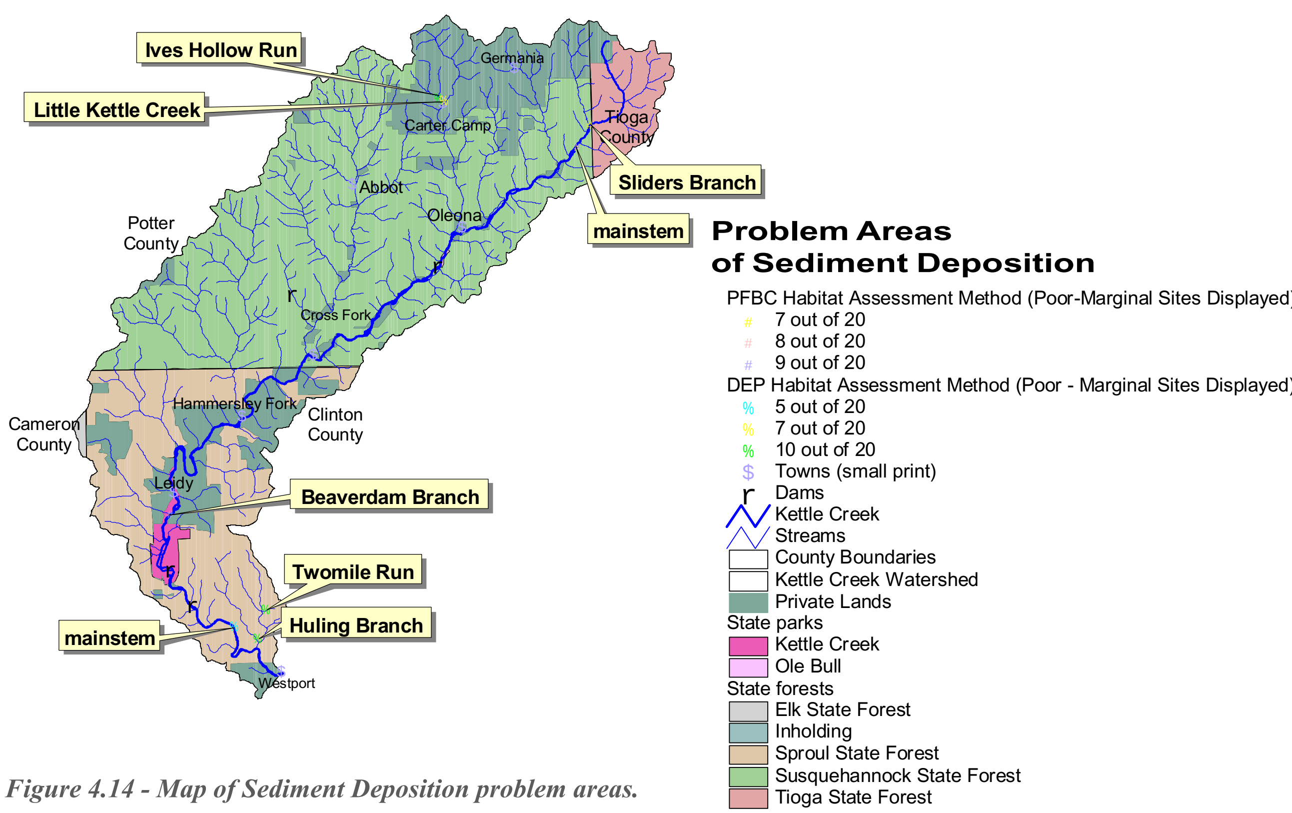
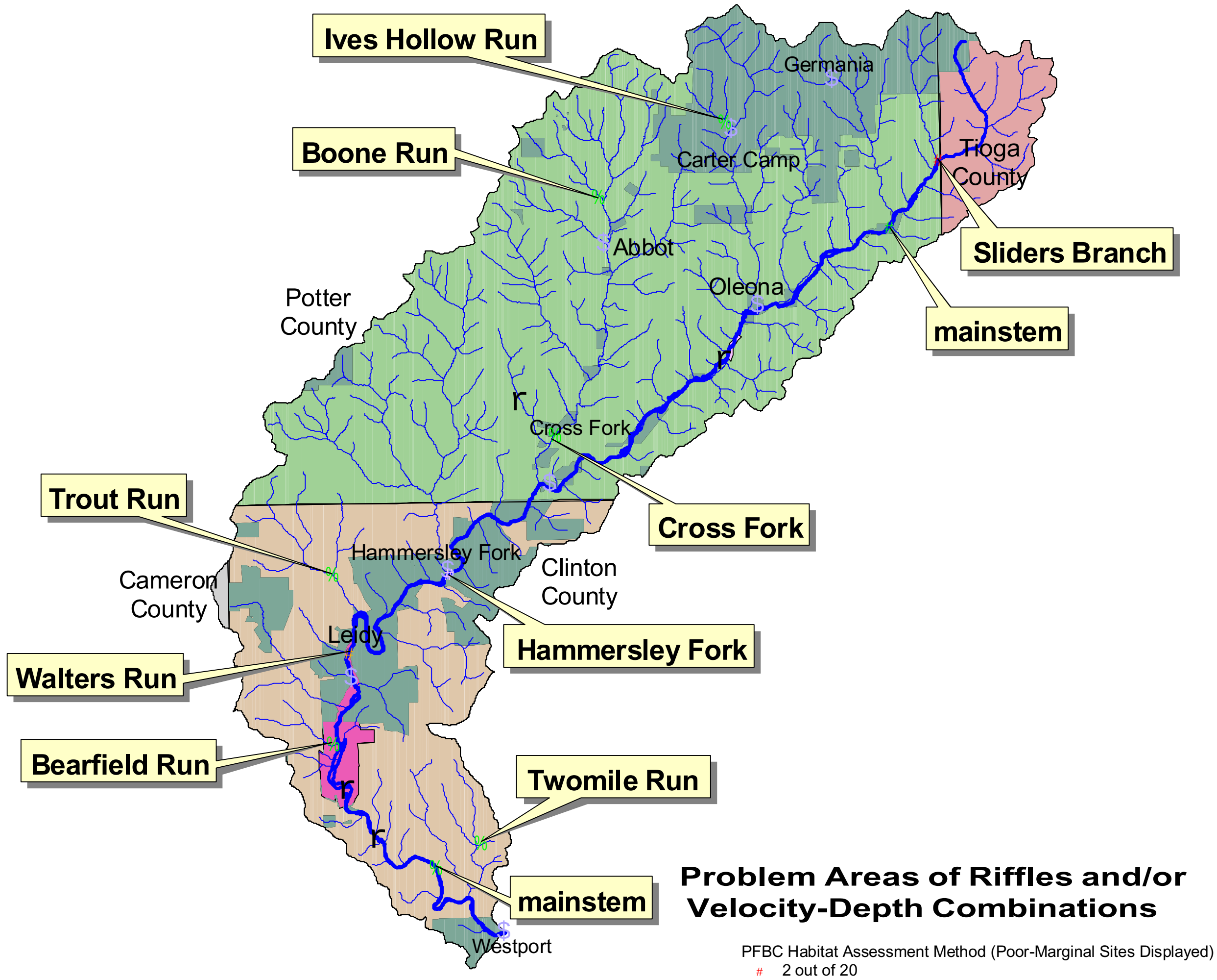
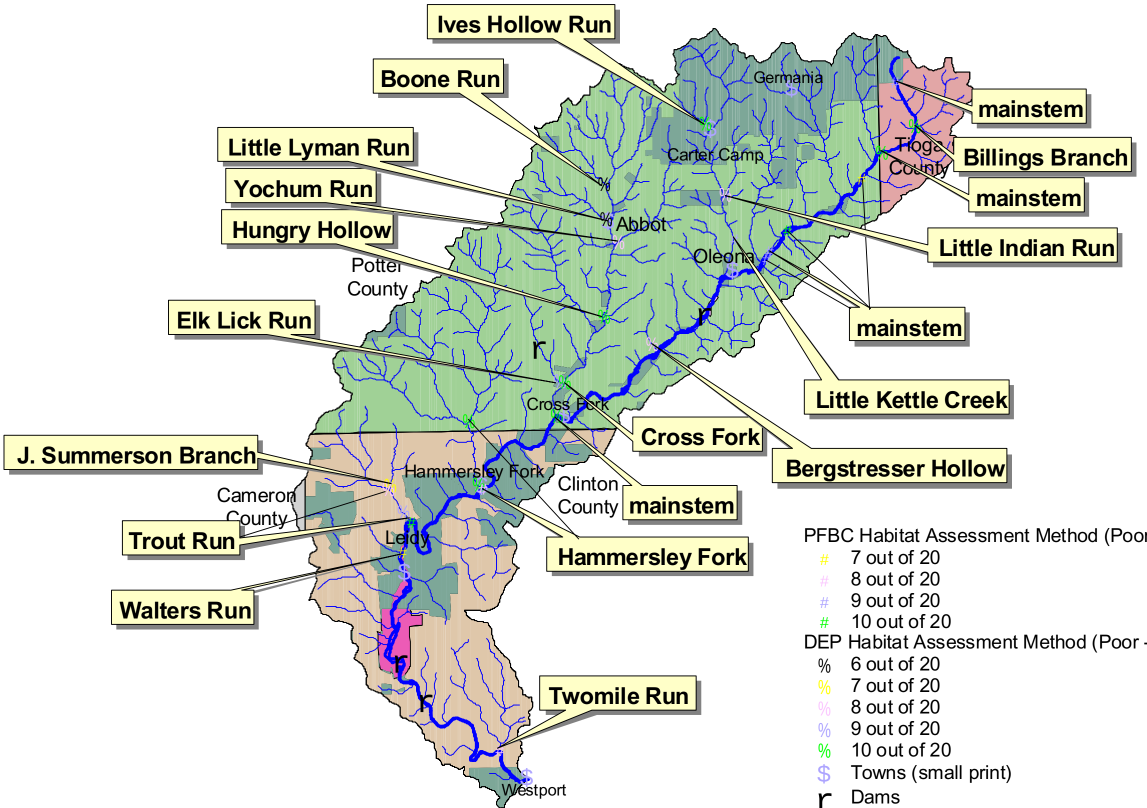


Figure 4.14 - Map of Sediment Deposition problem areas.



riffles good), Bearfield Run (velocity-depth low, but frequency of riffles good), Twomile Run (velocity-depth low, but frequency of riffles good), Sliders Branch, Hammersley Fork, Walters Run, and two locations on the mainstem of Kettle Creek (one on Kettle downstream of Germania Branch, the other upstream of the USGS gauging station at Cross Fork). Locations of these sites can be found on the map in Figure 4.15.

Figure 4.15 - Map of Frequency of Riffles and/or Velocity-Depth Combinations problem areas.



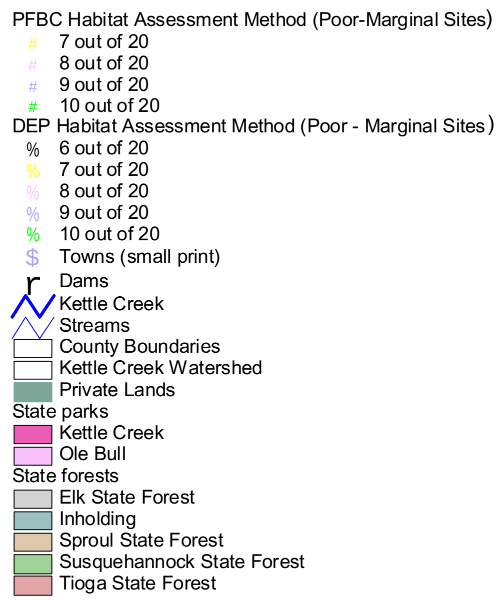


Figure 4.16 - Map of Channel Flow Status problem areas.

PFBC and DEP Channel Flow Status

Channel Flow Status assesses if the stream reaches both the left and right banks. It also indicates whether there is an abundance of channel substrate exposed. This category can depend on the time of year the stream is assessed. The flow should be noted because during low flow a stream section may score very low, but at high flow, it would score much higher. Channel flow status is important because if the channel substrate becomes exposed macroinvertebrate populations will decrease. Fish and macroinvertebrates populations depend strongly on the amount of water within the stream banks. Channel Flow Status seems to be a common problem in areas throughout the Kettle Creek watershed. Sections of streams that received a marginal - poor rating in this category within the Kettle Creek watershed are Billings Branch, Ives Hollow, Little Indian Run, Bergstressor Hollow, Boone Run, Little Lyman Run, Yochum Run, Hungry Hollow, Elk Lick, Cross Fork, Hammersley Fork, John Summerson Branch, Trout Run, Little Kettle Creek, Walters Run, Twomile Run, and seven sites on the mainstem of Kettle Creek. Locations of all these sites are located on the map in Figure 4.16.

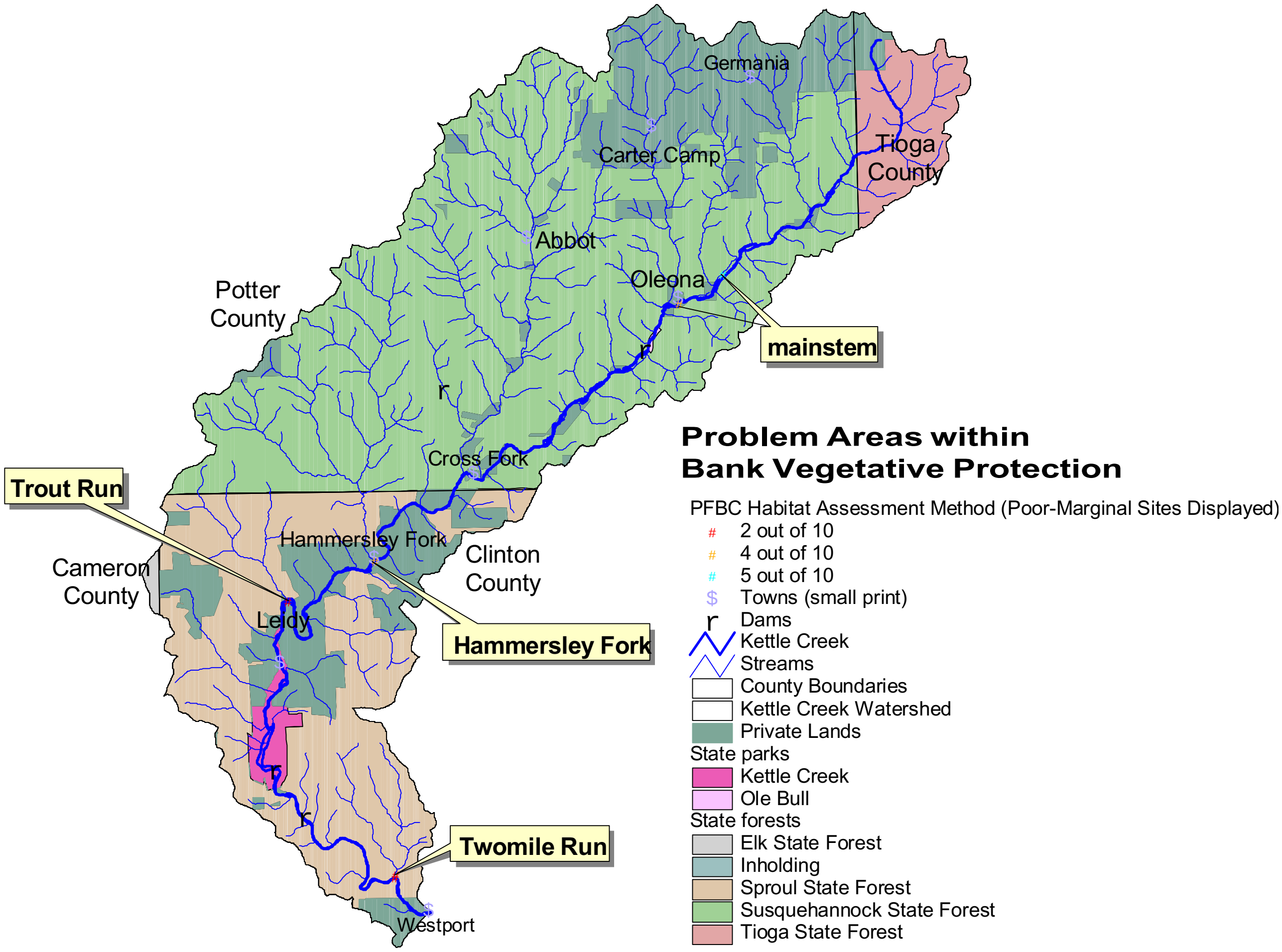


Figure 4.17 - Map of problem areas within the Bank Vegetative Protection category.

PFBC and DEP Bank Vegetative Protection

Bank Vegetative Protection is the amount of vegetation located on the streambanks. Bank vegetation aids in preventing erosion from occurring. Trees, shrubs, and grasses are the general categories of bank vegetative protection. Trees have the advantage of providing canopy cover over the stream, which helps to prevent a rise in stream temperature. The advantages of grasses and shrubs are to provide habitat and to prevent erosion of the stream banks. An optimal rated stream in this category would consist of more than ninety percent of the bank surface covered in vegetation. As previously mentioned, the DEP data sheet does not score the left and right banks separately, however no studies using the DEP sheet were rated marginal - poor. Areas with a marginal - poor bank vegetative protection rating within the Kettle Creek watershed were Trout Run (left bank), Twomile Run (left and right bank), and at two sites on Kettle Creek (one is upstream of Long Run, the other is upstream of Little Kettle Creek). Locations of these problem areas are found in Figure 4.17.

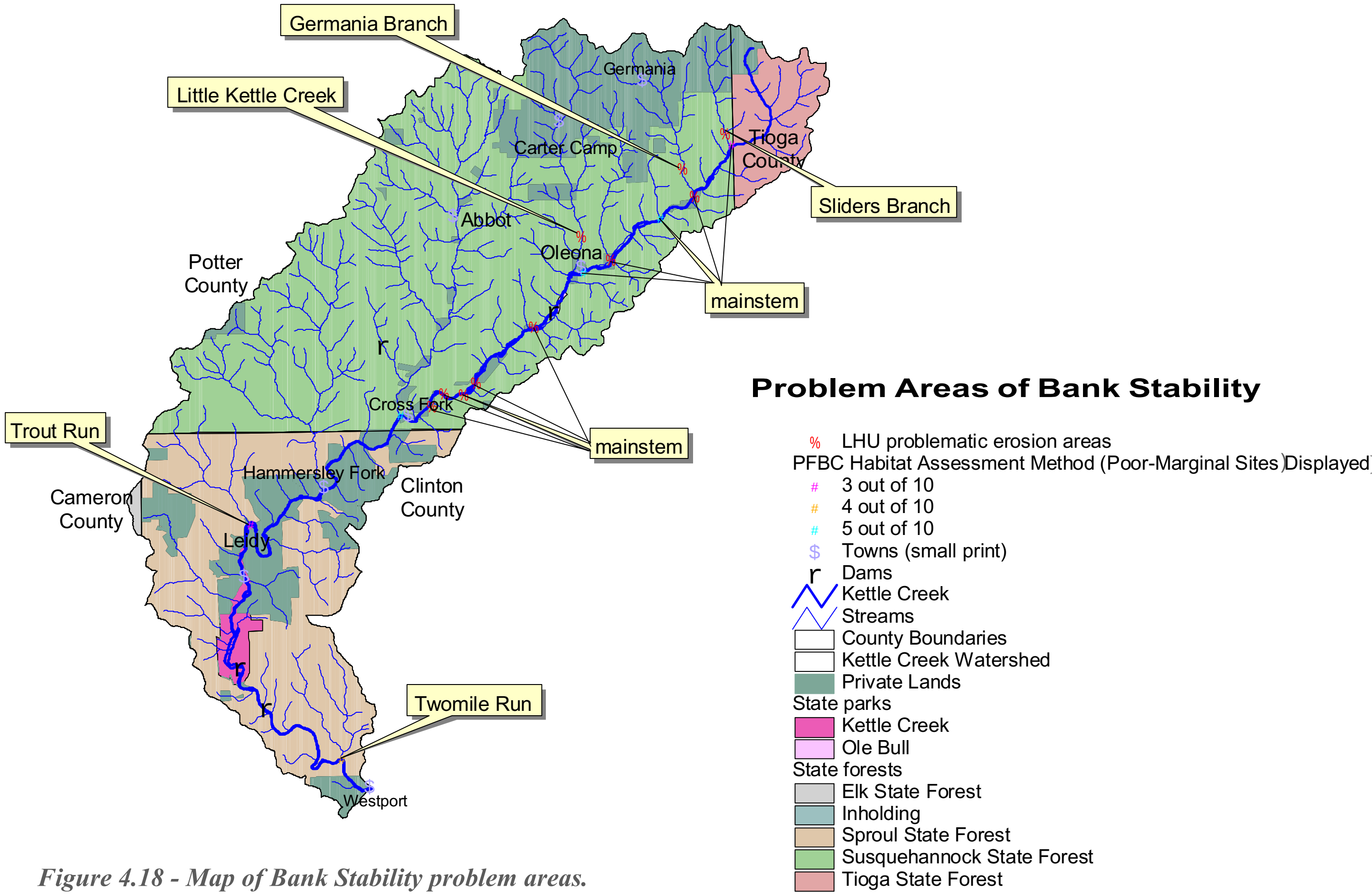


Figure 4.18 - Map of Bank Stability problem areas.

PFBC Bank Stability and DEP Condition of Banks

Bank Stability (or Condition of Banks) measures the amount of erodibility of the stream banks. This measurement is either the amount of erosion present or the potential for erosion to occur. Some indicators of erosion include unvegetated banks, exposed tree roots, exposed soil, and crumbling of banks. An optimal bank stability rating would have vegetated banks, and little or no signs of erosion or potential for erosion. Sections of streams within the Kettle Creek watershed which obtained a marginal - poor category rating are Trout Run (left bank), Cross Fork (right bank), Twomile Run (right bank) and two sites on the mainstem of Kettle Creek (one at the confluence of Kettle Creek with Germania Branch and the other site is located downstream of the Germania Branch). The LHU study noted that sections of Sliders Branch, Germania Branch, Little Kettle Creek, and four areas on Kettle Creek (one near Long Run, one near Germania Branch, and one near Berstresser Hollow, and a stretch upstream of Little Kettle Creek) also had some stability problems. Locations of all these problem areas are found in Figure 4.18.

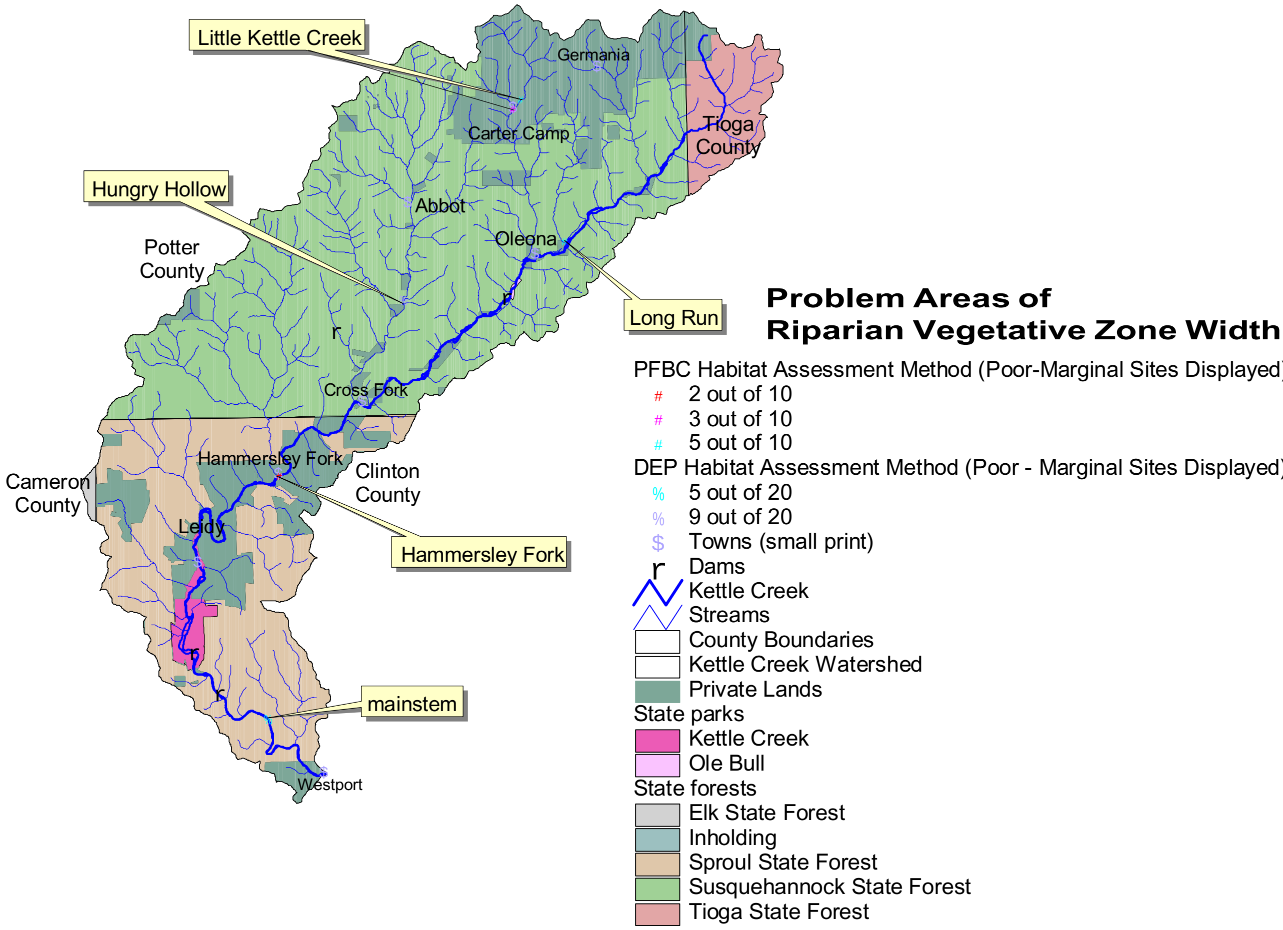


Figure 4.19 - Map of Riparian Vegetative Zone Width problem areas.

DEP Grazing or Other Disruptive Pressure

The Grazing or Other Disruptive Pressure category was only observed on the DEP data sheet. This category examines any vegetation disruption due to grazing or mowing. An optimal rating would have little or no sign of grazing or mowing. There were no marginal - poor ratings throughout the Kettle Creek watershed observed at the previous study sites.

PFBC and DEP Riparian Vegetative Zone Width

The Riparian Vegetative Zone Width measures the width of the area vegetated alongside the stream banks. Wide riparian vegetative zones are important because these zones can buffer pollutants entering a stream through runoff, prevent erosion, and provides habitat. An optimal rating is received when the riparian vegetative zone is greater than 59 feet (18 meters). No human activity is present within this zone. Marginal - poor category ratings in the Kettle Creek watershed occurred on sections of Hungry Hollow, Long Run (left bank), Hammersley Fork (both banks), Little Kettle Creek (right bank), and two sites on Kettle Creek (one is upstream of USGS gauging station at Cross Fork, the other is upstream of Long Run. Locations of these problem areas can be found on the map in Figure 4.19.

GOALS: HABITAT

FH 1.1 Improve and develop habitat assessments.

FH 1.2 Improve stream habitat focusing on flow, substrate and riparian areas.

EO 1.1 Promote baseline knowledge of the watershed and watershed issues to enable full participation in local resouce decision making by community members.

EO 2.1 Supply complete and accurate information on resources to enable effective participation in watershed decision-making discussions.

Cross vane on the mainstem of Kettle Creek

Summary

Based on the habitat assessments completed, marginal-poor site specific problems exist throughout the watershed. The subwatersheds of Hammersley Fork, Cross Fork, Little Kettle Creek, and Walters Run and also sections of the mainstem (near the Cross Fork USGS gauging station) seem to have the most variety of potential problems. These locations should be studied further to determine the extent of the problem(s). Many different improvement projects can be implemented in order to alleviate any problems and will be discussed in the Recommendation Section of this document.

Habitat enhancement project on Germania Branch

Gabion on Elk Lick Run

Introduction

Wildlife is defined as all mammals, birds, amphibians, snakes, and turtles which are plentiful in the watershed. Wildlife is plentiful and diverse in the watershed because of the large contiguous expanses of forest, the diverse habitats, the interconnectivity of the habitat, and the low human population density. Pennsylvania's Natural Diversity Inventory (PNDI) and the Gap Analysis Program (GAP) are two tools used to describe biological diversity. PNDI conducts inventories and collects data to identify and describe the Commonwealth's rarest and most significant ecological features. These features include plant and animal species of special concern, rare and exemplary natural communities, and outstanding geologic features. (Refer to page 101 for more information about PNDI designated areas in Kettle Creek, Refer to Appendix, page 312 for a discussion of PNDI). The purpose of GAP is to provide broad geographic information on the status of ordinary species (those not threatened with extinction or naturally rare) and their habitats by finding gaps in coverage of protected areas and species in need providing land managers, planners, scientists, and policy makers with the information needed to make better-informed decisions. (USGS 2000). GAP is a potential list of species based on multiple factors, including habitat (Refer to page 151 for a discussion of GAP analysis). GAP lists 285 potential wildlife species including mammals, birds, fish, amphibians, snakes & lizards, and turtles. GAP lists 27 PNDI species potentially in the watershed (See appendix, page 305) and the PNDI had confirmed that 7 unique species and 2 unique habitats exist in the watershed (Figure 4.20). Kettle Creek lake is frequented by American bald eagles (*Haliaeetus leucocephalus*) and osprey (*Pandion haliaetus*). Other birds of prey inhabit the watershed while migrating. The wetlands, ponds, and streams are prime habitat for waterfowl including herons, Canada geese (*Branta elaphus*), mallard ducks (*Anas platyrhynchos*), and wood ducks (*Aix sponsa*). Song birds are distributed throughout the watershed.

Pennsylvania Elk

Elk *(Cervis canadensis)* are attracted to forest clearcuts, revegetated strip mines, grassy meadows, open stream bottoms, and agricultural lands. They tend to avoid contact with humans, although they will venture into settled areas to reach favored food sources. Pennsylvania's elk live in Cameron, Clearfield, Clinton, Elk and Potter counties, in the state's north central region. The elk range covers about 835 square miles including portions of the Kettle Creek watershed. The Pennsylvania Game Commission (PGC) and state Department of Conservation and Natural Resources (DCNR) are managing public lands to make them more attractive to elk. The agencies create and maintain high-quality foraging areas and limit disturbance by humans. Elk habitat enhancement projects also benefit deer, turkeys, grouse and other wildlife.

Thousands of visitors travel to the watershed and surrounding areas to watch and

TERRESTRIAL WILDLIFE

GAP is a program developed by the USGS to assess unprotected areas at the landscape scale which have a high potential species diversity. Unprotected means that the habitat could be degraded or destroyed. Identification of unprotected areas is the first step in protecting the diverse habitat resources

PNDI is a state developed program to inventory species of special concern in PA.

PNDI Species and Habitat list			
Scientific Name	Common Name	PA Status	*Last Recorded Date
Crotalus horridus	Timber rattlesnake	PC	1998
Ardea herodias	Great blue heron		1974
Alasmidonta varicosa	Brook floater(fresh water mussel)		1997
Pyganodon cataracta	Eastern floater(freshwater mussel)		1994
Botaurus lentiginosus**	American bittern(migratory bird)	PE	1890
Sorex palustris albibarbis	Water shrew		1945
Neotoma magister	Allegheny woodrat	PT	1898
Habitats of interest:			
Meandering Channels			
High-gradient clearwater creek			
* Last recorded date is the date of the most recent documentation of the occurrence of the species in our database.			
** Record is based on an 1890 specimen with its location given only as Clinton County, so it might not actually have come from the Kettle Creek watershed.			
Source: PNDI database, search conducted by Kierstin Carlson of Western Pennsylvania Conservancy			

Figure 4.20 - List of species and habitats of special concern developed from the PNDI database.

A young black bear(Ursus americanus) spotted in the Kettle Creek watershed in Septem-

photograph the Pennsylvania Elk. An elk reintroduction release site is located adjacent to Bitumen near the southern western boundary of the watershed. Elk frequent the gas line right of ways and floodplains along the mainstem of Kettle Creek. Elk viewing areas have been developed in nearby Elk County which is a primary destination. However attempts are being to enhance elk viewing opportunities in the watershed through habitat enhancement associated with surface mine reclamation.

The Pennsylvania Game Commission

The Pennsylvania Game Commission (PGC) is responsible for managing both game and non-game wildlife species in Pennsylvania. Wildlife management is primarily accomplished through habitat management, hunting, trapping, and education. The PGC primarily develops land management practice on state game lands. State game lands do not exist on the watershed, thus minimizing the opportunity for wildlife management. Approximately 20 acres of land, located adjacent to Beaverdam Run downstream of Leidy, is actively managed for wildlife in the Kettle Creek watershed by the PGC in collaboration with Kettle Creek State Park (Dennis Dusza, personal communication). The wildlife management area has been planted with grains, grasses, and shrubs to enhance food and cover sources for elk, white tailed deer (*Odocoileus virginianus*), eastern wild turkey (*Meleagris gallopavo*), and song birds. Brush piles have been constructed to provide cover for small mammals and song birds.

The PGC has collaborated with the Bureau of Forestry (DCNR) to enhance wildlife habitat by sharing equipment, financial, and labor resources on projects located in the watershed.

The PGC recognizes the diversity of wildlife in the watershed and has made several attempts to increase wildlife diversity by introducing some species to historic ranges of those species. Elk, fishers (*Martes pennanti*) and river otters (*Lontra canadensis*) have been reintroduced to the watershed. (Dennis Dusza, personal communication). Elk and fisher populations are actively monitored, but it is undetermined if the river otter population is established or is currently monitored.

A recommendation from the PGC (Dennis Dusza, personal communication) is to acquire private lands along the riparian corridor for wildlife management areas. Currently, most of the private lands are located in the riparian corridor (see land use section for more information). Riparian areas provide ideal management opportunities because the land is typically flat, fertile, and accessible. Riparian areas are also under increasing development pressure and one preservation method is public ownership. Riparian areas provide movement corridors for wildlife, stable stream banks, thermal protection for the stream channel, and floodwater storage.

Hunting is a very popular activity in the watershed. Ninety-two percent of the watershed is publicly owned, providing large areas to hunt. The vast expanses of state land attract hunters from throughout Pennsylvania and the adjacent states. The big game species pursued are black bear, white tailed deer, and eastern wild turkey. The PGC has recently authorized a limited season for elk. Coyote (*Canis latrans*) hunting

THE PGC MISSION STATEMENT

"The basic goal of our (PGC) wildlife management program is to manage for healthy wildlife populations that are acceptable to Pennsylvanians and their communities. We (PGC) survey and monitor wildlife populations, study the relationships between wildlife, habitat and humans and theircommunities, develop management plans, and apply the management tools of hunting, trapping, habitat management, enforcement, communications and education to achieve the balance between biological and social acceptability." (PGC website).

Big Game Harvest in Clinton and Potter Counties						
	Clinton County Big Game Harvest Statistics			Potter County Big Game Harvest Statistics		
Year	Bear	Antlered Deer	Antlerless Deer	Bear	Antlered Deer	Antlerless Deer
1993	166	1,939	1,605	79	4,405	6,152
1994	95	1,961	1,768	41	3,438	5,958
1995	157	2,203	2,461	110	3,900	5,996
1996	134	1,608	1,258	69	3,869	3,748
1997	168	2,278	1,268	175	4,443	4,550
1998	219	2,045	1,294	89	4,828	3,982
1999	129	2,573	1,427	59	5,138	3,883
2000	248	2,493	2,186	203	4,660	6,409
Source: Pennsylvania Game Commission website.						

Figure 4.21 - Big Game Harvest in Clinton & Potter Counties.

and trapping is increasing in popularity and Kettle Creek provides prime habitat for this species. Small game species pursued include gray squirrels (*Sciurus carolinensis*), ruffed grouse (*Bonasa umbellus*), and ring-necked pheasants (*Phasianus colchicus*). Trapping of beaver (*Castor canadensis*), red fox (*Vulpes vulpes)* and grey fox (*Urocyon cinereoargenteus*), raccoons (*Procyon lotor*), mink (*Mustela vison*), and bobcats (*Lynx rufus*) is also popular.

Turtles caught basking in the sun at the Cross Fork mill ponds

Summary

Wildlife is an important economic and recreational resource in the Kettle Creek watershed. Wildlife diversity is high in the watershed, and diversity is dependent on many types of habitats that remain interconnected. Riparian habitats must remain connected to upland habitats. Mountain tops must remain connected to valleys. The corridors that are present in Kettle Creek must remain to preserve the abundance and diversity of wildlife in the watershed.

White tailed deer

1999 Pennsylvania Gap Analysis Project

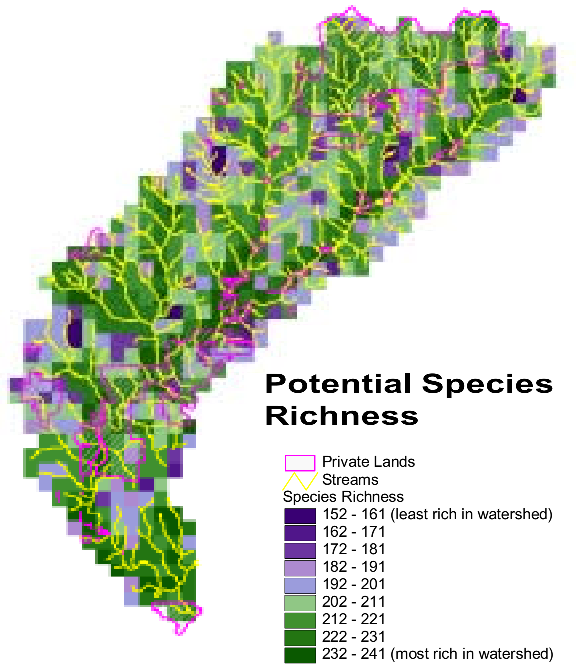


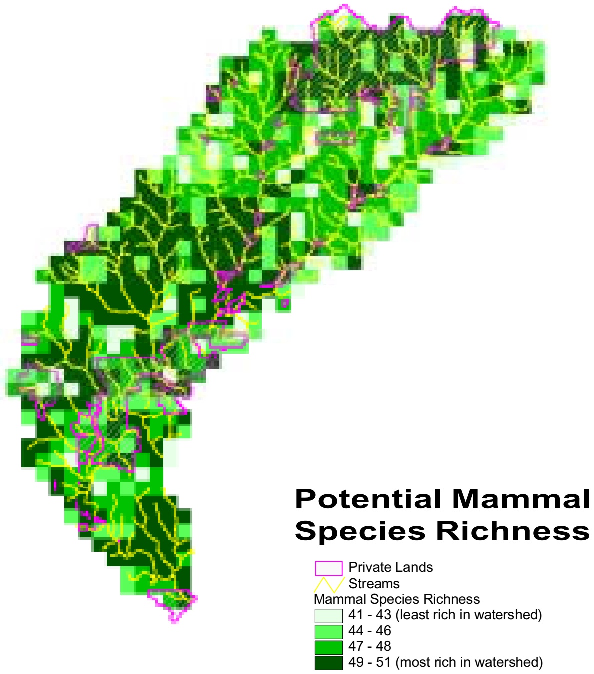
Figure 4.22 - Potential wildlife species richness throughout watershed. The riparian corridors are particularly species rich.

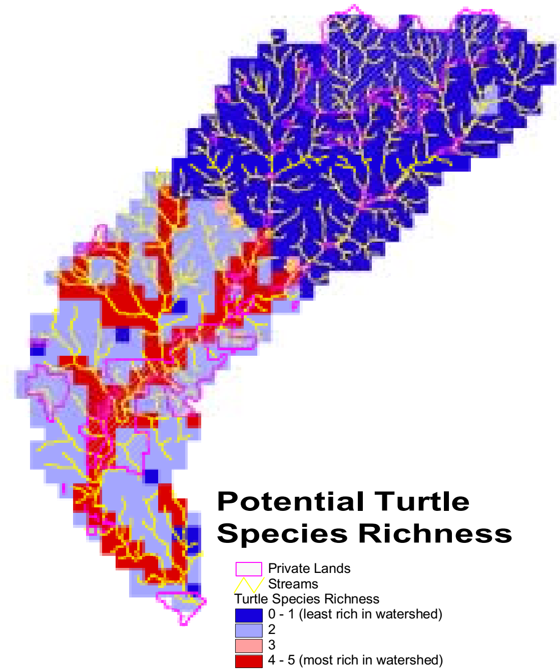
The goal of the National Gap Analysis Project (GAP) is to provide regional landscape assessments of the conservation status of vertebrate species found throughout the nation as well as land cover types and to facilitate the application of this information to land management activities (USGS National Gap Analysis 2000). The Pennsylvania Gap Analysis Project primarily attempts to locate unprotected areas where there is potential for high vertebrate diversity. The first step in accomplishing this task was to map major areas that serve long-term conservation purposes. No gaps were found because the Kettle Creek watershed consists of 92% state forestland and is considered protected.

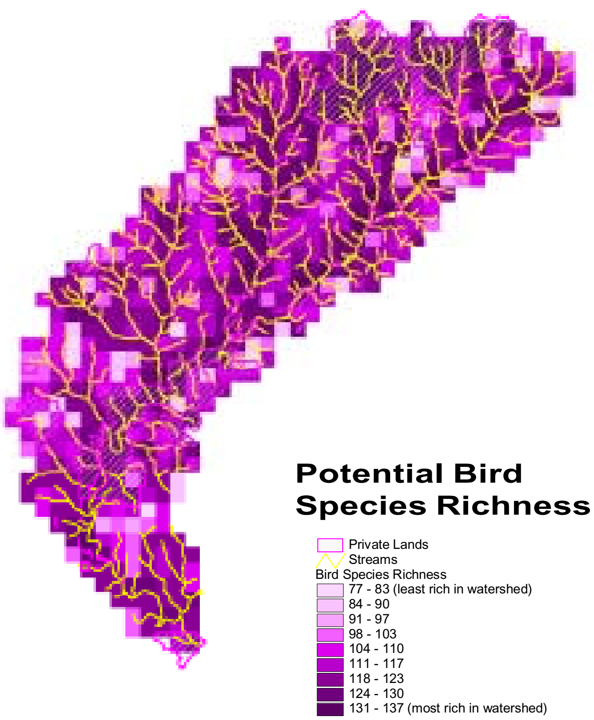
Other uses of GAP are to locate areas of potential species richness and to locate potential good habitat for an individual species. All maps developed using GAP have the state partitioned into landscape areas, which are further divided into one-kilometer square cells (0.62 miles). Pennsylvania GAP has considered 470 vertebrate species that are found in the state and has also taken into account the type of habitat each species prefers, the present landuse, and several other parameters. Out of these 470 vertebrate species, 285 vertebrate species have at least potential habitat in the Kettle Creek watershed. When mapped, it is apparent that stream corridors are high in total potential vertebrate diversity, especially along the mainstem of Kettle Creek (Figure 4.22). It is important to note that a large amount of the stream corridor is owned by private landowners and therefore opportunity exists for landowner participation in conservation efforts.

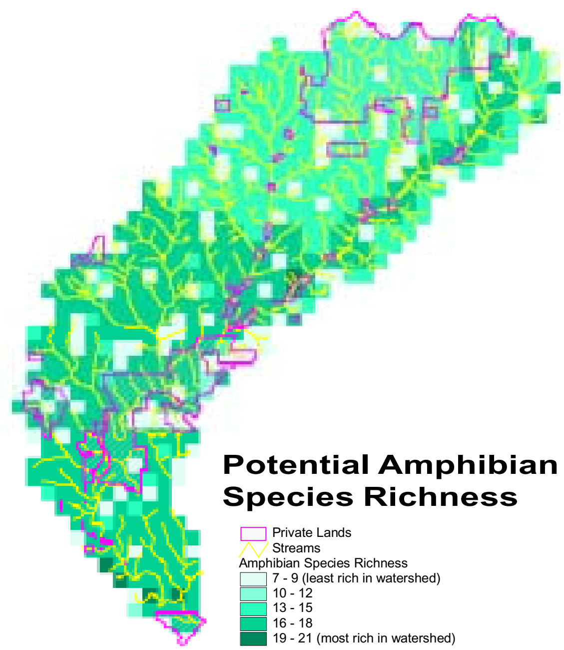
Individual richness maps were also created for this watershed (Figures 4.23, 4.24). Mammal and bird diversity potentially exists throughout the watershed but is highest along stream corridors. Turtle, amphibian, snake and lizard diversity was highest along stream corridors in the southern part of the watershed. Potentially, the most fish diverse area in the watershed is in the Twomile Run Subwatershed. This is important to note because presently this area is affected by acid mine drainage which has reduced or eliminated fish populations. According to GAP once the area is remediated, this could potentially host a very diverse fish population.

Another use of GAP is to use habitat maps as an aid in wildlife management. For example, if the watershed was to be managed for a specific species, the maps could locate areas in the watershed with suitable potential habitat for that species. Because there are 285 potential species in the Kettle Creek watershed, not all will be discussed here. However, maps are easily attainable using GAP data. Individual species, such as elk, white tailed deer, Allegheny wood rat (*Neotoma magister)*, northern goshawk (*Accipiter gentiles)*, brook trout, brown trout, and rainbow trout were selected to discuss here as examples of how GAP data may



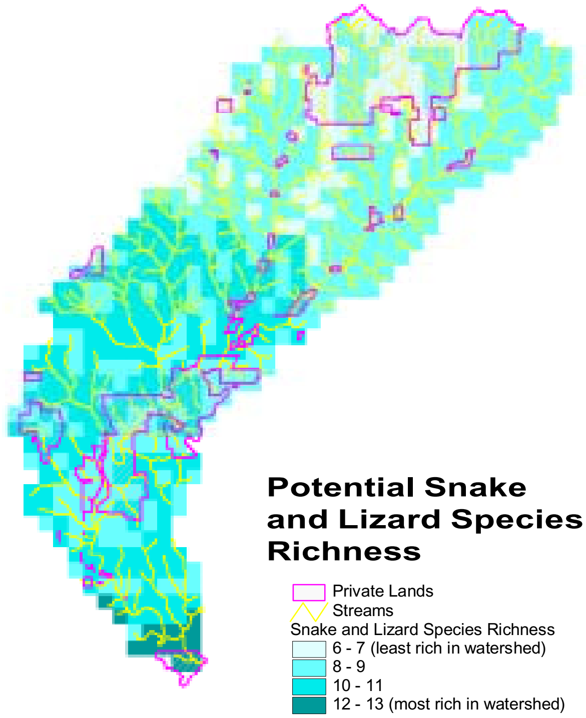


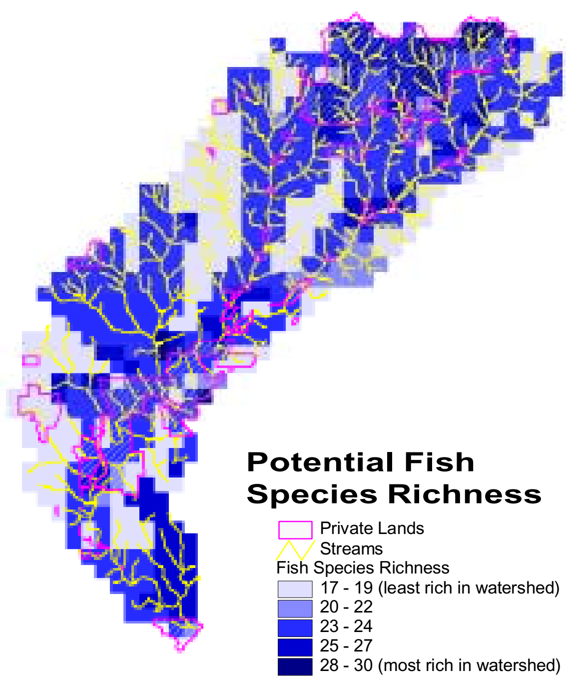




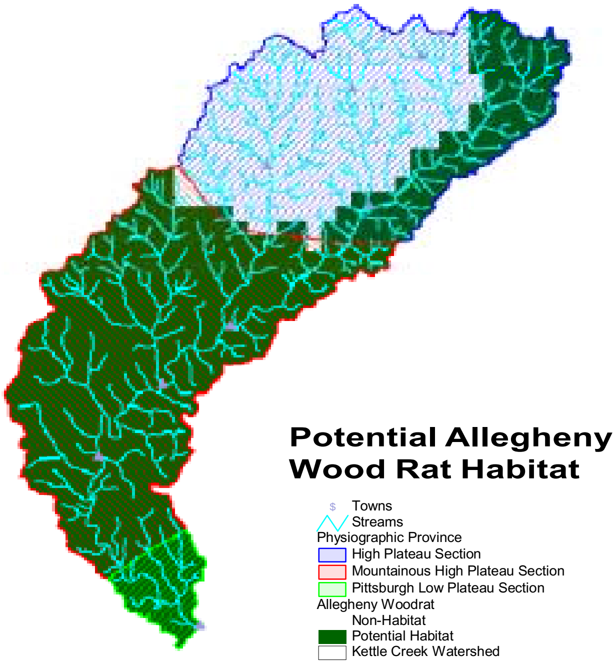
Figures 4.23 - 4.26 - Potential species richness maps aggragated by major groups: mammals, turtles, birds, and amphibians.

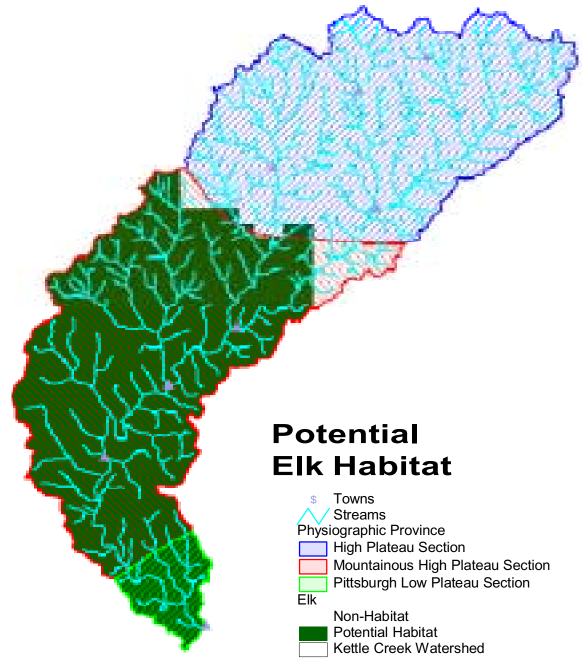
be interpreted. The best potential elk habitat is in the southern portion of the watershed, within the Mountainous High Plateau Section and the Pittsburgh Low Plateau Section of the Appalachian Plateau physiographic province (Figure 4.25). This distribution of potential habitat was true for many species. According to GAP, it seems that the High Plateau Section of the Appalachian Plateau physiographic province was potentially uninhabitable for various species, including elk. The Allegheny wood rat has potential habitat throughout the watershed, however in a small section of the northern half of the watershed, habitat is inadequate (Figure 4.25). White tailed deer and northern goshawk have potential habitat throughout the entire watershed. Northern goshawk and Allegheny wood rat are rare and uncommon species in Pennsylvania (Pennsylvania Natural Diversity Index). In the Kettle Creek watershed, there is potential habitat for 27 PNDI species (See Appendix G, page 305 for list and maps). Brown and rainbow trout can potentially exist thro out the watershed, except for a few localiz areas of the mainstem as can be seen in Fig 4.25. Brook trout also can potentially inhal most of the watershed, however, there are ı localized areas that are not suitable for bro trout habitat (Figure 4.25).

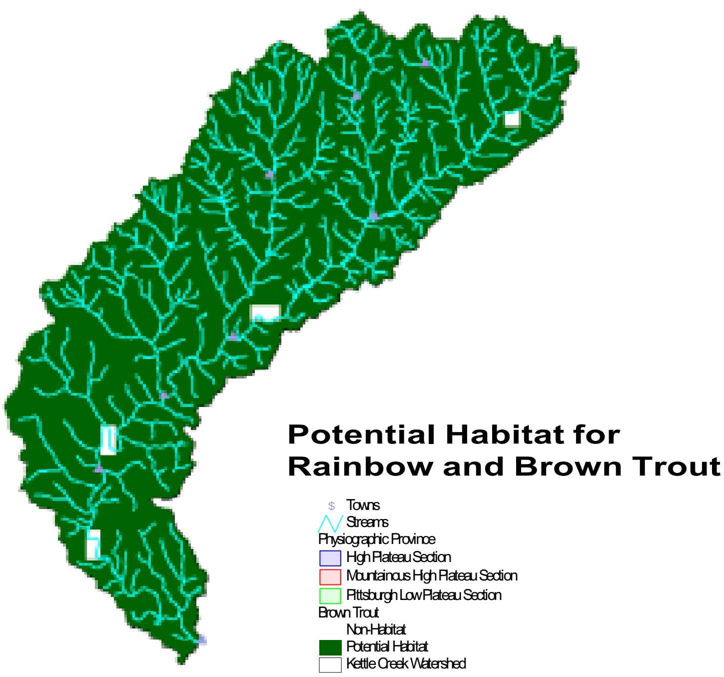


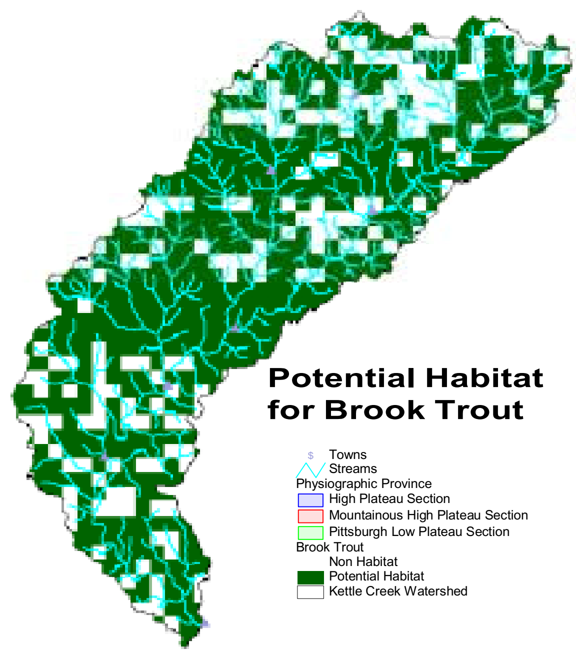


Figures 4.27, 4.28 - Potential species richness maps for snakes and lizards and fish.









Figures 4.29-32 - GAP Analysis maps displaying potential habitat for a specific species within the Kettle Creek watershed.

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THE QUALITY OF OUR

WATERS

Aquatic ecosystems have always been a vital part of our lives for recreation, aesthetics, and industry. Over the last two centuries, the waters of Kettle Creek have been adversely impacted by agriculture, logging, mining, atmospheric emissions, and development practices that were unsympathetic to their influence on aquatic systems and the surrounding landscape. More recent awareness for the interconnectedness of natural systems has drawn attention to conservation of current water conditions and mitigation of historic impacts for the continued health and enjoyment of the waters. The following chapter assesses the physical, chemical, and biological aspects of surface and ground water quality.

WATER QUALITY
PARAMETERS

Thermal Assessment

Temperature is one of the most important factors in determining the distribution of fish and macroinvertebrates. Even minimal fluctuations in temperature can influence which organisms inhabit a specific stream. The thermal regime of a stream can be of particular concern if the water temperature increases. Streams that lack vegetative cover or have wide channels (making the vegetative cover ineffective) are at risk of extreme temperatures. Also, long stretches of streams without cold water inputs from seeps, springs, or tributaries may be at risk of higher temperatures.

The Kettle Creek watershed was designated an "exceptional value" stream from the Alvin Bush Dam to the headwaters based on the Chapter 93 Water Quality Standards by the Pennsylvania Department of Environmental Protection (DEP 1998). Although the water quality is excellent throughout most of the watershed, thermal pollution has been a concern for more than 60 years (Watts and Harvey 1946). Kettle Creek is known for having wild trout, however habitat problems and high temperatures during the summer months have limited their populations. Typically 66° Fahrenheit is the ideal summer temperature for brook trout and they can withstand temperatures up to 75°. Brown and rainbow trout prefer 70° water in the summer while being able to survive up to 80° (Watts and Harvey 1946). Watts and Harvey (1946) concluded that in July and August temperature readings at many locations in the Kettle Creek watershed were too high for the survival of any species of trout. Today, this issue is still a threat to Kettle Creek's wild trout populations.

In the fall of 2000, the Kettle Creek Watershed Association (KCWA) requested the help of the

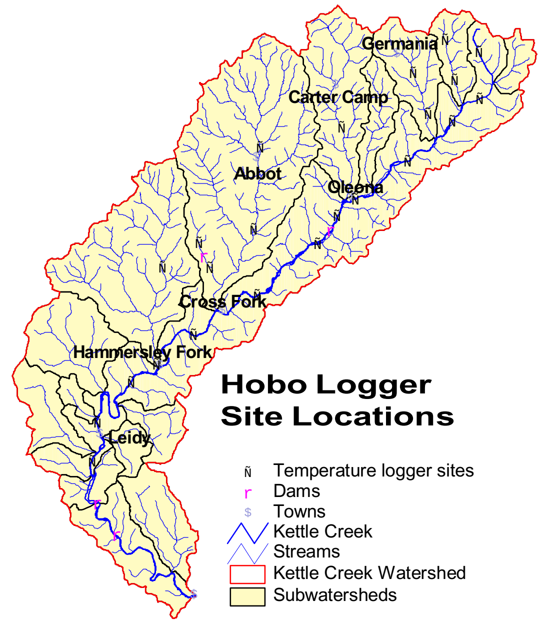


Figure 5.1 - Site locations for current thermal monitoring study using HOBO temperature loggers, installed Spring 2001.

Center for Watershed Stewardship (CWS) to complete a thermal assessment of the entire Kettle Creek watershed. Due to channel alterations and lack of canopy cover, many of Kettle Creek's "cold water" tributaries may not have optimal capacity to cool the mainstem.

After completion of a watershed habitat assessment, in the spring of 2001, the CWS, in cooperation with the KCWA, will begin monitoring the thermal regime of Kettle Creek and its tributaries. The objective is to establish a comprehensive long-term thermal study on Kettle Creek (from the headwaters to the Alvin Bush Dam) and its main tributaries and to provide a study plan that can be continued by the KCWA over a longer time period than the 2-semester Keystone Project. This study consists of 23 sites with HOBO temperature loggers calibrated to record stream temperature every hour (Figure 5.1). At time of publication, this study will be implemented and an example of the type of data that will be collected is located in appendix H, page 321.

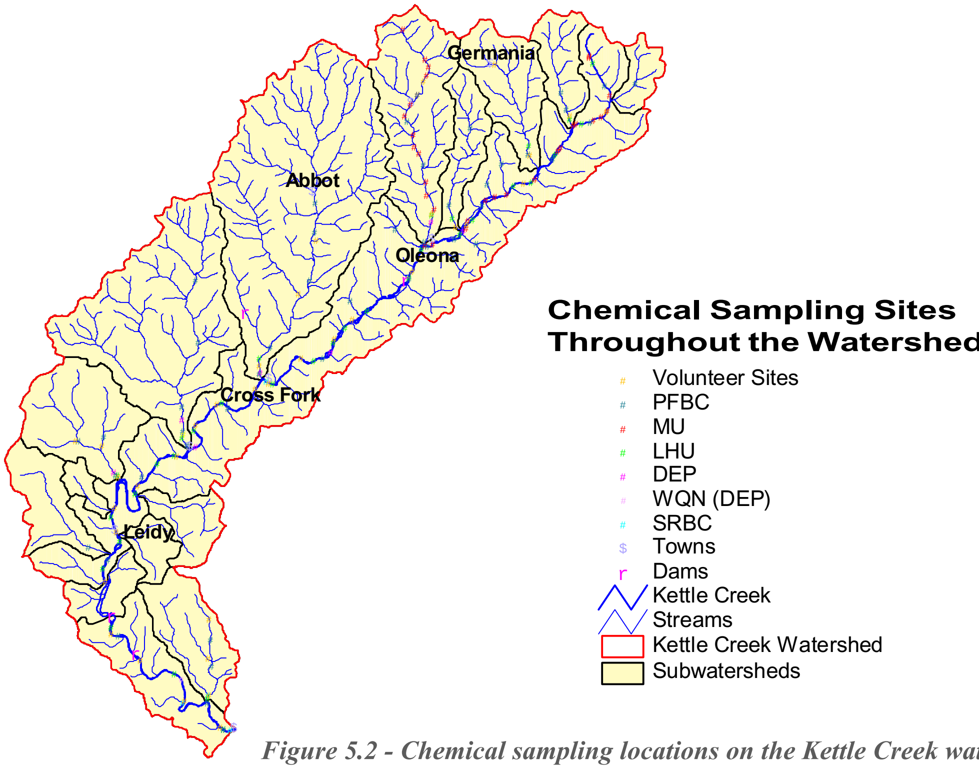


Figure 5.2 - Chemical sampling locations on the Kettle Creek watershed

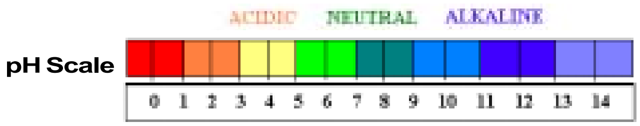
Chemical Assessment

The Kettle Creek watershed, from the Alvin Bush reservoir to the headwaters, is designated an Exceptional Value watershed by the Department of Environmental Protection’s Chapter 93 Water Quality Standards. Frequent monitoring of the water quality is necessary if this status is to be maintained. The Pennsylvania Fish and Boat Commission (PFBC), the Pennsylvania Department of Environmental Protection (DEP), Lock Haven University (LHU), Mansfield University (MU), the Susquehanna River Basin Commission (SRBC), the Water Quality Network (WQN), and the KCWA Volunteers have all gathered water chemistry data throughout the watershed (Figure 5.2). The WQN data pertains to one individual site (near the Westport USGS gauging station) that has been monitored frequently since 1972. The other studies have been one or two time measurements at many sites throughout the watershed. The various studies cannot be accurately compared due to different parameters analyzed, various locations, and the variety of dates sampled. Another important difference between studies is that LHU and MU used field sampling water quality kits (HACH) to obtain their data. This data may differ from data analyzed in a lab.

WATER CHEMISTRY

In this section, any parameter that has been sampled for will be defined and described. Parameters are reported in parts per million (ppm) or parts per billion (ppb). Parts per million is equal to the measurement mg/L and parts per billion is equal to micrograms per liter (µg/L). The majority of the parameters studied have been found to be at healthy levels throughout the watershed above the Alvin Bush Dam. Any parameters that are beyond healthy levels will be noted and discussed thoroughly. Healthy levels are defined by DEP's Chapter 93 Water

pH and Aquatic Organisms



Mayfly	5.5 to 7.5	Rainbow trout	5.5 to 9.5
Caddisfly	5.5 to 7.5	Brown trout	5.0 to 9.5
Stonefly	5.5 to 7.5	Brook trout	4.5 to 7.5
Crayfish	5.5 to 7.5	Smallmouth bass	5.5 to 7.5
Snails	6.0 to 9.0	Bullfrog	4.5 to 7.5

Figure. 5.3 - pH and aquatic organisms. (Taken from the PA Fish and Boat Commission).

Quality Standards (DEP, 1999) or the EPA's National Recommended Water Quality Criteria (EPA, 1998). If no standard level is indicated by either agency, then biological survival recommendations are defined by the Kentucky Water Watch (2001).

Acidity

Acidity is the measure of the ability of the stream water to neutralize bases. There are two types of acidity: potential acidity and active acidity. Active acidity is a measurement of free hydrogen ions in solution. A measure of active acidity is pH (For more information on pH see Figure 5.3 and page 166). Potential acidity measures the free hydrogen ions and also hydrogen ions that are tied up in complexes that have the potential to become free. When a study tests for acidity, they are testing for potential acidity.

1 part per million can be visualized as one fish in a million fish.

Potential acidity can be measured using a variety of methods. Two methods used by the Water Quality Network site are carbon dioxide (CO2) acidity and hot acidity (due to limestone inputs at the sampling site). Other acidity methods exist and various methods are used in the current Kettle Creek watershed studies. Because of the differences between all the methods, no potential problematic areas could be determined and no limit could be given.

Alkalinity

Alkalinity is the measure of the ability of the stream water to neutralize acids (Swistock 2000). Alkalinity is related to calcium and hardness in the water (for more information on calcium and hardness refer to pages 162-163). If alkalinity levels are high, most likely hardness levels will also be high. Alkalinity can also either be measured in the field or in the lab. Alkalinity levels should be at least 20 ppm in order for the stream to be able to resist acidity (DEP 1998). There are many areas in the Kettle Creek watershed that do not reach the DEP levels of alkalinity. According to the PFBC, freestone streams are very sensitive to acid precipitation at an alkalinity (calcium carbonate) 10 ppm or less. Freestone streams are somewhat sensitive to acid precipitation at 10-20 ppm and are not sensitive when the alkalinity is greater than 20 ppm.

Alkalinity levels within the Kettle Creek watershed range from 0.57 ppm - 41 ppm, with the majority of the levels being in the range of 11 ppm - 18 ppm. Alkalinity is related to bedrock geology of the watershed. If the geology consists primarily of limestone, alkalinity levels would be expected to be high. A mixture of gravel and stone substrate, which is derived from sandstone, shale, and conglomerate rock dominates Kettle Creek (for more information on geology refer to page199). This causes the stream to have little buffering capacity and low alkalinity. The AMD affected areas have extremely low alkalinity levels due to the acidity and dissolved metals in the stream and are discussed further in the AMD section of this report (page 187).

Aluminum

Aluminum (Al) is the third most abundant element in soil and is a large component of clays and silicate rock minerals. While it is a constituent of all soils, Al is not usually found in aquatic ecosystems at concentrations damaging to fish and insect life, unless introduced by human activities. In soils, Al is typically in the solid form, which is not available for uptake by plant roots and does not have the ability to flow into streams. When the pH of the soil goes below 5.0 (Meiwes and others 1986) Al is in the soluble form and replaces base cations like calcium (Ca) and magnesium (Mg) which are then leached into streams. After the Ca and Mg are completely leached from the soil, Al then follows. Once Al enters the stream system, even small concentrations negatively affect aquatic life. Reproductive problems in fish are common when streams have elevated Al and low pH levels (Carline and others 1998). It is common to have extremely high Al levels in AMD affected waters.

The Pennsylvania DEP Chapter 93 Water Quality Standards indicate that streams with Al levels above 0.1 ppm are harmful to aquatic life. On the entire Kettle Creek watershed, only two studies (DEP and SRBC) analyzed water samples for Al. The DEP study (that only sampled above the dam) found Al below the detection limit in all cases. The SRBC study found two areas above the dam with Al levels exceeding water quality standards (DEP 1998). These sites were on Kettle Creek at the confluence with Cross Fork Creek (0.24 ppm) and at the PA 120 Bridge (0.49 ppm). The other sites sampled below the dam had much higher levels of Al: 14.3 ppm at Twomile Run and 42.4 ppm along an acid mine seep on Kettle Creek at river mile 3. High levels of Al found below the Alvin Bush Dam are a result of AMD affected water.

Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Zinc

The following describes parameters tested for in the Kettle Creek watershed that were not at detectable limits.

Arsenic is a naturally occurring element that also has sources from human activities such as gas and oil well drilling. It is an extremely toxic inorganic chemical, which is why it has a primary drinking water standard. Once in the water supply, arsenic can cause problems with the circulatory and nervous systems, it can cause skin lesions, and it is a known carcinogen when exposure occurs for prolonged periods of time. Arsenic can also negatively impact aquatic life. The water quality standard for arsenic is 0.05 ppm (Swistock and others 2000).

Cadmium is not an essential element and it is detrimental to plant growth and very toxic to humans and aquatic life at high levels. In humans and aquatic life, reproductive problems are a common known side effect. Cadmium can be found in high concentrations in sewage sludge and it is also widely used for industrial purposes. A water quality standard of 0.001 ppm is considered protection for aquatic life and the drinking water standard is <0.01 ppm (Kentucky Water Watch 2001).

Chromium is an essential trace element that occurs naturally in the air, water, rocks and soil. It is commonly used in manufacturing of stainless steel, leather tanning, wood preservatives, and various others. Within stream systems it occurs in assorted forms with the two most common being chromium VI and chromium III. Chromium has a pH dependency. High doses of chromium VI can be extremely toxic to animals and humans (Kentucky Water Watch 2001), however other forms are not associated with any of these same effects. Total chromium is calculated by adding all sources of chromium in the water supply, but no criteria have been found for protecting aquatic life. However, the

Small dam located on Elk Lick Run

criteria for aquatic life is less than 0.011 ppm for chromium VI (Kentucky Water Watch 2001).

Copper is essential for all plant and animal nutrition. Copper is acutely toxic to most forms of aquatic life at relatively low concentrations. Copper sources include industrial effluents, mining, and urban developments (plumbing). Copper is hardness dependent. Aquatic life is under stress after copper levels reach 0.002 ppm (2 ppb) with the hardness = 50 µg/L (Resources Inventory Committee Publications 1998).

Lead is not an essential element and is toxic to both plants and animals. Lead can be found in batteries, pigments, and other metal products. Previously, lead was used as an additive in gasoline and became dispersed in the air, soils, and waters. Mining, smelting, solid waste incinerators, and other industrial emissions are now primary sources of lead. Lead reaches streams either through urban runoff or discharges such as sewage treatment plants and industrial plants. It also may be transferred from the air to surface water through precipitation (rain or snow). Lead's toxicity depends on its solubility and this, in turn, depends on pH and is affected by hardness. The level considered protective for aquatic life at a hardness of 100 is less than 0.003 ppm (Kentucky Water Watch 2001).

Nickel is a metal that occurs naturally at low levels in soil and rocks. It is released into the environment by volcanos, forest fires, vegetation, and human activities (sewage and metal waste). Nickel enters streams and water bodies through natural weathering and erosion processes. Nickel levels in surface water are normally very low (often undetectable).

Zinc is a naturally occurring essential element that is used in the vulcanization of rubber. Therefore zinc is found at higher concentrations in streams located near highways. Although it is found commonly in stream systems at low levels, it is not considered very toxic to humans or aquatic organisms. Water quality standards for aquatic life have been set at <0.106 ppm based on hardness of 100 ppm (Kentucky Water Watch 2001).

Calcium, Magnesium, and Hardness

Calcium and magnesium are common elements naturally occurring in streams. Both are necessary nutrients, but when in abundance, can be harmful. Calcium and magnesium both contribute to hardness. Hardness is a measure of the amount of calcium, magnesium and sometimes other nutrients (such as iron and manganese). It ranges from soft (< 75 ppm) to very hard (> 300 ppm). Calcium originates from the leaching of soil and other natural sources (such as rocks) or may come from man-made sources such as sewage and some industrial wastes. Calcium is very important in stream water because it is known to reduce the toxicity of many chemical compounds on fish and other aquatic life (Kentucky Water Watch 2001). Magnesium originates in ores and minerals and like calcium, is beneficial to fish during times of pollution stress. Levels of magnesium and calcium may be a factor in the distribution of species of fish and macroinvertebrates. All three parameters are measured in the laboratory. Magnesium

Classification of Water by Hardness Content	
Level (in ppm)	Description
0 - 75	soft
76 - 150	moderately hard
151 - 300	hard
> 300	very hard

Data taken from Kentucky Water Watch (2001), but are based on DEP Ch.93 Standards (DEP 1998)

Figure 5.4 - Description of levels (in ppm) of hardness.

does not have recommended levels or standards. For optimal trout conditions, calcium levels should be within 4-160 ppm (Larsen, unpublished). Levels below 150 ppm are recommended for hardness (DEP 1998). Figure 5.4 displays the classification of water by hardness content.

The stream water of the Kettle Creek watershed can be classified as soft; hardness levels range from 6 ppm - 45 ppm throughout the watershed.

Chloride

Chloride is a salt compound resulting from the combination of the gas chlorine and a metal. At low levels, chloride is commonly found in Pennsylvania streams. Small amounts of chlorides are required for normal cell functions in plant and animal life. Chloride may become elevated due to leaching from salt storage areas around highways, excessive road salting, rocks containing chloride, or from brines produced during gas well drilling. Other possible sources of chloride are sewage effluent, animal manure, and industrial waste (Swistock and others 2000). Fish and aquatic communities cannot survive in high levels of chlorides. After levels of 150 ppm and above, stress and eventually death may occur in fish and other aquatic communities (DEP 1998). Chloride is measured in the lab from a water sample taken from the stream.

The levels of chloride in the Kettle Creek watershed are very low, indicating no chloride pollution effects. The levels range from <1.0 ppm - 3.0 ppm and so are much lower than the DEP Ch. 93 water quality limit of 150 ppm.

Dissolved Oxygen and Biological Oxygen Demand

Dissolved oxygen (DO) is the amount of gaseous oxygen (O2) dissolved in water. Oxygen is necessary to most life forms and is a very important water quality parameter. Natural stream purification cannot occur without oxygen. Fish, plants, and macroinvertebrates are put under stress if the DO level drops below 4 ppm (DEP, 1998). If the DO level remains below 4 ppm for an extended period of time, fish mortality may occur. DO may enter water by circulating from surrounding air, rapid movement of fishes or other life, and as a waste product of photosynthesis. In areas of high water movement, such as riffles or waterfalls, DO is high. Cooler stream temperatures also allow for higher DO levels. Pollutants such as sediment, nutrients, and organic matter can cause DO to decrease due to an increase in microbial activity. As certain microbes break down pollutants, they use more oxygen, thus decreasing the stream oxygen levels. The amount of oxygen required for decomposition of a pollutant source is measured by the biochemical (or biological) oxygen demand (BOD). DO must be measured in the field with a dissolved oxygen meter because it changes rapidly. BOD is measured in a lab.

Dissolved oxygen and BOD levels are both very healthy throughout the Kettle Creek watershed. DO levels range from 6.5 ppm - 18.2 ppm, and so are well above the DEP minimum of 4 ppm. However, DO levels in the Kettle Creek Lake violated the minimum limit in lakes (5 ppm) in August of 1997 (Figure 5.5). BOD levels were only measured by one study, but found that the levels were around 0.2 ppm, indicating healthy levels.

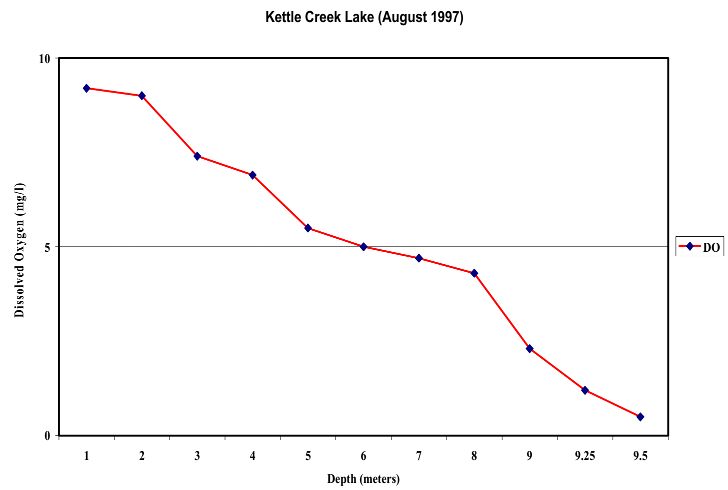


Figure 5.5 - Graph repreprenting Dissolved Oxygen (DO) in Kettle Creek Lake in August of 1997 (adapted from DEP data).

Fecal Coliform/Fecal Streptococcus Bacteria

Various types of coliform bacteria are found in the environment (Swistock and others 2000). Streams with high levels of these organisms indicate that the water has the ability to cause disease or make people ill if ingested. The higher the number of coliform bacteria in a particular area, the more likely disease-causing bacteria exist there as well. These types of bacteria commonly occur in areas where the stream has been contaminated by human and/or animal waste.

Coliform bacteria are a type of bacteria found in the excrement of living organisms.

The differences between fecal coliform bacteria and fecal streptococcus are minimal. However, by comparing the ratio of coliform to streptococcus, a probable source can be determined. Fecal coliform are only found in the intestinal tracts of humans and other warm-blooded animals and commonly a result of inadequate treatment of sewage. Fecal streptococcus is a bacterium that thrives in animal waste. If you compare the ratio of coliform to streptococcus and it is above 4.0, the bacteria is likely a result of human waste. If streptococcus is found in greater numbers, animal waste is probably the cause of contamination.

Regardless of the type of coliform bacteria and the source, it is an important parameter to test in water quality sampling. For drinking water standards no fecal coliforms are allowed to be detected (Swistock and others 2000). For swimming and other recreational purposes the standard is 200 per 0.211 pints (100 ml). On Kettle Creek, at the confluence of Cross Fork Creek, levels for fecal coliform reached 200 per 0.211 pints (100 ml) and levels for fecal streptococcus reached 240 per 0.211 pints (100 ml) during sampling. Analysis for fecal coliform bacteria is a lab procedure only.

Iron

By weight, iron (Fe) is the fourth most abundant element in the earth's crust. Fe is a ubiquitous trace element that is required for survival of plants and animals. It can be found in varying quantities within streams depending on the geology and water chemistry. In groundwater, Fe is commonly in a soluble state (Fe^{++}), however upon exposure to air it oxidizes into an insoluble state (Fe^{+++}). The soluble form Fe^{++} can remain in water with low DO for long periods of time; streams with low DO typically originate from groundwater or mines (Kentucky Water Watch 2001).

The DEP's safe water quality standards for aquatic life is 1.5 ppm for total Fe (soluble and insoluble). Throughout the Kettle Creek watershed the range in total Fe was from <10 ppb to 50 ppm. Two locations exceeded the standards to ensure safe levels for aquatic life. The first site, on Twomile Run, registered at 12.4 ppm of total Fe and the second site, a seep on lower Kettle Creek, registered 50 ppm of total Fe. Both of these areas were located in AMD affected waters. Optimal levels of total iron for trout is 0.15 ppm (Larsen, unpublished). This level is exceeded at a site on the mainstem by Westport and at the site mentioned previously. Analysis of total Fe is a lab procedure only.

SALTS

A salt compound is formed when a metal replaces hydrogen in an acid.

ORGANIC

Organic is material derived from living organisms. Inorganic materials are everything not derived from living organisms.

EUTROPHICATION

Eutrophication is a process whereby the waters become rich in mineral and organic nutrients. This may result in a drastic increase in plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.

Manganese

Manganese is usually in the form of salt compounds. It is a vital micro-nutrient for both plants and animals. Low levels of manganese can cause plant leaves to develop improperly. In animals, inadequate levels of manganese can result in reduced reproduction and poorly maturing young. High levels of manganese can cause fish kills. In natural waters manganese levels rarely exceed 1 ppm. The primary uses of manganese are in metal alloys, dry cell batteries, and micronutrient fertilizer additives. Levels above 1 ppm are not recommended and can be harmful to the stream life (DEP Ch. 93 standards). Levels above this standard frequently exist in acid mine drainage areas (Rose and Cravotta 1998). Optimal manganese levels for trout are at 0.01 ppm (Larsen, unpublished).

Manganese levels in the Kettle Creek watershed range from <0.001 ppm - 10.8 ppm. Excluding acid mine drainage affected areas, manganese levels are well under the recommended standard. At Twomile Run, manganese levels reach 10.8 ppm and on Kettle Creek (at an acid mine seep) manganese levels reach 8.7 ppm. (For more AMD information refer to page 187).

Forms of Nitrogen

Nitrogen in streams comes in various forms. Ammonia (NH_3), nitrite (NO_2), nitrate (NO_3), and organic nitrogen are just a few of the different forms. Total nitrogen is a measurement of organic and inorganic of nitrogen. Kjeldahl nitrogen (also abbreviated as Kjeld-N) refers to the laboratory method used to determine both the ammonia and the organic form of nitrogen. Results recorded in NH_3-N measures only the concentration of N in the form of ammonia. Kjeld-N refers to the combination of ammonia and organic nitrogen. Excess ammonia contributes to eutrophication of streams and lakes resulting in algal growths that have deleterious impacts on other aquatic life, drinking water supplies, and recreation. Ammonia at high concentrations is toxic to aquatic life. Organic nitrogen is not immediately available for biological activity. It first would have to be broken down into inorganic nitrogen. Once it is broken down into inorganic nitrogen, then it further causes the algal and plant life to increase at a rapid rate. Nitrate and nitrite also increase eutrophication. These nitrogen forms can naturally occur in the stream at low levels. An increase could be caused by sewage treatment plant effluents, agriculture, urban developments, paper plants, industrial effluents, recreation, mining, or septic systems. Recommended

Recommended Levels for Forms of Nitrogen	
Form of Nitrogen	**Maximum Level (ppm)***
Nitrite	90
Nitrate	0.5
Ammonia	0.05**
Organic	None
Kjeld-N	None
Total-N	None
*(Kentucky Water Watch, 2001)	
**This value is the un-ionized form and can be calculated from total ammonia, temperature, and pH	

Figure 5.6 - Recommended levels for the various forms of Nitrogen.

levels of the forms of nitrogen are found on Figure 5.6.

According to these studies, there are no sites with nitrite levels above the standard. Nitrate levels are high at a site on Little Kettle Creek and two sites on the mainstem (one site at the mouth of Long Run, one site is located between Bergstresser Hollow and Cross Fork). Due to the various sources of nitrate pollution a cause of these high levels cannot be pinpointed from this data. Further monitoring of these locations is recommended. Ammonia levels may or may not be lower than the standard. Because ammonia is pH and temperature dependent, a complicated calculation is needed to set a standard level (DEP 1998).

pH

pH measures the hydrogen concentration in the water and indicates how acidic or basic a stream is on a scale of 0 to 14 (7 being neutral, 0 being extremely acidic, and 14 being extremely basic). Natural waters usually have a pH between 6.5 and 8.5. Generally, pH is an expression of the intensity of the basic or acid condition of a liquid (Swistock and others 2000). pH is measured either in the field with a probe or in a lab with a laboratory meter. There are many factors that can cause the pH to fluctuate. The presence of limestone (calcium-carbonate) will raise the pH. Acid mine drainage and acidic deposition are two factors that can lower pH.

Within the Kettle Creek watershed, pH values above the Alvin Bush dam to the headwaters range from 5.5 - 8.6. The majority of the pH values are in the 6.5-8.0 range. These are normal levels for natural surface waters. According to DEP water quality standards, pH below 6.0 or above 9.0 is a cause for concern. Out of all studies, only two pH values were below 6.0 (above the Alvin Bush Dam to the headwaters). Both these values were found on Little Kettle Creek and are not a major area of concern, but it may be beneficial to monitor these sites further.

According to the studies mentioned above, sites on the mainstem of Kettle Creek seem to have normal pH levels except for streams with AMD problems in the lower watershed (for more information on AMD refer to page 187).

Phosphorus

Phosphorus is one of the key elements necessary for growth of plants and animals. Phosphorus forms phosphates (PO4) that are found in sewage, detergents (in minimal amounts), and fertilizers. Each source of phosphate has only one form. There is also a form of phosphate, called organic phosphate, which exists in the natural stream environment. Organic phosphates help break down other forms of phosphate when they enter an aquatic system. Phosphorous can stimulate the growth of aquatic plants and plankton. However, high levels of phosphorous can cause algae to grow wildly and "choke" the stream life by using up all the oxygen in the stream (eutrophication). During eutrophication high levels of nitrogen also may exist. Eutrophication caused by an increase in phosphorus is more easily remediated than nitrogen because once the form of phosphate is known, the source is also determined. Phosphorus is tested in the laboratory by obtaining a water sample from the stream. Recommended levels of phosphorous are no more than 0.1 ppm for streams that do not empty into reservoirs, no more than 0.05 ppm for streams discharging into reservoirs, and no more than 0.025 ppm for reservoirs (Kentucky Water Watch 2001).

In the Kettle Creek watershed, phosphorous levels range from <0.02 ppm - 0.06 ppm. These are borderline levels recommended for streams discharging into reservoirs. However, above the reservoir, all levels are less than or equal to 0.03 ppm. The higher levels of phosphorous are in the stream downstream of the Alvin Bush reservoir. These levels are not a cause of concern, but should be monitored to observe any increases or decreases.

Sulfate

Small levels of sulfates (SO_4) are normally present in streams. Sulfates occur naturally as a result of leaching from sulfur deposits in the earth (Swistock and others 2000). High levels of sulfates are common in areas where coal mining was prevalent. Acid mine drainage results from the oxidation of sulfide materials in the rock disturbed by mining (Callaghan and others 1998). Sulfates in stream water are usually measured in the lab from a water sample from the stream. The maximum level of sulfate is 250 ppm (DEP 1998) in surface waters.

Sulfate levels in the Kettle Creek watershed ranged from <10 ppm - 17 ppm in non-AMD affected areas and from 37 ppm - 1375 ppm in AMD affected areas. Above the Alvin Bush dam, sulfate levels are well under the maximum level and are considered at a healthy level. In the lower section of the watershed, sulfate levels are extremely high, due to the acid mine drainage problems (for more information on AMD refer to page 187).

CWS students measuring stream flow.

Total Suspended Solids and Total Dissolved Solids (estimated Specific Conductance)

Total suspended solids (TSS) consist of an inorganic fraction (such as silts or clays) and an organic fraction (algae, zooplankton, bacteria, and detritus) that are carried by water from surface runoff (Kentucky Water Watch 2001). This is a common occurrence on streams with steep adjacent slopes and/or poor riparian buffers. Vegetative cover on stream banks and hill slopes is very important for trapping and filtering sediment from entering the waterway. Another way that streams receive high levels of suspended solids is from the human activity of dredging. This process causes resuspension of sediments from the bottom of the stream. It is obvious when a stream is high in suspended solids because the water has a muddy appearance, commonly referred to as turbidity.

Turbidity can be harmful to various aquatic organisms. Suspended solids can directly affect fish by clogging gills, causing growth declines or mortality. It can indirectly affect fish by impeding light penetration, and reducing the ability of algae to produce food and oxygen. When siltation occurs, a coating is formed on the stream bottom, which can smother bottom-dwelling organisms and eggs. Turbidity also

Siltation is the process in which heavy loads of suspended solids, or fine particles, settle to the stream bottom.

interferes with stream temperature, DO, drinking water treatment, recreation and aesthetics.

No standard limit exists for this parameter. However, studies indicated that when water levels reached 80 ppm, the macroinvertebrate population was decreased by 60% (Kentucky Water Watch 2001). All sampling points on the Kettle Creek watershed had ranges of TSS well below 80 ppm.

Total Dissolved Solids (TDS), frequently estimated by specific conductance, is a measure of the amount of dissolved material in a water column and can be used as an indicator of chemical water quality. Conductance is the ability of a body of water to conduct electricity. This is highly variable spatially between streams depending on geology and pollution levels. There are many purposes for determining conductance, one of which is to compare the water quality of two separate stream systems or to determine the rate in which TDS are transported from streams into the ocean. Conductivity is often used to estimate TDS because conductivity increases as levels of TDS increase.

High levels of TDS can be caused by sources such as mining, industrial effluent, sewage treatment, agriculture, road salts. Once high levels are reached, the water becomes undrinkable due to a bad taste and a laxative effect. It can also cause corrosion and have negative effects on aquatic life. Levels of specific conductivity range from 50-1500 µS/cm, however no critical levels have been established. TDS levels for water quality standards must not exceed 500 ppm (Kentucky Water Watch 2001). The Kettle Creek watershed has TDS levels ranging from 18-44 ppm. All TDS sampling sites are located above the Alvin Bush Dam.

GOALS: WATER QUALITY

WQ 2.1: Develop water quality sampling protocol

WQ 2.2: Establish Water Quality Network station above Alvin Bush Dam

WQ 1.1: Reduce nutrient, sediment, and chemical non-point source pollution delivery to target areas and key tributaries

WQ 1.2: Identify and mitigate acid mine drainage sources

LU 1.2: Develop and encourage the use of Best Management Practices (BMPs) on Agricultural Production lands to minimize impacts on adjacent natural resources

Introduction

Macroinvertebrates are organisms that live on the bottom of streams. For over 70 years macroinvertebrates have been used to determine stream quality for either fishermen or scientists (Merritt and Cummins 1996). Within the last 30 years, the use of macro-invertebrates as indicators of water quality has become a dominant technique in stream ecology. Fish, algae, and protozoans have all been used as water quality indicators in the past, however, aquatic macroinvertebrates have become the leading bioindicator. Because macroinvertebrates are found all over the world and they have many species with long life cycles, macroinvertebrates are superior over all other biota for monitoring the quality of streams. Bioindicators are also a preferable method over chemical testing because the latter is more expensive, more complex, and it only provides a snapshot of the stream's water quality at a single point in time.

The complexity of using bioindicators to assess water quality in streams is largely due to taxonomic identification. Without proper identification of each macroinvertebrate, the assessment will be inconclusive. Also, bioindicators can be misleading if other ecological factors such as substrate and velocity affect macroinvertebrate diversity and abundance. This would suggest that when determining water quality of a stream, macroinvertebrates should be used in conjunction with physical assessments or chemical monitoring for the most accuracy.

When using macroinvertebrates to determine water quality, a variety of rapid assessment approaches can be used (Rosenberger and Resh 1996). These rapid assessment approaches were created to reduce costs of environmental assessments. The following is a description of each of the rapid assessment approaches used on the Kettle Creek watershed. Taxa richness is one type of rapid assessment that is based on the number of taxa in a given community. This approach uses the idea that the larger the diversity of macroinvertebrates, the better the water quality. This method can be inaccurate due the inability to identify to the species level; hence identification to genera or family is often employed. Another assessment approach is EPT richness. This method, which is a variation of the above technique, determines the richness of mayflies (*Ephemeroptera*), stoneflies (*Plecoptera*) and caddisflies (*Trichoptera*). The theory behind the approach is that all three of these aquatic taxa are intolerant to pollution. Therefore a stream that is rich in all three of these insects would be considered to have good water quality.

Protozoans are any of a large group of single-celled, usually microscopic organisms, such as amoebas, ciliates, flagellates, and sporozoans.

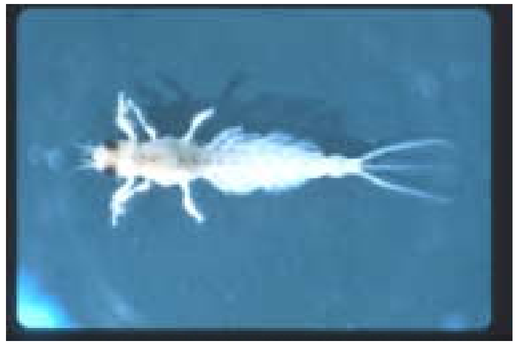
A Bioindicator is an organism used to monitor water quality.

MACRO-INVERTEBRATES

Diversity indices were developed originally because ecologists theorized that diversity in any biotic community signals a balanced and stable ecosystem. Diversity indices count the number of macroinvertebrates in each individual species and calculates the evenness between species. When applied to macroinvertebrate populations, this theory does not consider the specific tolerance of each individual macro-invertebrate. Biotic index (BI) is a frequently used

Taxa (Order)	Common Name	Class*
Ephemeroptera	Mayfly	I
Plecoptera	Stonefly	I
Trichoptera	Caddisfly	I
Decapoda	Crayfish	I
Peleycypoda	Fingernail Clams	I
Coleoptera	Water Penny	II
Isopoda	Aquatic Sowbug	II
Amphipoda	Scud	II
Odonata	Dragonfly/Damselfly	II
Megaloptera	Hellgrammite	II
Diptera	Black Fly/Cranefly	III
Gastropoda	Snails	III
Tricladida	Flatworms	III
Hemiptera	Water Strider/Boatman	III

*Table 5.7 - Indicator organisms grouped by class according to W. M. Beck, Jr. *Class I taxa are pollution sensitive, Class II taxa are moderately pollution sensitive, and Class III taxa are pollution tolerant*



Mayfly (Order Ephemeroptera)

Stonefly (Order Plecoptera)

Damselfly (Order Odonata)

Caddisfly (Order Trichoptera)

Water Boatman (Order Hmiptera)

Crayfish (Order Decapoda)

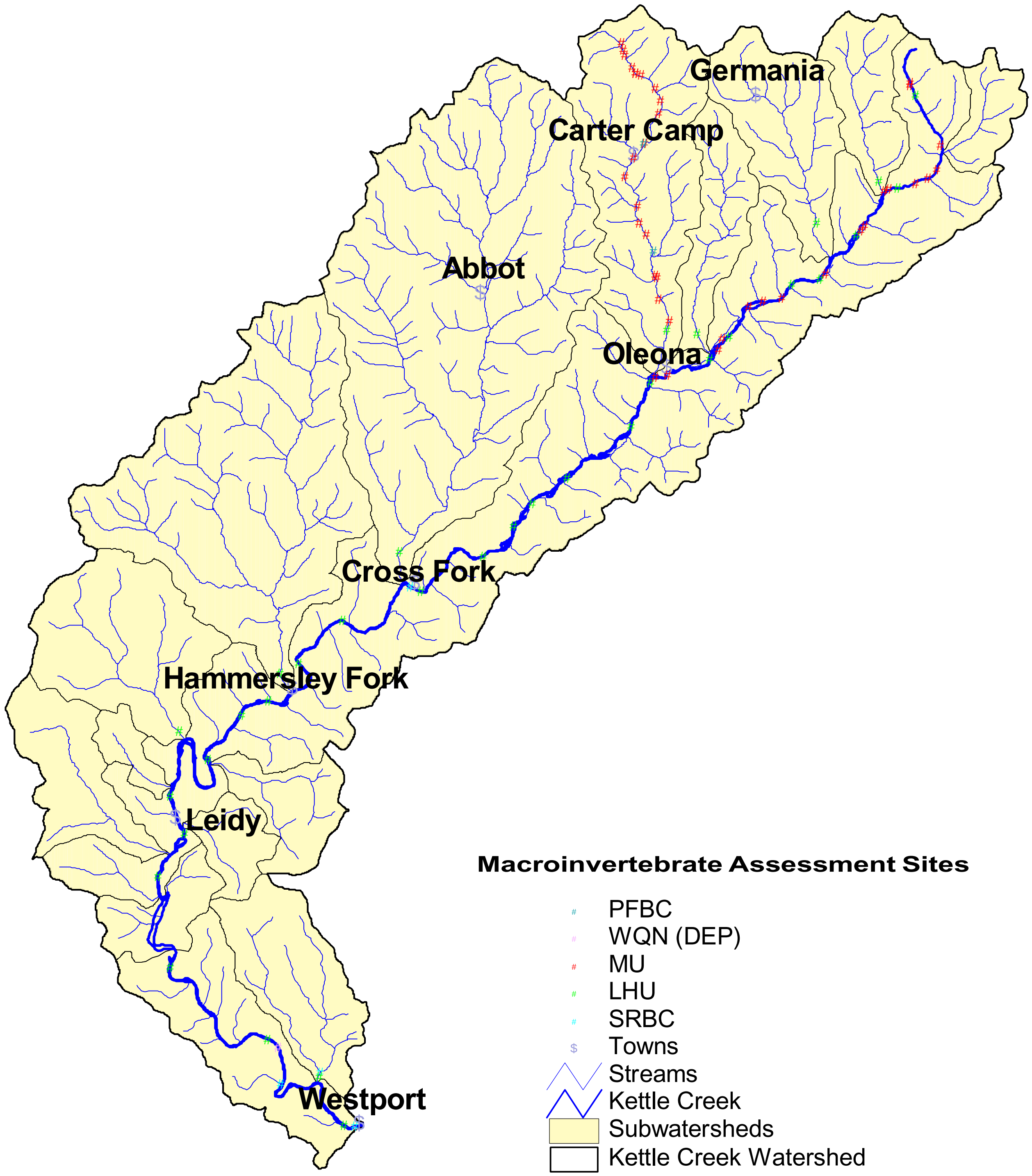


Figure 5.8 - Map of site locations of macroinvertebrate assessments conducted in the Kettle Creek watershed.

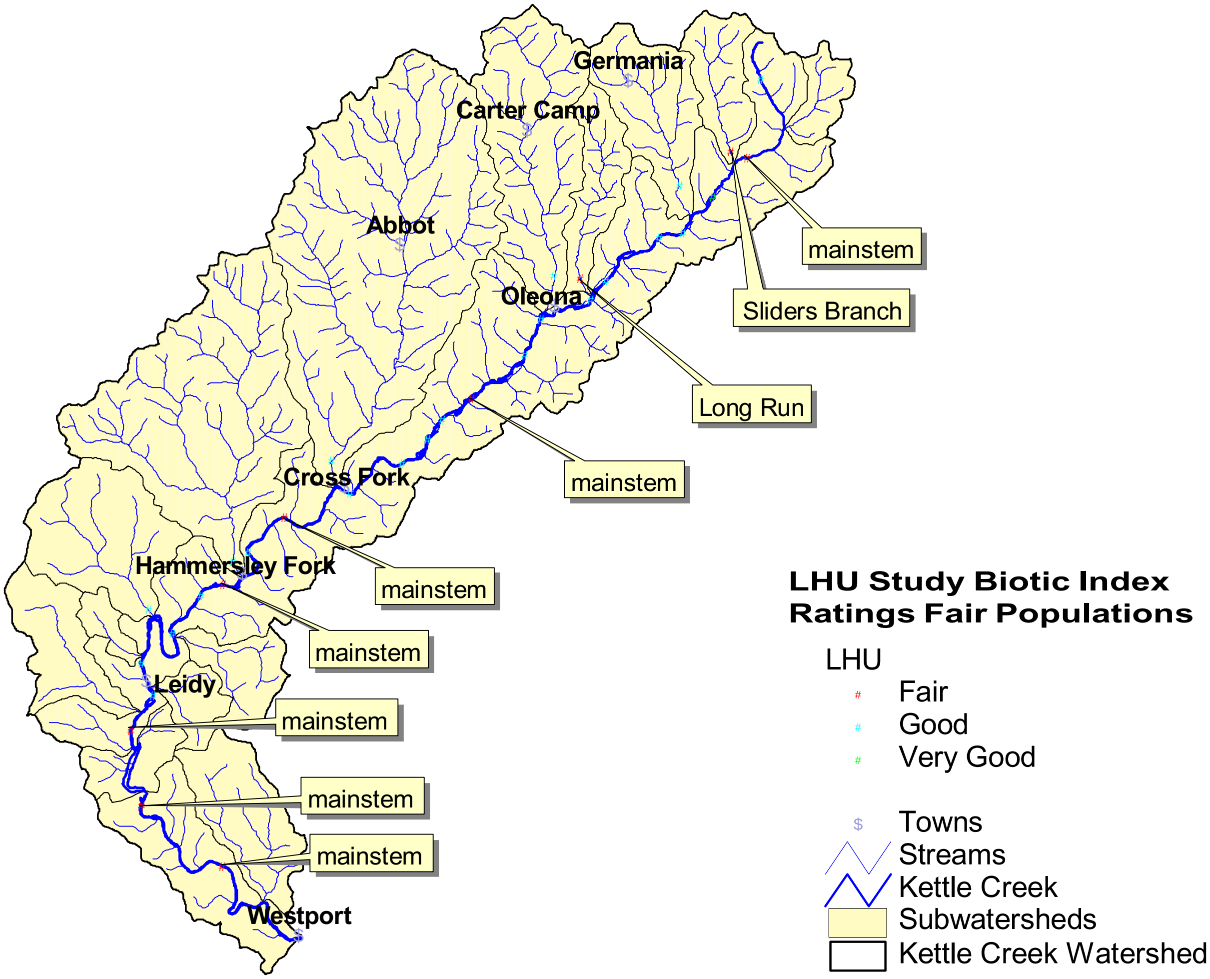


Figure 5.9: Map of LHU sites that obtained a Fair Value Rating.

Taxa refers to any taxonomic category or group, such as a phylum, order, family, genus, or species.

method of assessing macroinvertebrates because it is easy to understand. The BI method gives each insect a tolerance rating and then, after calculating abundance, gives a measure of the amount of pollution at that site based on the number and type of organisms found. This measure can be inaccurate if the insects are not given the correct rating before they are sampled.

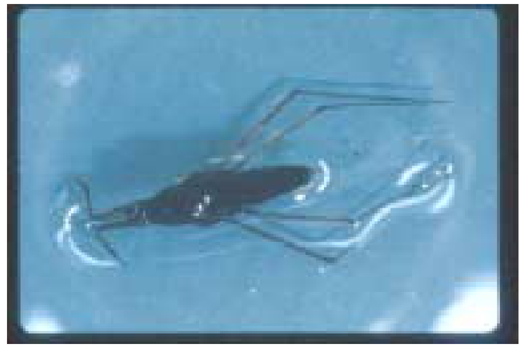
One final approach used on the Kettle Creek watershed is the Family Biotic Index (FBI), which is also called the Hilsenhoff family level biotic index (HBI). The HBI is similar to the BI except that taxonomic identification is at the family level in the HBI instead of at the species level as it is in the BI. The HBI is extremely useful in regions where taxonomic identification keys and details on the area are difficult to obtain. Beck's index is a method that classifies aquatic invertebrates into categories depending on their response to organic pollution. However, Beck's index has also been useful in classifying other types of pollution (Sharpe and others 2000). Beck divided macroinvertebrates into three groups based on their ability to tolerate organic pollution (Figure 5.7).

This analysis summarizes macroinvertebrate sampling that has occurred on the Kettle Creek watershed within the last 20 years. Kettle Creek watershed studies within this time frame were completed by the Pennsylvania Fish and Boat Commission (PFBC), the Susquehanna River Basin Commission (SRBC), Water Quality Network Station sampled by the Pennsylvania Department of Environmental Protection (DEP), Mansfield University (MU), and Lock Haven University (LHU). Site locations can be viewed in Figure 5.8.

The Beck's Index was applied to most of the macroinvertebrate data collected on the Kettle Creek watershed. The results of this index indicate that there is minimal organic pollution throughout the watershed except at the confluence of Kettle Creek and the West Branch of the Susquehanna River (near PA 120 bridge at Westport).

The LHU study used a different version of the Beck's Index and found that the majority of the watershed is in good condition. At sites on Sliders Branch, Long Run, and at 7 locations on the mainstem Kettle Creek fair conditions were found (Figure 5.9).

As previously mentioned, Beck's Biotic Index ratings only consider organic pollution as a problem. In the AMD affected areas in the lower watershed, some sites still scored high according to Beck's Index. Acid tolerant and intolerant species may differ from those tolerant



Water strider (Order Hemiptera)

Snails (Order Gastropoda)

Dragonfly (Order Odonata)

Biota are all the plant and animal life of a particular region.

to organic pollution. A good indicator of high acidity is the absence of mayflies and the presence of crustaceans (Kimmel 1998). To measure stream acidity using biological processes, the macroinvertebrates need to be identified to species. There are some species within an order (ex. Stoneflies) that are acid tolerant and other species within the same order that are acid intolerant (Kimmel 1998). As a result identifying macroinvertebrates just to order or family would not be sufficient in measuring acid tolerance. None of the study sites in the AMD affected areas of the watershed identified macroinvertebrates to species and so no conclusions can be made dealing with any effects the acidity of the stream had on macroinvertebrate communities.

GOALS: MACROINVERTEBRATES

WQ 2.1: Develop water quality sampling protocol

FH 1.2: Improve stream habitat focusing on flow, substrate, and riparian areas

WQ 1.1: Reduce nutrient, sediment, and chemical non-point source pollution delivery to target areas and key tributaries

Introduction

Surface water quality is important in the Kettle Creek watershed because the high water quality differentiates this stream from other streams in Pennsylvania. The surface water has been designated by the DEP as exceptional value (EV) to the citizens of the commonwealth. Much of the activity in the watershed is dependent on high water quality with trout fishing as the primary example. High water quality is maintained through wise land-use and management of water resources. Continual monitoring is necessary to preserve and protect Kettle Creek's water quality.

Water Quality Network Station near Westport (WQN434).

Water Quality Network (WQN)

The WQN is a nationwide monitoring system that collects surface water quality data at designated sample sites on a routine time schedule. The data are used to assess long term water quality trends. The water quality parameterslisted below were evaluated to assess the surface water quality of Kettle Creek (at WQN station 434 which is located at the USGS gauging station 3.0 miles north of Westport). The data for these parameters was queried from the United States Environmental Protection Agency's (EPA) STORET database (Figure 5.10). STORET (short for STOrage and RETrieval) is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others (EPA website 2000)

SURFACE WATER

The surface water quality is high at the WQN station. Long-term trends show that summertime temperatures exceed optimal temperature for trout. The high temperatures are attributed to low flows and wide shallow channels. Dissolved oxygen (DO) also decreases with summertime temperatures. The chemical parameters are also representative of high water quality. The WQN station shows that the mean values fall within the parameters that designate this

Water Quality Network Parameters	
ACIDITY, TOTAL HOT (MG/L AS CACO3)	MANGANESE, TOTAL (UG/L AS MN)
ACIDITY, CO2 (PHENOPHTHALEIN)	NITRATE NITROGEN, TOTAL (MG/L AS N)
ALKALINITY, TOTAL (MG/L AS CACO3)	NITRITE NITROGEN, TOTAL (MG/L AS N)
ALUMINUM, TOTAL (UG/L AS AL)	NITROGEN, AMMONIA, TOTAL (MG/L AS N)
BOD, NITROGEN INHIB.,TOTAL, 5 DAY, 20 DEG C MG/L	OXYGEN, DISSOLVED*(DO)
CHLORIDE,TOTAL IN WATER	PH (STANDARD UNITS)
NITRATE NITROGEN, TOTAL (MG/L AS N)	PH, LAB, STANDARD UNITS*
FLOW, STREAM (MEAN DAILY)	STAGE, STREAM (FEET)
IRON, TOTAL (UG/L AS FE)	TEMPERATURE, WATER (DEGREES CENTIGRADE)

Figure 5.10 - Water quality parameters collected at water quality network station and analyzed for watershed assessment.

stream as EV The sampling frequency may not be high enough to catch water quality events that possibly inhibit the aquatic ecosystem. Data queried from the STORET database have many gaps exceeding 90 days and a lack of continuously sampled parameters. It is possible that the data are not sufficient to adequately assess the surface water quality of Kettle Creek. The other problem is that the WQN station is located below the Alvin Bush Dam which influences parameters being measured.

The Stormwater Management Act regulates stormwater runoff from land alteration through stormwater management plans developed by the county governments and implemented by township ordinances. Stormwater will only be effectively mitigated if each citizen makes an effort to minimize impacts locally and develop a watershed wide approach to address present and future stormwater issues.

WQN Data Summary:

Some parameters are measured in mg/l or parts per million (ppm). Parameters with even lower relative concentrations are measured in ug/l or parts per billion (ppb) For more detailed information about the implications of the parameters refer to chemical descriptions of water quality in previous section. The data analyzed were collected from September 1972 to December of 1998. The values for total acidity ranged from a max of 54 ppm and a min of 0. The mean is 2.4 ppm. Total alkalinity ranged from 38 to 0 ppm with a mean 11 ppm. Total Aluminum values ranged from 1920 to 30 ppb. Mean was 148.9 ppb. BOD ranged from 0.2 to 3.2. Chlorides ranged from 7.0 to 0.3 ppm with the mean being 3.1 ppm. Total Nitrogen ranged from 1.0 to 0.3 ppm with mean 0.4 ppm. Flow at the WQN is moderated by the Alvin Bush Dam (ABD) and does not characterize the dynamic flow regime of the watershed above ABD. Flow ranged from 3230 cfs to 6.6 cfs with the mean instantaneous flow of 335.2 cfs. Iron (mg/l) ranged from 2.8 to 0 ppm with mean of 1.87 ppm. Manganese values ranged from 1.4 to 0.02 ppm with mean of 0.07 ppm. Nitrate values ranged from 0.166 to 0.002 mg/L with a mean of 0.012 ppm. Ammonia (NH4) values ranged from 1.0 to 0.0 ppm with a mean of 0.04 mg/L. Dissolved oxygen values ranged from 14.1 to 0.0 ppm with a mean value

of 10.57 mg/L. Lab pH ranged from 9.2 to 4.5 with mean pH of 6.6 units. Temperature ranged from 29.2 C (84.6 F) to 0 C (32.0 F) degrees centigrade with a mean temperature of 12.2 C (54.0 F) degrees centigrade. Using guidelines developed by Piper and others (1982) for fish raised in hatchery conditions only the ammonia, chlorides, and iron parameters exceed acceptable values for trout propagation. Maximum temperature value exceeds the value described by Piper and others (1982), but the mean temperature falls into the acceptable range. DO, alkalinity, pH, and nitrate are at acceptable levels.

Stormwater Management

Stormwater runoff is produced during a rainfall event in which water falling on impervious surfaces within a developed area to infiltrate in the soil and takes the form of surface runoff. A developed area is defined as an area where the natural land surface has been modified by changing the vegetation type or physical surface. This surface runoff, while traveling over impervious surfaces, carries with it pollutants present on them and discharges them into a nearby stream, pond, or wetland. The pollutants in runoff varies with differing land uses and could contain high nutrient levels in runoff from residential housing and other managed lawn areas and could contain metals, organic and inorganic compounds in runoff from industrial sites. Road runoff can contain oils, road salt, and sediment. This polluted runoff joins nearby streams and causes long-term impacts on aquatic life and drinking water sources. In addition to impairing the water quality, increasing runoff volumes, due to significant increase in impervious areas, causes localized flooding. The storm flows are typically of higher volume over a shorter period of time and thus causes severe impacts to stream morphology; including stream bank erosion, scour of streambed, and resulting sedimentation of streambed. The changes in stream morphology significantly impact fish communities.

Small culvert at Ole Bull State Park.

In the case of the Kettle Creek watershed, similar effects could be anticipated in the near future considering the potential for future development. Although the watershed has extremely small-developed areas in size, polluted runoff from these areas could cause significant negative impacts to its water resources. Especially in the headwaters, the impact from local stormwater runoff pollution could be extended throughout and felt in the lower stream reaches as well. Stormwater management has been identified as an important issue in both Potter and Clinton counties, but a watershed wide plan has yet to be developed. The Potter County Comprehensive Plan released in 1998 recognized urban runoff problems that ranged from backyard flooding to major stream flooding and streambank erosion and thus accepted as a major concern for the County and the Township Officials. The Allegheny River Watershed Stormwater Management Plan developed by Potter County in 1992 covered areas falling in the Allegheny River watershed only.

Lack of adequate stormwater controls in the headwater areas of the watershed along with the potential for further development it becomes imperative to address this non-point source of pollution to preserve and restore the water quality of this otherwise healthy watershed. The development and implementation of watershed stormwater management planning can be carried out under Act 167, the Stormwater Management Act released in 1978 that addresses stormwater issues prevalent in various land-use type developments.

NON-POINT SOURCE POLLUTION

Introduction

Non-point source pollution is defined as discharges entering surface waters in a diffuse manner at intervals that are related mostly to the occurrence of storm events (Novotny and Olem 1994). In other words, non-point source pollution can come from land areas during storm events as runoff. Road sediment, agricultural fertilizers, and septic systems are common non-point sources of pollution. Unlike the traditional "point" sources of pollution, that we can “treat” at the pipe, the most effective method of pollution control for non-point sources is focused on land management practices. Non-point sources are difficult to manage and equally difficult to assess. Due to the time and expense of extensive ground-based analysis, simulation modeling has become common for the development and implementation of non-point source control programs (Novotny and Olem 1994).

The Kettle Creek Keystone Project has identified non-point pollution as the most common form of water pollution on Kettle Creek. In order to assess the potential influence of non-point pollution sources on the health of the watershed we used three different strategies:

- Total nitrogen, total phosphorus and total sediment loading rates from various land-use areas on an annual basis.
- Daily nitrogen concentrations based on water quality sampling data.
- Potential sediment delivery from dirt and gravel roads.

Nitrogen and phosphorus are common nutrients of concern in aquatic systems for their effect on the algal growth and eventual depletion of oxygen for fish and other organisms (Novotny and Olem 1994). High levels of these

LOADING RATE

It is helpful to describe non-point sources of pollutants in terms of loading rates. This way we can easily compare different areas in a watershed or region in a similar fashion. Loading rates are the amount of a given pollutant that washes off of an area of land over a period of time. These data (presented as pounds per acre per year) are used by natural resource managers to determine when streams have reached their maximum pollution load.

Algae blooms on Kettle Creek indicate a high level of nutrients in the water. These algae blooms can create an oxygen depletion that will affect fish and other stream organisms.

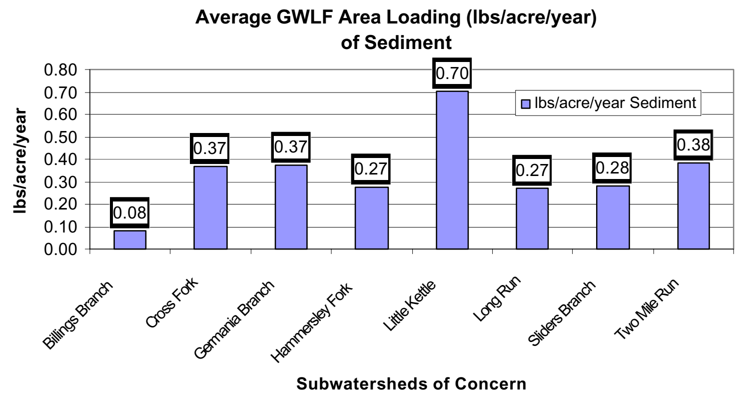
nutrients in the Chesapeake Bay have had detrimental effects on human health, local fisheries and the economies of the region. This has created a high level of concern over land use in the Chesapeake Bay watershed, of which Kettle Creek is a part. Non-point pollution can be greatly reduced using best management practices in agriculture, forestry or residential development.

Sediment and erosion is a natural part of any watershed. Stream channels can accept certain levels of sediment depending on the stream type, but if erosion delivers sediment to a channel frequently and in large quantities, this form of pollution will become detrimental to a stream's health and may create instability in stream channels. Sediment can also contribute to the increased transport of other pollutants, such as phosphorus, carrying them downstream.

Other probable non-point pollutants on Kettle Creek would include salt and organic chemicals from roads, herbicides and pesticides from forestry and agricultural application.

The Generalized Watershed Loading Function Model

To assess the potential for non-point source pollution from various subwatersheds in Kettle Creek the ArcView version of the Generalized Watershed Loading Function (AVGWLF) model (Evans and others, 1999). This simulation uses current information regarding rainfall, soils, land use, and census information to predict monthly and annual loading rates of nitrogen, phosphorus and sediment (Appendix I, page 322). The AVGWLF provides us with a valuable tool to compare the non-point pollution loads of streams in the Kettle Creek watershed. As a simulation of conditions, the outputs of the model are best used as relative values of pollutant loads on the watershed. From the model priority areas can be determined that would be most suitable for non-point pollution reduction strategies (See Figures 5.11, 5.12). The watersheds with the lowest loading rates on Kettle Creek are predominately forested and can provide reference conditions as "pristine" Pennsylvania streams. Unfortunately, some watersheds on Kettle Creek do appear to be contributing to increased nutrient loads and are losing soil at higher rates of erosion.



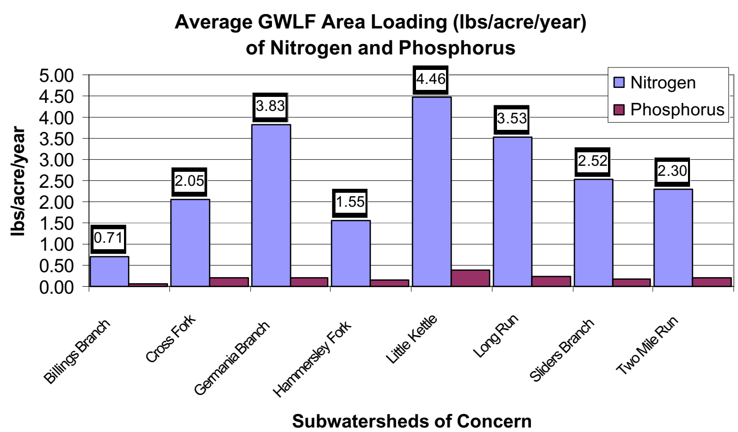


Figure 5.11, 5.12 - Nutrient and sediment runoff values shown here give an indication of potential subwatersheds to begin non-point source reduction strategies. Nutrient loading on Kettle Creek can be reduced using voluntary best management practices on agricultural and forestry lands, reducing sediment runoff from roads and developed areas and improving the design and maintenance of septic systems in floodplains.

EFFECTS OF DAMS

Reservoirs can be useful in reducing flood flows, creating recreation opportunities or storing water for drinking supplies. But these changes to a stream can also affect the transport of pollutants, the erosive power of the stream and stream habitat.

Dams also store sediment. As water velocity slows above a dam, the sediment carried in the water will often settle out. Sediment will carry certain nutrients and pollutants with it. In this way some pollutants can be stored behind a dam actually improving downstream water quality. But this storage can also create problems when the sediment is dredged, as it can often contain high levels of toxic material that must be disposed of in sensitive ways. This storage of sediment and nutrients in the Alvin Bush Reservoir probably reduces the usefulness of the Kettle Creek Water Quality Network (WQN) monitoring station.

Water Quality Network (WQN) Information

Water quality data monitored by the EPA at the Westport stream gage, provides us with information to construct a probable concentration of nitrogen at various levels of stream flow (for more information on the WQN station refer to page 175). Phosphorus has not been included in this analysis because of the location of the water quality network site below the Alvin Bush Reservoir. Phosphorus is often adsorbed, or attached to, sediments and will be deposited in the reservoir.

The nitrogen concentration to stream flow relationship allows us to determine probable concentrations of pollutants over time instead of as monthly or annual loading rates (See Figure 5.13). Changes in concentrations of nutrients at particular times of year may help to indicate the potential sources of pollutants or when water quality sampling may be most effective. The annual loading rate can also be compared with AVGWLF outputs for comparison of two different approaches to assessment of nitrogen pollution (see Figure 5.14).

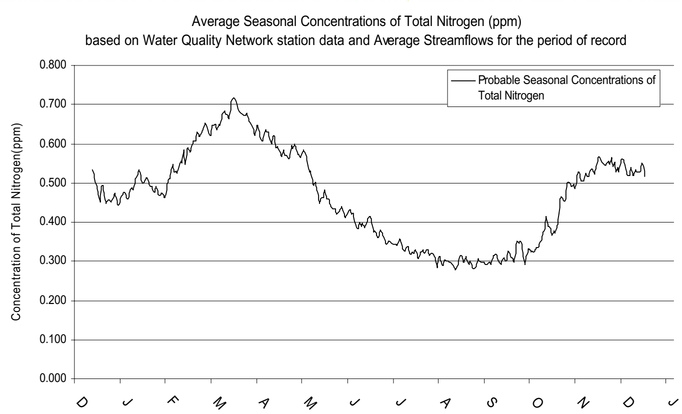


Figure 5.13 - Concentrations of some pollutants can depend on streamflow or season. In this chart the seasonal changes of nitrogen are exhibited. For effective sampling of nitrogen concentration peaks, sampling should be focused on spring and winter high flows.

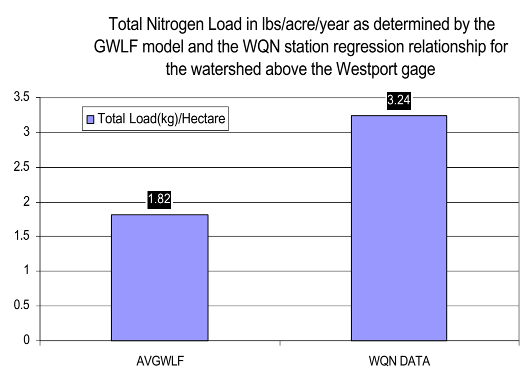


Figure 5.14 - The comparisons of GWLF and WQN modeled nitrogen values provide a probable range of values for non-point pollution area loading. These loading values for nitrogen are much lower than agricultural watersheds in other parts of the state.

DIRT AND GRAVEL ROAD MAINTENANCE PROGRAM

The Conservation Commission's Dirt and Gravel Road Maintenance Program is a voluntary pollution prevention program authorized and funded with an annual $5 million by the state Vehicle Code. The law recognizes that dirt and gravel roads are a distinct form of permanent roadway that require unique standards and guidelines for construction, maintenance and environmental protection. Local decision-making is the key to the continued success of this program.

The Dirt and Gravel Road Program is currently involved in delivering 2-day training workshops to township supervisors on environmentally sensitive road maintenance. The program has identified, with the help of local citizens, townships, and county conservation districts over 8,000 sites in need of anti-pollution work. Funds are available for these problem road segments through the county conservation districts.

Dirt and Gravel Road Sediment Production

Roads and other paved areas can be significant sources of water-borne pollutants (United Nations 1999). Oil, salt, and sediment are just a few of the pollutants that can flow from roads during storm events. In the Kettle Creek watershed there are 294 miles (473 km) of state, township, state forest and private roads. That is an average of 1.2 miles of road for every square mile of land area. In general the roads closest to a stream or body of water have the greatest potential for pollution. Kettle Creek has 119 miles of road within 250' (76m) of the stream. Of this, 48% are state forest or private roads, 26% are township roads, and the remaining 26% are state-owned (see figure 5.15). The majority of the township, private, and state forest roads are not paved.

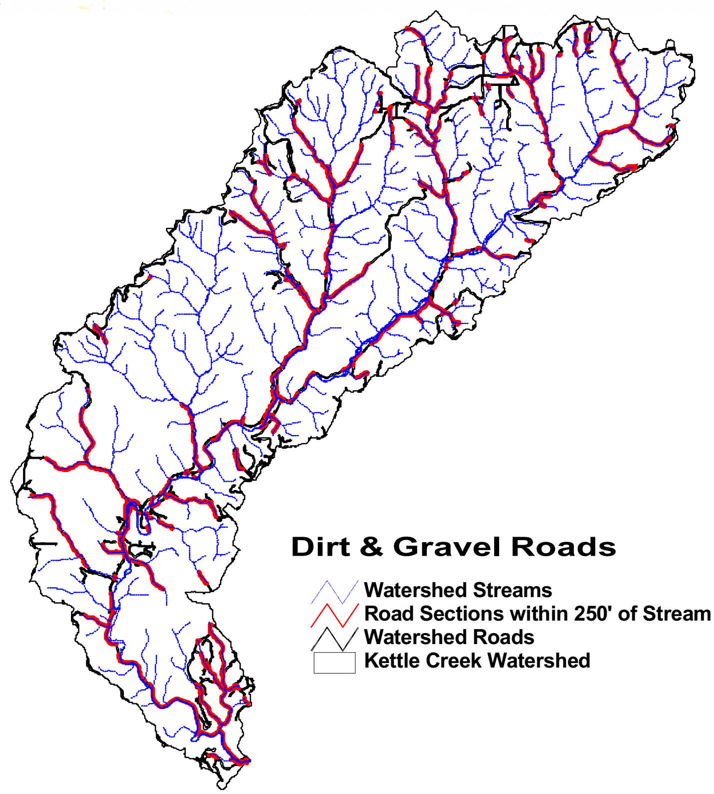
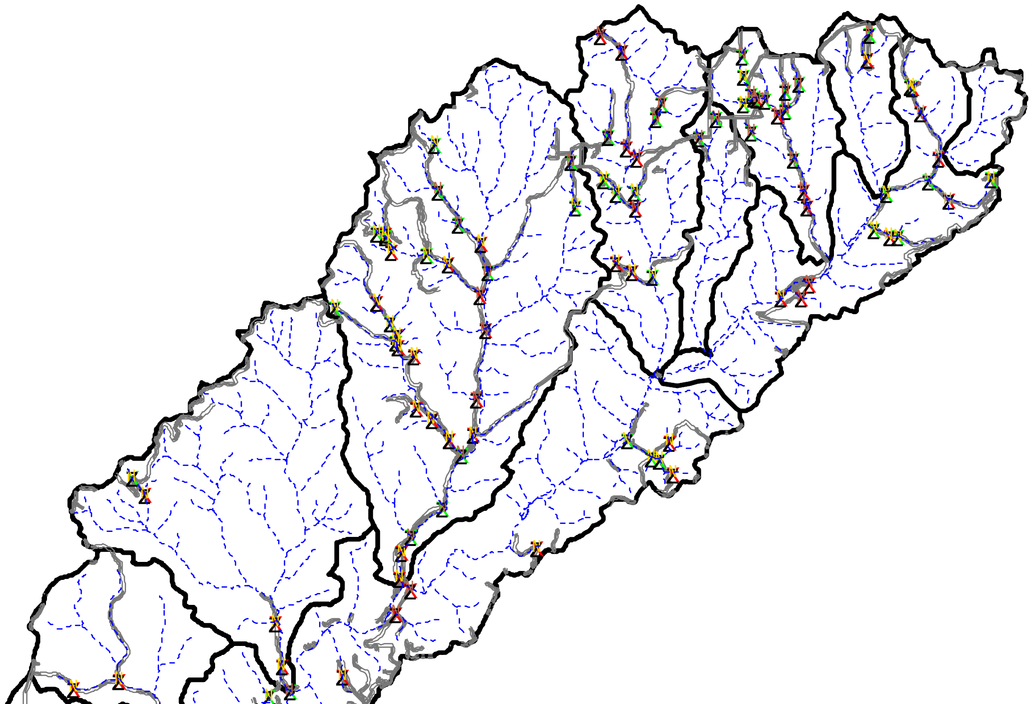
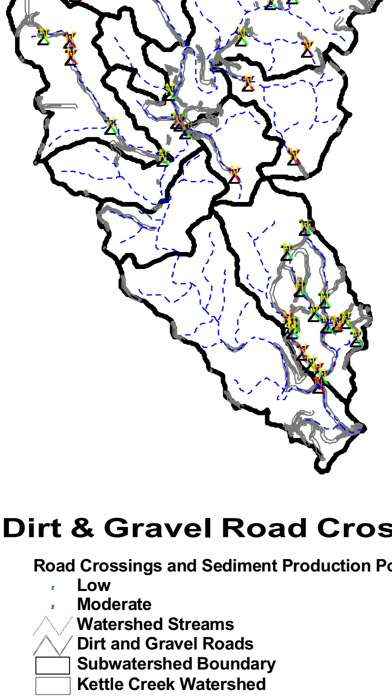
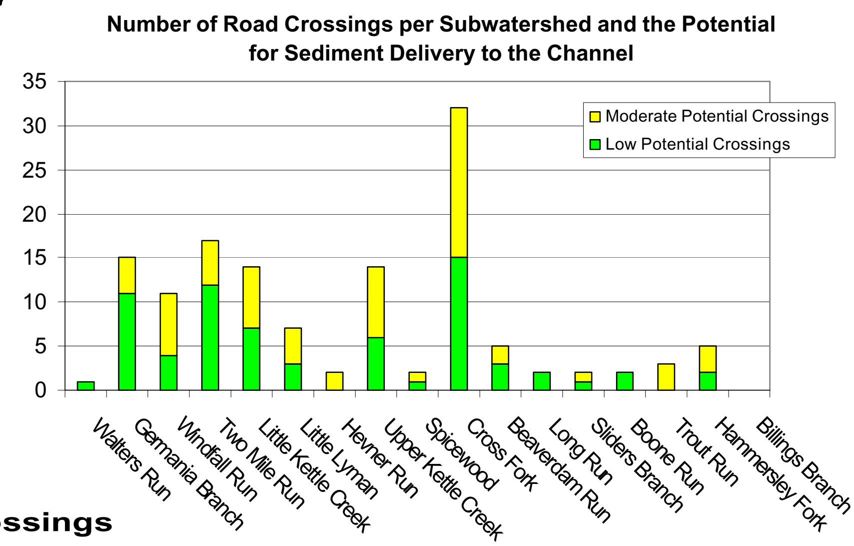


Figure 5.15 - Salt, sediment and oil are likely to be delivered to streams from roads and paved surfaces within 250 feet of streams. The map above shows the 119 miles of roads that are wtihin 250 feet of streams on Kettle Creek.

Dirt and gravel roads can be significant sources of fine sediment and in some cases can severely affect the habitat needs of fish, particularly wild trout. The potential impacts of dirt and gravel road erosion on wild trout streams became the



Figures 5.16, 5.17 - Road crossings can be the single largest contributor of sediment to a stream on forested watersheds. Additionally, road crossings can limit fish passage, cause localized erosion and be a costly maintenance problem after floods. Stream crossings are listed by subwatershed in the chart above for comparison.

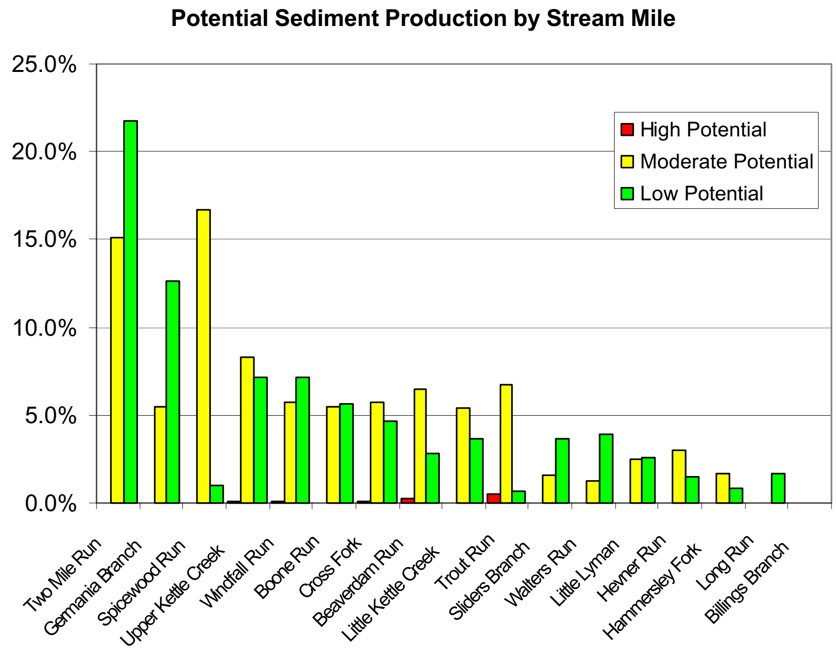


Figure 5.18 - The delivery of sediment to streams from dirt and gravel roads can be a significant non-point source of pollution. As shown above, there are subwatersheds on Kettle Creek that have almost 1/4 of their streams potentially influenced by road runoff. This chart helps us identify which watersheds are more prone to sediment pollution from dirt and gravel roads.

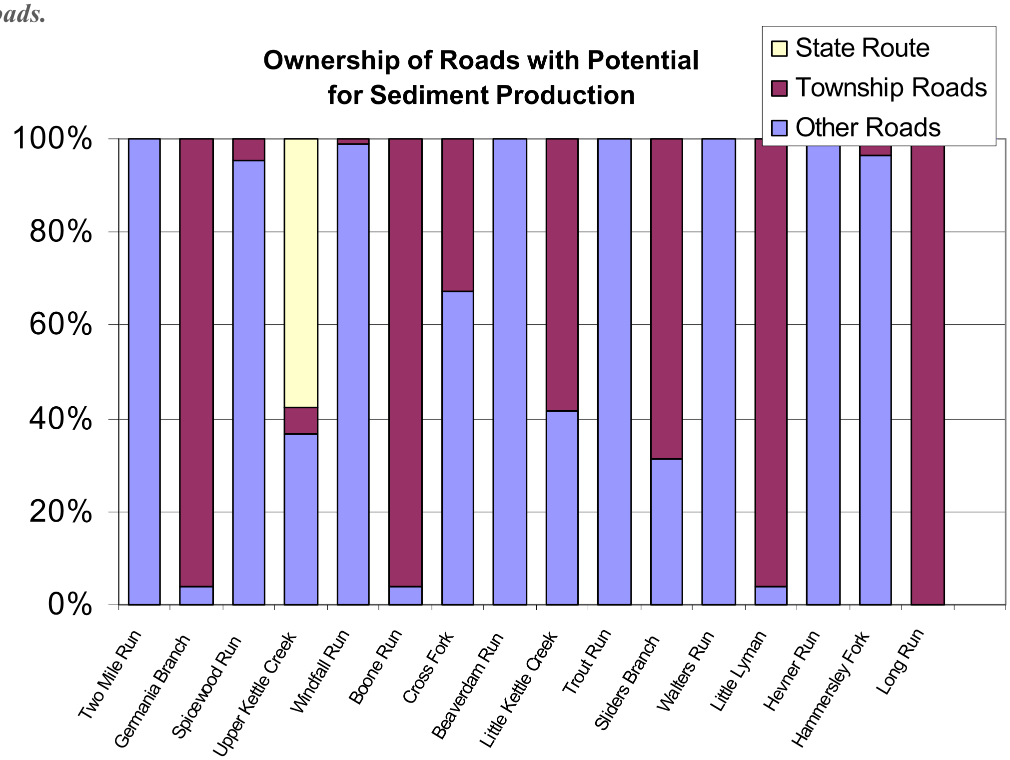


Figure 5.19 - The ownership of potential sediment producing segments of roads are a quick indication of potential partners for fixes.

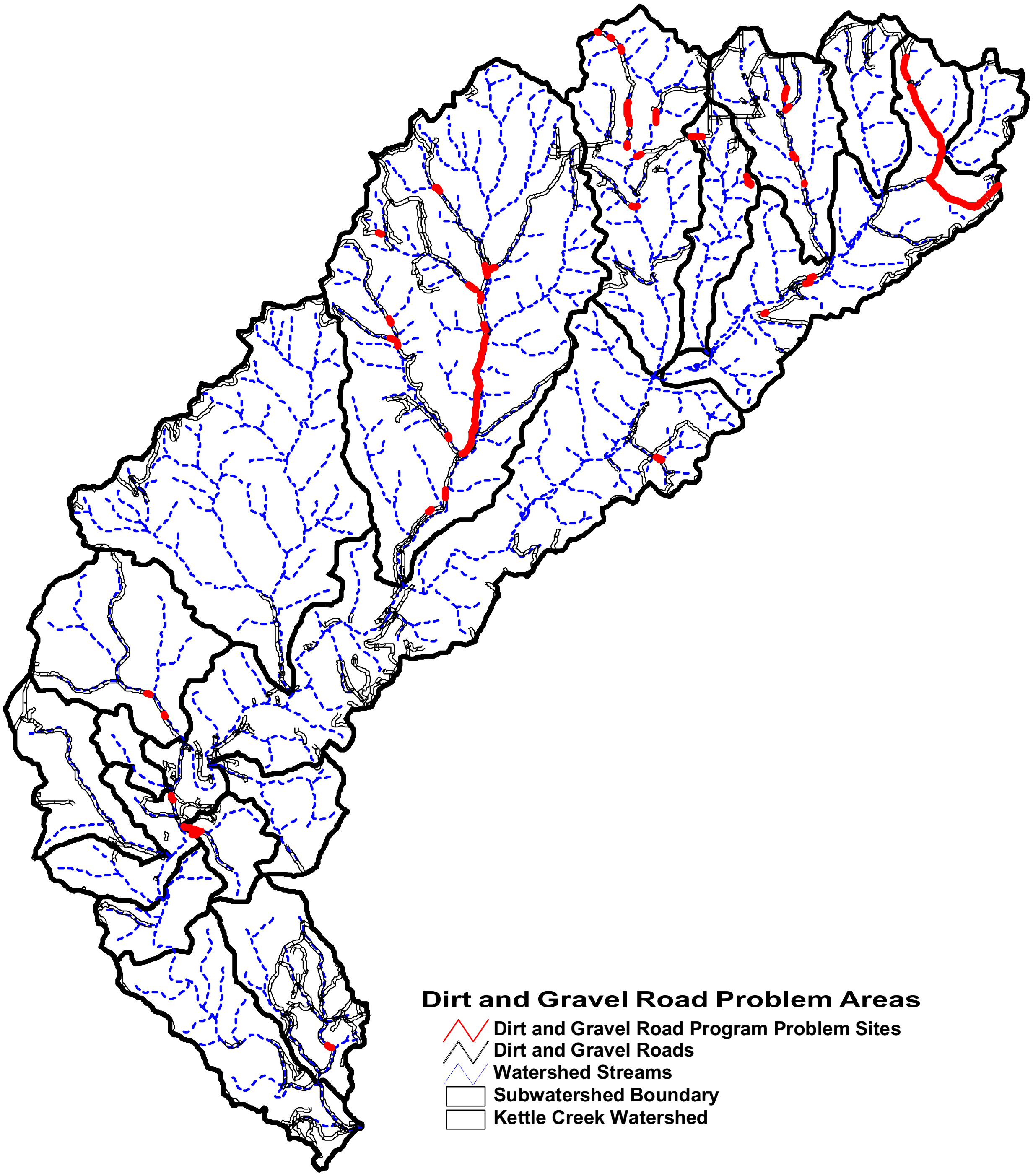


Figure 5.20 - The above map shows dirt and gravel road problem areas as identified by Trout Unlimited and the Potter and Clinton County Conservation Districts. These segments are immediately eligible for funding through the Dirt and Gravel Road program and can be prioritized based on the road sediment impacts ranking index.

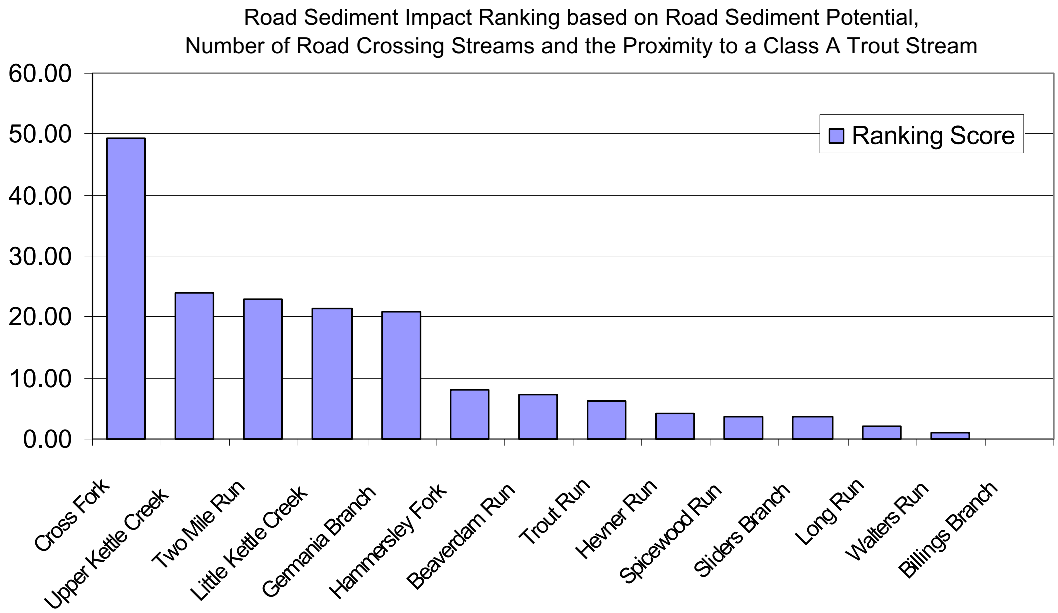


Figure 5.21 - These rankings represent an integration of potential dirt and gravel road problem areas, the number of road crossings per subwatershed and the proximity of those roads to a Class A trout stream. The ranking is a relative number and indicates which watersheds are most likely to be effected by sediment pollution from dirt and gravel roads.

driving force behind a statewide program to improve the maintenance and longevity of dirt and gravel roads. Gravel roads that require less maintenance are less expensive and longer lasting and create less pollution.

Surface erosion occurs from nearly all roads regardless of design and construction, but sediment delivery to a channel only occurs under certain conditions:

• When ditches and culverts drain near the channel (within 200' or 70m). Within this zone the sediment delivery to a stream can be 100% (Burroughs and King 1989).

• When roads are located on steep side slopes. As sediment delivery to a stream is based on the potential for downslope sediment transport, the steeper the ditch, road cut or culvert outfall the greater the potential for sediment to be carried to a stream (Ketcheson and Megahan 1996).

• When increases of traffic occur on roads. During wet weather, heavily trafficked roads produce substantially more sediment than do abandoned or low-use roads (Reid and Dunne 1984).

Based on the primary influences of slope and the proximity to streams, the Kettle Creek team developed a GIS-based model to predict sediment potential from all dirt and gravel roads on the watershed in order to prioritize road runoff reduction efforts by subwatershed. The model identifies road segments within 100' (30m) of a stream that are located on three ranges of slopes. These three slope classes indicate the low, moderate, or high potential for sediment

Dirt and gravel roads can contribute sediment to nearby streams.

GOALS: NON-POINT SOURCE

WQ 1.1: Reduce nutrient, sediment, and chemical non-point source pollution delivery to target areas and key tributaries.

LU 1.2: Develop and encourage the use of Best Management Practices (BMPs) on Agricultural Production lands to minimize impacts on adjacent natural resources.

delivery to the channel. A ratio of potential road sediment production to stream length provides a valuable comparison of the potential effects of dirt and gravel roads on the streams of Kettle Creek. The highest possible value is 100%, which indicates that every mile of stream is potentially influenced by road runoff (See Figure 5.18). Additionally, we identified all potential stream crossings in Kettle Creek. At these locations the production of sediment is likely, unless there is some effort to reduce or eliminate road runoff (See Figure 5.16 & 5.17). The ownership of sediment-producing segments of road was also assessed to assist with the identification of potential partners for road improvements (See Figure 5.20).

In order to integrate the affects of sediment runoff and to identify a list of priority subwatersheds, we developed an index that ranks subwatersheds based on miles of sediment delivery potential, the fishery-quality of receiving waters, the location in the watershed, and number of stream crossings (see figure 5.21). Problem road segments have been identified on the ground by the Dirt and Gravel Road Program, county conservation districts, townships and Trout Unlimited (See Figure 5.19). These problem areas can now be viewed in the context of a subwatershed's cumulative sediment impacts. These specific road segments can be targeted for erosion control that will create the greatest improvement to stream conditions.

Acid
Mine Drainage (AMD)

Overview of Mining

Soft coal was discovered by mineral prospectors hired by investors and speculators during the early 1870s (Parucha 1986). Most of the watershed had been logged at this point in time and landowners were looking for other resources. The Kettle Creek Coal Mining Company was chartered in 1874 and began operations on the west side of Kettle Creek. The town that developed as a result was Bitumen. At its peak, Bitumen harbored several thousand residents; today, Bitumen is a small village of permanent and seasonal dwellings

Mining in the watershed started with small hand dug mines where coal outcropped on the steep slopes. The Lower Kittaning Coal seam was the target of early miners. The room and pillar method was used to extract the coal. Shafts were dug to penetrate the coal vein then expanded horizontally, but support pillars were left to support the mine roof. When the veins were exhausted in all dimensions, the miners retreated and often removed the coal pillars as they exited the mine. The main problem with this type of mining was that it often was conducted up-slope and allowed the water within the mines to drain away into adjacent streams (Klimkos 2000). Water draining from the mines reacted with pyrite and acidified causing acidic mine drainage (AMD).

The remnants of the mines are still producing AMD today. Spoil piles, large dumps rock and lower grade coal extracted from the mines, are often located near the entrances of subsurface mines and are a source of AMD. Deep mining or subsurface mining occurred on both the eastern and western side of Kettle Creek. Mining was concentrated in the Twomile Run watershed on the eastern side of Kettle Creek. The last subsurface mine closed in the 1950s (Klimkos 2000).

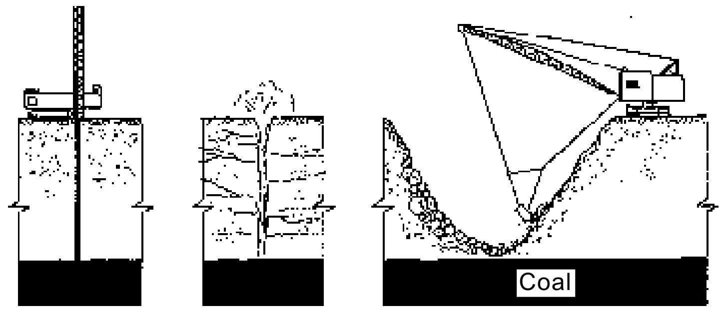


Figure 5.22 - Preliminary steps to access coal seams. Once the overburden is removed, the coal is loaded into trucks and hauled to a processing area.

Surface mining also occurred in the watershed. Surface mining (or strip mining) consists of removing the overlying soil or overburden to access the coal seams. Surface mining started during World War II and targeted the Middle Kittaning and Upper Freeport coal seems. Surface mining creates a large amount of spoil or overburden which is piled near the pits that contained the coal. The spoil piles were typically ungraded and unvegetated. Spoil piles are sources of AMD because the pyrite has been brought to the surface where it can combine with precipitation and oxygen to form AMD. The majority of the sites on the western side of Kettle Creek have been roughly graded to contour and planted with pine trees. The process meets older reclamation standards which requires rough grading to premining contours and planting of trees or grasses. Many of the sites on the eastern side of Kettle Creek have ungraded and unvegetated spoil piles. Some exposed rock faces or high walls exist which are the remains of contour mining. Open pits collect and direct surface water to flow through pyritic material and infiltrate into the groundwater resources with the potential to discharge into nearby streams as baseflow. Surface mining ceased in 1977.

ACID MINE
DRAINAGE

Acid mine drainage as seen today in Twomile Run.

AMD Production

Acidic mine drainage is caused by the reaction of oxygen, water, and pyrite (FeS_2). The primary chemical equation is diagramed below. To stop AMD production, the reaction cycle has to be interrupted. The ending products of AMD are iron oxide (FeO_2) or rust and sulfuric acid. Iron oxide precipitates and forms the orange plating commonly found on rocks in AMD impacted streams. The sulfuric acid is mobile and flows through the soil, leaching metals such as iron, aluminum, and manganese. Sulfate production also increases. The acidic water dissolves and carries the metal in solution until pH or oxygen levels increase. Aluminum is toxic to fish and macroinvertebrates. Iron plates the substrate impacting macroinvertebrate habitat. Unvegetated spoil piles, poorly vegetated reclaimed sites, and abandoned mine entrance shafts are the three largest producers of AMD. Some soils have the ability to buffer acid production, but those soils are not found in the lower Kettle Creek watershed.

AMD FORMATION REACTION

$$4FeS_2 + 15O_2 + 2H_2O \longrightarrow 2Fe_2(SO_4)_3 + 2H_2SO_4$$

Kettle Creek AMD Studies

Two studies describe the AMD issues on the lower watershed. A total maximum daily load (TMDL) study was published by the DEP, Bureau of District Mining Operations in October of 2000. Mike Klimkos from the Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation (BAMR) researched and identified AMD issues on the western side of the watershed. The Klimkos report does not suggest implementation procedures. Hedin Environmental was contracted by KCWA through a DEP Growing Greener Grant to inventory and identify the AMD issues on the eastern side of the watershed, primarily the Twomile Run subwatershed. The Hedin report also suggested implementation projects to mitigate AMD impacts in the study area. AMD analysis was also conducted in the Scarlift Report from the early 1970s sponsored by the DER (DEP) BAMR, however both recent studies question the validity of the earlier report. The TMDL study collated data from sampling points throughout the Twomile subwatershed and developed pollution loading values, developed pollution loading reduction goals, and listed several recommendations to reach the loading goals.

Summary of Eastern Side

Twomile Run is the largest tributary on the eastern side of lower Kettle Creek containing 16.6 miles of streams with 51 % or 8.5 miles are impaired by AMD generated from both deep and surface mines. (Hedin 2000). It covers 4 % of the entire Kettle Creek watershed and impacts 4% of the streams within the watershed. The AMD inputs from Twomile degrade the aquatic ecosystem to a level which does not support a fishery. The Twomile watershed has four major subwatersheds; Huling Branch, Macintosh Hollow, Middle Branch, and

Robbins Hollow. All of the subwatershed streams, except Macintosh Hollow, are impaired by AMD. Figure 5.23 shows a graphic representation of the selected sampling points for the TMDL study. The mainstem of Twomile above the confluence of Huling Branch has a very low pH (3.5) and high Al (9.11mg/L) and Fe (0.92 mg/L) concentrations. Huling Branch is the largest contributor of AMD with high Al (9.26 mg/L) concentrations and high acidity (117.5mg/L). Middle Branch ranks second behind Huling Branch in flow and has high acidity (41.24 mg/L). Robbins Hollow has a smaller discharge, but high concentrations of iron. The unique chemical characteristics of the major AMD sources provide challenges when considering restoration. The affected streams do have headwater sections that are unimpaired and support significant populations of aquatic organisms. For more detailed information, refer to the Hedin report.

Hedin Environmental was contracted by the KCWA to develop a restoration plan for the Twomile Run watershed. Restoration of the Twomile Run watershed will also facilitate the restoration of the lower six miles of Kettle Creek. Treatment systems on Middle Branch, the "Swamp", and Robbins Hollow will facilitate the restoration of the downstream sections of respective streams. The “Swamp” is a large area with multiple discharges located northeast of Robbins Hollow. The key is to restore Huling Branch which has the largest pollution load and the largest impact on the mainstem of Twomile Run and ultimately the mainstem of Kettle Creek. The restoration of Twomile is a priority, but adequate data and understanding are prohibiting the development of a complete efficient restoration plan.

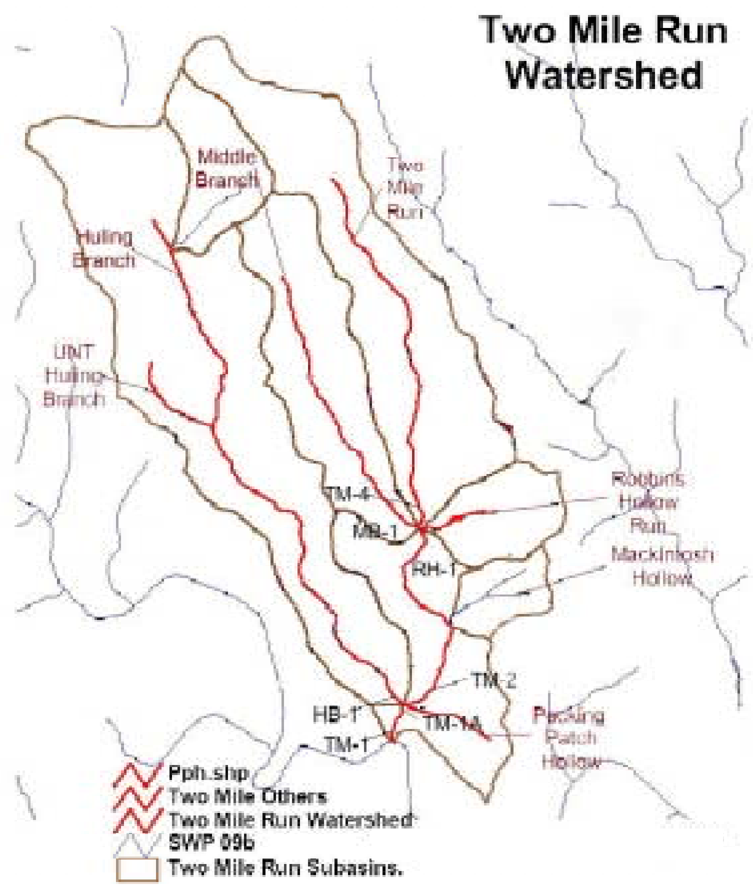


Figure 5.23 - Selected sampling points for the TMDL study. Values for these points are listed in The Summary Table (figure 5.24)- Twomile Run load reduction goals

Summary of Western Side

AMD impacted tributaries on the west side are significantly different marked by decreased volumes and larger geographic distribution area. The western side study area covers only 2 % of the Kettle Creek watershed (Klimkos 2000). The largest western tributary is Short Bend Run that drains 650 acres (263.2 ha). In contrast, the Twomile watershed is 5855 acres (2369 ha). The following streams are affected on the western side having discharges that are created by mine drainage: Slide Hollow North, North Steep Side, South Steep, "The Beach", Skunk Hollow, and Duck Hollow. The Beach is a broad area on the banks of Kettle Creek with diffuse AMD inputs. The western side has 2.35

Applicable Water Quality Criteria		
Parameter	**Criterion value (mg/l)**	**Total Recoverable/ Dissolved**
Aluminum*	0.1 of the 96 hour LC 50	Total Recoverable
	0.75	
Iron	1.50	Total Recoverable
	0.3	dissolved
Manganese	1.00	Total Recoverable
PH**	6-9	NA
*- This TMDL was developed using the value of 0.75 mg/l as the in-stream criterion for aluminum. This is the EPA national acute fish and aquatic life criterion for aluminum. Pennsylvania's current aluminum criterion is 0.1 mg/l of the 96-hour LC-50 and is contained in PA Title 25 Chapter 93. The EPA national criterion was used because the Department has recommended adopting the EPA criterion and is awaiting final promulgation of it.		
** - The pH values shown will be used when applicable. In the case of freestone streams with little or no buffering capacity, the TMDL endpoint for pH will be the natural background water quality. These values are typically as low as 5.4 (Pennsylvania Fish and Boat Commission). This condition is met when the net alkalinity is maintained above zero.		
Source: DEP, 2000		

Figure 5.24 - Water quality criteria for high quality and exceptional value streams used to develop AMD loading reduction goals.

Figure 5.25 - To restore lower Kettle Creek and Twomile, DEP has identified these reduction goals at TM-1a .

Necessary Reductions at Sample Point TM-1A				
	Al(#/day)	**Fe(#/day)**	**Mn(#/day)**	**Acidity(#/day)**
Existing loads at TM-1A	394.2	234.2	296	4162.7
Total Load Reduction (Sum of TM-4, MB-1, RH-1, TM-2 & HB-1)	368.9	201.8	290.4	3909.5
Remaining Load (Existing Loads atTM-1A - TLR Sum)	11.8	18.7	11.8	0
Percent Reduction	53%	42%	NA	100%
Additional Removal at TM1A	13.4	13.7	NA	253.2
Allowable loading values shown in Figure 5.24 represent (DEP, 2000)				

Summary Table -Two Mile Run load reduction goals										
Station		Measured Sample Data		Allowable		Reduction Identified	Present Loading		Reduction Goals	
	Parameter	Conc (mg/l)	Load(lbs/day)	**LTA Conc (mg/L)	Load (lbs/day)	%	lbs/year	tons/year	lbs/year	tons/year
TM-4	In-stream monitoring point located on Two Mile Run									
	Al	9.11	76.1	0.27	2.3	97%	27776.5	13.89	839.5	0.42
	Fe	0.92	7.7	0.67	5.6	92%	2810.5	1.41	2044	1.02
	Mn	6.83	57	0.27	2.3	96%	20805	10.40	839.5	0.42
	Acidity	73.67	615.3	0.15	1.23	100%	224584.5	112.29	448.95	0.22
	Alkalinity	0.37	3.1		N/A	N/A	1131.5	0.57	N/A	N/A
MB-1	In-stream monitoring point located on Middle Branch									
	Al	4.75	24.6	0.24	1.48	94%	8979	4.49	540.2	0.27
	Fe	0.22	1.1	0.22	1.1	0%	401.5	0.20	401.5	0.20
	Mn	1.66	8.463	0.41	2.11	75%	3088.995	1.54	770.15	0.39
	Acidity	41.24	216.3	0.8	1.9	99%	78949.5	39.47	693.5	0.35
	Alkalinity	0.72	3.7		N/A	N/A	1350.5	0.68	N/A	N/A
RH-1	In-stream monitoring point located on Robbins Hollow									
	Al	11.86	17.3	0.24	0.35	98%	6314.5	3.16	127.75	0.06
	Fe	0.27	0.4	0.27	0.4	0%	146	0.07	146	0.07
	Mn	9.59	14	0.29	0.4	97%	5110	2.56	146	0.07
	Acidity	90.67	132.2	0	0	100%	48253	24.13	0	0.00
	Alkalinity	0	0		N/A	N/A	0	0.00	N/A	N/A
TM-2	In-stream sampling point located on Two Mile Run									
	Al	7.48	191.9		17.7	92%	70043.5	35.02	6460.5	3.23
	Fe	0.41	10.5		N/A	N/A	3832.5	1.92	N/A	N/A
	Mn	6.72	172.3		90.8	93%	62889.5	31.44	33142	16.57
	Acidity	60.5	1552.2		576	97%	566553	283.28	210240	105.12
	Alkalinity	1.55	39.8		N/A	N/A	14527	7.26	N/A	N/A
HB-1	In-stream monitoring point located on Huling Branch									
	Al	9.26	187	0.19	3.7	98%	68255	34.13	1350.5	0.68
	Fe	10.3	208	0.41	8.3	96%	75920	37.96	3029.5	1.51
	Mn	6.45	130.1	0.26	5.2	96%	47486.5	23.74	1898	0.95
	Acidity	117.5	2372.8	0	0	100%	866072	433.04	0	0.00
	Alkalinity	0	0		N/A	N/A	0	0.00	N/A	N/A
TM-1A	In-stream monitoring point located on Two Mile Run									
	Al	8.57	394.2	0.26	11.8	97%	143883	71.94	4307	2.15
	Fe	5.09	234.2	0.41	18.7	92%	85483	42.74	6825.5	3.41
	Mn	6.43	296	0.26	11.8	96%	108040	54.02	4307	2.15
	Acidity	90.5	4162.7	0	0	100%	1519386	759.69	0	0.00
	Alkalinity	0	0		N/A	N/A	0	0.00	N/A	N/A
Summary table for loadings and reductions in Twomile Run watershed						**LTA = Long Term Average				
DEP, 2000										

Figure 5.26 - Twomile Run Load reduction Goals. Load values were converted from lbs/day to tons/year to demonstrate the magnitude of metal loading annually by the streams in the Twomile watershed.

miles (3.9 km) of perennial streams that do not support aquatic communities including 1.5 (2.5 km) of Short Bend Run 0.85 miles (1.38 km) of Butler Hollow and 0.56 miles (0.9 km) of Slide Hollow. Mike Klimkos, a water pollution biologist from DEP BAMR has conducted an assessment of AMD impacts on the western side of lower Kettle Creek (defined as the watershed below the Alvin Bush Dam). The goal of the study was to characterize the AMD sources on the western side of the watershed. The study defined 6 problem areas covering 908 ac (368 ha) with 22 problem features ranging from abandoned mine entrances to "dry strip mines". Fifteen of the problems are AMD discharges, three dry strip pits, two refuse piles, one open shaft mine entry, and 1 subsidence prone area. Twenty-two sample sites were designated by the study and samples were collected. Seven sample sites were on the mainstem of Kettle Creek. For more detailed information, refer to the Klimkos report.

Total Maximum Daily Load (TMDL) Study

One of the major components of a TMDL is the establishment of an instream numeric endpoint, which is used to evaluate the attainment

Unreclaimed spoil pile capable of reducing large volumes of AMD. Reclamation at this site entails regrading the pile to existing contours, addition of organic matter, and revegetating the surface.

Ecological connectivity is important because components of one ecosystem are dependent on components of another ecosystem.

of acceptable water quality. An instream numeric endpoint, therefore, represents the water quality goal that is to be achieved by implementing the load reductions specified in the TMDL. The endpoint allows for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The endpoint is based on either the narrative or numeric criteria available in water quality standards. Because of the nature of the pollution sources in the watershed, most of the TMDL component makeup will be load allocations (LA) that are specified above a point in the stream segment. All allocations will be specified as long-term average concentrations. These long-term average concentrations are expected to meet water-quality criteria 99% of the time.

Title 25 Chapter 93.5(b) specifies that a minimum 99% level of protection is required. All metals criteria evaluated in these TMDLs are specified as total recoverable. The data used for this analysis report iron as total recoverable. The following table shows the applicable water-quality criteria for the selected parameters (DEP, TMDL 2000). Figure 5.25 displays the necessary reductions to restore lower Kettle Creek to the DEP designated water quality standards for a trout stocking fishery.

The DEP has identified quantifiable loading rates and reduction goals from the TMDL study which are displayed in figure 5.26. The values for lbs/day were converted to tons/year to demonstrate the cumulative daily impacts are substantial impacts on an annual scale. The reduction goals demonstrate the amount of metals and acidity that will be removed from the lower watershed ecosystem. Several strategies have been proposed to accomplish these goals including construction of passive and active treatment facilities, alkaline addition with backfilling, regrading and revegetation of pits and spoil areas, and remining.

Benefits of Reclamation

The lower Kettle Creek watershed, the portion of the watershed below the Alvin Bush Dam, has 30.1 miles (48.4 km) of streams. Fifty-six percent of the streams (16.9 miles, 27.1 km) are AMD impacted and do not support aquatic communities. An aquatic community is defined as a group of interacting organisms ranging from aquatic plants to game fish. The headwater tributaries of the lower watershed do support wild brook trout. The AMD impaired reaches have similar habitat potential in the Twomile Run watershed and the small tributaries that discharge directly to the mainstem. The lower mainstem is a transitional area between the cold water fishery below the dam and a potential cool water fishery in the Susquehanna River. Restoring all of the streams in the lower watershed would increase the biologically productive areas by 4 %. Kettle Creek is a major tributary to the West Branch of the Susquehanna River and improvements of water quality of Kettle Creek could potentially increase the water quality of the river.

Reclamation and restoration of the lower watershed will have major impacts in three areas: water quality, recreational fishing, and ecosystem connectivity. The Susquehanna River is impacted by AMD with most sources located above the confluence of Kettle Creek. The current water quality of Kettle Creek does not improve the water quality of the Susquehanna River. Restoration of the lower watershed will remove large amounts of acidity, aluminum, iron, and manganese which are discharged to the Susquehanna River.

Kettle Creek is the only major impacting tributary on the north side of the river between Lock Haven and Keating. A cool water fishery exists below the dam near Lock Haven and the Pennsylvania Fish and Boat Commission (PFBC) stocked cool water species above the dam within the last ten years. An improvement in the water quality of Kettle Creek has the potential to extend upriver a cool water fishery several miles above Lock Haven. A productive unstocked fishery is an indicator of a healthy stream ecosystem.

Recreational fishing is very popular in north central Pennsylvania. Kettle Creek is famous for its trout fishery, but it also supports a cool water fishery on Kettle Creek Lake and the unpolluted sections of stream below the dam. Restoration of the lower watershed and sections will increase fishing opportunities. Increased recreational opportunities can potentially increase the amount of tourism in the watershed and surrounding areas. Increased tourism will bring additional income to areas that are economically stressed.

KCWA AMD mitigation efforts includes representatives from the Department of Environmental Protection, Bureau of Abandoned Mine Reclamation, Trout Unlimited, Clinton County Conservation District, Natural Resources Conservation Service, Department of Conservation and Natural Resources Bureau of Forestry Sproul State Forest, Senator Jake Corman's office,Department of the Interior, Office of Suface Mining, U.S. Army Corps of Engineers, and PA Fish & Boat Commission.

Another benefit of restoration of the lower watershed is increased ecological connectivity. Fish are the most obvious benefactors of increased water quality. The American shad is an example. The PFBC has committed to restoring shad to the Susquehanna River. Shad were stocked below the dam in Lock Haven several years ago. This migratory species is dependent on good water quality to survive. The unimpacted sections of Kettle Creek are inaccessible to these fish because the stream connectivity is disrupted by the AMD impacted sections of Kettle Creek and the river. The Alvin Bush Dam is also a barrier to migrating fish because it does not have a fish ladder. Migratory fish recovery would be limited to stream segments below the Alvin Bush Dam.

Passive AMD treatment system near completion on Middle Branch in the Twomile Run subwatershed. Passive systems, like this vertical flow pond will be, implemented in other parts of the Twomile watershed.

Many species of wildlife such as mink or river otters, are dependent on aquatic food sources. There is potential habitat in the lower watershed for these species, but they are unable to find food and consequently do not develop reproducing populations. Increased ecological connectivity will increase the wildlife diversity in the Kettle Creek watershed. Refer to the Wildlife and Fisheries section for more information.

Terrestrial ecosystems will benefit from the AMD reclamation activities on the watershed. The unreclaimed mine sites have little vegetation, low forest productivity, and high rates of erosion. Regrading and revegetating spoil piles will create potential wildlife habitat and increase the potential for plant community succession to occur. The spoil piles currently do not provide favorable conditions for plant germination and growth. The soil profile in the surface mined areas has been inverted and homogenized. The soil profile is important because upper layers provide a growing medium for plants and the lower layers store and transport groundwater. Reclamation will be unable to restore the soil profile, but amendments to the surface after regrading will increase the ability of plants to colonize the reclaimed sites. Established plant communities will begin to add organic material to the upper layers of the soil profile and mitigate soil temperature extremes which will create an environment conducive to succession. Succession of the reclaimed sites will eventually allow for the establishment of a mature stable community such as coniferous stands or mixed hardwood communities Eventually, the forestry industry may be able to harvest commercial timber from the reclaimed sites in 100 years or so.

AMD Treatment Systems

Currently there are two types of systems (active and passive) used to treat AMD in Pennsylvania. Active systems, such as lime neutralization, require electricity, use machinery, and are expensive to operate. Passive systems, such as treatment wetlands, use gravity flow, natural processes for treatment, and are inexpensive to operate. Passive treatment systems are the preferred method of treatment because the maintenance is much lower. Passive system are being considered for all sources except Huling Branch. Active treatment will most likely be used to treat this source. Hedin Environmental is currently developing a system for Robbins Hollow.

Remediation Projects

The KCWA has aggressively pursued the mitigation of AMD impacts. A large group of organizations including DEP, DCNR, TU, KCWA and others have cooperated to identify problem areas, collect information, analyze data, design treatment systems, construct treatment systems, and secure funding. AMD remediation is the most actively pursued issue in the watershed. The KCWA is making progress to neutralize the impacts of AMD in the watershed. One project has been constructed and several more are in the planning stage. Information is still needed about the impacted areas. Data collection has become a step in developing future remediation projects.

Completed Projects

The first project to be completed was in the Middle Branch subwatershed within the Twomile watershed. The system was constructed to collect and treat several AMD seeps. The passive treatment system is defined as a vertical flow pond. The system is powered by gravity. The collected discharges flow into a lined pond partially filled with a bed of limestone capped with a layer of compost. As the water flows through the compost, oxygen is stripped from the water creating anoxic conditions inhibit precipitation of metals. The limestone increases the pH of the water which will facilitate the precipitation of metals when the water is exposed to air. The water flows through a drain under the limestone into a sedimentation basin. The water contacts air and the metals (Al, Fe) begin to precipitate. The water flows through constructed wetlands to remove more iron. The final stage of the treatment process discharges the water into a limestone bed to increase alkalinity. Alkalinity increases the pH of the water and neutralizes downstream AMD impacts. This system has two limestone beds. One bed has been inoculated with pyrolusite which removes manganese from the treated water. The beds are constructed in parallel to evaluate the effectiveness of the pyrolusite-inoculation.

Projects In Progress or Under Construction

Two projects will be completed by late summer 2001 in the upper Twomile watershed. A collection system will be constructed in Robbins Hollow to collect data needed to design a passive treatment system. Funding has been secured through a Growing Greener Grant and a grant from the Department of the Interior, Office of Surface Mining (OSM) in conjunction with the Appalachian Clean Streams Funding Initiative. A surface and subsurface collection system will be constructed with a weir at the lowest point in the system to concentrate the diffuse flows for sampling and treatment.

Iron deposition in lower mainstem of Twomile Run caused by Acid Mine Drainage.

The second project involves biocapping 57 acres of Robbins Hollow surface mine. Regrading spoil piles near the swamp and "biocapping" will decrease infiltration and decrease AMD discharges to the swamp. Biocapping consists of regrading the site to original contours, mixing soils on the site with amendments to enhance plant growth, and establishing permanent vegetative cover. The vegetative cover will decrease erosion and sedimentation. The permanent vegetative cover will decrease infiltration because the plants will transpire a large percentage of the water that falls as precipitation. Grading of the site will also direct surface runoff to decrease infiltration. The soil amendment is mulch made from the combination of trees cleared from the site and Wes tan Soil Plus, an alkaline byproduct of the tannery at Westfield, PA.

Proposed Projects

The KCWA AMD Committee meeting conducted on January 29th 2001 heard several proposals to address sites not previously mentioned. A representative from BAMR explained that a technology exists to remotely measure AMD impacts throughout the entire impact areas efficiently. Cost was stated as a drawback. The remote sensing equipment consists of thermal imaging, ground penetrating radar, and terrain conductivity. The remote sensing package can accurately map seeps and discharges and subsurface features over large areas with great accuracy. A proposal was made to investigate the use of this technology.

A second proposal was developed to address the Huling Branch. A collection system is proposed to determine if passive treatment is possible. Active chemical treatment is a proven method for discharges with high metal content and acidity. The problems with chemical treatment is the cost of maintenance and the lack of infrastructure at the site. The U.S. Army Corps of Engineers will be involved in the mitigation of the Huling Branch watershed under section 206 program. A site visit is scheduled for early summer of 2001.

Additional studies are proposed for the western side of the watershed including remote sensing and possible alkaline addition to the "old law" reclamation areas. An idea was proposed to drain the AMD from the Bitumen mine complex and treat it on Crowley Hollow which is located outside the watershed to the west.

GOAL: ACID MINE DRAINAGE

WQ 1.2 Identify and mitigate acid mine drainage.

Acidic Deposition

Acidic deposition is a form of pollution that has become an important environmental stress since the 1970s (Likens and Bormann 1974). Although this subject has just recently become of public interest, the chemical process provides evidence that humans have been contributing to this pollution for hundreds of years. The term acidic deposition refers to the release of acidic substances from the atmosphere to the earth's surface via wet, dry, or occult deposition (Laws 2000). In the US, approximately 2/3 of all sulfur dioxide (SO_2) and 1/4 of all nitrogen oxides (NO_x) come from electric power generation that relies on burning fossil fuels like coal (EPA 2000). In the atmosphere, SO_2 and NO_x mix with oxygen, water, and other chemicals to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3). These acids then fall on the soil, trees, and in streams as wet, dry, or occult deposition.

ACIDIC DEPOSITION is the release of acidic substances from the atmosphere to the earth's surface via wet, dry, or occult deposition - most commonly referred to as acid rain.

DRY DEPOSITION is a type of acidic deposition when in the form of particulate matter.

WET DEPOSITION is a type of acidic deposition when in the form of precipitation (i.e. snow or rain).

OCCULT DEPOSITION is a type of acidic deposition when in the form of fog.

The harmful effects of acidic deposition on forest ecosystems is of particular concern during the spring and early summer when episodic acidification occurs in areas where the geology has low carbonate content (DeWalle and Swistock 1994). Parent material with carbonate content serves as a buffer against acidic inputs into the ecosystem. For instance, a well buffered soil receiving regular inputs of precipitation with a pH of 4 or lower may not alter the soil from having a pH of 6 or higher. However, soils lacking this buffer with prolonged exposure to acidic deposition, may experience leaching of base cations. Chronic base cation depletion coupled with low soil pH will eventually lead to high concentrations of aluminum (Al) in soil water. Once Al has become mobile in the soil solution, it can damage trees by out-competing essential plant nutrients like calcium (Ca) and magnesium (Mg) (Sharpe and Drohan 1999). These nutrients will be flushed from the soil into nearby streams and rivers leaving only Al to nourish the trees and other vegetation. Unfortunately, Al is toxic to tree growth because it binds to roots and blocks uptake of Ca or Mg. Once these essential base cations are leached from the soil, Al will also begin to migrate into streams where it can then have negative impacts on other parts of the ecosystem.

Atmospheric Deposition

Streams with minimal buffering capacity may be directly affected by acidic deposition because it will cause the pH of the water to decrease. After a particular pH is reached, aquatic biota may be negatively impacted (depending on an individual organism's tolerance to acidity). Aquatic organisms may also be indirectly affected by acidic deposition when Al is leached out of soils and into stream systems. Al is not only harmful to trees, it is also toxic to fish embryos (Fiss and Carline 1993) and binds to fish gills where it can interfere with osmoregulation (Leivestad 1976). Studies have also demonstrated that amphibian reproduction and benthic macroinvertebrate populations are adversely affected by acidified bodies of water (Laws 2000).

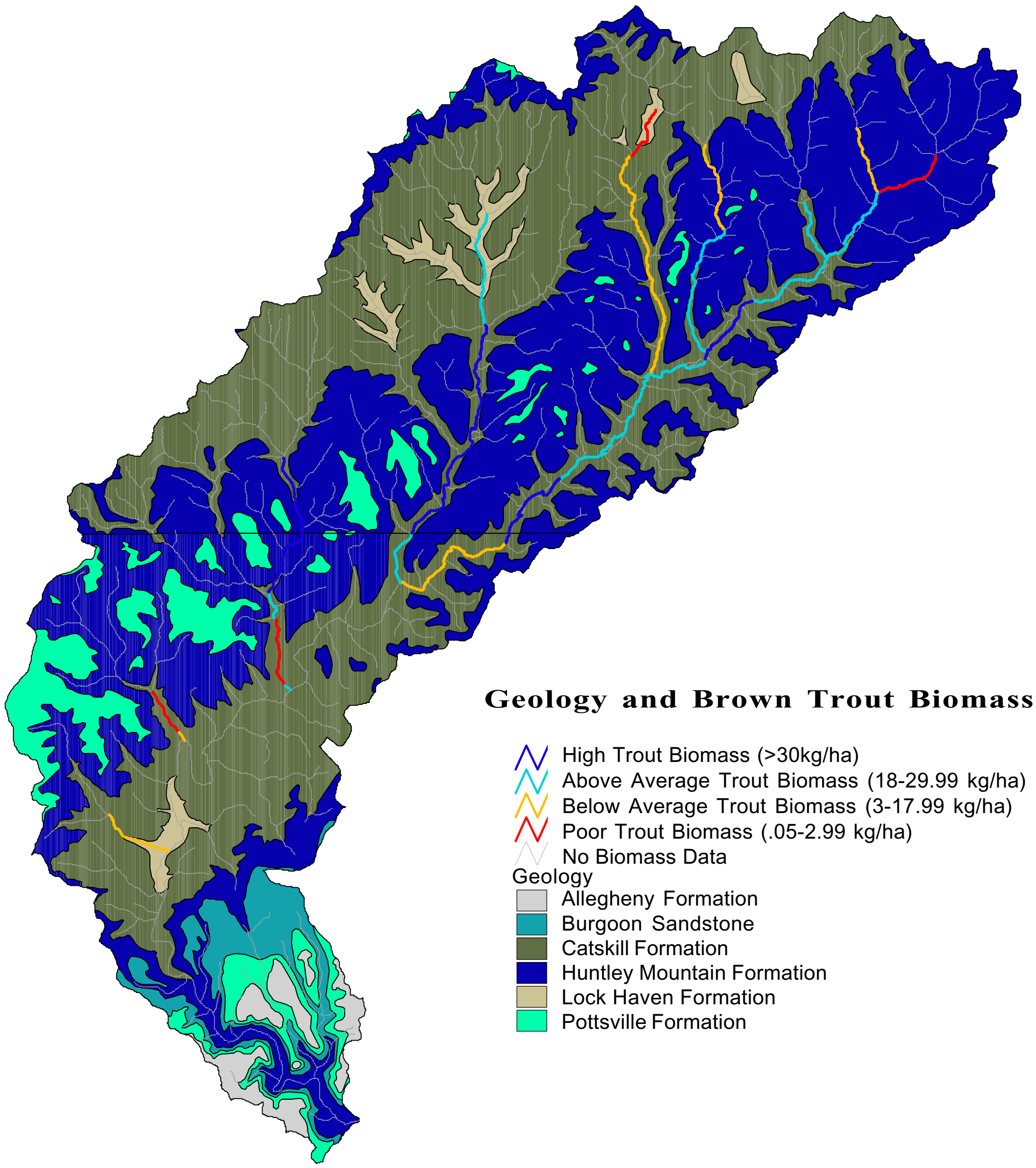


Figure 5.27: Geologic and brown trout biomass map of the Kettle Creek watershed

ACID DEPOSITION TERMS

PARENT MATERIAL is the weathered mineral or organic matter from which soils are derived.

EPISODIC ACIDIFICATION is a temporary decrease in stream pH with an associated increase in concentration of dissolved inorganic Al during periods of high flow.

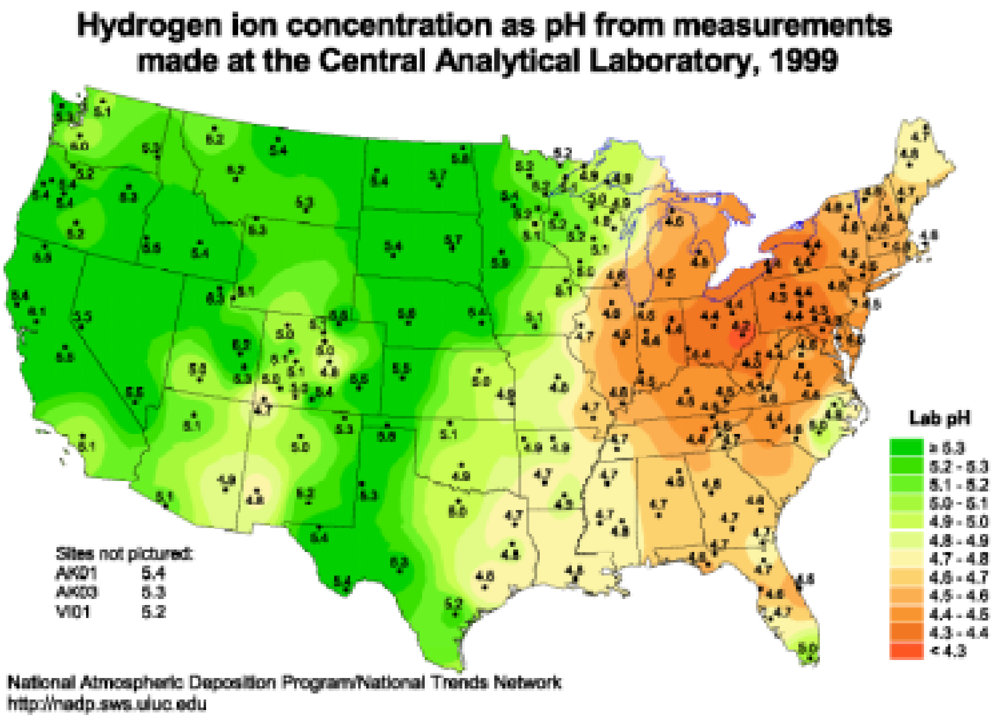


Figure 5.28 - pH data in precipitation throughout the U.S. This map indicates that potential problem areas are highest in the northeastern part of the U.S. (shown in orange).

A BUFFER is something that lessens or absorbs the shock of an impact or in chemistry something that minimizes change in the acidity of a solution when an acid or base is added to it.

LEACHING refers to the process of draining or emptying.

BASE CATIONS are positively charged ions that help buffer the soil from acidification.

OSMOREGULATION is the process by which fish exchange ions with the surrounding stream water resulting in proper body salt levels.

BENTHIC MACROINVERTEBRATES are bottom-dwelling organisms (without a backbone) that live in streams and are large enough to be seen without magnification.

Ferns are found in many parts of the forest throughout the watershed. Fern growth can be abundant where soils are too acidic for tree regeneration.

There is potential for the Kettle Creek watershed to be negatively impacted by acidic deposition. Many headwater streams included in the northern Appalachian Plateaus province of Pennsylvania are susceptible to acidification due to the bedrock composition and naturally low levels of Ca and Mg (Heard and others 1997). According to the Environmental Resources Research Institute (1994), portions of Beaverdam Run, Trout Run, Hammersley Fork, Cross Fork, and parts of Little Kettle Creek are of the Pottsville Formation, which is dominated by sandstones and conglomerates of thin shales and coals (Figure 5.27). Studies have indicated that bedrock of this type results in low levels of calcium carbonate and magnesium carbonate, making it extremely vulnerable to episodic acidification (DeWalle and others 1988). By reviewing the Pennsylvania Fish and Boat Commission's trout biomass data, it is observed that in some tributaries with low trout biomass, non-buffering geology is commonly present. Therefore, this low trout biomass may indicate areas experiencing episodic acidification (Figure 5.27).

While sections of the Kettle Creek watershed are susceptible to acidic deposition, no research has been done on the area. The Pennsylvania Atmospheric Deposition Monitoring Network, in cooperation with the National Atmospheric Deposition Program (NADP), Pennsylvania Department of Environmental Protection (PADEP), and The Pennsylvania State University, have designated sites to monitor precipitation chemistry throughout Pennsylvania since 1981. Although a monitoring site is not located within the boundaries of the Kettle Creek watershed, the information provided from the selected sites has been extrapolated to include all regions in the state. The monitoring sites were selected with the objective of representing each physiographic province, major geologic formations, soil associations, and following the distribution of annual precipitation within the state (Lynch and others 1999). (See Appendix K, page 331 - 339 for maps of pH, hydrogen ion concentration and deposition, sulfate ion concentration and deposition, nitrate ion concentration and deposition, calcium ion concentration and deposition, and precipitation data from 1987 through 1999). It is suggested that further research on the Kettle Creek watershed include spring snowmelt event sampling in high risk watersheds using the information provided by the Pennsylvania Atmospheric Deposition Monitoring Network as a baseline. The entire state of Pennsylvania is considered "at high risk" for acidic precipitation and therefore, the Kettle Creek watershed should be sampled for spring snowmelt events. Figure 5.28 shows pH data in precipitation throughout the U.S. This map indicates that potential problem areas are highest in the northeastern part of the U.S. (shown in orange).

GOALS: ACID DEPOSITION

WQ 3.2 Identify if any areas in the watershed are adversely affected by acidic deposition.

WQ 3.1 Stay abreast of regional trends in acidic deposition.

Groundwater Quality

Groundwater quality is an issue for residents of Kettle Creek because 66 percent of the wells in the watershed are used for domestic water supplies. A large percentage of the seasonal and year round residents use groundwater as their water supply, as well. Twenty-eight percent of the wells are used for commercial use and three percent are used for public water supplies. Springs are also used as a source of water, but they are surface discharges of groundwater.

Groundwater quality is also important to Kettle Creek itself. Groundwater provides the base flow to the stream. Base-flow provides cool water, which is discharged from springs and seeps in or near the streams. Trout especially need the cool groundwater discharges to survive the higher summer stream temperatures that affect the main stem of Kettle Creek. Changes in groundwater quality or quantity could potentially affect the trout populations.

BASEFLOW is the portion of stream volume contributed by groundwater. Baseflow maintains stream volume during periods of minimal rainfall and seasonally dry periods.

Kettle Creek has many wetlands associated with groundwater discharges. Many wetlands found on slopes or at the base of the slopes are dependent on springs to provide water throughout the year. (For more information on wetlands, refer to page 112.)

Secondary Drinking Water Quality Standards

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Source: EPA website, 2001

Figure 5.29 - Secondary water quality standards are not regulated, but can influence drinking water quality.

GROUND WATER

Drinking Water Quality Standards and Monitoring Data

Groundwater provides drinking water to many watershed residents. It is important that the water from the wells is safe to drink and remains safe to drink. The United States Environmental Protection Agency (EPA) has developed primary and secondary drinking water standards to ensure safe drinking water supplies to citizens (Figure 5.29). Primary standards cover the following categories: microorganisms, disinfectants and disinfectant by-products, inorganic chemicals, organic chemicals, and radionucleotides. Water supplies exceeding primary standards can cause potential health risks. Refer to the EPA webpage (http://www.epa.gov/safewater/mcl.html) for a complete list of primary water quality standards. Water supplies exceeding secondary standards may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water but do not pose potential health risks.

PA Code Title 25 Chapter 109 defines wellhead protection areas in the following manner:

Wellhead protection area - The surface and subsurface area surrounding a water well, well field, spring or infiltration gallery supplying a public water system, through which contaminants are reasonably likely to move toward and reach the water source. A wellhead protection area shall consist of the following zones:

(i) Zone I. The protective zone immediately surrounding a well, spring or infiltration gallery which shall be a 100-to-400-foot radius depending on site-specific source and aquifer characteristics.

(ii) Zone II. The zone encompassing the portion of the aquifer through which water is diverted to a well or flows to a spring or infiltration gallery. Zone II shall be a 1/2 mile radius around the source unless a more detailed delineation is approved.

(iii) Zone III. The zone beyond Zone II that contributes surface water and groundwater to Zones I and II. (www.pacode.com 2001)

The Pennsylvania Department of Environmental Protection (DEP) uses the water quality standards developed by the EPA. The DEP tests and certifies that wells provide safe water via a permitting process.

The Comprehensive State Groundwater Protection Program (CSGWPP) is a state-EPA initiative that provides a mechanism whereby states and EPA can work together to develop a comprehensive and consistent statewide approach to groundwater quality protection (DEP 1998). The program is not an additional regulatory process, but it is a plan with mechanisms to develop groundwater protection. Overall protection will be accomplished through six activities which have been summarized from the CSGWPP document (DEP 1998) including (1) establishing a groundwater protection goal, (2) establishing priorities, (3) defining authorities, roles, and responsibilities, (4) implementing efforts, (5) information collection and management, and (6) public education and participation. This plan provides the mechanism to protect groundwater resources, but implementation is needed for the groundwater resources to be truly protected.

The DEP also has wellhead protection programs that also help to protect wells that are used for drinking water. A wellhead is the land surface area through which water infiltrates and recharges the groundwater source from which the well draws water. Most of the wells in the watershed are shallow and susceptible to contamination from surface sources. The wells located in the floodplain or Kettle Creek have a high potential for contamination. Landuse should be carefully considered in wellhead areas. Activities that produce or handle water soluble contaminants should be carefully managed in wellheads. Protected wellheads mean protected drinking water.

The DEP has permitted 52 wells within the watershed. Statistical data for the wells has been collected and published on the Pennsylvania

Groundwater Inventory System (PaGWIS) CD. The PaGWIS records the following parameters: PaGWIS identification number (id), latitude, longitude, county, municipality, quadrangle, local well number, date drilled, owner, well depth, yield in gallons per minute (gpm), static level, casing top, well finish, site use, water use, and geologic formation. Water quality data are available for some of the wells and is obtainable from the PaGWIS CD or at the DEP North Central Regional Office in Williamsport, PA.

The DEP has developed guidelines to establish a wellhead protection plan. The only public water supply drawn from groundwater is located at Ole Bull State Park, but wellheads also apply to private water supplies. The goal is to protect drinking water, not classify types of water supplies. The shallow nature of the wells in the watershed, the predominant use as a domestic water supply, and their proximity to developments are several reasons to consider a wellhead protection plan. Refer to the Appendix L for wellhead protection plan guidelines.

A groundwater vulnerability model was applied to the Kettle Creek watershed, to demarcate areas with different pollution risk potentials. The DRASTIC model uses several watershed parameters to determine risk potentials. The wells were plotted over top of the model to determine potential vulnerability to pollution. A score was calculated for each well. Areas with moderate to high scores should be considered for assessment and protection.

Explanation of the DRASTIC model

DRASTIC is an empirical model developed by EPA in 1980's to evaluate groundwater pollution potential (Aller and others, 1987). The first letter of the seven variables that compose the models give the model its name (**D**epth of water table, **R**echarge of the aquifer, **A**quifer media, **S**oil media, **T**opography, **I**mpact to vadose zone, and **C**onductivity. This model includes various hydrogeologic settings whose physical characteristics affect the groundwater quality on a regional basis (Aller and others, 1990). This is a numerical ranking system that applies a relative ranking scheme to the hydrogeologic settings to obtain a measure of relative groundwater pollution potential in a region. A score of 150 in the northeast United States cannot be directly compared with a score of 150 in the southwestern United States.

The DRASTIC model was applied to the Kettle Creek watershed (figure 5.30). The scores are relative to the regional areas and not a national scale. Kettle Creek is located in the non-glaciated central region. Limestone valleys in the ridge and valley province of Pennsylvania have

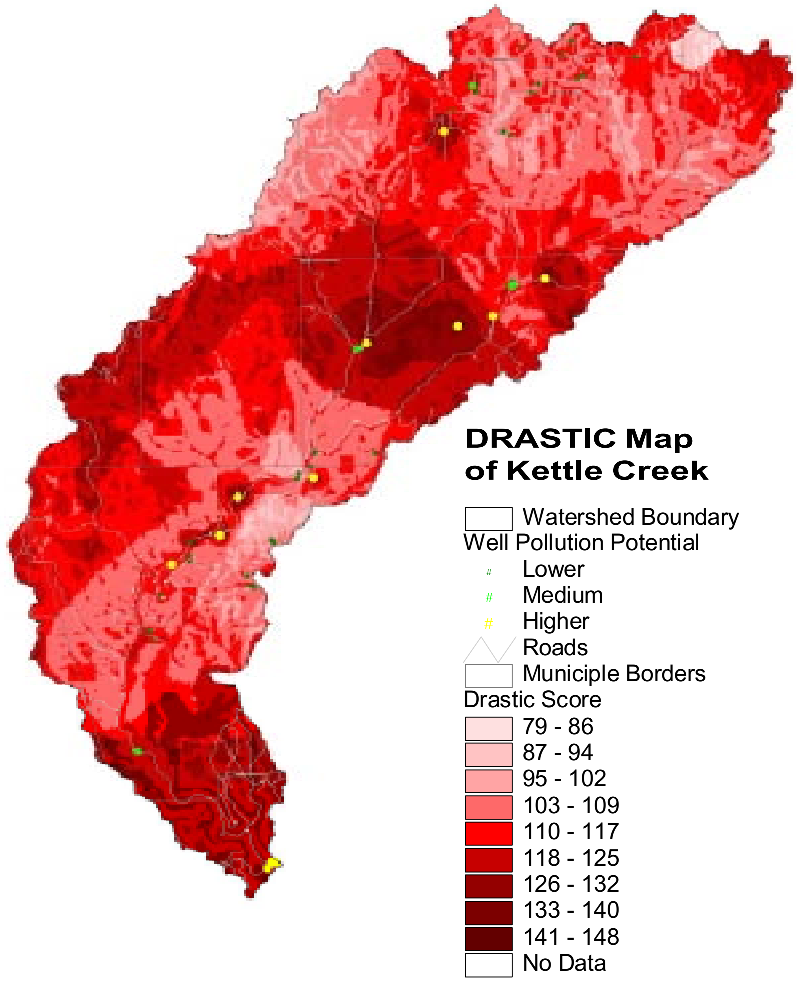


Figure 5.30 - The DRASTIC map shows groundwater pollution potential for the entire watershed. Areas of high potential contamination are located throughout the watershed and concentrated in the floodplains.

the highest values, the glaciated regions of the northeast have the lowest potential, and Kettle Creek has values, which are in between. The values for the entire watershed ranged from 79-148. The scores for the wells in the watershed ranged from 102 to 142.

The DRASTIC scores do not show any clear patterns in the watershed. The wells are distributed evenly throughout the range of scores. The ten highest scores were analyzed and 80% of those wells were found in the Catskill formation, with one in the Burgoon and Huntley Mountain formation, respectively. Seventy percent (7) of the ten provide domestic water supplies, 20%(2) provide recreational supply and 10%(1) commercial supply. The top ten percent are distributed evenly between the counties.

The ten lowest drastic scores were also evaluated. Ninety percent (9) of the wells are located in the Catskill formation. Ten percent (1) of the wells are located in the Huntley Mountain formation. Seventy percent of the wells provide domestic supplies and 30% provide commercial supplies. The wells are divided evenly across the counties in the watershed. The DRASTIC map does show some of the highest scoring wells (yellow dots) are located in the floodplain of the mainstem. The high scoring wells are also located next to lower scoring wells because each well has a different value for the variables that make up the model. Well depth is the variable most of the time.

Groundwater Pollutants

Pollutants are found in many forms from powders to liquids to solids. Any substance that can be dissolved in water or is transported in water could become a groundwater contaminant. Figure 5.31 provides a list of common groundwater pollutants and their sources.

In summary, groundwater quality is an important resource for Kettle Creek. It supplies potable water to homes and business. Groundwater is an important part of the aquatic ecosystems found in the watersheds. Wetlands develop around seeps and springs. Fish survive high summer time water temperatures by holding near areas with groundwater discharges. Efforts must be made to quantify and protect this resource.

Groundwater Quantity

Groundwater quantity is difficult to measure because results are derived from expensive and extensive sampling. Quantification of groundwater resources requires extensive drilling, detailed geologic analysis, and sophisticated modeling which is expensive and beyond the capabilities of the watershed association. However, water supply wells provide information needed to measure groundwater quantity. The watershed is sparsely inhabited with a small number of wells per area. The wells are the best measure of groundwater quantity and do provide limited data which is applicable on a watershed scale (Figure 5.32).

Of the 52 permitted wells in the watershed, the average depth of the wells is 173.9 feet from the

Figure 5.31 - Common potential groundwater contaminants for Kettle Creek.

Common Groundwater Contaminants			
Commercial	Industrial	Residential	Agriculture
gasoline	brine water (gas well exploration)	solvents	Nitrates
motor oil	nitrates	fecal coliform/sewage	N,P,K, fertilizer
industrial solvents	salts, chlorides	paint	coliforms
dry cleaning chemicals	heavy metals		

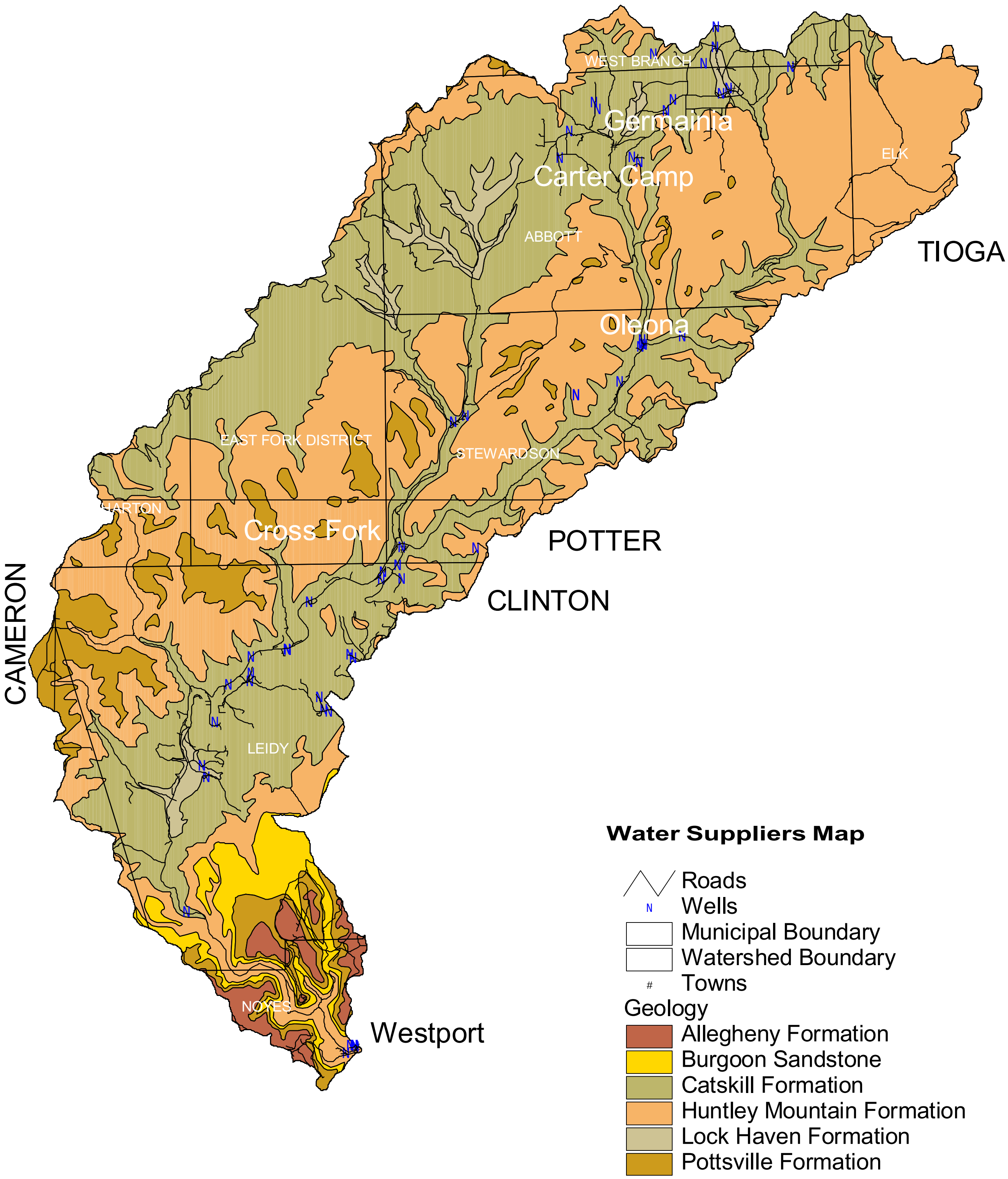


Figure 5.32 - Water suppliers map

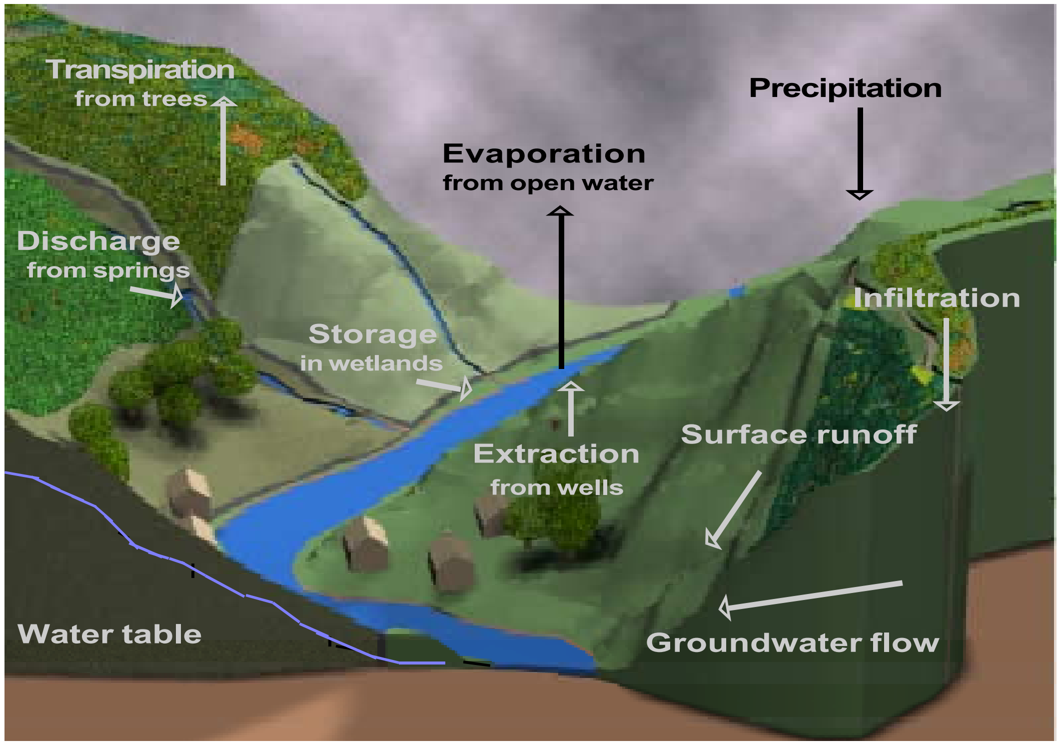


Figure 5.33 - The hydrologic cycle was applied to a digital topographic representation of the confluence of Kettle Creek Lake and a tributary. Structures have been added to represent wells and cabins located elsewhere along the mainstem of Kettle Creek.

surface, with the deepest well at 326.0 feet deep and the shallowest well is 40.0 ft deep. The average yield is 13.0 gallons per minute (gpm); the maximum yield is 40.0 gpm and the minimum yield is 4.0 gpm. There are four prevalent uses of water in the watershed; commercial (28%), domestic (66%), public use (3%), and recreational use (3%).

Six geologic formations cover the watershed. They are the Allegheny, Burgoon Sandstone, Catskill, Huntley Mountain, Lock Haven, and Pottsville formations (for more information on geology refer to page 198). The wells are found in four major formations, the Burgoon Sandstone, Catskill, Huntley Mountain, and Lock Haven, but are concentrated in the Catskill formation (80% of all wells), which aligns with the major tributaries and the mainstem. These wells have an average depth of 152 feet and average yield of 14 gpm. Ten percent of the wells are drilled in the Huntley Mountain formation with an average depth of 298 feet and average yield of 5 gpm. The remaining wells are drilled in the Burgoon sandstone and Lock Haven formations with average depths of 84 and 71 feet, respectively. Average yields are 5 gpm for both formations. See map of water suppliers with locations for graphical representation.

Groundwater Recharge Areas

Recharge areas are those regions where water infiltrates into the ground. They are typically located on broad flat hilltops, in depressional areas without standing water, or on shallow sloping hillsides. Precipitation falls onto the land surface and infiltrates. Gravity draws the water deeper into the soil until the water reaches a barrier that resists further infiltration. A pool of groundwater develops. This underground pool is called an aquifer. Some aquifers are intercepted by the land surface and consequently form seeps or springs. Streams can also intercept aquifers and the groundwater discharges under the surface of the water and contributes to base-flow. This type of groundwater is referred to as shallow groundwater. Deep aquifers can develop if they do not intercept the land surface (Watson and Burnett 1995). Drilling wells accesses deep aquifers. Recharge areas are critical to the groundwater resource. Activities in recharge areas should be carefully monitored to preserve and protect groundwater resources.

The hydrologic cycle (refer to Figure 5.33) is displayed in the Twomile Run watershed. Rain falls on the unreclaimed strip mines on top of the hills. The water infiltrates and becomes acidic after coming in contact with pyrite. The acidic water dissolves metals and discharges, by surface flow, to streams. There are also a number of seeps and abandoned mineshafts which discharge groundwater that eventually flows into a stream in the watershed. Mining activities and the lack reclamation have greatly impacted the groundwater resources in that watershed. The surface water or streams has also been greatly affected. Many other activities such as landfill construction and oil and gas exploration could have similar effects. It is important to identify recharge areas in the watershed by using available data from other studies like the AMD remediation projects, the thermal assessment study, and the wetland prediction model. A more detailed GIS analysis by a hydrogeologist will also help determine recharge areas.

GOALS: GROUNDWATER

WQ 5.1 Preserve and protect groundwater.

WQ 5.2 Preserve and protect surface water.

WQ 5.3 Preserve and protect drinking water supplies.

References: Water Quality

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WATERSHED
RECOMMENDATIONS

The recommendations that follow are the result of a collaborative effort of the project team. Throughout the assessment process, a number of resource issues or concerns were discussed, each seeming to have both social and scientific components. Therefore, multiple goals were defined to address these aspects. Individual recommendations then follow to direct management and community discussion toward resource stewardship.

Issues, goals, and recommendations are systematically numbered for reference throughout the document.
For example, WQ 1.2 refers to goal 1.2 in the water quality recommendations chapter.

WATERSHED IDENTITY

WI 1.0 Issue: Each watershed has unique ecological and cultural features that distinguish it from its surrounding region.

The Kettle Creek watershed certainly has much in common with the surrounding north central Pennsylvania region: logging and mining histories, a dispersed rural population, and thousands of acres managed by the state forests and parks, to name a few. But it also has features and qualities that distinguish it from its surrounding region. The exceptional coldwater streams, the natural formation of the Oxbow Bend, and natural gas fields and storage set the Kettle Creek watershed apart from other watersheds along the West Branch of the Susquehanna. Its cultural distinction lies in its rich agricultural history, its immigrant communities, its layers of resource extraction and conservation, its scenic quality from roads, streams, and trails, and its recreational network within and beyond the watershed. These features, whether specific sites, landscape patterns, architectural styles and details, or the history that connects them, create a unique character and identity that draws residents and visitors to the Kettle Creek watershed.

1.1 Goal: Develop a vision of the common goal(s) of the watershed community.

See also Community Capacity, page 225.

1.1.1 Develop a watershed logo and slogan for use on all official watershed (association) publications and signs. These could be solicited from watershed residents, through a contest, through a school art class competition, or from a consultant. Example: The Lititz Watershed Alliance chose their logo from entries submitted by a 5th grade art class from a local elementary school.

1.1.2 Develop a song, poem, T-shirt, hat, bumper sticker, fly, and/or fishing vest to publicize awareness for the watershed conservation. These too could be designed by residents, other watershed stakeholders, or hired consultants.

1.2 Goal: Explore and celebrate the rich cultural history of the watershed as a community and for visitors.

1.2.1 Identify a cultural history committee to incorporate historic and cultural components into watershed efforts.

This committee could include the following potential candidates: Historical Society representatives, local historians (e.g. Jim McGuire), regional historians, journal and/or news archivists, university faculty from history, geography, and/or leisure studies, state forest/park managers, local developers, contractors, building trades personnel who would be familiar with local buildings and building styles, and PennDOT public relations staff, among others.

1.2.2 Seek information, assistance and funding partnerships with local, county, and state agencies.

Contact the county historical society, the county conservation district, the State Archives, the Nature Conservancy, Preservation Pennsylvania, the Pennsylvania Historical and Museum Commission, the Bureau of Forestry, and the Bureau of State Parks. These agencies and organizations may have historical files that include documents, photographs, and maps that depict historical conditions. They may also have grant and cost-share programs for research and interpretation.

1.2.3 Develop and prioritize projects that evaluate and conserve historic and cultural resources and that portray local history as a common link among stakeholders. Potential projects include:

- Celebrate the historic and cultural significance of sites throughout the watershed.

- Utilize historical markers to celebrate significant people, places, and events of the watershed. Examples: mill location of Lackawanna Lumber Company, William Radde and Charles Meine, the Germania Hotel. Funding available from Pennsylvania Historical and Museum Commission - 50% matching grant for sign production.

An historical marker in Abbott Township

- Nominate additional historic sites to be recognized for their local, regional, state, and national significance. Consider the use of rural historic landscape designation (again, at local, regional, state, or national levels) for areas or corridors that exhibit historic features across numerous, contiguous sites.

- Continue to integrate local history with recreational opportunities.

- Enhance existing historical routes with signage, such as logging rail beds along trails. Develop and interpret new sites that have both historical significance and recreational access, such as CCC camps (throughout state forests and parks), the town of Germania, Hammersley Village, and the flooded town of Leidy (at Kettle Creek State Park). Expand or enhance trail


Logging grade in Ole Bull State Park


Ole Bull Lodge built by the CCC

networks to access new sites, such as the historic town of Bitumen.

• Explore historically and culturally significant watershed sites

as a group tour by bus, caravan, or hike;

as self-guided tour;

as a group paddling tour; and/or

through events hosted at significant sites.

• Complete a building inventory to discover the historic value and architectural patterns in building and development. Inquire about dates of construction, materials and their sources, current and previous owners, exterior design and interior layout, and outbuildings (past and present).

• Capture oral history through focus groups and interviews. Gather hunting and fishing tales, CCC descriptions and stories, notes on the agricultural history, and personal experiences of the flooding of Leidy.

• Host commemorative events, such as a splash dam parade, a log float, a fishing trip from Bitumen to Kettle Creek, and/or the whiskey robbery to celebrate the local history for current residents and visitors.

• Develop database of historic documents.

• Document current people, achievements, and events: local history. Develop an ongoing archive or collection of watershed news (newsletters, news articles, audio/video recordings, public gossip, etc.).

• Publicize the watershed history through outreach. Publish historical snippets in newsletter, newspaper or on local radio. The stories could be titled: “kettle creek cuts,” “hooks on history,” “hook some history of your watershed,” “extract the past,” “ remember when ...”.

through an almanac style of “One year, five years, ten years, fifty years, one hundred years ago today...” or

through excerpts from the cultural history assessment.

• Hold competitions for oldest photo, oldest letter, longest-living resident, newest resident, largest family, smallest outhouse, and oldest farm in the watershed.

1.2.4 Utilize history as an objective perspective to introduce the impacts of land use and land management.

Sources of Assistance:

Pennsylvania Historical and Museum Commission Grants:

- Archives and Records Management Grants
- Historic Preservation Grants
- Historical Marker Grants
- Local History Grants
- Technical Assistance Grants

Contact: Bureau for Historic Preservation, Commonwealth Keystone Building, 400 North Street, Harrisburg, Pennsylvania 17120-0093

http://www.artsnet.org/phmc/

Preservation Pennsylvania:

Preservation Fund of Pennsylvania

- Priority Issues
- Discretionary Projects

Contact: Preservation Pennsylvania, 257 North Street, Harrisburg, PA 17101

http://www.preservationpa.org/FrameFunding.htm

1.3 Goal: Recognize that the current visual quality of the watershed is characterized by a forested landscape of valley slopes and ridges and acknowledge that visual quality results from land use and management actions.

1.3.1 Document present watershed landscape. Implement a photo journal of the watershed.

1.3.2 Consider conservation programs that limit change in community-identified scenic areas.

Agricultural fields of Germania Branch

- Agricultural Areas
- Wild and Scenic Rivers Program (see appendix X for contact information)
- Scenic Road corridor
- Greenways (trails)

1.3.3 Develop voluntary guidelines for architectural development. This could follow from inventory and analysis of the building architecture in the watershed. (See above recommendation 1.2.3)

1.3.4 Identify areas for visual (and ecological) enhancement projects. Plan enhancement in coordination with PennDot and local road maintenance supervisors.

· Roadside vegetation for visual and ecological enhancement

1.3.5 Document historic watershed landscapes (e.g. during the logging and mining eras) for comparison with current and future landscapes.

1.4 Goal: Recognize and protect the unique natural features of the watershed that have influenced resident life and visitor experiences.

1.4.1 Develop promotional slide/video show about the watershed.

1.4.2 Develop and prioritize projects for recognition.

· Signage of the 'kettle' (the distinctive shape of the creek), Leidy gas field, streams, geologic features - incorporate watershed logo

· Heritage and recreational connections to these features

1.4.3 Explore a variety of resource conservation mechanisms. Select and apply those that the community feels would provide the most appropriate protection.

- Greenways - local and state
- Scenic rivers
- National, State historic sites/corridors/ landscape and recreation
- Local planning and purchase of development rights (PDRs)
- Conservation easements

WI 2.0 Issue: A watershed is part of both ecological and social systems.

As water moves throughout the landscape as surface and groundwater, its drainage patterns form a network of corresponding land units-watersheds. But as a result of human interaction with the natural environment, a watershed is also part of, or affected by, social systems. Various political, social, and cultural associations also define land units or regions. Residents abide by government policies that are implemented across state and municipal boundaries. Individuals identify with socioeconomic structures. Watershed residents also identify with cultural organizations and associations, such as churches, granges, and sporting clubs.

As part of these systems, the watershed plays a major or a minor role but nonetheless affects or is affected by other parts or members. Knowing what these interactions are, how they operate, and how they can be managed is critical to understanding the impacts of decision-making in any system.

2.1 Goal: Work cooperatively with organizations and associations of the north central Pennsylvania region, the West Branch of the Susquehanna River, and the Chesapeake Bay to achieve local goals, to rally support for local efforts, and to support regional goals.

2.1.1 Dialogue/Partner with county resources: conservation district, planning department, and historical societies.

2.1.2 Dialogue/Partner with other West Branch watersheds and the larger Susquehanna River Basin community: Pine Creek, Sinnemahoning, First Fork, Susquehanna River Basin Commission.

2.1.3 Dialogue/Partner with Chesapeake Bay organizations. Organizations and associations support a wide range of efforts and interests from stream improvement projects to education and outreach programs to recreational events such as hiking, biking and paddling.

2.1.4 Dialogue/Partner State Agencies, such as state foresters/Bureau of Forestry, state park manager/Bureau of State Parks, the North Central Regional Planning Office, and the Department of Community and Economic Development.

2.1.5 Dialogue/Partner efforts in the Lumber Heritage Region.

In the context of watersheds, education typically refers to the process of instilling in watershed association members a basic knowledge of social and ecological systems. Outreach works toward a similar goal but to a wider audience, generally those not currently involved in the association.

EDUCATION & OUTREACH

The project statement for this assessment and stewardship plan asked the team to develop education and outreach programs relevant to the resource issues of the watershed. This was a somewhat challenging task. As the team examined a wide range of natural and cultural resources, the assessment suggested that resource management discussions (whether watershed scale or not) would benefit from some type of educational effort. To this end the following list of educational topic ideas has been generated.

On culture:

Why is history important to a watershed?
History as

...storytelling as a social event
...the story of continuous change
...a reference for resource management

Recreation: Contributions to economy and landscape conservation

Appreciation, documentation, and conservation of scenic qualities of Kettle Creek

On land use:

The impact of individual land use on shared (watershed) resources.

Land use planning as a tool for rural communities (residents) to guide 'smart' development: How to consider cultural and 'natural' resources, quality of life and the general character of the landscape in planning policy.

The benefits and costs of watershed planning?

Stormwater management: What is it? How can landowners address it?

What is watershed identity and why is it important?

The potential for sprawl in north central Pennsylvania's mountains.

The definition and functional importance of 'natural areas'.

Precedents for watershed stewardship: Environmental and economic benefits from environmentally friendly site design practices.

Wetlands in the Kettle Creek watershed: Where are they and why are they important? How can I identify wetlands?

Regional impacts of AMD mitigation on Kettle Creek.

Corridors: Important linkages for wildlife, recreation, and streams.

On fisheries:

What is a habitat assessment and how can it be useful?

The importance of temperature on coldwater fisheries

> What causes temperature increases in a stream?
>
> What can be done to mediate thermal problems in streams?

The importance of woody debris in streams.

On water quality:

Acidic deposition: Effects on streams and forest ecosystems, specifically potential effects on Kettle Creek.

How do riparian buffers influence a stream?

Ways to reduce sediment deposition.

Ways to measure and protect water quality: Chemical and biological (macroinvertebrates) indicators.

What causes erosion and what can be done to stop it.

What is a wellhead? How does a wellhead affect private landowners?

How does development impact drinking water?

On general environmental stewardship:

Simple ways that a landowner can be a watershed steward.

Stream improvement projects in your watershed.

While this list may seem to suggest that education is needed in all areas, these topics may not all be pertinent to the current priority issues in the watershed. Therefore, as the KCWA sets its goals for each year, it can prioritize educational and outreach efforts to support current and upcoming resource discussions.

The project team recognized that community members have a variable understanding of watershed delineation, what constitutes a resource, how public and private resource management affect them personally, and how they can participate in resource management discussions. This led to a broader series of recommendations regarding education and outreach.

EO 1.0 Issue: Public understanding of watershed boundaries and the purpose of a watershed association are essential for public support and involvement.

Community members need to understand what a watershed is and how the watershed boundary and the resources within affect them. Without an understanding of how resource management decisions affect them personally, community members often see little or no need for participation in resource decision-making. As a result of an attitude of self-sufficiency in rural areas, residents are often skeptical about new community organizations, suspecting ulterior motives on the part of government regulators. Clear, consistent communication of community-initiated goals are critical in clarifying that the association is non-governmental and is acting on behalf of the community.

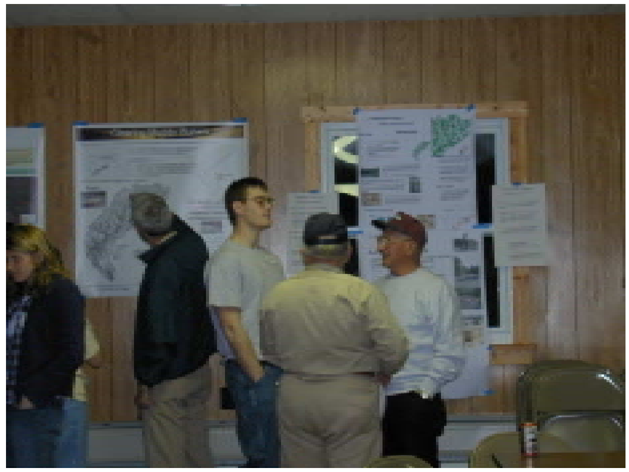
1.1 Goal: Promote baseline knowledge of the watershed and watershed issues to enable full participation in local resource decision-making by community members.

1.1.1 Post signs identifying the boundaries of the watershed along roads, trails, and vistas. Look to PennDot and state forests as potential partners for this project.

1.1.2 Distribute printed copies of any annual report to all landowners or land managers in the watershed.

1.1.3 Display a printed copy of any annual report at locations where community members can discuss it. Locations might include public bulletin boards at post offices and stores, the bar at watershed restaurants, and the reception desk of township offices.

1.1.4 Host an annual retreat to inform new and potential association members about resource delineation and resource management. This retreat could be held in conjunction with the KCWA annual meeting each spring. The retreat could be targeted to adult, child, or family audiences.



April 26 public meeting

1.2 Goal: Clearly and consistently post a KCWA mission statement

1.2.1 Develop a mission statement to guide the activities of the association.

1.2.2 Post the mission statement at locations where KCWA announcements are displayed.

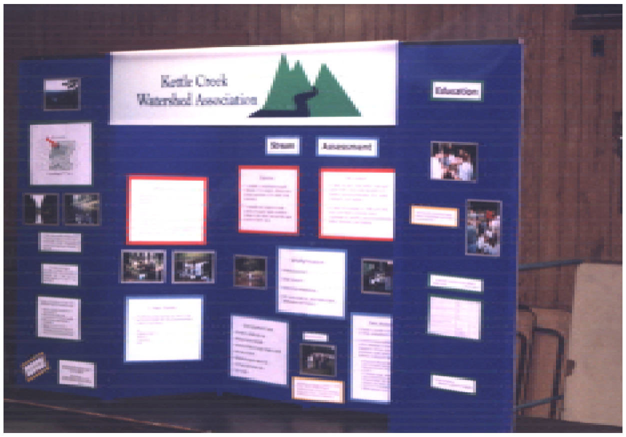
1.2.3 Review the mission statement once a year based on new projects and initiatives.

1.3 Goal: Use consistent media coverage to promote awareness for the watershed association and its activities.

1.3.1 Contribute KCWA updates to other local organizations' newsletters (e.g. churches, granges, and sportsmen's clubs).

1.3.2 Announce all KCWA events via newspaper, radio, and TV "community calendars" (e.g. association meetings, project groundbreaking).

1.3.3 Invite newspaper, radio, and TV coverage to all KCWA events (e.g. the annual meeting/annual retreat, project groundbreaking and project completion).



Project display

1.3.4 Submit press releases or articles to local newspapers on a bimonthly, or monthly basis.

1.3.5 Update the KCWA website regularly (monthly).

1.3.6 Circulate a traveling display of current events and issues throughout the watershed. Locations could include restaurants, hotels, parks, stores, the grange hall and churches.

EO 2.0 Issue: Watershed stakeholders need accurate information on resource management to confidently and effectively participate in decision-making discussions.

Stakeholders often seek or receive information on resource management (and other community issues) from a number of sources. Each source may have somewhat different information to share. In some cases, the information may be incomplete, inaccurate, or even biased. As an advocate for watershed stewardship, the Kettle Creek Watershed Association should deliver complete, accurate, and unbiased information to watershed stakeholders.

Education and Outreach (E&O) requires continuous support and development. As watershed priorities and stakeholders change over time, an on-going effort is required to tailor educational programs and outreach efforts toward current and upcoming watershed issues. Therefore, education and outreach activities need to become a permanent part of the Kettle Creek Watershed Association's program.

2.1 Goal: Supply complete and accurate information on resources to enable effective participation in watershed decision-making discussions.

2.1.1 Form an E & O committee or utilize an E & O coordinator.

2.1.2 Develop E & O programs that respond to watershed issues

- · Develop, prioritize, and implement educational efforts on current and upcoming watershed issues.
- · Create and install educational displays along streams to describe key issues in the watershed.
- · Re-prioritize efforts as issues and stakeholders change.
- · Target different audiences, who may have different priorities and knowledge bases.

2.1.3 Enable understanding of natural systems and their relation to human systems through a consistent program outline. The following model could be used to develop a variety of educational materials and programs that cover these points. The materials and programs could include printed pamphlets, slide presentations, field talks, presentations supplemented with overhead transparencies, and even project reviews. It outlines the most basic points that should be covered to give the audience a basic understanding of their local environment.

Outline:

What is (the topic) - definition of terms.

How does it work/function.

What does it look like (through images, illustrations, and diagrams).

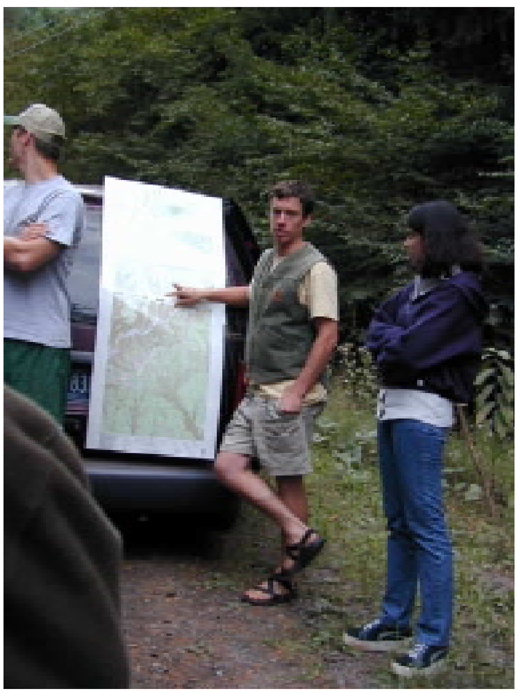
Where can I find it (potential map).

What relies on it/What does it depend on.

Why does it matter to me.

How can I improve it.

2.1.4. Seek active involvement from all current and future/potential stakeholders.



Touring the watershed

· Seek knowledgeable community residents to lead and/or present programs. Acknowledge leaders with a certificate for outstanding leadership and service.

· Document participation in education and outreach efforts.

· Photograph and record names and dates of participants.

State park campers

· Invite media coverage to all events/send press report.

· Include event coverage in the KCWA newsletter so people can see how much fun their neighbors had.

· Incorporate brief, consistent education information in the KCWA newsletter.

· Highlight news and information about the West Branch basin to convey a greater sense of hydrologic scale and the neighbors downstream.

· Develop or include "Tips to improve your watershed" or a "Tip of the month" to address landowner influences on natural resource quality.

· Invite watershed visitors from state parks, lodges, camps, and motels to participate in single-day or short-term programs and events. Their participation may help economize outreach efforts and encourage their support of watershed activities in Kettle Creek and in their home watersheds.

2.1.5. Seek assistance (funding, materials, and educators) from resource agencies and organizations. Options include, but are not limited to county conservation districts, Susquehanna River Basin Commission, Chesapeake Bay organizations, and DEP/DCNR.

· Explore partnerships with state forests and state parks for funding and assistance for education on natural resource management.

· Explore existing programs and materials available through PA DEP.

Fact Sheets (on environmental topics for aid in making pamphlets) (http://www.dep.state.pa.us/dep/deputate/watermgt/watermgt.htm)

Pennsylvania Chesapeake Bay Mini-Project Education Program

· Tap federal agencies, such as EPA and U.S. Fish and Wildlife Service, and Americorps for a number of funding options specific to education efforts.

http://www.epa.gov/owow/watershed/wacademy/fund/wag.html

http://www.epa.gov/owow/watershed/wacademy/fund/envedu.html

http://www.epa.gov/owow/watershed/wacademy/fund/envjustice.html

http://www.epa.gov/greenkit/whoweare.htm

http://www.epa.gov/enviroed/grants.html

http://www.epa.gov/greenkit/grants.htm

U.S. Fish and Wildlife Service (http://www.fws.gov/educon.html)

http://www.americorps.org

EO 3.0 Issue: Regional education efforts can more efficiently utilize funding and technical resources in sparsely populated areas.

Successful partnerships start with partners understanding each other's current needs and concerns about watershed issues. Awareness over a regional area of the important environmental issues in each watershed benefits each partner, by creating a working relationship with other areas to increase the amount of support and recognition. Educational funding may be most easily obtained in sparsely populated areas by combining efforts to obtain funding resources. Sharing funding resources may benefit each watershed partner in a unique way. Materials may be shared or rotated through out a region or labor forces united to accomplish environmental tasks. In addition, establishing connections within a region may benefit local business owners to promote business and employment from new areas.

3.1 Goal: Create a regional watershed education network by partnering with adjacent watersheds and/or school districts.

3.1.1 Employ a regional watershed/environmental education coordinator.

3.1.2 Share costs of equipment and supplies with all partner watersheds through the network.

HOBO temperature loggers were purchased with funding from partner Trout Unlimited and installed to assess thermal impacts to the stream network.

Young anglers in Ole Bull State Park

3.1.3 Invite educators from regional resource agencies and organizations to discuss common resource issues. Educators could spend several days talking with schools, sportsmen's clubs, church organizations, and township officials throughout the region.

3.1.4 Work with local school districts and other watershed coordinators to develop programs that address Kettle Creek and neighboring watersheds.

· Students could do a project in Kettle Creek, then one in Pine Creek, then one along the Sinnemahoning.

· Publicize research needs to high school students, Eagle Scouts, and others who may be looking for community service projects.

· Students could work in a native plants nursery - watering, repotting, weeding, and fertilizing native species for planting across the watershed. Specify funding sources (e.g. Chesapeake Bay Foundation).

COMMUNITY CAPACITY

CC 1.0 Issue: Inter-municipal collaborative capacity can capitalize on existing and future resources.

There are often times when people and communities face the same or similar situations in how to provide the services and resources for the benefit of the entire community. A first step in building a sense of community is for people to get to know each other. Communication is of the utmost importance especially with people already in prominent leadership positions.

1.1 Goal: Increase dialogue between local levels of government, business leaders and the Kettle Creek Watershed Association.

1.1.1 Identify Kettle Creek Watershed Association members to attend and represent the association at public meetings of the school districts, municipalities, and counties.

1.1.2 Personally invite all elected and nonelected representatives of the different branches and levels of government to all public activities of the Kettle Creek Watershed Association.

1.1.3 Establish or attend regular business or nonprofit organizations breakfast / lunches in or near the watershed

CC 2.0 Issue: Kettle Creek Watershed Association can help to further establish and maintain a sense of community.

Nonprofit organizations can often help in the process in building pride and a stronger sense of community by working with individuals, government, and other interest groups. Finding common themes, topics, issues that people can agree on goes a long way to help build consensus for the future decisions of a community.

Water is something that everyone shares and needs. Water is critical to a community whether it be for human consumption, wildlife, or recreation.

KCWA meeting held on November 2, 2000

2.1 Goal: Envision the future of the KCWA as a potential long-term community-based organization for the conservation of natural and cultural watershed resources.

2.1.1 Periodically reassess vision of KCWA.

2.1.2 Develop a financial plan for the next five years.

2.1.3 Produce an annual financial report.

2.1.4 Develop a fund raising plan.

2.1.5 Explore the possibility to secure a grant or grants to establish an endowment.

2.1.6 Develop a membership recruitment and retention plan.

2.1.7 Evaluate the association through an annual assessment or report card.

2.1.8 Increase the number of partnerships with people and organizations within the community.

2.2 Goal: Increase the dialogue with people and other community organizations in the watershed, counties, and region.

2.2.1 Go on tour to give slide presentations about the KCWA to other civic organizations (e.g. Grange(s), Church Groups).

2.2.2 Set up and staff a display at all civic events such as Cross Fork Snake Hunt and County Fairs.

2.2.3 Co-sponsor roadside cleanup maintenance along a heavily traveled state and or township roadway with one or more other civic organizations.

2.2.4 Invite other civic organizations to give presentations at KCWA meetings

KCWA meeting held on November 2, 2000

2.2.5 Co-sponsor social fund raising activities with other civic organizations

CC 3.0 Issue: Identify known and potential differing viewpoints that could influence future community decisions.

Conflict is often the first way people start to address concerns in the society. However, conflict is not the only way and sometimes not the best way to resolve differing viewpoints in the community. Engaging people on a regular personal basis can help to foster trust and connections for expanded community interaction.

KCWA meeting held on April 26, 2001

Project team discussion of watershed recommentations

KCWA meeting held on April 26, 2001

Consensus democracy can often lead to more long term productive relationships.

3.1 Goal: Reach out to under represented and non-traditional stakeholders to improve understanding of community.

3.1.1 Develop a written list of business and other organizations that might have a conflicting view points in the region that are not in partnership with KCWA.

3.1.2 Invite the developed list of stakeholders to KCWA activities.

3.1.3 Brainstorm ways KCWA and business or organizations can find benefits of mutual interest.

3.1.4 Further develop understanding of community attitudes with Penn State Cooperative Extension and County Conservation Districts through survey and focus group activities.

3.1.5 Explore getting involved with the Community Information Network through Penn State Cooperative Extension.

FISHERIES RECOMMENDATIONS

FH 1.0 Issue: Stream habitat characteristics determine the number, size, and species of fish that can be sustained.

Understanding the interactions of habitat factors is important in determining the characteristics of the fish communities in a stream. Five classes of factors affect the distribution and abundance of stream fish: streamflow, water quality, energy source, physical habitat structure, and biotic interactions. These interact to determine the characteristics of the fish community along with characteristics of the riparian zone and the watershed.

Rapid bioassessments are the first step in determining potential fish habitat problem areas with habitat throughout the watershed. These assessments look at: instream cover, favorable epifaunal colonization, riffle quality, riffle quantity, various velocity-depth combinations, embeddedness, sediment deposition, channel alteration, channel flow status, bank vegetative protection, grazing or other disruptive pressure, bank stability, and riparian vegetative zone width. The current habitat assessments that have been used in the watershed need to be more detailed in order to better characterize the stream. One issue is that the same assessment sheet has been used regardless of the gradient of the stream being assessed. The gradient of the stream greatly affects the type of habitat that are available and needs to be considered. The Kettle Creek watershed consists of both low and high gradient streams, therefore a single habitat assessment sheet is insufficient. A detailed habitat assessment also needs to be completed in order to pinpoint locations that are in need of habitat improvement projects.

The recommendations pertaining to the complete previous habitat assessments are divided into five categories: fish and macroinvertebrate living conditions, riffle and velocity-depth

A typical stream bottom condition in Cross Fork

combinations, sediment in the stream, channel of the stream, and bank condition.

1.1 Goal: Improve and develop habitat assessments.

1.1.1 Perform a detailed habitat assessment (Level 2 or also called EMAP Analysis) throughout the watershed. An appropriate sampling design is critical to the success of any habitat. By taking an inventory on the amount of different habitat types, biologists can quantify habitat availability, identify potential limiting factors, and estimate fish species abundance. Before and after inventories of habitat types can also quantify the effects of habitat alterations and assess effective habitat enhancements. Coarse woody debris and available fish spawning beds are two examples of categories crucial in determining optimal habitats. These are not considered in detail using the Level 1 habitat assessments, but are examined in the Level 2 habitat assessments. More information can be obtained by reviewing Ch. 5 of the EPA rapid bioassessment protocol (EPA rapid bioassessment protocol website 2001). Some examples of this more detailed (level 2) habitat assessment can be found in Meador and others 1993, Klemm Lazorchak (editors) 1994, and Kauffman and Robison 1997, or by the American Fisheries Society, Humboldt Center (http://www.northcoast.com/~humbafs/fishmod.html).

- Locations to look for funding or research assistance for this level 2 assessment are the EPA, Fish & Wildlife Service, Trout Unlimited, Bureau of Forestry, Penn State University, Lock Haven University, Mansfield University, and/or the Army Corps of Engineers (specifically, Section 206 of the Water Resources Development Act of 1996).

1.1.2 Utilize the existing habitat advisory board to guide coopertive efforts. Detailed habitat assessments involve many different fields of studies and include agency and community cooperation. An advisory board could consist of the Pennsylvania Fish and Boat Commission (PFBC), Bureau of Forestry, Trout Unlimited, and local townships.

Scenic views of Kettle Creek's main stem

1.1.3 Conduct (Level 1) habitat assessments using gradient specific habitat assessment protocols, one for low gradient streams and one for high gradient streams. According to the stream class map on page 7, the high gradient habitat assessment data sheet would be used on class A or B streams (>2% slope). The low gradient habitat assessment data sheet would be used on streams with class C (<2% slope). A suggested example of these gradient habitat assessment data sheets is included in Appendix, pages 301-304, and are available on the rapid bioassessment protocol website (http://www.epa.gov/owow/monitoring/rbp).

1.1.4 In conjunction with habitat assessment sheets, require that the Physical Characterization/Water Quality Field Data Sheet also be completed. This form (see appendix, pages 299-300) includes observations on riparian vegetation, instream features, watershed features, large wood debris, aquatic vegetation, sediment/substrate, along with water quality parameters. It is also available on the rapid bioassessment protocol website (see above).

1.1.5 Create a uniform sampling protocol which is conducted during the same season. Some categories in the habitat assessment change depending on season and may not be seasonally comparable. For example, channel flow status would score marginal in most streams during the summer months due to low flow conditions. If the assessment was conducted at the same location during the spring months (high flow conditions), the site may score higher in the channel flow status category. If a standard season was set to collect the data for these habitat assessments this problem could be eliminated.

1.1.6 Train volunteers and anyone else that will be conducting the Level 1 habitat assessments. Training is essential for the habitat assessments to be valid. The Chesapeake Bay Foundation or the EPA are two organizations that may offer training workshops.

Clean, stream bottom rocks provide essential habitat for macroinvertebrates.

1.1.7 Make the rapid bioassessment protocol document available to the public, especially those conducting assessments. Chapter 5 of this document explains in detail the definitions of each category, why they are important, and gives pictures of examples of optimal and poor conditions in both high and low gradient streams. This is important for everyone conducting assessments to know and review.

1.2 Goal: Improve stream habitat focusing on flow, substrate, and riparian areas

1.2.1 A completed detailed habitat assessment, will identify potential areas that can be improved and then methods of habitat enhancement can be discussed.

1.2.2 Improve habitat conditions for fish and macroinvertebrates. Management for diversity will usually keep the stream in sound condition for biological resources. A well-functioning trout stream has plunges, backwaters, large woody debris and streamside vegetation, cobble, gravel, even sand and silt, depth, pockets, undercuts, and an optimal relationship between this diversity and yearlong food and habitat requirements. By providing complex habitats, the overall biotic diversity is increased throughout the stream. Sections of Bergstresser Hollow, Cross Fork, Hammersley Fork, John Summerson Branch, Walters Run, Bearfield Run, and the mainstem all have some areas that potentially need improvement of these living conditions (For specific locations see page 137).

1.2.3 Maintain and improve riffle quality, quantity and ensure a mixture of velocity-depth combinations. Billings Branch, Sliders Branch, Ives Hollow Run, Boone Run, Cross Fork, Hammersley Fork, Trout Run, Walters Run, Bearfield Run, Twomile Run and the mainstem all contain sections that may need some riffle or velocity-depth combination improvements (For specific locations see pages 138 & 141). Macroinvertebrates prefer riffles over pools due to the availability of substrate to inhabit. Generally, different habitat types, including riffles, pools and backwaters provide different


Hevner Run

value to different fish species or certain life history stages of a particular species.

- Adding cobble sized rocks and boulders would improve riffle quality and cause a variety of velocity-depth combinations to occur. This also adds macroinvertebrate habitat. Be aware streamflow may move material downstream with storm events, thus stream type and discharge should be considered.

- Adding coarse woody debris has many advantages. Installing woody debris increases the amount of fish cover. Pools are formed which can provide fish habitat and add to the variety of stream characteristics

- Trout productivity can be altered by the availability of spawning habitats, common techniques are to clean trap or secure gravels

1.2.4 Reduce sediment deposition in streams. Sections of Sliders Branch, Ives Hollow Run, Little Kettle Creek, Spicewood Run, Beaverdam Branch, Twomile Run, Huling Branch, and the mainstem all contain potential sediment problems (For specific locations see pages 138 & 140). Sediment deposition causes embeddedness and smaller channels which limits habitat potential for both fish and macroinvertebrates. Siltation is a major cause of degraded spawning habitat for fish species. Silt can smother eggs and decrease survival of juvenile fish. Silt can be a limiting factor in natural reproduction of trout. Sediment deposition can be caused by dirt and gravel roads (see goal WQ 1.1), agricultural practices (see goal LU 1.2), and stream bank erosion (see recommendation FH 1.2.6).

1.2.5 Maintain natural channel of stream and improve areas where the channel has been affected by human activities. Channel flow status needs to be studied more closely throughout the watershed due to seasonal variations in the data. The confluence of Kettle Creek and Hammersley Fork needs improvements due to a wide and shallow channel. The channel was altered when a bridge was installed and now does not follow its natural path. Some instream improvements to this section could be:

- Decrease erosion by implementing stream improvement projects (see FH 1.2.6 reccommendation)

- Research bridge removal

1.2.6 Decrease erosion potential and increase stream bank vegetation. Sliders Branch, Germania Branch, Hungry Hollow, Long Run, Little Kettle Creek, Cross Fork, Hammersley Fork, Trout Run, Twomile Run, and the mainstem all had sections that had some potential bank problems (For specific locations, see pages 143 - 145). Stream bank erosion is an effect of the natural process of streams to change their course. Landowners living near these streams want to stop this movement of the stream so that they can enjoy the recreational and aesthetic benefits of their land. Stream bank erosion occurs when soil is worn away from the bank and transported by the stream flow. Streams whose banks are protected by trees and other vegetation can alleviate the normal stresses of flooding and stream velocity. The first step to erosion control is to prevent bank erosion from occurring. Key characteristics of a protected bank are:

- Vegetated banks

- No structures located on stream banks

- Minimal channel changes

Many effective means of stream bank erosion control are available, but all are situation specific. To choose the best solution, local conditions, possible techniques, and the objectives of the landowner must be considered. A concerned landowner could build some of the structures mentioned below and funding is available to aid in the construction. For further information, consult the book "A Stream Bank Stabilization and Management Guide for Pennsylvania Landowners," which is referenced at the end of this chapter. However, be aware that before improvement structures can be built on stream banks, a permit is needed from the DEP. Some potential erosion improving structures include:

- Live Stakes

- Live Fascines (bundles)

- Branch Packings

- Live Cribwall

- Stone Riprap

- Channel Block

- Log Frame Deflector

Gabions along Elk Lick Run

- Dry Stone Walls
- Gabions
- Cross vanes and J-hooks
- Streamside plantings of vegetation

1.2.7 Encourage landowners to implement habitat improvement projects on their own land. Private landowners should be a part of the conservation process. Funding is available for them to voluntarily improve the habitat on their own property. The U.S. Fish and Wildlife Service (Partners for Fish and Wildlife) is one example of this type of funding (http://partners.fws.gov/index.htm)

Fishing in Ole Bull State Park

1.3 Goal: Monitor habitat to attain more self-sustaining wild trout populations.

1.3.1 Completion of an angler survey on different trout streams to determine angler pressure and attitude on current management strategies.

The three fundamental descriptors of a fishery are the catch, angler effort expended and catch per unit effort. All are typically estimated by the angler survey technique which consists of interviews of anglers, inspection of catch, and tabulation of hours spent fishing. The surveys are completed by the Pennsylvania Fish and Boat Commission (PFBC) and prioritized by the Unit Leaders and Fisheries Management, then executed if sufficient funds are available to conduct. The KCWA volunteers could work with PFBC to target stream sections or management strategies to determine angler attitudes and pressure specific to an area. The last survey completed on Kettle Creek was in 1984 on one of the catchable trout sections of the mainstem.

1.3.2 Manipulation of the biotic community by stocking.

A commonly used management approach to modify the fish community structure of a stream is to stock hatchery trout. The role of hatchery reared fish is to either supplement wild trout populations or to provide angling where no wild trout exist. Stocking can reduce the number of wild trout available to anglers and may cause some genetic alterations of the wild stocks. Kettle Creek is one of the most intensively stocked streams in Pennsylvania due to the high angling pressure. The PFBC has developed many trout management strategies for the Kettle Creek watershed. Completion of a more comprehensive angler survey will help target stream areas and will lead to a better understanding of the fishery.

1.3.3 Regulate the catch

Management of self-sustaining wild trout streams would be better directed at maintaining or enhancing riparian habitat, maintaining adequate water flows, and applying appropriate catch regulations. The PFBC decides and enforces all the catch regulations on Kettle Creek. Angler surveys could provide target areas for which regulation changes may be needed.

FH 2.0 Issue: Warm water fish habitats constitute an important component of recreational fisheries.

Success of a fishery is determined largely by the degree to which the desires and expectations of the fishing public are fulfilled. Fishing harvest can have a major affect on the numbers, size growth rates, and productivity of fish populations. Other factors that influence fish communities in lakes include the water level, timing and nature of fishing harvest which in turn affects the quantity, sizes, and types of fish available for future harvests. Angler regulations and controls on lake access are the primary means of controlling angler harvest. Problems can result from both over fishing and under utilized.

2.1 Goal: Recognize values and opportunities in the Kettle Creek Watershed

2.1.1 Establish a balance between allocations to the different users groups and the health of the resources that serve them in the Kettle Creek Lake recreational fishery

Potential Lead Organizations and/or Funding Sources for Fisheries Recommendations:

U.S. Fish and Wildlife Service

Trout Unlimited

County Conservation Districts

Pennsylvania Fish and Boat Commission

DCNR Scenic Rivers Program (See Appendix C for more details)

NRCS- branch of the USDA

State soil conservation services

Local Universities (labor and research)

U. S. Corps of Engineers (specifically, Section 206 of the Water Resources Development Act of 1996)

Kettle Creek Lake

Available funding sources for recreational fisheries partnership projects opportunities http://swr.ucsd.edu/funding.htm

References

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American Fisheries Society, Humboldt Center- ... lysis: ... s/

Northern pike (Esox lucius)

Largemouth bass (Micropterus salmoides)

Rock bass (Ambloplites rupestris)

Bluegill sunfish (Lepomis macrochirus)

Brown Bullhead catfish (Ameiurus nebulosus)

Longnose dace (Rhinichthys cataractae)

THERMAL PROTECTION

TP 1.0 Issue: Data are needed to evaluate changes in temperature that may threaten coldwater fisheries.

Aquatic ecosystems are extremely sensitive to minimal fluctuations in water temperature. The Kettle Creek watershed is known for having a thriving coldwater fishery and an abundant trout population. Besides having the proper habitat and available food sources, cool stream temperatures are essential for survival of trout populations.

To ensure the protection of Kettle Creek's coldwater fisheries, any factors that influence the thermal regime of the stream must be monitored and evaluated periodically. Thermal issues have been a concern on the Kettle Creek watershed for over 60 years, yet no comprehensive thermal study has been completed. Currently, coldwater fisheries with thermal problems have not been located and cannot be remediated.

1.1 Goal: Continuation and annual re-evaluation of the newly established thermal study on the Kettle Creek watershed.

1.1.1 Continue monitoring water temperatures throughout the watershed. In the spring of 2001, a comprehensive thermal study was implemented on the Kettle Creek watershed. The study implemented must continue for one year of time for the data to be useful in evaluation of the thermal regime of streams throughout the watershed and to locate potential problem areas.

1.1.2 Re-evaluate thermal study annually. After one year of data collection, data must be evaluated to locate areas along the watershed with and without thermal problems. The HOBO temperature loggers should then be relocated from areas without problems to other areas in the watershed that have not yet been thermally assessed.

1.1.3 Annually document thermal study progress. After each year of data, a formal report should be written. This will document changes over time and serve as a historical reference in future studies.

1.2 Goal: Monitor temperature stratification of the Kettle Creek Lake.

1.2.1 Develop and implement a thermal study of the Kettle Creek Lake. In August of 1997, it was documented that the Kettle Creek Lake had violated the minimum limit of dissolved oxygen (DO) for lakes (Clean Water Act Section 303d Impaired Waters Listing). Low levels of DO may be caused by increased temperatures and both can adversely affect fish populations. A cooperative thermal study should be developed with the PFBC and the PADEP to monitor temperature stratification and identify any thermal problems.

1.2.2 Annually document thermal study progress. After each year of data, a formal report should be written. This will document changes over time and serve as a historical reference in future studies.

Alvin R. Bush Dam

1.3 Goal: Monitor and evaluate each dam's influence on the thermal regime of Kettle Creek, and (if necessary) implement improvement projects.

1.3.1 Develop and implement a thermal study of each dam on Kettle Creek. Dams can have a significant effect on water temperatures in a stream, which can, over time, lead to changes in fish assemblages. A study should be designed to monitor the temperatures above and below each dam to determine if any changes occur as a result of the dam.

1.3.2 Implement a thermal improvement project below each dam with thermal problems.

- Erosion and streamside revegetation projects (For more information see recommendation FH 1.2.6)
- Consult with the Pennsylvania Fish and Boat Commission on dam breeching and improvement projects (http://sites.state.pa.us/PA_Exec/Fish_Boat/pfbchom2.html)

1.4 Goal: Monitor and evaluate each tributary's influence on the thermal regime of Kettle Creek, and (if necessary) implement improvement projects.

1.4.1 Develop and implement a thermal study of each tributary's influence on Kettle Creek. Kettle Creek's coldwater fisheries are dependent on the cooling provided by the coldwater tributaries. In some locations along Kettle Creek, tributaries have experienced channel alteration at the confluence with the mainstem. This stream modification has caused increased temperatures along the tributary, which then does not contribute coldwater to the mainstem. Some major tributaries in the Kettle Creek watershed have already been included and will be assessed by the comprehensive thermal study already implemented (as mentioned above). After evaluation of the major tributaries, all other tributaries should be studied and evaluated for thermal problems.

1.4.2 Implement a thermal improvement project at each tributary with thermal problems.

- Erosion control and streamside revegetation projects (For more information see recommendation FH 1.2.6)

- Agricultural runoff reduction projects (For more information see goal LU 1.2)

1.5 Goal: Monitor and evaluate the effects of land use on the thermal regime of Kettle Creek, and (if necessary) implement improvement projects.

1.5.1 Develop and implement a thermal study of land use impacts on the thermal regime of Kettle Creek and its tributaries. Many streams in the Kettle Creek Watershed may have experienced or are experiencing increased temperatures due to changes in land use in the area. These areas need to be evaluated to determine if they are contributing to watershed-wide thermal problems.

- Evaluate headwater agricultural areas.

- Evaluate streams below camps or towns

- Evaluate streams below state parks

1.6 Goal: Monitor and evaluate any instream or riparian thermal improvement projects implemented.

1.6.1 Evaluate all thermal improvement projects. By periodic monitoring and evaluation of the projects implemented, a determination of the significance of the project can be made and future projects can be modeled after successful ones.

1.7 Goal: Identify and raise awareness among streamside residents on steps they can take to reduce habitat disturbances.

(For more information see EO 2.1)

Lack of riparian cover along Kettle Creek mainstem.

TP 2.0 Issue: Minimal instream and riparian cover and buffers contribute to the increasing temperature of coldwater fisheries.

Streamside forest canopy is one factor that significantly contributes to the cooling of stream ecosystems. Loss of shade from vegetation removal or stream widening can warm streams above temperatures trout can withstand while, at the same time, reducing dissolved oxygen available for all aquatic biota. Agricultural areas may also contribute to increased stream temperatures when cooler groundwater is drained to unshaded ditches (USDA 1991).

2.1 Goal: Continue to identify and prioritize areas lacking adequate canopy cover.

2.1.1 Complete the identification of areas lacking streamside forest/riparian canopy cover. The watershed above Long Run has been remotely assessed for riparian buffers to determine where canopy cover is lacking and temperature increases are probable. This assessment could be continued within Arc View GIS to determine other areas with potential for thermal problems and where vegetative cover is needed. Coordinating this project with instream

Watercress in Germania Branch.

thermal studies, and detailed habitat studies will provide areas for improvement.

2.1.2 Prioritize areas lacking canopy cover. Those areas identified as problems should be evaluated to determine which spots should be a priority. These areas are based on need for improvement and potential for success. Areas that need improvement, but may not support a fish population regardless of the canopy cover should be last to receive attention. Those problem locations with adequate food availability and excellent instream habitat should have canopy improvements first.

2.1.3 Implement canopy cover improvement projects. After identification and prioritization of areas needing improved vegetative cover, implement projects to increase canopy cover on those areas.

- Plant native trees that will provide adequate canopy cover.
- Plant native trees that grow fast and grow well in riparian conditions.

The Chesapeake Bay Program's Riparian Handbook: A Guide for Establishing Maintaining Riparian Forest Buffers (1997). (photocopies available from 1-800-YOUR-BAY, or USDA Forest Service 304-285-1592)

2.1.4 Periodically re-assess the watershed for areas lacking canopy cover. Over time, streams may widen and other areas may be added to those with inadequate canopy cover. Every few years, this riparian buffer assessment should be done to detect new problem areas and observe successful ones.

2.2 Goal: Protect and improve canopy cover and riparian buffers throughout entire watershed.

2.2.1 Identify and protect exemplary riparian buffers throughout watershed to ensure that these important resources are maintained.

2.2.2 Improve riparian buffers throughout the watershed. Besides the benefits of erosion, flooding, and sediment control, adequate riparian buffers protect streams from thermal pollution. Even well-established riparian buffers can be enhanced to ensure temperature increases do not occur.

- Continue periodic planting of native riparian vegetation.

Potential Lead Organizations and/or Funding Sources

Pennsylvania Fish and Boat Commission
http://sites.state.pa.us/PA_Exec/Fish_Boat/pfbchom2.html

Environmental Protection Agency - Cooperative State Research Education and Extension Service
http://www.epa.gov/owow/watershed/wacademy/fund/special.html

The Chesapeake Bay Program's Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers (1997). Photocopies available from 1-800-YOUR-BAY, or USDA Forest Service at 304-285-1592.

WATER QUALITY

Water quality is a measure of watershed health. Water is positively and negatively influenced as it flows across the surface and through the subsurface of a watershed. The water is the ultimate indicator of watershed health because it collects and transports chemicals, soil, and energy through a watershed. Water quality also influences the biotic communities that develop in a watershed. All life is dependent on water. The quality or characteristics of the water inhibit or enhance the abilities of certain organisms to exist. Trout need clean cold water to reproduce and survive. Largemouth bass need warm, nutrient rich water to survive and reproduce. The water quality of a stream or lake influences whether bass or trout will be found there.

Water quality can be measured and classified using parameters ranging from chemical thresholds to depth of light penetration in the water column. Most classifications use a combination of chemical and physical parameters to express water quality. Legal regulations have been developed that use water quality as a determinant of a violation. The Clean Water Act and the National Pollution and Discharge and Elimination System are examples.

WQ 1.0 Issue: Non-point source (NPS) pollution in surface waters degrades water quality.

Several NPS pollution sources exist within the Kettle Creek watershed including dirt and gravel roads, acid mine drainage (AMD), acidic depostion, and agricultural runoff. These and other sources impact the water quality of the watershed by increasing siltation, decreasing pH, and increasing nitrogen and phosphorous levels in streams and wetlands. Stormwater runoff also influences water quality by washing oils, silt, and salt from roadways into adjacent streams and wetlands.

1.1 Goal: Reduce nutrient, sediment, and chemical non-point source pollution delivery to target areas and key tributaries.

Nutrients

1.1.1 Prioritize subwatersheds of concern based on potential nutrient pollution from the Generalized Watershed Loading Function (GWLF) model. Balance priority with fishery issues and riparian habitat inventory data. The priority watersheds appear to be Long Run (protection/conservation), Sliders Branch (improvement), Germania Branch (improvement), Cross Fork (conservation/improvement) and Little Kettle Creek (improvement/restoration), in that order.

1.1.2 Develop a means for ground-based investigation within priority subwatersheds. This ground inventory should identify watershed landowners (public or private) that have actively employed Best Management Practices (BMPs) for demonstration opportunities and landowners that may need assistance in employing BMPs.

1.1.3 Develop strategies to improve wastewater treatment systems on the watershed. Develop educational programs on maintenance and potential harmful effects of poorly designed or maintained septic systems. Identify landowners with exemplary systems for demonstration to other residents. Cooperate with state parks to develop alternative/effective wastewater demonstration in floodplains. Assist Bureau of Forestry (BOF) to achieve compliance on seasonal homes and camp systems through education. Connect with Penn State University for research regarding alternative wastewater systems technology.

Chemicals

1.1.4 Cooperate with utility industry and the State Forests to assist and develop maintenance of gas pipeline rights-of-way with non-herbicide maintenance near stream crossings, wetlands, and sensitive areas. Identify current practices and procedures related to gas pipeline hazard mitigation.

1.1.5 Cooperate with PennDOT, State Forests and Townships to develop road maintenance alternatives to salt as well as environmentally-benign dust suppressants. Utilize the opportunities as demonstration areas within the state.

1.1.6 Inventory specific areas where paved roads approach and parallel streams for potential road runoff directly to streams. Cooperate with PennDOT to develop strategies and mitigate the paved road runoff problem sites.

1.1.7 Assist the Bureau of Forestry with announcements relating to the application of herbicides.

1.1.8 Cooperate with conservation districts and Penn State Cooperative Extension to improve BMPs at agricultural sites and work with landowners on chemical application safety.

Sediment

1.1.9 Prioritize the Dirt and Gravel Road program's identified problem sites for improvement based on subwatershed sediment runoff rankings. Long Run should be an immediate priority related to the quality of the stream and minimal work required to improve the current conditions. Cross Fork, Upper Kettle Creek, Sliders Branch, Germania Branch, and Little Kettle Creek are other priority subwatersheds. Work with the Potter and Clinton counties QAB and relevant townships to target funds for these sites. Implement demonstration areas using the most innovative road erosion reduction strategies for educational benefit/demonstration.

1.1.10 Monitor runoff from the sites before and after implementation using community volunteers and county conservation districts.

1.1.11 Develop a "road husbandry" program with community volunteers for monitoring potential problem areas, trash clean-up and erosion control maintenance.

1.1.12 Inventory road-crossings for problems with scour, fish passage blockages, and infrastructure damage. Cooperate with PennDOT on routine maintenance assessments for bridges and culverts.

1.1.13 Attend county-level Dirt and Gravel Road training events to develop knowledge base for monitoring and husbandry program.

1.1.14 Work with landowners, townships and counties to reduce erosion from private lands within priority subwatersheds. Develop a driveway inventory during storm-events and work with landowners to correct local problems.

1.1.15 Cooperate with Bureau of Forestry, USDA Forest Service, and Farm Bureau for assistance on streamside tree-planting efforts to reduce erosion at identified problem sites.

1.1.16 Cooperate with the Bureau of Forestry to identify problematic old roads, trails, and harvest sites that may not have fully revegetated. Complete this forest lands problem sites inventory in key watersheds, (i.e. Cross Fork)

1.1.17 Identify forested lands in private ownership within target watersheds that could be assisted by state and federal cost-sharing programs for forestry BMPs.

1.2 Goal: Identify and mitigate acid mine drainage sources.

1.2.1 Identify and inventory secondary AMD sources using advanced technology including ground penetrating radar, terrain conductivity, and thermal infrared imaging. Seek assitance from Terry Akerman (U.S. Department of Energy, Pittsburgh Office) to use state of the art tools. The Klimkos, Hedin, and TMDL studies have identified the primary sources of AMD, however there is the potential for multiple diffuse sources to contribute significant volumes of AMD. Examples are springs discharging to stream beds and early spring flows.

AMD remediation on the Kettle Creek watershed

1.2.2 Collaborate with other watershed organization in the region to share the costs of expensive sampling techniques listed in 1.2.1 and EO3.1.2. Several watershed associations located in the surrounding region, including Anderson Creek, Beech Creek, and Babbs Creek Watershed Associations, also have AMD impacts and a collaboration between the groups would economize expensive sampling techniques.

1.2.3 Continue to construct passive treatment systems to mitigate AMD impacts. Passive treatment systems are less expensive to maintain and mitigate aluminum and iron loads. Passive systems with wetland components also provide wildlife habitat.

1.2.4 Dedicate an area to AMD mitigation research. Publicize this area to attract groups (local universities, research groups, and government agencies) conducting AMD research. Research organizations continually search for sites to conduct research. Volunteering a site will provide increased information and potentially subsidized treatment of AMD impacts.

Potential Lead Organizations and/or Funding Sources

Lock Haven University, West Virginia University Extension Service, Penn State University, Acid Drainage Technology Initiative (ADTI), and Appalachian Clean Streams Initiative from Office of Surface Mining , Department of the Interior.

1.2.5 Aggressively pursue the remediation of AMD on Huling Branch even if it includes active treatment. Huling Branch contributes approximately 50 % of the metals and acidity discharged via Twomile Run into Kettle Creek. Full restoration of the lower Kettle Creek is dependent on improved water quality on Huling Branch. A small reservoir could be constructed on the headwaters of the Huling branch to collect diffuse sources near the tipple. The hydraulic head developed by the reservoir could be used to power lime dosing devices or other chemical addition devices without the construction of expensive utility lines. The standing water could facilitate the construction of treatment wetlands to naturally mitigate AMD sources.

1.2.6 Use the reclamation of both terrestrial and aquatic ecosystems, and regional water quality improvement to increase potential sources of funding. Kettle Creek is a major tributary to the West Branch of the Susquehanna River. Reclamation of Kettle Creek has ecosystem scale impacts which could attract funding from the Chesapeake Bay Foundation, Nature Conservancy, and US Env. Protection Agency. The following website has a list of federal funding sources for watershed projects: http://www.epa.gov/owow/watershed/wacademy/fund/sources.html

1.3 Goal: Identify, reduce and mitigate stormwater runoff.

1.3.1 Identify present and potential problem areas. Develop an inventory of problem areas using community members to locate and describe stormwater issues.

1.3.2 Develop a comprehensive stormwater management plan based on watershed boundaries not political boundaries. Stormwater problems occur across municipal boundaries and are unresolvable unless addressed at the watershed scale.

1.3.3 Implement plan under Act 167, the Stormwater Management Act. Resources are available under the stormwater management act to develop the plan.

1.3.4 Develop landuse policies requiring stormwater retention basins for 25 year events, reduction/limitation of impervious surfaces, and implementation of BMPs. Retention of stormwater reduces runoff and erosion to streams and wetlands, reduction of impervious surfaces also decreases run off, and application of BMPs will have benefits beyond stormwater including, wildlife and visual benefits.

WQ 2.0 Issue: Comparable studies are necessary for effective evaluation of water quality

Many resource agencies, universities, and volunteer groups take part in watershed water quality monitoring. Each of these groups functions independently and problems can arise when the watershed organization attempts to use the data provided from each group. In order for studies to be useful, a standard set of parameters needs to be measured enabling a comparison of the data to other studies and other areas of the watershed. The Water Quality Network station is a continuous monitoring study currently on the watershed. Continuous monitoring studies are extremely important in determining changes in the water quality. The data collected should be representative of the majority of the watershed. Being that the station is located below the Alvin Bush Dam, the data are not a clear representative of the whole watershed due to the impoundment effects on water quality.

2.1. Goal: Develop a water quality sampling protocol.

2.1.1 Develop a standard set of parameters that each group working on the watershed should use (for a list of suggested parameters see Appendix L, page 340). This standard list is also a suggested standard practice when conducting the Level 1 habitat assessments. It is acceptable if a certain group would like to expand on the standard parameters as long as the standard set is always sampled. This enables the KCWA to compare data between studies and throughout the watershed.

- For macroinvertebrate field and lab analysis, it is suggested that Ch.7 of the rapid bioassessment protocol (see references) should be reviewed and followed. A standard index should be chosen from the rapid bioassessment protocol indices (also in Ch.7 of the rapid bioassessment protocol).
- Air temperature needs to be taken every time water temperature is taken for comparison purposes and for seasonal or yearly variations. The air temperature is taken frequently at the Alvin Bush Dam and this can be used while monitoring or it can provide historical air temperature data.

2.1.2 Develop standard methods for sampling standard set of parameters. This will ensure that data collected will be usable and comparable to data collected by all groups.

Temperature readings along Germania Branch

2.1.3 Attempt to use previous sites for new studies. By using the same sites for newer studies, background data are available for comparison. For example, any new studies focusing on the mainstem could use the same sites as the thermal monitoring project.

2.1.4 Add an estimation of flow to the Volunteer Sampling Protocol. Rather than reporting flow as high, normal, or low, a numeric flow value would be more beneficial to use. Flow can be estimated without using expensive equipment and is fairly accurate (see Appendix L, page 339).

2.1.5 Develop a rating curve relating water level to flow. By the end of the summer of 2001, several staff gauges will be installed throughout the mainstem and some tributaries of Kettle Creek (at most of the thermal monitoring sites). At these locations, it is most desirable to develop a rating curve to enable samplers to estimate flow without having flow measuring equipment (see Appendix L, page 339).

2.2. Goal: Establish Water Quality Network station above Alvin Bush Dam.

2.2.1 Establish a Water Quality Network station at the USGS gauge at Cross Fork to collect water quality information not impacted by the Alvin Bush Dam.

Potential Lead Organizations and Funding Sources

Pennsylvania Department of Environmental Protection (PA DEP)

Pennsylvania Department of Conservation of Natural Resources (PA DCNR)

Pennsylvania Fish and Boat Commission (PFBC)

Susquehanna River Basin Commission (SRBC)

Chesapeake Bay Foundation - Chesapeake Bay Program Financial Assistance Funding Program http://www.epa.gov/r3chespk/

(http://www.dep.state.pa.us/dep/local_gov/GrantStatusCalendar.htm)

Trout Unlimited

Local Universities

Environmental Protection Agency (EPA) http://www.epa.gov/owow/nps/funding.html

WQ 3.0 Issue: Acidic Deposition has potential to impact the water quality.

Many areas in the northeastern U.S. have become concerned over atmospheric deposition of pollutants to natural ecosystems. The Kettle Creek watershed is centrally located in a state that experiences some of the highest levels of acidic deposition in the country. Although areas of Pennsylvania are not adversely affected by the occurrence of acid rain, there are many locations throughout the Kettle Creek watershed that are potentially susceptible.

The impacts of acidic deposition can be substantial in forested watersheds because it negatively affects both terrestrial and aquatic resources. Extreme acidification of soil can cause infertility of the soil, leading to reduced growth in many acid sensitive tree species. Aquatic ecosystems are very sensitive to acidification. Fish populations and other aquatic biota may be compromised if severely impacted by acidic deposition. No comprehensive study has been conducted on the Kettle Creek watershed concerning acidic deposition and, therefore, its impact on the watershed is unknown.

3.1. Goal: Stay abreast of regional trends in acidic deposition

3.1.1 Continue looking at acidic deposition data for Pennsylvania by the using the information provided by the Pennsylvania Atmospheric Deposition Monitoring Network. By periodically accessing the website (http://nadp.sws.uiuc.edu/) for National Atmospheric Deposition Program (NADP), the Kettle Creek Watershed Association can remain informed on regional trends.

3.2. Goal: Identify if any areas in the Kettle Creek watershed are adversely affected by acidic deposition.

3.2.1 Develop study of episodic acidification. Episodic acidification occurs when a stream is impacted by sudden high water events carrying water low in pH (such as snow melt or rain events). If a stream is affected by acidic deposition, during rain events, the pH of the stream will temporarily greatly decrease. Sampling of this type should be done during high flow, which usually occurs during spring snow melt events (see Appendix K, pages 329 - 330).

Potential Lead Organizations and Funding Sources

Local universities (labor and research)

National Atmospheric Deposition Program

Pennsylvania Atmospheric Deposition Monitoring Network

Fern growth is abundant throughout the forests in the Kettle Creek watershed.

Pennsylvania Department of Environmental Protection

Environmental Protection Agency - The Science to Achieve Results (STAR) program

http://www.epa.gov/owow/watershed/wacademy/fund/science.html

http://www.epa.gov/owow/nps/funding.html

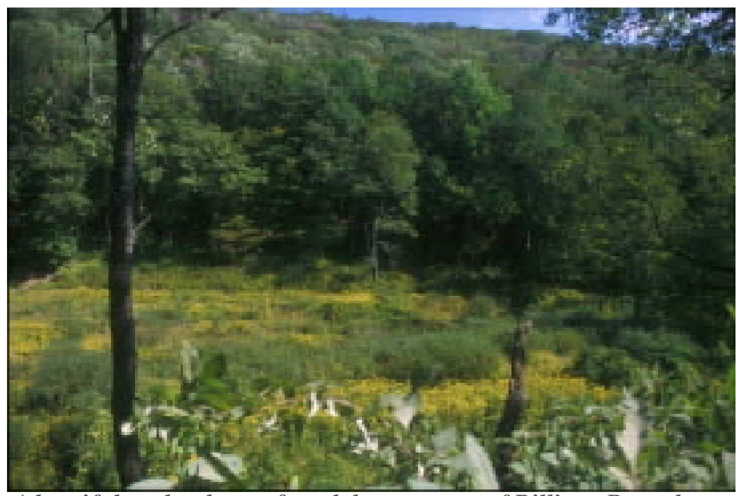
WQ 4.0 Issue: Wetlands perform critical functions in protecting water quality.

Wetlands can remove nutrients (nitrogen, phosphorous, potassium), retain sediments, store flood flows, and provide habitat for many species of wildlife. Wetlands in the watershed have been mapped by the United States Geological Survey (USGS) on National Wetland Inventory (NWI) maps. The delineation of the wetlands was completed using aerial photography. Very little ground verification was conducted. Wetland resources need to be protected in the watershed as a step to protecting the exceptional water quality of Kettle Creek.

4.1 Goal: Identify wetland resources in the watershed.

4.1.1 Develop a detailed inventory of all wetlands in the watershed using NWI maps, thermal infrared imaging, ground verification, and wetland models. The wetland model (see appendix, pages 293-294) applied to the watershed identified 472 acres of additional potential wetlands in the watershed.

4.1.2 Develop a GIS to inventory and display wetlands identified by methods in 4.1.1. Use the GIS to develop wetland protection areas



A beutiful wetland area found downstream of Billings Branch

4.1.3 Develop an agreement with a local university or DCNR to conduct the wetland inventory.

4.2 Goal: Protect wetland resources in the watershed.

4.2.1 Develop landuse policies to protect wetlands throughout the watershed including:

- Twenty-five foot buffer between identified wetlands and any development (road construction, building construction, etc).

Looking for fish in a pool on Billings Branch

- Require 2:1 mitigation ratio for impacted wetlands including a functional assessment after replacement is completed to determine if the constructed wetland replaces the impacted.

4.2.2 Develop a program encouraging landowners to sell development rights for wetlands and wetland buffers.

4.2.3 Educate landowners about the potential availability of Wetlands Reserve Program (USDA) which protects wetlands via the purchase of easements.

4.2.4 Incorporate wetlands in stream restoration projects via development of backwater areas, overbank flooding to naturally low areas, and grading banks to facilitate natural wetland development.

Federal funding sources for wetland protection are listed on the following website: http://www.epa.gov/owow/watershed/wacademy/fund/sources.html

The National Audubon Society has an active wetlands protection program and multiple funding sources can be found at this website: http://www.audubon.org/campaign/wetland/funding.html

See Appendix E page 291 for a list of programs and funding sources

WQ 5.0 Issue: High quality water supplies are essential.

Biotic communities depend on high quality surface water to grow, reproduce, and survive. Groundwater provides baseflow to streams and wetlands. Springs and seeps are used as drinking water sources for wildlife and people. Residents of Kettle Creek depend on high quality ground and surface water for drinking, cooking, bathing, and commercial uses. Every organism in the watershed is dependent on high quality water supplies.

5.1 Goal: Preserve and protect groundwater.

5.1.1 Identify major groundwater recharge areas. Positive identification of recharge areas is beyond the capabilities of the Keystone Project. A detailed identification of recharge areas will delineate areas that should be protected via landuse practices.

5.1.2 Develop landuse policies to protect recharge areas including restricting activities that potentially threaten groundwater quality, such as mining or landfill development.

5.1.3 Identify zones of discharge and features associated with discharge including wetlands, springs, and seeps and use landuse practices to protect discharge areas.

5.1.4 Seek assistance from the DEP to assist with implementation of Comprehensive State Groundwater Protection Program (CSGWPP) in the watershed.

5.1.5 Coordinate ground water quality protection practices with the DCNR.

5.2 Goal: Preserve and protect surface water.

5.2.1 Develop a comprehensive surface water quality policy with benchmarks including current water quality and future water quality goals.

5.2.2 Identify present and potential impacts to surface water quality.

5.2.3 Develop and implement a plan to address the impacts.

5.2.4 Develop landuse policy creating a minimum of 25 ft. buffers around surface water bodies including: ponds, springs, seeps, streams, and wetlands.

5.2.5 Coordinate surface water quality protection practices with the DCNR.

5.3 Goal: Preserve and protect drinking water supplies.

5.3.1 Identify drinking water supplies in the watershed. The watershed assessment identifies 52 wells that have been permitted by the DEP; however, there are a large number of private wells that are not identified.

5.3.2 Delineate surface areas that supply drinking water and delineate areas with signs to increase awareness of impacts of certian activities to the water supples of the watershed.

5.3.3 Identify source of supply and develop landuse policy to protect that source.

5.3.4 Seek assistance for development and implementation of a DEP wellhead protection program.

LANDUSE
RECOMMENDATIONS

LU 1.0 Issue: Conservation can maintain the amount of agricultural lands in the watershed.

Productive farmland in Kettle Creek was once dispersed throughout the watershed. Today, few remnants of the once extensive agricultural landscape exist. Agricultural lands are rapidly declining as smaller scale farming operations can simply no longer afford to stay in production. Today, these lands are increasing in economic value. They are being sold off to developers for potential residential, commercial and even resort development, resulting in a changing watershed identity.

In addition to the potential loss of agricultural heritage, private agricultural lands in Kettle Creek are situated in areas that have the greatest impact on the watershed. Specifically, private agricultural lands in the northern portion of the watershed rest within the headwaters of Kettle Creek. Development in this area could not only have a direct impact on the water quality and wildlife habitat, but also on all reaches further downstream.

Conservation of agricultural lands, in addition to careful management of production practices, particularly within the northern portion of the watershed, could serve to preserve the agricultural identity and the ecological integrity of the watershed.

1.1 Goal: Identify and prioritize high value agricultural lands for conservation.

1.1.1 Consider land with high agricultural productivity a priority for easement programs and PDRs (Purchased Development Rights) to prevent future development in these areas. This might include limiting road construction on high productivity soils to perpetuate agricultural use and promote connectivity of the vegetated areas.

1.1.2 Encourage resident participation in agricultural preservation programs such as the

Billings Branch

Farmland Preservation program, ASAs (Agricultural Security Areas), Conservation Easements, Environmental Quality Incentives Program (EQIP) and Clean and Green. Promote these programs, not only as conservation initiates, but also according to their benefits to the landowner through federal and state tax cuts and technical and financial assistance.

1.1.3 Develop separate tax rates for open space. For example agricultural land and forested land are taxed at 50% of the rate for developed land to encourage landowners to maintain their land as undeveloped green space.

1.2 Goal: Develop and encourage the use of Best Management Practices (BMPs) on Agricultural Production lands to minimize impacts on adjacent natural resources.

1.2.1 Implement buffer programs in areas where agricultural lands are situated in close proximity to the stream (particularly in the headwaters in Potter County).

1.2.2 Promote NRCS (Natural Resource Conservation Service) BMP practices for agricultural production.

- nutrient management
- no till farming
- sustainable agriculture

LU 2.0 Issue: There is a potential for more intense development of existing private lands.

The rural character of the watershed is important to both residents and visitors. Both groups enjoy the abundant open space and low-density development that maintains a high quality of natural space. Yet, limited landuse planning could invite development that does not follow the existing, low-density (and in many cases historic) development character.

Cross Fork

Development potential within the watershed could occur via redevelopment of existing private lands or through new development on open parcels such as the agricultural areas discussed above. While lands in private ownership today might have a minimal affect on the resources offered in the watershed, this land, if sold, could be developed with larger homes, inviting greater infrastructure to serve those parcels. Private open spaces, in areas with limited or no zoning, present an even greater chance of development that does not follow the character of the watershed today.

While zoning and landuse planning provide vehicles for the community to guide future development in their neighborhood, alternatives, such as Conservation Easements and the Purchase or Transfer of Development Rights (PDRs and TDRs) could allow residents to maintain ownership of their valued property, yet ensure its conservation through time.

2.1 Goal: Monitor growth and development in the watershed

2.1.1 Inventory existing structures and continue this inventory on an annual basis to document change.

2.1.2 Inventory existing historical and cultural resources.

Yochum Hill Cemetery

2.2 Goal: Encourage positive future residential and commercial development that not only maintains the rural architectural identity of the watershed but which also follows sustainable 'BMP' development.

2.2.1 Educate residents, local officials and business about the heritage in their watershed and its value to both the watershed and the region. Monitor local development patterns, identify potential development sites, and guide growth to desirable sites.

The Folded Hills Lodge

2.2.2 Consider and educate about the potential for future development; plan for future development.

2.2.3 Demonstrate that property values will increase in areas adjacent to a greenway or recreational corridor.

2.2.4 Encourage developers to create green ways in developments.

2.2.5 Develop policy to limit growth at a sustainable rate that increases the value of each parcel without explosive growth.

2.3 Goal: Encourage development that follows the existing architectural and cultural identity of the watershed.

2.3.1 Maintain open space.

2.3.2 Identify conservation areas prior to development and encourage the conservation of these areas as open space.

2.3.3 Link natural conservation areas to larger natural areas and to greater recreational corridor.

2.3.4 Encourage infill and redevelopment to minimize impervious surfaces.

The rural landscape along Route 144

2.3.5 Encourage new development in close proximity to existing infrastructure such as roads and utilities.

2.3.6 Acknowledge, publicize, and give awards to builders who follow BMP building techniques.

2.4 Goal: Encourage development in environmentally suitable areas (site suitability) and cluster new development around existing infrastructure.

2.4.1 Consider stormwater management: future development should consider impact on water quality and quantity (following the Clean Water Act and the Stormwater Act 167). Create a zero storm water discharge policy for the 25-year storm event.

2.4.2 Encourage flood control programs: through flood proofing and rehabilitation, clearance and relocation of structures, safety inspections, flood insurance, flood warning and community education.

a. Enable relocation of residences in the flood plains through agencies such as Federal Emergency Management Agency (FEMA). (http://www.fema.gov)

b. Land swaps with the state forest: Swap a floodplain parcel for upland plateau parcel 1:1.5 ratio to make the swap an incentive.

c. TDRs: transfer of development rights from the floodplains to uplands and more suitable sites.

2.4.3 Consider septic suitability in new developments and encourage maintenance of existing septic systems through tax incentives or financial support.

2.4.4 Consider the placement and management of utility lines and its impact on the adjacent environment.

a. Limit the use of pesticides and other harsh chemicals in utility corridors.

b. Plan future utility corridors around identified natural / conservation areas.

2.4.5 Create a 50-foot buffer between development (buildings and roads) and natural features: streams, dry channels, and wetlands.

2.5 Goal: Encourage coordination between the county comprehensive plan and the township zoning ordinance.

See also community capacity recommendations starting on page 225.

2.5.1 Collaborate with the county extension offices to guide inter- and intra-municipality efforts.

LU 3.0 Issue. Conserve natural areas. There is no comprehensive inventory of natural and sensitive areas in the watershed.

High value streams and fisheries, large tracts of contiguous, densely forested lands and abundant wildlife habitat make the Kettle Creek watershed a cherished landscape to residents and visitors from all over the state.

Natural and sensitive areas include places such as wetlands, floodplains, riparian corridors and slopes that both are particularly vulnerable to development and have a high capacity to support unique biota. While undeveloped natural lands are abundant in the watershed, substantive mapping has yet to identify key natural areas throughout the watershed. For example, the heavily forested landscape prevents remote sensing NWI (National Wetlands Inventory) mapping from accurately inventorying wetland occurrences in the watershed. PNDI (Pennsylvania Natural Diversity Index) inventories identify individual areas of concern, however there is no existing inventory for Potter County.

Accurate and thorough identification of these areas could facilitate conservation by the state and by the local Kettle Creek residents. While the state forests expressly manage sensitive areas, greater identification would allow more state land to be designated managed lands. On private lands, the identification of these areas could bring with it a greater awareness of the existence of these areas in addition to an awareness of the implications of developing near natural areas. It could furthermore facilitate the prioritization of development that has minimal impacts on these areas. Finally, it could help to identify potential recreational and wildlife corridors throughout the watershed.

3.1 Goal: Educate local residents, municipal officials and business representatives about the value of these areas.

3.1.1 Promote awareness of these areas through signage.

3.1.2 Educational topics: landscape fragmentation, the value of wetlands, riparian corridors and floodplains.

3.1.3 Develop a comprehensive map of natural and sensitive areas including wetlands, slopes, seeps, high value forests based upon GAP analysis, PNDI, NWI and further inventory of wetland areas. Make this map available to all stakeholders in the watershed. Promote the use of this map in the development of future landuse plans and zoning within the municipalities.

3.1.4 Encourage the donation of conservation easements for wetland and riparian areas, in addition to other identified areas of special concern.

3.2 Goal: Designate and protect high value areas. Encourage the protection of these areas through large buffers and the promotion of natural areas or recreational open spaces.

3.2.1 Work with the state forests in the designation and conservation of natural areas. This might include partnerships with organizations such as The Nature Conservancy.

3.2.2 Explore the land preservation and protection tools available through participation in the PA Wild and Scenic Rivers Program under the direction of the DCNR (For more informaion on the Scenic Rivers Program, see page 88 and Appendix C page 271).

3.2.3 Explore possibilities of connecting natural resource protection on private and public lands to recreation interests; recognize the importance of recreation in fostering stewardship of existing natural resources. Greenways (one form of large scale recreation planning) are becoming increasingly popular in the state of Pennsylvania and may present opportunities for the Kettle Creek watershed. (For more information on greenways, see the Appendix B page 267).

3.2.4 Develop management options for natural and sensitive areas - emphasizing those in or adjacent to private lands.

Wetlands:

a. Develop landuse policies to protect wetland resources including development of 50 ft buffer around wetlands. Apply to programs such as the Wetland Reserve Program (USDA) and wetlands conservation projects (USFWS).

Spicewood Run

b. Actively pursue wetland restoration and creation in watershed. Use Wetland Restoration/Creation Registry program (DEP) to identify and include potential landowners.

Floodplains:

a. Develop policies that outline ecologically sound land use in floodplains. Can be accomplished under Municipal Planning Code Section 603 and "Environmental Rights Amendment" of the Pennsylvania Constitution (Act 1, Section 27) (Wetland and Riparian Stewardship in Pennsylvania, 1997).

Wild areas:

a. Participate in the Wild Areas Program to limit the development of utility lines through wild areas.

3.2.5 Develop a land acquisition program with Western Pennsylvania Conservancy, North Central Pennsylvania Conservancy, Wildlands Trust, Pennsylvania Game Commission, and the Pennsylvania Fish and Boat Commission (PFBC). The watershed association can locate properties particularly in floodplains and in contiguous natural areas. A land trust could retain this land until an agency such as the DCNR, PGC (Pennsylvania Game Commission), or PFBC can purchase it.

3.2.6 Develop land use policy to protect wellheads, groundwater recharge areas, drinking water and high quality groundwater discharges to wetlands and streams.

3.3 Goal: Minimize landscape fragmentation:

3.3.1 Minimize the use of Utility Line Rights of Way (ROW) through designated natural areas such as the F.H. Dutlinger and proposed Hammersley Fork Wild area. If a ROW must be placed in these areas, encourage the use of vegetation within that ROW.

3.3 2 Minimize the use of applied herbicides and pesticides in managed areas - particularly ROW.

3.3.3 Acquire private inholdings on existing state forest land.

A CASE STUDY: Bucks County

Bucks County has revised existing residential landuse ordinances to consider the historical character and identity of the areas in addition to environmental principles. They have successfully reduced the width of streets, minimum required residential street right-of-way widths and the size and number of residential cul-de-sacs. Open space designs for community developments have been incorporated the Farmview subdivision; this development uses smaller lot sizes, conserves natural areas, provides community recreational space and promotes watershed protection.

Impervious covers are a major cause of water related problems. Not only do impervious surfaces increase the prevalence of flooding in an area, but also they contribute heavily to sediment and nutrient loading in a stream. (For more information see page 178). Reduction in impervious cover through the use of development BMP's can thus improve water quality. These revised ordinances have not only helped achieve recognizable environmental benefits but also resulted in numerous economic benefits achieved from reduced clearing and grading infrastructure, stormwater management costs and long term maintenance costs.

Kettle Creek's main stem in Ole Bull State Park

For more information on Bucks County:

1. Bucks County Planning Commission (1980). Performance Streets: A Concept and Model Standards for Residential Streets.

    Bucks County Planning Commission
    Route 611 and Almshouse Road
    Neshaminy Manor Center
    Doylestown PA 18901
    215-345-3400

2. Montgomery County (PA) Planning Commission. Guidelines for Open Space Management in the Land Preservation District.

    Montgomery County Planning
    Commission Courthouse
    Norristown PA 19404
    215-278-3722

3. Reid Ewing (1996). Best Development Practices: Doing the Right Thing and Making Money at the Same Time.

4. Center for Watershed Protection. Better Site Design: A Handbook for Changing Development Rules in your Community

View from the castle vista in Ole Bull State Park

Programs and Resources:
Below are just a few of the available resources relating to natural resource conservation, rural preservation and sustainable development. Each of the groups listed below provide sources for economic funding and technical assistance. Admittedly, assistance opportunities overlap from one source to another, providing multiple options for conservation.

Natural Resource Conservation

Conservation Plant Material Centers
Contact: USDA, Natural Resources Conservation Service

This program provides native plants that could solve natural resource problems. This program provides for stream bank and riparian area protection (one of the considerations in the Kettle Creek watershed), wetland restoration, water quality restoration, erosion reduction. This program is carried out with the help of State and federal agencies, commercial businesses and seed and nursery association.

Emergency Watershed Protection (EWP)
Contact: USDA, Natural Resources Conservation Service

This program includes drastic measures in case of an emergency such as purchase of flood plain easements, flood protection, protection to life and property in case of a flood event, or protection in case of natural disasters like fire and flood which may lead to erosion events that could cause a sudden changes in the watershed. It includes providing financial and technical assistance to the carry out the necessary recovery measures.

Flood Risk Reduction Program (FRR)
Contact: USDA, Farm Service Agency

Farmers who enter this program voluntarily would receive payments on lands that run a risk of flooding. (Relevant to the headwaters of the Kettle Creek watershed.) This program provides incentives to move farming operations from frequently flooded land.

Forestry Incentives Program (FIP)
Contact: USDA, Natural Resources Conservation Service

This programs support sustainable forest management practices on privately owned or non-industrial forestland.

Watershed Surveys and Planning
Contact: USDA, Natural Resources
Conservation Service

The program is designed to assist the local watershed groups to control erosion, flood water and sedimentation problems and to conserve and develop land and water resources. Could be considered as a possible funding source for the watershed organization.

Stewardship Incentives Program (SIP)
Contact: USDA, Forest Service

The program provides technical and financial assistance to private forest landowners to maintain their lands and the natural resources sustainably.

NRCS Buffers Program
NRCS Initiatives: http://www.nh.nrcs.usda.gov/

State NRCS and FSA Contacts-

PA Technical: Barry Isaacs
USDA-NRCS
One Credit Union Pl., Ste. 340
Harrisburg PA 17110-2993
717-782-2202

Communications:
Stacy Mitchell, PAS
USDA-NRCS
One Credit Union Pl., Ste. 340
Harrisburg PA 17110-2993
717-237-2208

FSA: Rex Wright, Program Specialist
USDA-FSA
One Credit Union Pl., Ste. 320
Harrisburg PA 17110
717-782-4593

Pennsylvania Fish and Wildlife Service Conservation Buffer Initiative

Spotts, David E.
Fisheries Biologist
PA Fish & Boat Commission
450 Robinson Lane
Bellefonte, PA 16823
814-359-5115

Resource Conservation & Development Councils (RC&Ds)
Another NRCS program that seeks to sustain and improve the natural and economic resources of rural areas. RC & Ds foster municipal collaboration through encouraging the participation of representative of local stakeholder groups and organizations in addition to municipal officials. Provides technical assistance to communities in the development of business and recreational opportunities. For an overview of all NRCS conservation programs:

http://www.pa.nrcs.usda.gov/publications/resconstoc.pdf

The Nature Conservancy:
The Nature Conservancy is a national organization that provides technical and financial assistance in the conservation of plants, animals and other natural communities. It also will acquire and manage sensitive lands for conservation such as the West Branch Wilderness located in Clinton County.

For more information:

http://nature.org/states/pennsylvania/preserves/

Pennsylvania Field Office
Lee Park, Suite 470
1100 East Hector Street
Conshohocken, PA 19428
610-834-1323

Agricultural Conservation

Farmland Protection Program
The Farmland Protection Program funds the purchase of development rights on agricultural lands. It seeks to maintain productive farmland in agricultural use. The program is a joint program with the United States Department of Agriculture (USDA), the state and local governments - easements. The USDA will provide up to 50% of the fair market easement value. To qualify, farmland must:

- be part of a pending offer from a State, tribe, or local farmland protection program;
- be privately owned;
- have a conservation plan;
- be large enough to sustain agricultural production;
- be accessible to markets for what the land produces;
- have adequate infrastructure and agricultural support services; and
- have surrounding parcels of land that can support long-term agricultural production.

For more information: http://www.info.usda.gov/nrcs/fpcp/fpp.htm

Conservation Reserve Program (CRP)
A program established by the NRCS to promote the conservation of agricultural lands in addition to the reduction of soil erosion, the conservation of water and the provision of wildlife habitat. The CRP offers financial incentive in the form of rental payments and cost-share assistance for particular agricultural activities. It also provides technical assistance in the revegetation of particular lands. The participation in the program is 10 to 15 years at which point it can be renewed.

For more information in the CRP, visit the NRCS website at http://www.pa.nrcs.usda.gov/programshome.htm

Environmental Quality Incentives Program (EQIP)
Contact: NRCS, USDA

A voluntary conservation program that facilitates the implementation of structural or vegetation management practices in areas that have been identified as a priority by the local conservation districts. It offers financial, educa-tion al and technical assistance to a locally led initiative. Contracts ranges from 5 to 10 years and include cost share and incentive payments to carry out individual land management practices.

Conservation Farm Option (CFO)
Contact: USDA, Farm Service Agency or Natural Resources Conservation Service

A voluntary program for wheat, feed grains cotton and rice producers, its purpose being conservation of soil water, and related resources, water quality protection and improvement, wild life habitat protection and development, wetland restoration and similar other conservation purposes. The farmers have to be a part of the Agricultural Market Transition program to be a par of this program. The farmers would receive annual payments to implement the CFO program. However the farmer cannot receive payments from the Conservation reserve program, the wetlands reserve program, and the Environmental Quality Incentives program in exchange for one consolidated payment.

Rural Landscape Conservation

Center for Rural Pennsylvania
Works with organizations and municipalities to provide financial and technical assistance in the form of grants and information.
For more information:

http://www.ruralpa.org

USDA Rural Development Program
Providing funding and technical assistance to rural communities. For more information:

http://www.ruraldev.usda.gov

Small Watershed Program
Providing funding and technical assistance for natural resource and economic problems for a host of issues including flood control, water quality, fish and wildlife habitat and wetlands. For more information:

http://www.ftw.nrcs.gov/pl566/pl566.html

PA Environmental Council
An example of Municipal Collaboration in the regional development of heritage corridors, recreational networks and open space. The PA Environmental Council promotes awareness of historical, natural and recreational resources.

http://www.libertynet.org/~pecphila

Example:
Project Green Space Alliance (a collaboration of 5 counties in the Philadelphia region:

http://www.perpa.org/greenspace/index.html

PA State Association of Township Supervisors
http://www.psats.org

Cultural Resource Conservation

Bureau for Historic Preservation:
PA Historical and Museum Commission (PHMC)

The PHMC collaborated on the preservation PA program in the development of a Preservation Plan for the state. Specifically, within the PHMC, the bureau for Historic Preservation provides technical and financial assistance in the protection of "buildings, structures, roads, districts and neighborhoods of historic significance in public and private ownership." For more information:

http://www.phmc.state.pa.us/BHP/preservation.htm

Preservation Pennsylvania:
http://www.preservationpa.org

Collaborate with the PHMC on Preservation PA (available online). Focuses on initiatives to protect rural lands with a focus on historic preservation. Lays out guidelines for considering historical character while encouraging positive future growth.

Community Development Block Grant (CDBG):
The CDBG is a national initiative run through HUD that provides funding to low to moderate income communities to develop community based programs such as public works and facilities, housing improvement projects and rehabilitation, conservation programs, economic development and others. For more information visit HUD's website:

http://www.hud.gov/cpd/statefct.html

To apply for a grant in PA:

http://www.dced.state.pa.us/PA_Exec/DCED/community/housing.htm

Governors Center for Local Government Services
http://www.dced.state.pa.us

Friends of Pennsylvania
www.10000friends.org

North Central Pennsylvania Regional Planning and Development Commission
www.ncentral.comPrograms:

Conservation for Recreational Value

Scenic Rivers
The Pennsylvania DCNR Web Site: Scenic Rivers Home Page. <http://www.dcnr.state.pa.us/rivers/srhome.htm>

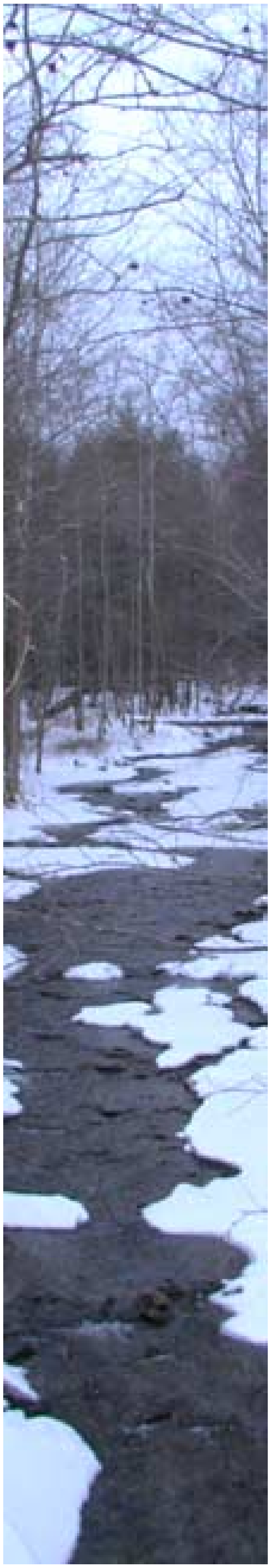
The Pennsylvania DCNR Bureau of Recreation & Conservation, which "provides a variety of educational and informational services on several environmental issues, most notably on the subject of land use, rails-to-trails, and rivers conservation. These services include facilitation, technical advice and support for educators, and discussion facilitation for citizen groups and local officials" (PADNCR web site). To contact the Bureau of Recreation & Conservation, phone its main office at (717) 783-2658.

Greenways
The Pennsylvania Greenways Partnership Commission (a joint effort between the PADCNR and several non-profit organizations). The PAGCP can be contacted through the PADCNR Bureau of Reclamation and Conservation.

The PADCNR Bureau of Recreation & Conservation, which "provides a variety of educational and informational services on several environmental issues, most notably on the subject of land use, rails-to-trails, and rivers conservation. These services include facilitation, technical advice and support for educators, and discussion facilitation for citizen groups and local officials" (PADNCR web site). To contact the Bureau of Recreation & Conservation on the subject of greenways, phone its office at 717-783-5877.

Other Tools for Resource Conservation

Conservation Easements
Conservation easements are a viable alternative to strict zoning regulation at the local level. They ensure the perpetual protection of a piece of property in return for property tax cuts. Easements are a voluntary contract between a landowner and a conservation organization such as the Kettle Creek Watershed Association. They seek to conserve the natural features of the landscape through limiting future development of that land while allowing the landowner to retain ownership of the property. Easements provide a feasible alternative to zoning in that each agreement is unique to both the piece of land and the needs or desires of the owner.



APPENDICES

APPENDICES

Appendix A - Sample Building Inventory Form

Supplied by the Centre County Historical Society

Property No.:_________________ Roll/Photo no.

Township______________ Tax # ________________ Acreage________________

Location____________________________________ ________________Survey date

Owner ________________ ________ Historic Name____________________________

Type: Agricultural/residential ______ Residential ______ Church______ School______ Other____________

Setting: Farmstead_______ Farmette ______ House/grounds only_______ Village_______Other______

Dwelling	Date	Structural System	Facade Material	Style/Form	Bays	Stories	Ell
___1790-1830	______	______		______	______	______	______
___1830-1890	______	______	______	______	______	______	______
___1890-1920	______	______	______	______	______	______	______
___1920-1950	______		______	______	______	______	______

Architectural details: Entrance ____________________ Porch ____________ Windows ______

Shutters ______________ Chimneys__________ Eave returns Gingerbread ____________

Other features ____

Condition ________________ Alterations ____________________ Threats ________ ________

Barn	Date	Type, bank "L"	Structural system	Condition
___1790-1830	______	______	______	______
___1830-1890	______	______	______	______
___1890-1920	______	______	______	______
1920-1950	______	______	______	

Silo ______ Other information ____

Outbuildings	Date	Description
Summer kitchen	______	______________
Spring house	______	______________
Smoke house	______	______________
Corn crib	______	______________
Machinery shed	______	______________
Poultry house		______________
Milk house	______	______________
Other		______________

Hedgerows______________________ Walls __________ Fencing____________

Trees/vegetation______________________ Crops______ ____________________

Other ____

Creek_________________ Springs ____________ Wells____________ Wetlands

Archaeological evidence ____________________________________

Agricultural security program __________ Permanent agricultural easement ________________

____

National Register ______ Eligible ________ Non-contributing/after 1950 ____________

No of structures: contributing ________; non-contributing__________

Acres of landscape: contributing ________; non-contributing ________

As was indicated earlier in this study (see Land Use, Economics, and Demographic Assessments), there is a state-wide trend of families and individuals who are choosing to relocate within northern and central Pennsylvania. The land value per acre of agricultural land in northern Potter County is rising rapidly and more and more former agricultural fields are being primed for subdivision and development.

Greenways are mentioned here because they provide one of several possible mechanisms for protecting the pastoral, open lands of northern Potter County and the northern region of the Kettle Creek watershed. They also provide a means of emphasizing the connection between these open scenic agricultural spaces with other open spaces (agricultural, recreational, and natural places) to the north and in the Kettle Creek watershed to the south.

Greenways have been identified as an excellent means for "protecting the natural, historic, and recreational river resources that are a defining geographical feature of the Commonwealth" (adapted from Johnson 1998). Greenway efforts are most often initiated at the local level, by local volunteers in partnership with local officials who share a common vision of their region's future.

In 1997, Pennsylvania Governor Tom Ridge issued an executive order to create the PA Greenways Partnership Commission (PAGPC) with the vision of creating an "outstanding statewide greenways system that enhances the quality of life and is highly valued by Pennsylvanians." This system would provide state assistance and expertise to many local initiatives in the hopes of establishing a "hub and spoke" network in which state-wide natural, cultural, and recreational destinations, e.g. parks, forests, gamelands, and lakes, would function as "hubs," and equally widespread, newly established greenways or "spokes" would interconnect these hubs. (PAGPC 2001).

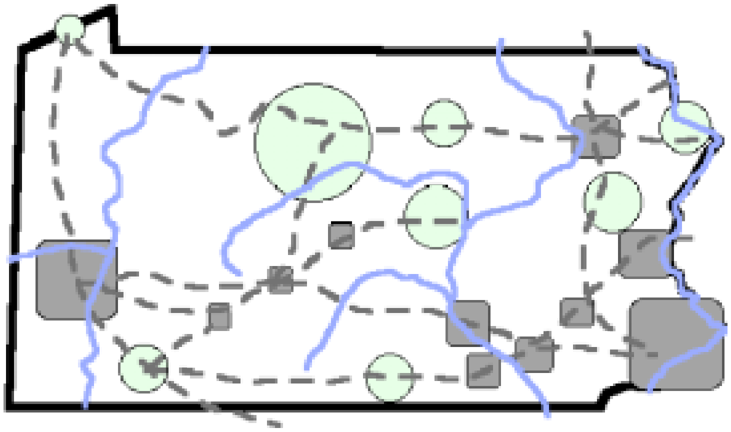
Greenway: 1. A linear open space established either along a natural corridor such as a riverfront, stream valley, or ridge line, or overland along a railroad right of way converted to recreational use, a canal, a scenic road, or other route. 2. Any natural or landscaped course for pedestrian or bicycle passage. 3. An open space connector linking parks, nature reserves, cultural features, or historic sites with each other and populated areas. 4. Locally certain strip or linear parks designated as a parkway or greenbelt. (PA Greenways Partnership Commission 2001)

Blueway: 1. Blueways are "primarily recreational routes through scenic areas where rivers, themthemselves, form the corridor and are used for extended trips by canoe, kayak, or raft" (adapted from Johnson 1998).

APPENDIX B
GREENWAYS

Greenways have been gaining increased attention as focal points for community design and land use strategies over the past decade. In the PAGPC draft plan of 2001, the PA Greenways Partnership Commission listed the following benefits of greenways:

1. Greenways can enhance a sense of community



This map has been adopted from the PAGPC Commission Draft Report (2001) and shows the relative position of Kettle Creek (the state's largest natural area) in the proposed 'hub and spoke' system. Natural areas (destinations) are represented as green circles and metropolitan centers are represented as gray squares. Overland spokes are respresented by dashed lines and waterways (or "blueways") are represented by blue lines.

2. Greenways can accentuate the beauty of our state

3. Greenways can provide recreation and alternative transportation

4. Greenways can add positively to our economic climate

5. Greenways can be a core component of strategies to foster health and wellness

The Governor's vision for the statewide greenways program also included many of the following, more specific benefits: preserving Pennsylvania's natural resources, stewardship of it's farmland legacy, economic prosperity, conservation of historical and cultural resources, fostering of public recreation, health, and fitness, the creation of educational opportunities, the promotion of sustainable community growth and development, the provision of alternative transportation, and the building of partnerships between community stakeholders and beneficiaries of the greenways program (PAGPC, 2001).

As a means of preserving natural and agricultural landscapes like those of the Kettle Creek watershed, greenways are unique for several reasons. First, they do not require the transfer of landholdings into public ownership. Private property owners are encouraged to participate in greenway initiatives for some of the benefits are directly received by landowners. Greenways programs are more effective with the active involvement of all stakeholders, but their participation is entirely voluntary.

Second, greenways also allow for a wide range of transportation and recreation opportunities. They can incorporate highways and bikeways, hiking trails (there is no single, designated mode of travel throughout greenways). In this aspect, the Kettle Creek watershed is well suited for greenway designation because it already offers a range of travel opportunities as well as an even greater range of recreation destinations.

A final reason for the watersheds predisposition to greenway establishment is its 91.6% of the total land area in public ownership. The Kettle Creek watershed provides an excellent opportunity for the establishment of a green, linear connector between the Susquehanna River corridor and other recreational and vacation destinations to the north of the watershed (PAGPC 2001). In short, greenways are intended as a means of preserving the natural character of a given corridor or region through the promotion of its exceptional natural qualities.

The PAGPC (2001) greenway initiative is particularly relevant to the Kettle Creek watershed for several more reasons. The most significant of these is the fact that Kettle Creek was designated as one of the state's largest recreational hubs in the PAGPC Draft Plan. The Kettle Creek Hub would be connected to other destinations (or hubs) in the PA greenway network (see the figure in the upper left-hand corner of this page) by the Susquehanna River corridor (also referred to as an aquatic "blueway") and overland greenways (or spokes) passing through other natural destinations like the Allegheny National Forest to the west and the Tiadoghton State Forest to the east.

In conclusion, regional and statewide greenway planning present an excellent opportunity for the Kettle Creek watershed to become involved in the future of Pennsylvania's public lands use and management. Successfully incorporating increases in recreation use and the number of visitors to the watershed not only means sound stewardship of recreational resources, but also implies increased recognition of the watershed as a quality recreational destination and more revenues for funding local, community and environmental initiatives. And as mentioned earlier in this appendix, greenway planning also provides one more mechanism for the protection of Kettle Creek's valuable open spaces in the face of possible, future development pressures.

More information on greenways and greenway planning can be obtained from several agencies:

The Pennsylvania Greenways Partnership Commission (a joint effort between the PADCNR and several non-profit organizations). The PAGCP can be contacted through the PADCNR Bureau of Reclamation and Conservation.

The PADCNR Bureau of Recreation & Conservation, which "provides a variety of educational and informational services on several environmental issues, most notably on the subject of land use, rails-to-trails, and rivers conservation. These services include facilitation, technical advice and support for educators, and discussion facilitation for citizen groups and local officials" (PADNCR web site).   To contact the Bureau of Recreation & Conservation on the subject of greenways, phone its office at (717) 783-5877.

The Pennsylvania Fish and Boat Commission (PFBC). The PFBC may be able to offer funding for stream improvement efforts. Many times, when the PFBC acquires stream-side land within PA, it creates a de-facto greenway. To contact the PFBC, phone (717) 657-4518.

Images like this one (taken in Ole Bull State Park) demonstrate the scenic potential of the Kettle Creek as a recreational destination.

The National Park Service (NPS) can provide unique services, as well as expertise, to aid in greenway establishment, planning and maintenance. Call the office of the Rails, Trails, and Conservation Assistance Program at (215) 597-1581 for more information.

Literature Cited

Johnson, Russ. 1998. "Greenways: Great Ways to Keep Open Spaces Green." Pages83-85 in A Watershed Primer for Pennsylvania: A Collection of Essays on Watershed Issues. Eds. Janette M. Novak and William H. Woodwell, Jr. PADEP, Harrisburg.

PA Greenways Partnership Commission. 2001. Pennsylvania Greenways: An Action Plan for Creating Connections (Draft).

PADCNR web site. 2001. http://www.dcnr.state.pa.us.

APPENDIX C
SCENIC RIVERS/ VISUAL CORRIDOR STUDY

The following pages are intended to more fully explain the process of PA Scenic Rivers Designation. The main stem of Kettle Creek has been selected for an example inventory and eligibility study (as defined in Battaglia and Jones 2001).

Applying for Scenic Rivers status typically requires several steps. First, a community must decide that it wishes to participate in the Scenic Rivers Program and begins by collect adequate information on the river corridor or other waterway in question with the intent of completing a river conservation plan (much like the very document you are reading now). Once that plan is completed, a nominating petition for inclusion in the Scenic Rivers Program is submitted to PADCNR and justification for inclusion in the Scenic Rivers Program is provided. Then, the waterway undergoes an eligibility study (an example of such a study follows in this appendix). The final steps include a set of public hearings in which the PADCNR explains the scope and impact of the official, legislative act which will then be introduced to the PA General Assembly by the proper representatives (Battaglia and Jones 2001). Once they have been officially included in the Scenic Rivers Program, waterways can benefit from increased recognition and certain state-supported protective legislation (examples of this protection are listed later in the introduction to the Scenic Rivers Program in the visual assessment chapter).

PA Scenic Rivers Eligibility: Criteria

In order to qualify for the Pennsylvania Scenic Rivers Program, a waterway must meet qualifying criteria in two broad categories of evaluation: minimum required values and outstandlingly remarkable values. Minimum required values (MRVs) include minimum requirements for each of the following stream attributes: water quality, flow volume, river length, access, and scenic resources (Battaglia and Jones 2001). Examples of these minimum requirements include a flow volume during normal years that will permit full enjoyment of recreation activities and a river or segment length that can provide a distinct experience.

Scenic Rivers Designation can offer a measure of protection to wild streams.

This study does not demonstrate MRVs for Kettle Creek, because, as indicated earlier, it is only a sample eligibility study. If an actual Scenic Rivers Study were to be completed, specific data with respect to particular MRVs (and ORVs) and would need to be collected and organized in cooperation with DCNR to insure that Kettle Creek meets the MRVs defined in Chapter 41, Section 1920-A of PA Administrative Code of 1929 (71 P.S. § 510—20) and the Pennsylvania Scenic Rivers Act (32 P.S. § § 820.22—820.29). Because much of the Kettle Creek watershed is designated “Exceptional Value” by the state, its streams may also qualify for special exceptions in meeting minimum requirements.

The second category of elegibility criteria are “outstandingly remarkable values” (ORVs) and include primary and supporting values. The "primary ORVs" include wildness, scenic resource, and recreational resource values. Any proposed river, waterway, or segment thereof must exemplify at least one primary ORV in order to be included within the Scenic Rivers Program. Sample primary ORVs have been designated in the eligibility study located in this appendix.

The second category of ORVs are called "supporting ORVs." While supporting ORVs may assist waterways in achieving Scenic Rivers designation, they are "not directly eligible to trigger the designation of a Pennsylvania Scenic River, [and they] are often indirectly related to the qualification of a primary value [i.e. wilderness, scenic value, or recreational value]" (Battaglia and Jones 2001). Supporting ORVs include natural resources, biological resources, and archeological/historical/cultural resource amenities. Supporting ORVs are not established in this example study, however, information that may aid in establishing supporting ORVs may be found throughout the Kettle Creek Watershed document. (See cultural assessment chapters.)

Once MRVs and ORVs have been established, the waterway or segment thereof can be considered for one of five designations. The specific designation depends on which MRVs and ORVs are exemplified by that river or segment thereof. For example, a waterway or segment meeting all MRVs and exhibiting "wilderness" as an ORV would likely qualify as a wild segment. The five potential designations for the scenic rivers system are detailed here (adapted from 32 P.S. § 820.22 and 17 PA § Code 41.2).

The picture of the main stem of Kettle Creek, located below, was taken from the roadway and illustrates the qualities of a "Scenic" segment.

1) Wild rivers are those rivers or segments that exhibit a minimum of disturbance and/or human influence. They are free of impoundments and development, and are accessible by trails only. The shorelines of wild rivers are "essentially primitive" and the waters are unpolluted. The primary intent of designating these segments is to preserve the river's natural heritage and to impart notions of preservation and the feelings of freedom that a natural landscapes foster.

2) Scenic rivers are those rivers or segments that exhibit little disturbance and/or human influence. Scenic rivers segments are also free of impoundments. They are accessible by road, but only at defined points, such that their shorelines remain "largely primitive and undeveloped." Much like wild river segments, the intent of scenic river segments is to preserve and promote natural river landscapes.

3) Pastoral rivers are those rivers or segments whose shorelines or watersheds exhibit "a full range of farm or farm-related activities." Pastoral rivers may possess impoundments of historic significance and may support the diversion of their waters for agricultural activities. The emphasis on the rural, agriculture landscape in the river corridor differentiates pastoral river segments from wild or scenic segments.

4) Recreational rivers are those rivers or segments that are "readily accessible" for recreational activities, such as boating, fishing, swimming, and canoeing. Therefore, their shorelines may possess development and/or roadways, though these should not impair habitat and cover types. Recreational rivers may have also been impounded or diverted at some time. The intent of these segments is the "more coordinated utilization of those river segments that "best portray outstanding aesthetic and recreational values and that are ideally suited for active or intensive recreational uses. The utilization shall, however, be maintained within the constraints imposed by the resource capability to adequately support use without degradation" (17 PA § Code 41.2).

5) Modified recreational rivers are those rivers or segments that may be subject to the regulation of their waters by an upstream impoundment. For all other intents and purposes, they fall under the same criterion for consideration and management as recreational rivers, though their use is often more intensive.

Both of the watershed's state parks provide excellent access to the main stem of Kettle Creek. The stream segments contained within the parks are examples of segments that could be designated modified-recreational. The presence and scale of existing stream impoundments may prevent other types of designations.

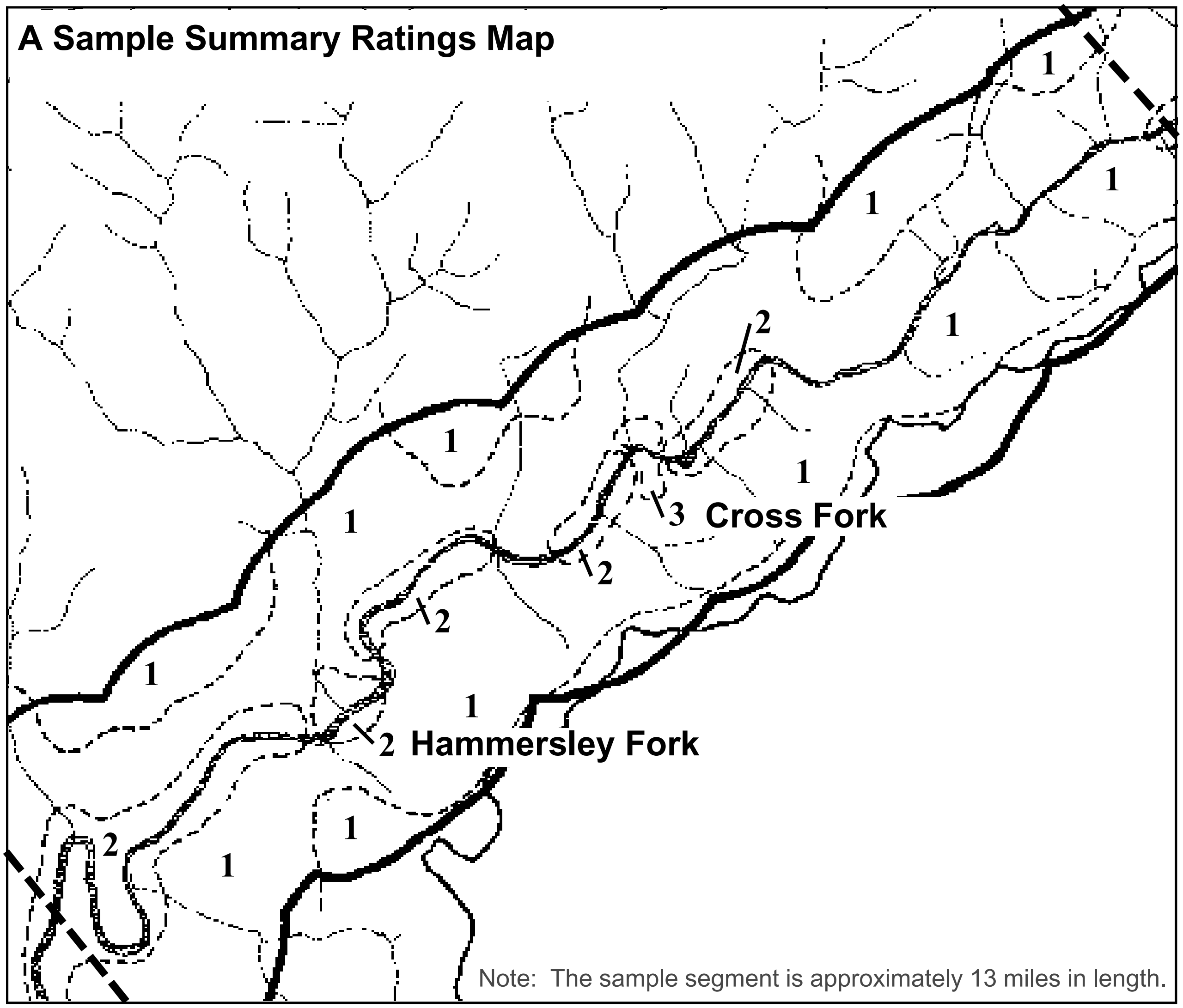
PA Scenic Rivers Eligibility: Process

The map on Page 277 identifies ORVs for sample segments designated on the main stem of Kettle Creek. The following paragraphs are intended to briefly explain the reasoning and processes behind the those ORV selections and segment designations.

The Wild Segments: Segments exhibiting "Wild" ORV's are valued for exhibiting a minimum of human influence. As indicated previously, they must be free of impoundments and should not be located along major circulation or transportation routes. Wild segments depend heavily on the quality of their scenic resources and, therefore, must undergo the same scenic analysis process as a "Scenic" river segment (see Scenic Segments for a more complete description of this process). When a proposed "Wild" segment exhibits both a minimum of disturbance and adequate scenic resources, then the ORV is achieved (Battaglia and Jones 2001).

The Scenic Segments: "Scenic resources are fundamental to the Pennsylvania Scenic Rivers program, and are one of the primary values recognized by people to be associated with river corridors" (2001). Battaglia and Jones' protocol for Scenic Rivers designation, which provided the model for this example study, involves the following steps for determining a "Scenic" ORV (as well as many "Wild" ORVs).

In the first step, the waterway in question is divided into homogenous landscape units (usually no smaller than several acres) as defined by common land character, appearance, landform, and land cover type. This is typically done by drawing these units on a map. Battaglia and Jones state (2001), "[a] typical unit would be comprised of characteristic repetitive topography, with repetitive vegetative cover, and unified land uses. Where these conditions change, another unit is identified." Examples of these types of units include rolling forested hills, forested uplands, and towns and camps (See page 277 for sample designations and their locations in the Kettle Creek watershed).



After these units have been identified and mapped, they are then rated on a scale of one to three according to three separate, qualifying criterion: landform, water features, and cultural modifications. (See page 279 for a more complete description of how one might systematically locate and rate each of these three criteria).

The rated criteria for each designated unit are then summarized. Those segments with over 75% of their designated units rating a summary "class one" achieve the outstandingly remarkable "Scenic" value. A sample summary ratings map for the sample segment of Kettle Creek might look like the one located above.

The Recreational and Modified Recreational Segments: Battaglia and Jones (2001) also indicate that "the recreational values of a river corridor may be so exceptional that an outstandingly remarkable value is created." To achieve a Recreational ORV, the quality of available recreational resources, the extent or scale of the resources, and the rarity of the recreational resources in the particular region of Pennsylvania are often taken into account.

A sample summary map of ORVs shows that over 75% of the area in question received a summary rating of "class one" and could have achieved a "Scenic" ORV.

Kettle Creek would likely receive favorable ratings in these areas of qualification due to several factors, including:

A) the fact that many Pennsylvanians (and visitors from outside the state) travel several hours to reach Kettle Creek,

B) the fact that 82% of Kettle Creek's streamside land is in public ownership,

C) the presence of readily available recreational facilities at Kettle Creek State Park and at Ole Bull State Park, as well as the presence of those facilities provided by private entrepreneurs in the watershed,

D) the well known trout fishing opportunities provided by Kettle Creek, and

E) the popularity of the watershed as a recreational destination. It is easy to see why any of a number of segments along the main stem of Kettle Creek could achieve Recreational ORV designations. For the purpose of this sample study, segments surrounding the reservoir at Kettle Creek State Park and Ole Bull State Park have been designated as Recreational segments because they already allow for easy access to streamside recreation and possess the facilities to accommodate visitor demands.

Conclusion

In closing, it is important to note once more that the eligibility study included in this chapter was only a sample study. It was intended to familiarize the reader with the scope of the Scenic Rivers Designation process. As indicated in the visual assessment chapter, the Pennsylvania State Scenic Rivers Program is a tool available to concerned communities to preserve and protect the water and immediate land resources they value.

In order to learn more about how the Scenic Rivers Program could apply to the Kettle Creek watershed contact the following offices of the PADCNR:

The PADCNR Web Site: Scenic Rivers Home Page. (http://www.dcnr.state.pa.us/rivers/srhome.htm).

The PADCNR Bureau of Recreation & Conservation, which "provides a variety of educational and informational services on several environmental issues, most notably on the subject of land use, rails-to-trails, and rivers conservation. These services include facilitation, technical advice and support for educators, and discussion facilitation for citizen groups and local officials" (PADNCR web site). To contact the Bureau of Recreation & Conservation, phone its main office at (717) 783-2658.

Literature Cited

Allegheny Watershed Network. 1999. Scenic River Designations, It's Official: It's Scenic. Pages 86-89 in A Watershed Primer for Pennsylvania: A Collection of Essays on Watershed Issues. Eds. Janette M. Novak and William H. Woodwell, Jr. PADEP, Harrisburg.

Battaglia, M. and Jones, D. 2001. Pennsylvania Scenic Rivers Program: Eligibility Process and Criteria (DRAFT). PADCNR, Harrisburg, 27 pp.

Landuse Methods
who we contacted and why

GIS mapping and content analysis of existing planning and zoning documents allowed us to understand patterns of landuse in Kettle Creek. Interviews with the Clinton and Potter County planners revealed that while Clinton County has a strong, relatively new, Comprehensive Landuse Plan instilled in addition to zoning, Potter county has only begun to revisit and revise their 1998 county comprehensive plan and has no active landuse protection. Interviews with the township supervisors generally suggested that there is limited participation, if any, in the watershed association and there is great potential for involvement in landuse protection programs.

County Planning Commission Organization
Planning commissions serve to develop landuse-planning strategies that consider existing resources of the county and seek to encourage sound economic development, encourage the sustainable use of natural resources, etc. In Pennsylvania specifically, while it is the planning commission that establish the inventory and make recommendations for landuse practices in addition to zoning, it is up to the townships to chose whether they wish to follow these regulations. In the case of Kettle Creek specifically, in most cases, individual townships have chosen to lean towards the rights of the private property owner as opposed to those of the greater community.

Townships Organization (MCD's)
Historically, township supervisors have been responsible for road and bridge maintenance alone; today their role has broadened to include the consideration of public safety, emergency services and environmental protection. They

APPENDIX D
LANDUSE

have the ability to
adopt local ordinance, manage and adopt township budgets and levy taxes. Governed by supervisor boards of 3-5 people, they are elected by resident voters for 6-year terms. In smaller districts, such as Kettle Creek, positions are often held on a volunteer basis; furthermore, there is often limited structure and funding available. Thus, the involvement of township supervisors becomes key in the planning process.

PNDI Designations

Natural Areas (NA):

a. Pristine Natural Areas: Areas characterized by ecological conditions that are believed to have existed prior to European settlement; size and scale of the area must be large enough to support and protect natural community forests.

b. Recovering Natural Areas: Areas that are relatively undisturbed, or past disturbance is relatively minor and the landscape is largely recovered to its pristine condition. For example: the cultivation of new old growth forest community.

Biological Diversity Areas (BDA):

a. Special Species Habitat: Areas that include natural or human habitat and that harbors one or more occurrences of plants or animals recognized as state or national species of special concern.

b. High Diversity Areas: Area thats maintain diverse native plants and animal species.

c. Community Ecosystem Conservation Areas: Areas that support rare or exemplary natural plant and aniumal communities or the highest quality or least disturbed examples of common community types. For example: a marshland that supports a wetland community found in no or few other sites in the county.

d. Dedicated Areas (DA): Properties, including previously disturbed sites, where the current owner's stated objectives are to protect and maintain the ecological integrity and biological diversity of the site largely through a “hands off” management approach. For example: control of highly invasive exotic species.

Landscape Conservation Areas (LCA): Large contiguous areas that are important due to their size, open space, and habitat qualities and that retain much of their natural character, even though a variety of land uses may have caused some disturbance. For example: an entire watershed that includes several thousand acres of forests, interspersed with agricultural lands, limited residential and commercial development and parklands.

Other Heritage Areas:

1. Scientific Areas: Areas that are consistently utilized for scientific environmental monitoring or other natural science studies.

2. Educational Areas: Land regularly used by educational institutions, local environmental organizations, or the general public for nature study or instruction.

Managed Lands: Owned or leased properties that are designated for their importance (or potential importance) to the overall maintenance and protection of ecological resources. Managed lands can be classified as public or private properties. Public properties are established and managed for the current and potential natural resources that maintain ecological assets in the county. Such lands are classified as “the most ecologically valuable” public properties. For example: state game lands, state parks, and national historic sites. Private lands are held by private organizations concerned with the management and protection of natural resources.

For example: private natural reserves. Managed lands are not included within identified natural heritage areas such as NAs or BDAs. However, these properties are often large in size. For this reseaon and for their association with an area identified for natural heritage significance, these areas are ecologically important. For example: a managed land within the boundaries of an NA or BDA.

High Quality Streams:

a) Qualifying as a High Quality Water. Surface water that meets one or more of the following conditions is a High Quality Water.

(1) Chemistry

(i) Water that has long-term water quality, based on at least one year of data that exceeds levels necessary to support the propagation of fish, shellfish and wildlife and recreation in and on the water by being better than the water quality criteria in § 93.7, Table 3 (relating to specific water quality criteria) or otherwise authorized by § 93.8a.

(b) Relating to Toxic Substances. Surface water that meets conditionds at least 99% of the time for the following parameters:

dissolved oxygen aluminum, iron, dissolved nickel, dissolved copper, dissolved cadmium, temperature, pH, dissolved arsenic, ammonia nitrogen, dissolved lead, dissolved zinc.

(ii) Additional chemical and toxicity information, which characterizes or indicates the quality of a water, may be consdered in the designation process.

(2) Biology

One or more of the following shall exist:

(i) Biological assessment qualifier

(A) Surface water supports a high quality, aquatic community based upon peer-reviewed biological assessments that consider physical habitat, benthic macroinvertebrates or fishes based on updated and amended editions of *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish* (Plafkin, et al., EPA/444/4-89-001). The surface water is compared to a reference stream or watershed, and an integrated benthic macroinvertebrate score of at least 83% shall be attained by the referenced stream or watershed.

(B) Surface water support a high quality, aquatic community based upon information gathered using other widely accepted and published peer-reviewed biological assessment procedures that the Department approves.

(C) The Department may consider additional biological information that characterizes or indicates the quality of a water in making its determination.

Carter Camp

(ii) Class A wild trout stream qualifier. The surface water has been designated a Class A wild trout stream by the Fish and Boat Commission following public notice and comment.

Exceptional Value Streams:

Qualifying as an Exceptional Value Water. A surface water that meets one or more of the following conditions is an Exceptional Value Water:

(1) The water meets the requirements of subsection (a) and one or more of the following:

(i) The water is located in a National wildlife refuge or a State game propagation and protection area.

(ii) The water is located in a designated State park natural area or State forest natural area, National Natural landmark, Federal or State wild river, Federal wilderness area or National recreational area.

(iii) The water is an outstanding National, State, regional or local resource water.

(iv) The water is a surface water of exceptional recreational significance.

(v) The water achieves a score of at least 92% (or its equivalent) using the methods and procedures described in subsection (a)(2)(i)(A) or (B).

(vi) The water is designated as a "wilderness trout stream" by the Fish and Boat Commission following public notice and comment.

i. The water is a surface water of exceptional ecological significance.

Agricultural Security Areas (ASAs)

The Pennsylvania State Legislature Agricultural Areas Security Law established agricultural Security Areas, organized by the local government, in 1981. ASAs, established through the townships, are created through a petition signed by farmers who own 500 acres of land collectively. In return, farmers receive special consideration with respect to local ordinances, rules and regulations dealing with farming activities and projects. In exchange for development rights, farms receive financial compensation. In cases of extreme development pressures, farmers are given financial assistance that exceeds the income they would be making farming the land.

ASAs are open for review every 7 years. The preservation of farmland is encouraged through an extensive review board of agricultural advising committee, township supervisors, county commissioners, PA agricultural land condemnation approval board who determine whether a farmland area can be transferred to development.

APPENDIX E
WETLANDS

Wetland Definitions and Functions

§ 105.1. Definitions.
The following words and terms, when used in this chapter, have the following meanings, unless the context clearly indicates otherwise:

Wetlands-Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas.

Wetland functions include, but are not limited to, the following:

(i) Serving natural biological functions, including food chain production; general habitat; and nesting, spawning, rearing and resting sites for aquatic or land species.

(ii) Providing areas for study of the environment or as sanctuaries or refuges.

(iii) Maintaining natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, natural water filtration processes, current patterns or other environmental characteristics.

(iv) Shielding other areas from wave action, erosion or storm damage.

(v) Serving as a storage area for storm and flood waters.

(vi) Providing a groundwater discharge area that maintains minimum baseflows.

(vii) Serving as a prime natural recharge area where surface water and groundwater are directly interconnected.

(viii) Preventing pollution.

(ix) Providing recreation.

Authority

The provisions of this § 105.1 amended under the Dam and Safety Encroachments Act (32 P. S. § § 693.1-693.27); The Clean Streams Law (35 P. S. § § 691.1-691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. § § 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. § § 679.101-679.601).

§ 105.17. Wetlands.

Wetlands are a valuable public natural resource. This chapter will be construed broadly to protect this valuable resource.

(1) Exceptional value wetlands. This category of wetlands deserves special protection. Exceptional value wetlands are wetlands that exhibit one or more of the following characteristics:

(i) Wetlands which serve as habitat for fauna or flora listed as "threatened" or "endangered" under the Endangered Species Act of 1973 (7 U.S.C.A. § 136; 16 U.S.C.A. § § 4601-9, 460k-1, 668dd, 715i, 715a, 1362, 1371, 1372, 1402 and 1531-1543), the Wild Resource Conservation Act (32 P. S. § § 5301-5314), 30 Pa.C.S. (relating to the Fish and Boat Code) or 34 Pa.C.S. (relating to the Game and Wildlife Code).

(ii) Wetlands that are hydrologically connected to or located within 1/2-mile of wetlands identified under subparagraph (i) and that maintain the habitat of the threatened or endangered species within the wetland identified under subparagraph (i).

(iii) Wetlands that are located in or along the floodplain of the reach of a wild trout stream or waters listed as exceptional value under Chapter 93 (relating to water quality standards) and the floodplain of streams tributary thereto, or wetlands within the corridor of a watercourse or body of water that has been designated as a National wild or scenic river in accordance with the Wild and Scenic Rivers Act of 1968 (16 U.S.C.A. § § 1271-1287) or designated as wild or scenic under the Pennsylvania Scenic Rivers Act (32 P. S. § § 820.21-820.29).

(iv) Wetlands located along an existing public or private drinking water supply, including both surface water and groundwater sources, that maintain the quality or quantity of the drinking water supply.

(v) Wetlands located in areas designated by the Department as "natural" or "wild" areas within State forest or park lands, wetlands located in areas designated as Federal wilderness areas under the Wilderness Act (16 U.S.C.A. § § 1131-1136) or the Federal Eastern Wilderness Act of 1975 (16 U.S.C.A. § 1132) or wetlands located in areas designated as National natural landmarks by the Secretary of the Interior under the Historic Sites Act of 1935 (16 U.S.C.A. § § 461-467).

(2) Other wetlands. This category includes wetlands not categorized as exceptional value wetlands.

(3) Permits. The Department will maintain a list of permit decisions involving wetlands. This list will be a matter of public record and will be available for inspection at the Department's offices.

Authority

The provisions of this § 105.17 amended under the Dam Safety and Encroachments Act (32 P. S. § § 693.1-693.27); The Clean Streams Law (35 P. S. § § 691.1-691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. § § 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. § § 679.101-679.601).

Source

The provisions of this § 105.17 adopted November 2, 1979, effective November 3, 1979, 9 Pa.B. 3640; amended September 26, 1980, effective September 27, 1980, 10 Pa.B. 3843; amended October 11, 1991, effective October 12, 1991, 21 Pa.B. 4911. Immediately preceding text appears at serial pages (117654) and (126083).

Notes of Decisions

Exceptional Value Wetlands

Wetlands adjacent to corporate water project meet the criteria for "exceptional value" wetlands as defined by this regulation because they: (1) serve as habitat for threatened or endangered plants and animals; (2) there are areas of wetland on the property of the proposed well that are hydro geologically connected to and within one-half mile of wetlands that serve as habitat to endangered and threatened species; and (3) the wetlands are located in or along the floodplain of a wild trout stream or "exceptional value waters." Therefore, because the Department of Environmental Protection failed to consider the effects of the project on the wetlands and adjacent exceptional value creek, and failed to determine whether the proposed activity was environmentally inconsequential, the permit was remanded for further consideration. Oley Township v. Department of Environmental Protection, 1996 EHB 1098.

Standing

In appeal from Environmental Hearing Board adjudication under the Dam Safety and Encroachments Act (32 P. S. § § 693.1-693.27), Game Commission lacked standing to invoke review under Article I, Section 27 of the Pennsylvania Constitution since Department of Environmental Resources and not the Game Commission has the duty to protect wildlife under the act. Game Commission v. Department of Environmental Resources, 509 A.2d 877 (Pa. Cmwlth. 1986).

Cross References

This section cited in 25 Pa. Code § 93.1 (relating to definitions); 25 Pa. Code § 96.3 (relating to water quality protection requirements); 25 Pa. Code § 105.13 (relating to permit applications-information and fees); 25 Pa. Code § 105.16 (relating to environmental, social and economic balancing); 25 Pa. Code § 105.442 (relating to authorization for general permits); 25 Pa. Code Chapter 105 Appendix E (relating to utility line stream crossings; general permit BDWM-GP-5); 25 Pa. Code Chapter 105 Appendix H (relating to temporary road crossings; general permit BDWM-GP-8); 25 Pa. Code § 250.1 (relating to definitions); 25 Pa. Code § 250.311 (relating to evaluation of ecological receptors); 25 Pa. Code § 271.915 (relating to management practices); 25 Pa. Code § 273.202 (relating to areas where municipal waste landfills are prohibited); 25 Pa. Code § 275.202 (relating to areas where the land application of sewage sludge is prohibited); § 277.202 (relating to areas where construction/demolition waste landfills are prohibited); 25 Pa. Code § 279.202 (relating to areas where transfer facilities are prohibited); 25 Pa. Code § 281.202 (relating to areas where general composting facilities are prohibited); and 25 Pa. Code § 283.202 (relating to areas where resource recovery facilities and other processing facilities are prohibited).

Wetland protection and restoration project funding

Land and Water Conservation Fund: In 1964, Congress established the Land and Water Conservation Fund (Public Law 88-578) to provide money for the acquisition of public lands to meet the needs of outdoor recreation and open space. Each year $900 million is deposited in the fund, primarily from the Outer Continental Shelf (OCS) oil and gas leasing. The LWCF Act directed Congress to allocate the money, through the annual appropriation process, for the purchase of land, waters and wetlands in our national parks, forests, wildlife refuges, and other resource lands and to provide matching grant assistance for state and community open space and recreation projects.

North American Waterfowl Management Plan Joint Venture Projects NAWMP): The US Fish and Wildlife Service, in cooperation with state governments as well as non-governmental partners, administers this program. It was authorized in 1986 between the United States and Canada with the purpose of protecting, restoring, and enhancing wetlands important to waterfowl. Mexico as also signed on. The plan is implemented at the grassroots level by partnerships called Joint Ventures. Wetlands identified under the NAWMP as "areas of major concern" for waterfowl and other bird habitat (for example, migration, nesting and forage areas) are targets for these joint ventures.

North American Wetlands Conservation Act: In 1989, recognizing the importance of wetland conservation for migratory birds, Congress passed the North American Wetlands Conservation Act to help support the Joint Ventures. In 1998, Congress authorized $30 million to make grants to private and public organizations and individuals for local wetland habitat conservation and restoration projects.

National Fish and Wildlife Foundation: The National Fish and Wildlife Foundation also funds local wetland conservation and restoration projects. The Foundation is dedicated to the conservation of natural resources-fish, wildlife, and plants. Its goals include habitat protection, environmental education, habitat and ecosystem rehabilitation and restoration. The Wetlands Campaign works with the Foundation to help secure funding for chapter wetland projects. More information can be found at this website: http:www.nfwf.org/about.htm.

Partners for Wildlife Program (PFW): The US Fish and Wildlife Service (USWS) administer this program, also known as the Private Lands Assistance and Restoration Program. The program offers technical and cost-share assistance to landowners who wish to restore wildlife habitat, including degraded or converted wetlands. The landowner works directly with USFWS to prepare a Habitat Restoration Proposal.

EPA Programs: The Environmental Protection Agency awards grants for environmental education. The Environmental Education Grants Program was established under Section 6 of the National Environmental Education Act of 1990. The goal of the program is to support environmental education projects that enhance the public's awareness, knowledge, and skills to make informed responsible decisions that affect environmental quality. Since 1992, Congress has appropriated $13 million for this program and funded about 1,500 projects.

U.S. Department of Agriculture: Wildlife habitat has been integrated into several conservation programs authorized in the last three farm acts. A variety of incentives afford landowners many opportunities to improve habitat for wildlife. Here's a summary of these programs.

Conservation Reserve Program (CRP) was authorized in 1985 to pay farmers rental payments for ten years to restore grass or trees on highly erodible croplands. In 1989 and 1997 wetlands were allowed to be restored through the CRP. The average payment is $39 per acre per year.

Conservation Reserve Enhancement Program (CREP): The CREP allows any state to target a specific region of special environmental significance, combining CRP with state funds to maximize protection of the land. Each state must submit a plan to USDA's Farm Services Agency for approval.

Conservation Reserve Program Buffer Initiative was authorized in 1996 to protect waterways with CRP funds. At any time during the year, landowners may sign-up to install conservation buffers (filterstrips, contour grass strips, grassed waterways, field windbreaks, shelterbelts, etc.) on cropland. The land must be along or around perennial streams, seasonal streams, sinkholes, or other permanent bodies of water, including wetlands. Land is enrolled in 10-15 year contracts. Payment is the acerage rental rate for comparable land in the CRP plus a 20 percent incentive for a riparian buffer.

Emergency Watershed Protection Program. The 1996 farm act authorized purchase of floodplain easements to help prevent future losses due to natural disasters under the Emergency Watershed Protection Program. Areas eligible for floodplain easement purchase include non-urban lowlands, which are predominately cropland (including orchards and vineyards), grazing land, hay land, or forest land, adjoining the channel of a river, stream, watercourse, lake or ocean, that have been subject to repeated damage associated with flooding.

The Emergency Wetland Reserve Program (EWRP) was created as a result of the 1993 floods along the upper Mississippi River. Landowners of flood-damaged cropland can get permanent easements if the cost of levee restoration and cropland renovation exceeded the value of the land. Environmental Quality Incentive Program (EQIP) was established in 1996 to pay for up to 75 percent of the costs of certain practices such as grassed waterways, filterstrips,manure management facilities, capping abandoned wells, and wildlife habitat enhancement. $200 million is authorized for each year through 2001.

The Wetland Reserve Program (WRP) was authorized in 1990 to pay farmers the land value plus wetland restoration and easement costs. One hundred percent of the land value and easement costs are paid for permanent easements. Seventy-five percent of the land value and easements costs for 30-year easements. For cost-share ten year agreements, seventy-five percent of the restoration costs are paid. By September 30, 1998 about 663,832 acres will be restored, largely in permanent easements. Through FY 98, $601,665,000 was made available to the program.

Wildlife Habitat Incentive Program (WHIP) was established in 1996 to help landowners develop upland and wetland habitat and threatened and endangered species habitat. Landowners agree to implement a wildlife habitat development plan, and NRCS agrees to provide cost-share assistance for the practices. The agreements are for five to ten years. Twenty-four million dollars was provided to fifty states plus Puerto Rico and the Pacific Basin during FY 1998.

Source: www.audubon.org/campaign/wetland/funding.html

Wetland Potential Model

Background:

The National Wetlands Inventory (NWI) maps under represent the amount of forested wetlands in the Pennsylvania landscape(A. Cole, CWS, personal communication). Forested wetlands are the primary wetland type in Pennsylvania(PAS 1998), but rank fourth (88 ac) in the watershed behind riverine (383 ac) lacustrine (133 ac), and palustrine emergent (112 ac). As 92% of the watershed is forested, forested wetlands might be expected to be the dominant type. The NWI maps were compiled using low elevation aerial photographs. Tree canopy cover often obscures forested wetlands making delineation difficult. Forested wetlands often appear to be uplands because standing water is usually absent.

Purpose:

The purpose of this model is to determine potential wetland locations that might be missed by NWI maps. Methods other than aerial photography were developed to independently compare the model with the NWI maps.

Method:

An additive model assigns a value to each pixel in an Arc View GIS (Geographic Information System) layer. The layers are then stacked and the value of each pixel is added together into a fourth layer which becomes the map. Using the references listed below, current NWI maps, and additional GIS information. It was determined that slope, geology, and proximity to streams were the three most influential variables to determine possible wetland presence. The values for the three variables (slope, geology, and proximity to streams) were broken into 5 ranges. Each value range was assigned a number from most important (5) to least important (0). ARC View 3.2 was used to manipulate the variables and apply the additive model. The variables (layers) were then added together in ARC View and output as The Wetlands Potential map (see figure x.x).

Description of layers:

Geology: Five geologic formations are present in the watershed. The Catskill formation harbors most wetlands based on NWI maps and was given a value of 5. The Huntley Mountain and Pottsville formations harbor a small percentage of wetlands and were given a value of 3. A value of 0 was given to the Lock Haven and Burgoon Sandstone formations.

Slope: Maximum slope conducive to wetland formation was defined as 3%. The slope was given a score in the following sequence 0 %(5), 1%(4), 2%(3), 3%(2), and greater than 3 % (0).

Proximity to streams: A 250 meter buffer was applied to the streams in the watershed. The buffer was broken into 5-50 meter intervals and values were designated in decreasing order [0-50m (5) through >250 (0)]

The wetlands potential map was ground verified in the upper portion of the watershed near Carter Camp, Dry Hollow/Leetonia Road, and Sliders branch. The pixels representing very high probability on the map were within 50 meters of the wetlands occurring on ground. The model predicts an additional 472 acres of wetlands not identified by NWI inventories (814 ac) resulting in a 58% potential increase in wetland acreage in the watershed. The potential acreage was calculated from the number of pixels from the Wetlands Potential map having a very high value. Each pixel is 900m2, during field checking some wetlands were found to be less than 900 m2meaning the model could overestimate the potential wetland acreage. Extensive ground verification is needed to validate percentage of wetlands contained in each pixel to more accurately estimate the potential wetland acreage. The model is an indicator of potential wetland resources. Because wetlands are important to water quality, it is important to consider the potential impact to water quality if broad scale landuse changes occur that impact wetlands. The streams in the upper watershed are classified as riverine wetlands by the Cowardin classification system. The streams were not included in the calculation because they have already been identified by USGS.

References:

Cowardin et al. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service. Office of Biological Services. FWS/OBS-79/31. 103

Mitsch, W. J., and Gosselink, J.G. 1993. Wetlands. John Wiley and Sons, New York, 722 pp.

Ecology of Wetlands and Associated Systems. 1998, The Pennsylvania Academy of Science, Easton, PA, 685 pp.

Wetland Soils: Genesis, Hydrology, Landscapes, and Classification. 2001 Lewis Publishers, New York, 417 pp.

Appendix F - Habitat Assessment

HABITAT ASSESSMENT FIELD DATA SHEETS (FRONT) RIFFLE/RUN

STREAM NAME:
COUNTY:

HMS STATION #
DATE: TIME

HABITAT PARAMETER	CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
1. Epifaunal Substrate/Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not transient.)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable. Substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious. Substrate unstable or lacking.
SCORE: ___ (F)	FISH 10 9	8 7 6	5 4 3	2 1 0
SCORE: ___ (M)	MACRO 10 9	8 7 6	5 4 3	2 1 0
2. Riffle Quality	Well developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble. (Boulders prevalent in headwater streams)	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than two times the stream width; gravel or bedrock prevalent; some cobble present.	Riffles or runs virtually nonexistent; bedrock prevalent; cobble lacking.
SCORE: ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE: ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past twenty years) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40-80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE: ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80%) for low gradient) of the bottom affected; sediment deposits at obstructions, constrictions and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material; increased bar development; more than 50% (80% for low gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

The Pennsylvania Fish and Boat Commission (PFBC) Habitat Assessment Sheet (Front)

HABITAT ASSESSMENT FIELD DATA SHEETS (BACK) **RIFFLE/RUN**

HABITAT PARAMETER	CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
6. Frequency of Riffles (or bends)/ Velocity-Depth Combinations	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. All 4 velocity/ depth patterns present.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. Only 3 of 4 velocity / depth patterns present (i.e., slow (<0.3 m/s)-deep (>0.5 meters), slow-shallow, fast-deep, fast-shallow)	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. May be only 2 velocity/depth patterns present, usually lacking deep areas	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. Dominated by one velocity/ depth pattern.
SCORE:____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE:____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by native vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE:____ (LB)	Left bank 10 9	8 7 6	5 4 3	2 1 0
SCORE:____ (RB)	Right bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE:____ (LB)	Left bank 10 9	8 7 6	5 4 3	2 1 0
SCORE:____ (RB)	Right bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE:____ (LB)	Left bank 10 9	8 7 6	5 4 3	2 1 0
SCORE:____ (RB)	Right bank 10 9	8 7 6	5 4 3	2 1 0

TOTAL SCORE:_______

The Pennsylvania Fish and Boat Commission (PFBC) Habitat Assessment Sheet (Back)

HABITAT ASSESSMENT FIELD DATA SHEET ***RIFFLE/RUN PREVALENCE***

DATE-TIME-INITIALS : ________ - ________ - ________ .

Surveyed by: ____________________ .

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
1. Instream Cover (fish)	Greater than 50% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat.	30-50% mix of boulder, cobble, or other stable habitat; adequate habitat	10-30% mix of boulder, cobble, or other stable habitat; habitat availability less than desirable	less than 10% mix of boulder, cobble, or other stable habitat; lack of habitat obvious
SCORE: ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Epifaunal Substrate	Well-developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble	Riffle is as wide as stream but length is less than 2 times width; abundance of cobble; boulders and gravel common	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; gravel or large boulders and bedrock prevalent; some cobble present	Riffles or run virtually nonexistent; large boulders and bedrock prevalent; cobble lacking
SCORE: ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment
SCORE: ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Velocity/Depth Regimes	All four velocity/depth regimes present (slow-deep; slow-shallow; fast-deep; fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes)	Only 2 of the 4 regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep)
SCORE: ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Alteration	No channelization or dredging present.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e. dredging (greater than 20 yr) may be present, but recent channelization is not present.	New embankments present on both banks; and 40-80% of stream reach channelized and disrupted	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted.
SCORE: ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from coarse gravel; 5-30% of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, coarse sand on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE: ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

TOTAL (Side 1): _____

Department of Environmental Protection (DEP) Habitat Assessment Sheet (Front)

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
7. Frequency of Riffles	Occurrence of riffles relatively frequent; distance between riffles divided by the width of the stream equals 5 to 7; variety of habitat.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream equals 7 to 15	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is > 25.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Channel Flow Status	Water reaches base of both lower banks and minimal amount of channel substrate is exposed	Water fills > 75% of the available channel, or < 25% of channel substrate is exposed	Water fills 25 - 75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Condition of Banks	Banks stable, no evidence of erosion of bank failure.	Moderately stable; infrequent, small areas of erosion mostly healed over.	Moderately unstable; up to 60% of banks in reach have areas of erosion.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; on side slopes, 60-100% of bank has erosional scars
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
10. Bank Vegetative Protection	More than 90% of the streambank surfaces covered by vegetation	70 - 90% of the streambank surfaces covered by vegetation	50 - 70% of the streambank surfaces covered by vegetation	Less than 50 % of the streambank surfaces covered by vegetation.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
11. Grazing or Other Disruptive Pressure	Vegetative disruption through grazing or mowing is minimal or not evident; almost all plants allowed to grow naturally	Disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining	Disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Disruption of streambank vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
12. Riparian Vegetative Zone Width	Width of riparian zone >18 meters; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally	Width of riparian zone 6 -12 meters; human activities have impacted zone a great deal	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Totals - (Side 2): _____

(Side 1): _____

STATION SCORE:

Department of Environmental Protection (DEP) Habitat Assessment Sheet (Back)

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME	LOCATION	
STATION #________ RIVERMILE________	STREAM CLASS	
LAT _____________ LONG _____________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ________ TIME _________ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS	**Now** ❑ ❑ ❑ ____%❑ ❑	storm (heavy rain) rain (steady rain) showers (intermittent) %cloud cover clear/sunny	**Past 24 hours** ❑ ❑ ❑ ❑____% ❑
	Has there been a heavy rain in the last 7 days? ❑ Yes ❑ No **Air Temperature**_____ ^{0} C **Other**_______________________________		
SITE LOCATION/MAP	**Draw a map of the site and indicate the areas sampled (or attach a photograph)**		
STREAM CHARACTERIZATION	**Stream Subsystem** ❑ Perennial ❑ Intermittent ❑ Tidal **Stream Origin** ❑ Glacial ❑ Spring-fed ❑ Non-glacial montane ❑ Mixture of origins ❑ Swamp and bog ❑ Other__________	**Stream Type** ❑ Coldwater ❑ Warmwater **Catchment Area**__________km^2	

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Physical Characterization/Water Quality Field Data Sheet (Front)

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ❑ Forest ❑ Commercial ❑ Field/Pasture ❑ Industrial ❑ Agricultural ❑ Other _______________ ❑ Residential **Local Watershed NPS Pollution** ❑ No evidence ❑ Some potential sources ❑ Obvious sources **Local Watershed Erosion** ❑ None ❑ Moderate ❑ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ❑ Trees ❑ Shrubs ❑ Grasses ❑ Herbaceous **dominant species present** ____
INSTREAM FEATURES	**Estimated Reach Length** _______m **Estimated Stream Width** _______m **Sampling Reach Area** _______m^2 **Area in km^2 (m^2x1000)** _______km^2 **Estimated Stream Depth** _______m **Surface Velocity (at thalweg)** _______m/sec **Canopy Cover** ❑ Partly open ❑ Partly shaded ❑ Shaded **High Water Mark** _______m **Proportion of Reach Represented by Stream Morphology Types** ❑ Riffle_______% ❑ Run_______% ❑ Pool_______% **Channelized** ❑ Yes ❑ No **Dam Present** ❑ Yes ❑ No
LARGE WOODY DEBRIS	**LWD** _______m^2 **Density of LWD** _______m^2/km^2 **(LWD/ reach area)**
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ❑ Rooted emergent ❑ Rooted submergent ❑ Rooted floating ❑ Free floating ❑ Floating Algae ❑ Attached Algae **dominant species present** ____ **Portion of the reach with aquatic vegetation** _____%
WATER QUALITY	**Temperature**________ ^{0} C **Specific Conductance**________ **Dissolved Oxygen** ________ **pH** ________ **Turbidity** ________ **WQ Instrument Used** _______________ **Water Odors** ❑ Normal/None ❑ Sewage ❑ Petroleum ❑ Chemical ❑ Fishy ❑ Other________________ **Water Surface Oils** ❑ Slick ❑ Sheen ❑ Globs ❑ Flecks ❑ None ❑ Other__________________________ **Turbidity (if not measured)** ❑ Clear ❑ Slightly turbid ❑ Turbid ❑ Opaque ❑ Stained ❑ Other________
SEDIMENT/ SUBSTRATE	**Odors** ❑ Normal ❑ Sewage ❑ Petroleum ❑ Chemical ❑ Anaerobic ❑ None ❑ Other_________________________________ **Oils** ❑ Absent ❑ Slight ❑ Moderate ❑ Profuse **Deposits** ❑ Sludge ❑ Sawdust ❑ Paper fiber ❑ Sand ❑ Relict shells ❑ Other________________ **Looking at stones which are not deeply embedded, are the undersides black in color?** ❑ Yes ❑ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	**Diameter**	**% Composition in Sampling Reach**	**Substrate Type**	**Characteristic**	**% Composition in Sampling Area**
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)		Marl	grey, shell fragments	
Silt	0.004-0.06 mm				
Clay	< 0.004 mm (slick)				

Physical Characterization/Water Quality Field Data Sheet (Back)

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #_________ RIVERMILE_________	STREAM CLASS	
LAT ______________ LONG ______________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _______ TIME ________ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

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High Gradient Stream Habitat Assessment Sheet (Front)

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score __________

High Gradient Stream Habitat Assessment Sheet (Back)

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION
STATION #________ RIVERMILE________	STREAM CLASS
LAT __________ LONG __________	RIVER BASIN
STORET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY	DATE ________ TIME ________ AM PM — REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

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Low Gradient Stream Habitat Assessment Sheet (Front)

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ________

Low Gradient Stream Habitat Assessment Sheet (Back)

Potential Habitat for the Kettle Creek Watershed (285 potential species)

Fish Species List for Potential Habitat in Kettle Creek Watershed (37 potential species)

Rainbow trout (*Oncorhynchus mykiss*)
Brown trout (*Salmo trutta*)
Brook trout (*Salvelinus fontinalis*)
Redfin pickerel (*Esox americanus americanus*)
Northern pike (*Esox lucius*)
Chain pickerel (*Esox niger*)
Central stoneroller (*Campostoma anomalum*)
Redside dace (*Clinostomus elongates*)
Cutlips minnow (*Exoglossum maxillingua*)
Common shiner (*Luxilus cornutus*)
Spottail shiner (*Notropis hudsonicus*)
Spotfin shiner (*Luxilus spiloptera*)
Mimic shiner (*Notropis volucellus*)
Blacknose dace (*Rhinichthys atratulus*)
Longnose dace (*Rhinichthys cataractae*)
Creek chub (*Semotilus atromaculatus*)
Fallfish (*Semotilus corporalis*)
Pearl dace (*Margariscus margarita*)
White sucker (*Catostomus commersoni*)
Northern hog sucker (*Hypentelium nigricans*)
Golden redhorse (*Moxostoma duquesnei*)
Brown bullhead (*Ameiurus nebulosus*)
Channel catfish (*Ictalurus punctatus*)
Stonecat (*Noturus flavus*)
Margined madtom (*Noturus insignis*)
American eel (*Anguilla rostrata*)
Rock bass (*Ambloplites rupestris*)
Green sunfish (*Lepomis cyanellus*)
Pumpkinseed (*Lepomis gibbosus*)
Bluegill (*Lepomis macrochirus*)
Longear sunfish (*Lepomis megalotis*)
Largemouth bass (*Micropterus salmoides*)
Greenside darter (*Etheostoma blennioides*)
Banded darter (*Etheostoma zonale*)
Shield darter (*Percina peltata*)
Mottled sculpin (*Cottus bairdi*)
Slimy sculpin (*Cottus cognatus*)

Amphibian Species List for Potential Habitat in Kettle Creek Watershed (23 potential species)

Jefferson salamander (*Ambystoma jerffersonianum*)
Spotted salamander (*Ambystoma maculatum*)
Eastern hellbender (*Cryptobranchus alleganiensis*)
Northern dusky salamander (*Desmognathus fuscus*)
Mountain dusky salamander (*Desmognathus ochrophaeus*)
Northern two lined salamander (*Eurycea bislineata*)
Longtail salamander (*Eurycea longicauda*)
Northern spring salamander (*Gyrinophilus porphyriticus*)
Four-toed salamander (*Hemidactylium scutatum*)
Redback salamander (*Plethodon cinereus*)
Slimy salamander (*Plethodon glutinosus*)
Valley & ridge salamander (*Plethodon hoffmani*)
Wehrle's salamander (*Plethodon wehrlei*)
Northern red salamander (*Pseudotriton rubber*)
Red-spotted newt (*Notophthalmus viridescens*)
Eastern american toad (*Bufo americanus*)
Fowlers toad (*Bufo woodhousii*)
Northern cricket frog (*Acris crepitans*)
Northern spring peeper (*Pseudacris crucifer*)
Bullfrog (*Rana catesbeiana*)
Northern green frog (*Rana clamitans*)
Pickerel frog (*Rana palustris*)
Wood frog (*Rana sylvatica*)

Snake and Lizard Species List for Potential Habitat in Kettle Creek Watershed (13 potential species)

Northern fence lizard (*Sceloporus undulates*)
Northern coal skink (*Eumeces anthracinus*)
Five-lined skink (*Eumeces faciatus*)
Northern black racer snake (*Coluber constrictor*)
Northern ringneck snake (*Diadophis punctatus*)
Black rat snake (*Elaphe obsolete*)
Eastern milk snake (*Lampropeltis triangulum*)
Northern water snake (*Nerodia sipedon*)
Eastern smooth green snake (*Opheodrys vernalis*)
Northern redbellied snake (*Storeria occipitomaculata*)
Eastern garter snake (*Thamnophis sirtalis*)
Earth snake (*Virginia valeriae*)
Timber rattlesnake (*Crotalus horridus*)

Turtle Species List for Potential Habitat in Kettle Creek Watershed (5 potential species)

Common snapping turtle (*Chelydra serpentina*)
Midland painted turtle (*Chrysemys picta*)
Wood turtle (*Clemmys insculpta*)
Redbellied turtle (*Pseudemys rubriventris*)
Eastern box turtle (*Terrapene carolina*)

Mammal Species List for Potential Habitat in Kettle Creek Watershed (53 potential species)

Virginia opossum (*Didelphis virginiana*)
Masked shrew (*Sorex cinereus*)
Northern water shrew (*Sorex palustris*)
Smoky shrew (*Sorex fumeus*)
Pygmy shrew (*Sorex hoyi*)
Shorttail shrew (*Blarina brevicauda*)
Hairy tail mole (*Parascalops breweri*)
Starnose mole (*Condylura cristata*)
Little brown myotis (*Myotis lucifugus*)
Eastern small-footed myotis (*Myotis leibii*)
Northern myotis (*Myotis septentrionalis*)
Silver haired bat (*Lasionycteris noctivagans*)
Eastern pipistrelle (*Pipistrellus subflavus*)
Big brown bat (*Eptesicus fuscus*)
Eastern red bat (*Lasiurus borealis*)
Hoary bat (*Lasiurus cinereus*)
Eastern cottontail (*Sylvilagus floridanus*)
Appalachian cottontail (*Sylvilagus obscurus*)
Snowshoe hare (*Lepus americanus*)
Eastern chipmunk (*Tamias striatus*)
Woodchuck (*Marmota monax*)
Gray squirrel (*Sciurus carolinensis*)
Red squirrel (*Tamiasciurus hudsonicus*)
Southern flying squirrel (*Glaucomys volans*)
Northern flying squirrel (*Glaucomys sabrinus*)
American beaver (*Castor canadensis*)
Deer mouse (*Peromyscus maniculatus*)
White footed mouse (*Peromyscus leucopus*)
Allegheny woodrat (*Neotoma magister*)
Southern redback vole (*Clethrionomys gapperi*)
Meadow vole (*Microtus pennsylvanicus*)
Woodland vole (*Microtus pinetorum*)
Common muskrat (*Ondatra zibethicus*)
Southern bog lemming (*Synaptomys cooperi*)
Norway rat (*Rattus norvegicus*)
House mouse (*Mus musculus*)
Meadow jumping mouse (*Zapus hudsonicus*)
Woodland jumping mouse (*Napaeozapus insignis*)
Common porcupine (*Erethizon dorsatum*)
Coyote (*Canis latrans*)
Red fox (*Vulpes vulpes*)
Gray fox (*Urocyon cinereoargenteus*)
Black bear (*Ursus americanus*)
Raccoon (*Procyon lotor*)
Ermine (*Mustela erminea*)
Longtail weasel (*Mustela frenata*)
American mink (*Mustela vison*)
Fisher (*Martes pennanti*)
Striped skunk (*Mephitis mephitis*)
River otter (*Lontra canadensis*)
Bobcat (*Lynx rufus*)
Whitetail deer (*Odocoileus virginianus*)
Elk (*Cervus canadensis*)

Bird Species List for Potential Habitat in Kettle Creek Watershed (154 potential species)

Great blue heron (*Ardea herodias*)
Green heron (*Butorides striatus*)
Black-crowned night-heron (*Nycticorax nycticorax*)
Canada goose (*Branta Canadensis*)
Wood duck (*Aix sponsa*)
Green-winged teal (*Anas crecca*)
American black duck (*Anas rubripes*)
Mallard (*Anas platyrhynchos*)
Blue-winged teal (*Anas discors*)
Hooded merganser (*Lophodytes cucullatus*)
Common merganser (*Mergus merganser*)
Turkey vulture (*Cathartes aura*)
Osprey (*Pandion haliaetus*)
Bald eagle (*Haliaeetus leucocephalus*)
Sharp-shinned hawk (*Accipiter striatus*)
Cooper's hawk (*Accipiter cooperii*)
Northern goshawk (*Accipiter gentilis*)
Northern harrier (*Circus cyaneus*)
Red-shouldered hawk (*Buteo lineatus*)
Broad-winged hawk (*Buteo platypterus*)
Red-tailed hawk (*Buteo jamaicensis*)
American kestrel (*Falco sparverius*)
Ring-necked pheasant (*Phasianus colchicus*)
Ruffed grouse (*Bonasa umbellus*)
Wild turkey (*Meleagris gallopavo*)
Northern bobwhite (*Colinus virginianus*)
Virginia rail (*Rallus limicola*)
Sora (*Porzana caroliniana*)
Common moorhen (*Gallinula chloropus*)
Killdeer (*Charadrius vociferous*)
Spotted sandpiper (*Actitis macularia*)
American woodcock (*Scolopax minor*)
Rock dove (*Columba livia*)
Mourning dove (*Zenaida macroura*)
Yellow-billed cuckoo (*Coccyzus americanus*)
Black-billed cuckoo (*Coccyzus erythrophthalmus*)
Barn owl (*Tyto alba*)
Eastern screech owl (*Otus asio*)
Great horned owl (*Bubo virginianus*)
Barred owl (*Strix varia*)
Northern saw-whet owl (*Aegolius acadicus*)
Common nighthawk (*Chordeiles minor*)
Whip-poor-will (*Caprimulgus vociferous*)
Chimney swift (*Chaetura pelagica*)
Ruby-throated hummingbird (*Archilochus colubris*)
Belted kingfisher (*Ceryle alcyon*)
Red-headed woodpecker (*Melanerpes erythrocephalus*)
Red-bellied woodpecker (*Melanerpes carolinus*)
Yellow-bellied sapsucker (*Sphyrapicus varius*)
Downy woodpecker (*Picoides pubescens*)
Hairy woodpecker (*Picoides villosus*)
Northern flicker (*Colaptes auratus*)
Pileated woodpecker (*Dryocopus pileatus*)
Eastern wood-pewee (*Contopus virens*)
Acadian flycatcher (*Empidonax virescens*)
Alder flycatcher (*Empidonax alnorum*)
Willow flycatcher (*Empidonax traillii*)
Least flycatcher (*Empidonax minimum*)
Eastern phoebe (*Sayornis phoebe*)
Great crested flycatcher (*Myiarchus crinitus*)
Eastern kingbird (*Tyrannus tyrannus*)
Horned lark (*Eremophila alpestris*)
Purple martin (*Progne subis*)
Tree swallow (*Tachycineta bicolor*)
Northern rough-winged swallow (*Stelgidopteryx serripennis*)
Bank swallow (*Riparia riparia*)
Cliff swallow (*Hirundo pyrrhonota*)
Barn swallow (*Hirundo rustica*)
Blue jay (*Cyanocitta cristata*)
American crow (*Corvus brachyrhynchos*)
Common raven (*Corvus corax*)
Black-capped chickadee (*Parus atricapillus*)
Tufted titmouse (*Parus bicolor*)
Red-breasted nuthatch (*Sitta Canadensis*)
White-breasted nuthatch (*Sitta carolinensis*)
Brown creeper (*Certhia Americana*)
Carolina wren (*Thryothorus ludovicianus*)
House wren (*Troglodytes aedon*)
Winter wren (*Troglodytes troglodytes*)
Marsh wren (*Cistothorus palustris*)
Golden-crowned kinglet (*Regulus satrapa*)

Blue-gray gnatcatcher (*Polioptila caerulea*)
Eastern bluebird (*Sialia sialis*)
Veery (*Catharus fuscescens*)
Swainson's thrush (*Catharus ustulatus*)
Hermit thrush (*Catharus guttatus*)
Wood thrush (*Hylocichla mustelina*)
American robin (*Turdus migratorius*)
Gray catbird (*Dumetella carolinensis*)
N. mockingbird (*Mimus polyglottos*)
Brown thrasher (*Toxostoma rufum*)
Cedar waxwing (*Bombycilla cedrorum*)
European starling (*Sturnus vulgaris*)
White-eyed vireo (*Vireo griseus*)
Blue-headed vireo (*Vireo solitarius*)
Yellow-throated vireo (*Vireo flavifrons*)
Warbling vireo (*Vireo gilvus*)
Red-eyed vireo (*Vireo olivaceus*)
Blue-winged warbler (*Vermivora pinus*)
Golden-winged warbler (*Vermivora chrysoptera*)
Nashville warbler (*Vermivora ruficapilla*)
Northern parula (*Parula americana*)
Yellow warbler (*Dendroica petechia*)
Chestnut-sided warbler (*Dendroica pensylvanica*)
Magnolia warbler (*Dendroica magnolia*)
Black-throated blue warbler (*Dendroica caerulescens*)
Yellow-rumped warbler (*Dendroica coronata*)
Black-throated green warbler (*Dendroica virens*)
Blackburnian warbler (*Dendroica fusca*)
Yellow-throated warbler (*Dendroica dominica*)
Pine warbler (*Dendroica pinus*)
Prairie warbler (*Dendroica discolor*)
Blackpoll warbler (*Dendroica striata*)
Cerulean warbler (*Dendroica cerulea*)
Black-and-white warbler (*Mniotilta varia*)
American redstart (*Setophaga ruticilla*)
Prothonotary warbler (*Protonotaria citrea*)
Worm-eating warbler (*Helmitheros vermivorus*)
Swainson's warbler (*Limnothlypis swainsonii*)
Ovenbird (*Seiurus aurocapillus*)
Northern waterthrush (*Seiurus noveboracensis*)
Louisiana waterthrush (*Seiurus motacilla*)
Kentucky warbler (*Oporornis formosus*)
Mourning warbler (*Oporornis philadelphia*)
Common yellowthroat (*Geothlypis trichas*)
Hooded warbler (*Wilsonia citrina*)
Canada warbler (*Wilsonia canadensis*)
Yellow-breasted chat (*Icteria virens*)
Scarlet tanager (*Piranga olivacea*)
Northern cardinal (*Cardinalis cardinalis*)
Rose-breasted grosbeak (*Pheucticus ludovicianus*)
Indigo bunting (*Passerina cyanea*)
Eastern towhee (*Pipilo erythrophthalmus*)
Chipping sparrow (*Spizella passerina*)
Field sparrow (*Spizella pusilla*)
Vesper sparrow (*Pooecetes gramineus*)
Savannah sparrow (*Passerculus sandwichensis*)
Grasshopper sparrow (*Ammodramus savannarum*)
Song sparrow (*Melospiza melodia*)
Swamp sparrow (*Melospiza Georgiana*)
White-throated sparrow (*Zonotrichia albicollis*)
Dark-eyed junco (*Junco hyemalis*)
Bobolink (*Dolichonyx orizyvorus*)
Red-winged blackbird (*Agelaius phoeniceus*)
Eastern meadowlark (*Sturnella magna*)
Common grackle (*Quiscalus quiscula*)
Brown-headed cowbird (*Molothrus ater*)
Orchard oriole (*Icterus spurious*)
Baltimore oriole (*Icterus galbula*)
Purple finch (*Carpodacus purpureus*)
House finch (*Carpodacus mexicanus*)
Pine siskin (*Carduelis pinus*)
American goldfinch (*Carduelis tristis*)
House sparrow (*Passer domesticus*)

Pennsylvania Natural Diversity Inventory

The Pennsylvania Natural Diversity Inventory (PNDI) is a partnership between the Pennsylvania Bureau of Forestry, The Nature Conservancy, and the Western Pennsylvania Conservancy to conduct inventories and collect data to describe the Commonwealth's rarest and most significant ecological features. These features include plant and animal species of special concern, rare and exemplary natural communities and outstanding geologic features. Site-specific information describing these features is stored in an integrated data management system created from map, manual, and computer files. The PNDI information system is continually refined and updated to include recently discovered locations and to describe environmental changes affecting known sites. The goal is to build, maintain and provide accurate and accessible ecological information needed for conservation, development planning and natural resource management.

PNDI methodology follows that of the Association for Biodiversity Information. This international network links programs throughout the United States, Canada, Latin America, and the Caribbean. Data collection and transcription procedures are standardized among the programs. Use of consistent methodology presents an opportunity to assess the status of a given species or natural community over a broad geographic area and crossing any number of political boundaries. Conservation strategies can then be based on local, state, national, global or bioregional perspectives.

Species tracked within the PNDI information system are those listed as Endangered, Threatened, or Rare by the Department of Conservation and Natural Resources, Pennsylvania Game Commission, Pennsylvania Fish and Boat Commission, U.S. Fish and Wildlife Service or species recommended for such listing by the Pennsylvania Biological Survey. Natural community types and geologic features are included based on the recommendations of PNDI ecologists and the Bureau of Topographic and Geologic Survey, respectively. Species and associated locational information are initially gathered from plant and animal specimens maintained in museums, universities, and personal collections. These data are supplemented by research publications and contacts with knowledgeable individuals. Intensive field surveys are conducted to verify historically known plant and animal sites and to search for previously undocumented locations. Through this scientifically-based inventory, vital ecological resources and sites rich in natural diversity are identified and monitored, and are indicated as candidates for future conservation efforts.

Protection of the Commonwealth's natural heritage can be accomplished in harmony with our needs to develop and use natural resources. With objective and accurate data, PNDI can help guide planning and development, avoiding damage to precious ecological areas. The Commonwealth has lost at least 192 species of plants and animals and diminished nearly 500 species to endangerment status. Since 1988, PNDI has become a routine component of most environmental assessments, and subsequently prevented losses of biological diversity without consequence to the economy. With advance planning or minor modifications to development plans, our natural heritage has been protected and brought to the attention of many Pennsylvanians. PNDI also assists conservation organizations in channeling funds toward land acquisition, easements, etc. for the protection of imperiled plant and animal species and natural communities.

PNDI relies upon information from a wide variety of sources to develop and sustain the ongoing inventory. Concerned citizens are encouraged to make suggestions or provide information that will assist with the project. The loss of species and natural communities is often inadvertent. The more complete our information on whatand where specie, the greater our chances of preventing species loss.

Department of Conservation and Natural Resources, Bureau of Forestry, P.O. Box 8552, Harrisburg, PA 17105-8552

Western Pennsylvania Conservancy, Natural Heritage Program, 209 Fourth Ave, Pittsburgh, PA 15222

The Nature Conservancy, Pennsylvania Science Office, 208 Airport Blvd, Middletown, PA 17057

Documented PNDI Species and Habitats in the Kettle Creek Watershed

Common Name	Scientific Name	PA Status	*Last Recorded Date
Timber rattlesnake	Crotalus horridus	PC	1998
Great blue heron	Ardea herodias		1974
Brook floater(fresh water musse	Alasmidonta varicosa		1997
Eastern floater(freshwater muss	Pyganodon cataracta		1994
American bittern(migratory bird)	Botaurus lentiginosus**	PE	1890
Water shrew	Sorex palustris albibarbis		1945
Allegheny woodrat	Neotoma magister	PT	1898
Habitats of interest:			
Meandering Channels			
High-gradient clearwater creek			

PC =Pennsylvania species of concern could become threatened or endangered
PE = Pennsylvania endangered species PT = Pennsylvania threatened species

* Last recorded date is the date of the most recent documentation of the occurrence of the species in our database.

** Record is based on an 1890 specimen with its location given only as Clinton County, so it might not actually have come from the Kettle Creek watershed.

Source: PNDI database, search conducted by Kierstin Carlson of Western Pennsylvania Conservancy

Potential PNDI Species in the the Kettle Creek Watershed

Common Name	Scientific Name	State Rank*	State Status*	Proposed State Status*
LONGEAR SUNFISH	*LEPOMIS MEGALOTIS*	S1	PE	PE
COAL SKINK	*ANTHRACINUS*	S3		
TIMBER RATTLESNAKE	*CROTALUS HORRIDUS*	S3S4	PC	CA
REDBELLY TURTLE	*PSEUDEMYS RUBRIVENTRIS*	S2	PT	CA
WATER SHREW	*SOREX PALUSTRIS ALBIBARBIS*	S3		CR
EASTERN SMALL-FOOTED MYOTIS	*MYOTIS LEIBII*	S1B,S1N	PT	PT
NORTHERN MYOTIS	*MYOTIS SEPTENTRIONALIS*	S3B,S3N		CR
SILVER-HAIRED BAT	*LASIONYCTERIS NOCTIVAGANS*	SUB		CR
APPALACHIAN COTTONTAIL	*SYLVILAGUS OBSCURUS*	SU		
NORTHERN FLYING SQUIRREL	*GLAUCOMYS SABRINUS*	SU		
ALLEGHENY WOODRAT	*NEOTOMA MAGISTER*	S3	PT	PT
FISHER	*MARTES PENNANTI*	SH		PX
NORTHERN RIVER OTTER	*LONTRA CANADENSIS*	S3		
GREAT BLUE HERON	*ARDEA HERODIAS*	S3S4B,S4N		
BLACK-CROWNED NIGHT-HERON	*NYCTICORAX NYCTICORAX*	S2S3B		CA
GREEN-WINGED TEAL	*ANAS CRECCA*	S1S2B,S3N		CR
OSPREY	*PANDION HALIAETUS*	S2B	PT	PT
BALD EAGLE	*HALIAEETUS LEUCOCEPHALUS*	S1S2B	PE	PE
NORTHERN GOSHAWK	*ACCIPITER GENTILIS*	S2S3B,S3N		CR
NORTHERN HARRIER	*CIRCUS CYANEUS*	S3B,S4N		CA
NORTHERN BOBWHITE	*VIRGINIANUS*	S3		CA
COMMON MOORHEN	*GALLINULA CHLOROPUS*	S3B		
BARN-OWL	*TYTO ALBA*	S3B,S3N		CA
NORTHERN SAW-WHET OWL	*AEGOLIUS ACADICUS*	S3B,S3N		CU
MARSH WREN	*CISTOTHORUS PALUSTRIS*	S2S3B		CR
SWAINSON'S THRUSH	*CATHARUS USTULATUS*	S2S3B,S5N		CR
PROTHONOTARY WARBLER	*PROTONOTARIA CITREA*	S2S3B		CR
*Note: Rank and Status code definitions are located on the following pages.				

PNDI definitions of Rankings and Status

(Source: http://www.dcnr.state.pa.us/forestry/pndi/pndiweb.htm)

State Rank Codes and Definitions

SX (Extirpated): Element is believed to be extirpated from the "state" (or province or other subnational unit).

SH (Historical): Element occurred historically in the state (with expectation that it may be rediscovered), perhaps having not been verified in the past 20 years, and suspected to be still extant. Naturally, an Element would become SH without such a 20-year delay if the only known occurrences in a state were destroyed or if it had been extensively and unsuccessfully looked for. Upon verification of an extant occurrence, SH-ranked Elements would typically receive an S1 rank. The SH rank should be reserved for Elements for which some effort has been made to relocate occurrences, rather than simply ranking all Elements not known from verified extant occurrences with this rank.

S1 (Critically Imperiled): Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state. Typically 5 or fewer occurrences or very few remaining individuals or acres.

S2 (Imperiled): Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state. Typically 6 to 20 occurrences or few remaining individuals or acres.

S3 (Vulnerable): Vulnerable in the state either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences.

S4 (Apparently Secure): Uncommon but not rare, and usually widespread in the state. Usually more than 100 occurrences.

S5 (Secure): Demonstrably widespread, abundant, and secure in the state, and essentially ineradicable under present conditions.

S? (Unranked): State rank is not yet assessed.

SU (Unrankable): Currently unrankable due to lack of information or due to substantially conflicting information about status or trends. NOTE: Whenever possible, the most likely rank is assigned and a question mark added (e.g. S2?) to express uncertainty, or a range rank (e.g. S2S3) is used to delineate the limits (range) of uncertainty.

S#S# (Range Rank): A numeric range rank (e.g., S2S3) is used to indicate the range of uncertainty about the exact status of the Element. Ranges cannot skip more than one rank (e.g.., SU should be used rather than S1S4).

HYB (Hybrid): Element represents an interspecific hybrid.

SE (Exotic): An exotic established in the state; may be native in nearby regions (e.g.., house finch or catalpa in eastern U.S.).

SE# (Exotic Numeric): An exotic established in the state that has been assigned a numeric rank to indicate its status, as with S1 through S5.

SA (Accidental): Accidental or casual in the state (i.e. infrequent and outside usual range). Includes species (usually birds or butterflies) recorded once or only a few times. A few of these species may have bred on the one or two occasions they were recorded. Examples include European strays or western birds on the East Coast and vice-versa.

SZ (Zero Occurrences): Not of practical conservation concern in the state because there are no definable occurrences, although the taxon is native and appears regularly in the state. An SZ rank will generally be used for long distance migrants whose occurrences during their migrations have little or no conservation value for the migrant as they are typically too irregular (in terms of repeated visitation to the same locations), transitory, and dispersed to be reliably identified, mapped, and protected. In other words, the migrant regularly passes through the subnation, but enduring, mappable Element Occurrences cannot be defined. Typically, the SZ rank applies to a non-breeding population in the subnation — for example, birds on migration. An SZ rank may in a few instances also apply to a breeding population, for example certain Lepidoptera which regularly die out every year with no significant return migration. Although the SZ rank typically applies to migrants, it should not be used indiscriminately. Just because a species is on migration does not mean it receives an SZ rank. SZ only applies when the migrants occur in an irregular, transitory, and dispersed manner.

SP (Potential): Potential that Element occurs in the state but no extant or historic occurrences reported.

SR (Reported): Element reported in the state but without a basis for either accepting or rejecting the report. Some of these are very recent discoveries for which the program hasn't yet received first-hand information; others are old, obscure reports.

SRF (Reported Falsely): Element erroneously reported in the state (e.g., misidentified specimen) and the error has persisted in the literature.

SSYN (Synonym): Element reported as occurring in the state, but state does not recognize the taxon; therefore the Element is not ranked by the state.

*S rank has been assigned and is under review. Contact the individual state Natural Heritage program for assigned rank.

Not Provided

Species is known to occur in this state. Contact the individual state Natural Heritage program for assigned rank.

Pennsylvania Biological Survey (PBS) Suggested Status Codes and Definitions

Note: the same PBS Status codes and definitions are used for all PNDI tracked species.

PE (Pennsylvania Endangered): Species in imminent danger of extinction or extirpation throughout their range in Pennsylvania if the deleterious factors affecting them continue to operate. These are: 1) species whose numbers have already been reduced to a critically low level or whose habitat has been so drastically reduced or degraded that immediate action is required to prevent their extirpation from the Commonwealth; or 2) species whose extreme rarity or peripherality places them in potential danger of precipitous declines or sudden extirpation throughout their range in Pennsylvania; or 3) species that have been classified as "Pennsylvania Extirpated", but which are subsequently found to exist in Pennsylvania as long as the above conditions 1 or 2 are met; or 4) species determined to be "Endangered" pursuant to the Endangered Species Act of 1973, Public Law 93 205 (87 Stat. 884), as amended.

PT (Pennsylvania Threatened): Species that may become endangered within the foreseeable future throughout their range in Pennsylvania unless the casual factors affecting the organism are abated. These are: 1) species whose populations within the Commonwealth are decreasing or have been heavily depleted by adverse factors and while not actually endangered, are still in critical condition; 2) species whose populations may be relatively abundant in the Commonwealth but are under severe threat from serious adverse factors that have been identified and documented; or 3) species whose populations are rare or peripheral and in possible danger of severe decline throughout their range in Pennsylvania; or 4) species determined to be "Threatened" pursuant to the Endangered Species Act of 1973, Public Law 93205 (87 Stat. 884), as amended, that are not listed as "Pennsylvania Endangered".

PR (Pennsylvania Rare): Plant species which are uncommon within this Commonwealth. All species of the native wild plants classified as Disjunct, Endemic, Limit of Range and Restricted are included within the Pennsylvania Rare classification.

Disjunct: Significantly separated from their main area of distribution

Endemic: Confined to a specialized habitat.

Limit of Range: At or near the periphery of their natural distribution

Restricted: Found in specialized habitats or habitats infrequent in Pennsylvania.

CP (Candidate Proposed): Species comprising taxa for which the Pennsylvania Biological Survey (PBS) currently has substantial information on hand to support the biological appropriateness of proposing to list as Endangered or Threatened.

CA (Candidate at Risk): Species that although relatively abundant now are particularly vulnerable to certain types of exploitation or environmental modification.

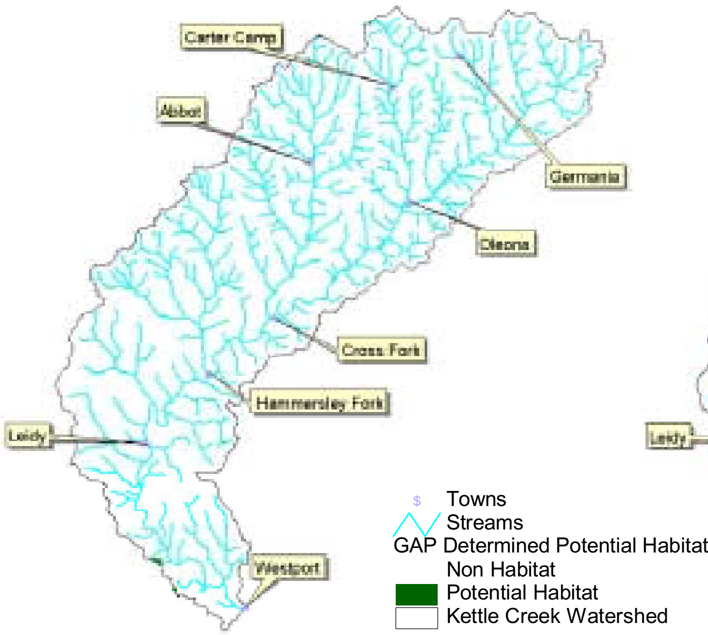
CR (Candidate Rare): Species which exist only in one of a few restricted geographic areas or habitats within Pennsylvania, or they occur in low numbers over a relatively broad area of the Commonwealth.

CU (Condition Undetermined): Species for which there is insufficient data available to provide an adequate basis for their assignment to other classes or categories.

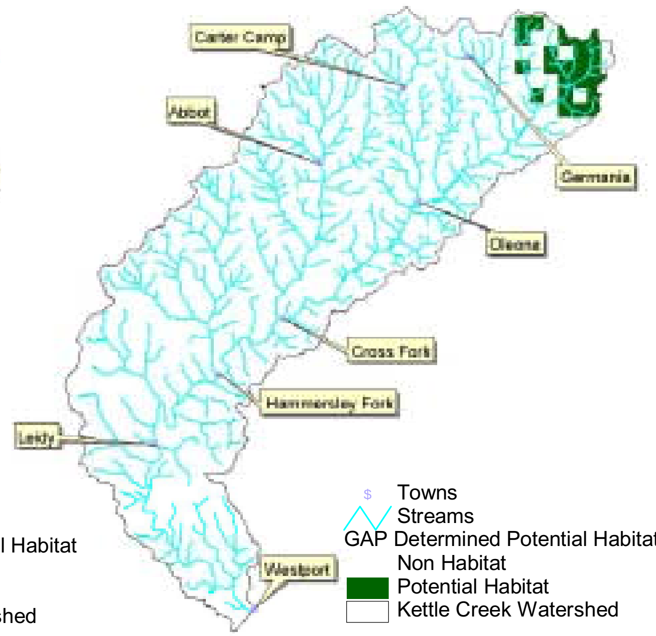
PX (Pennsylvania Extirpated): Species that have disappeared from Pennsylvania since 1600 but still exist elsewhere.

DL (Delisted): Species which were once listed but are now cited for delisting.

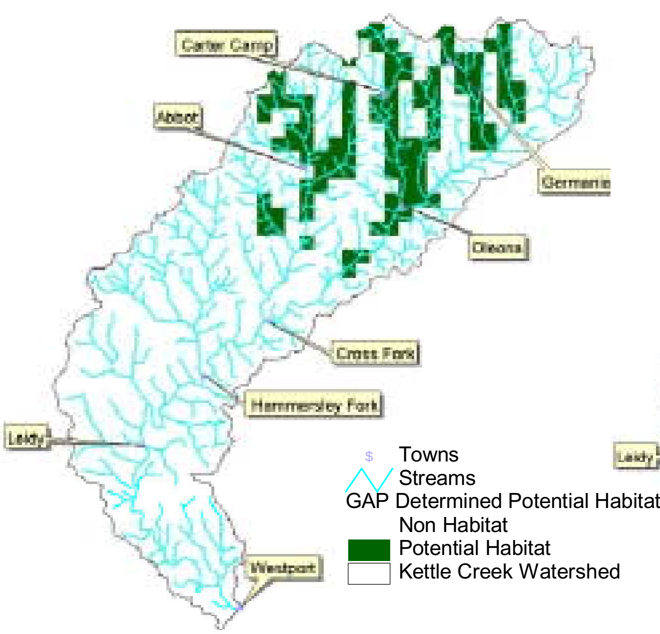
N (No current legal status): Species is under study for future listing.



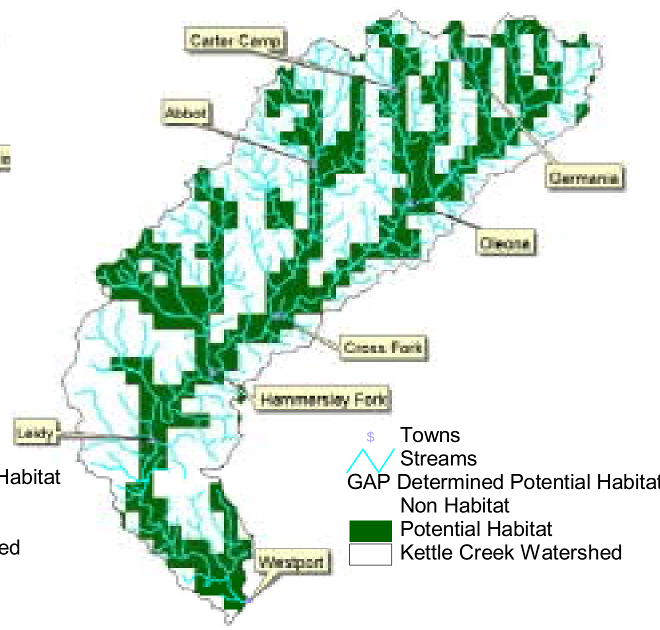
Potential Habitat for the Barn Owl



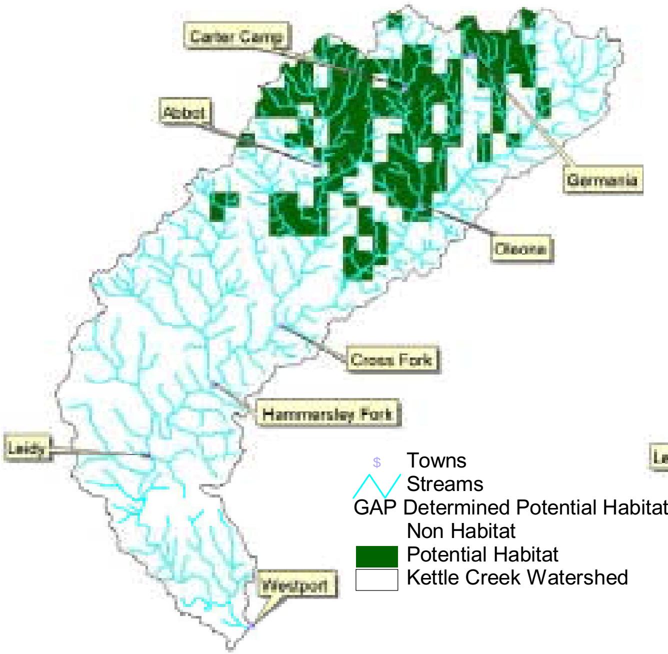
Potential Habitat for the Common Moorhen



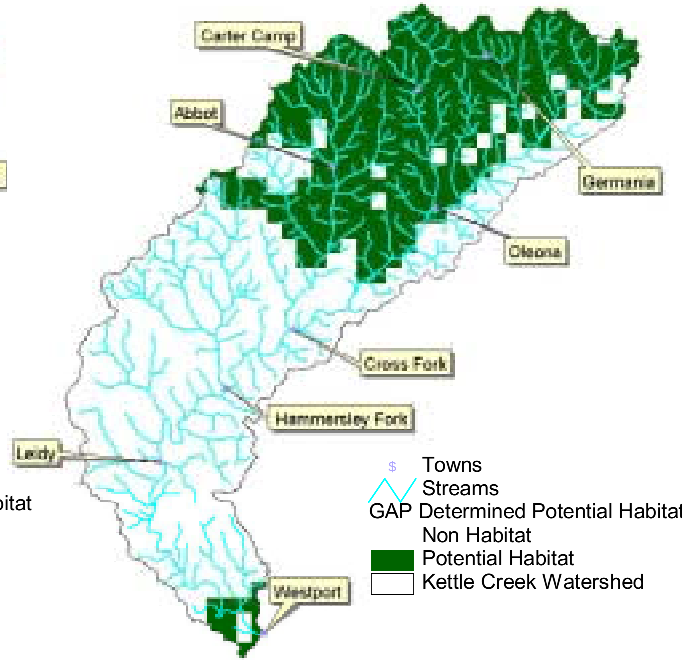
Potential Habitat for the Black Crowned Night Heron



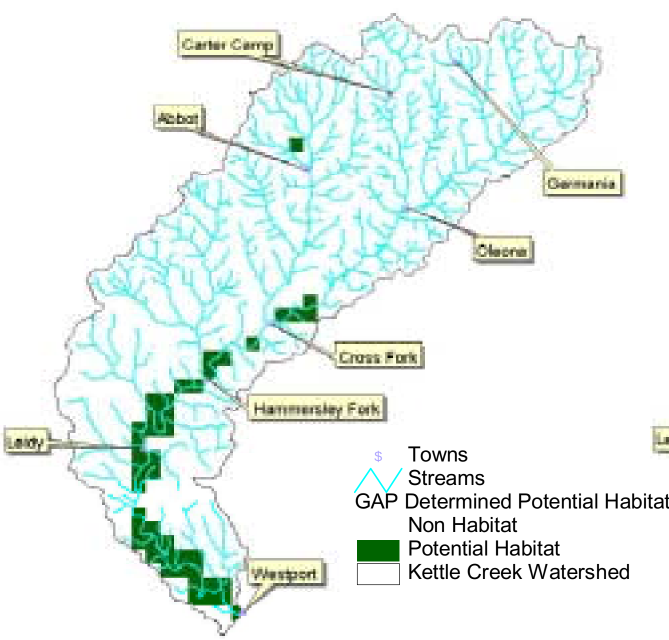
Potential Habitat for the Great Blue Heron



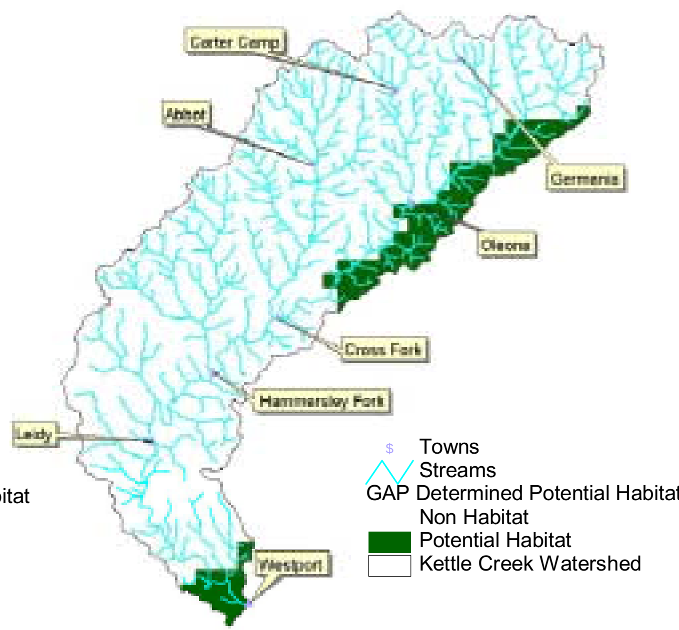
Potential habitat for the Green Winged Teal



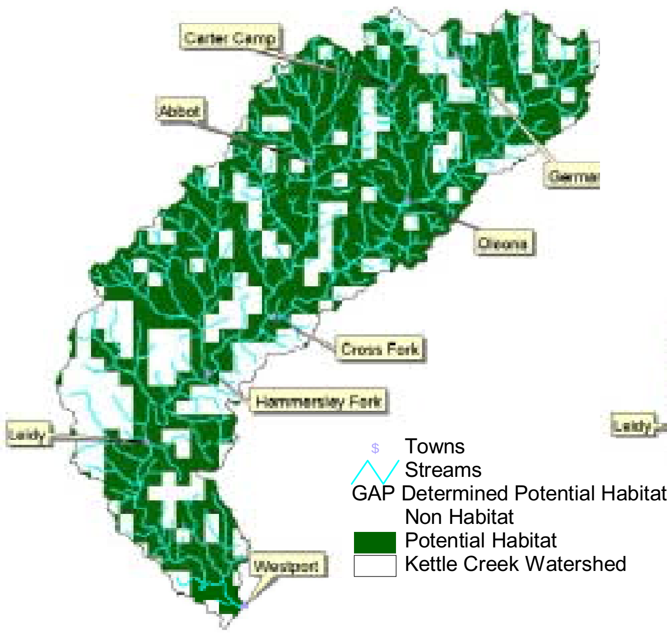
Potential habitat for the Northern Bobwhite



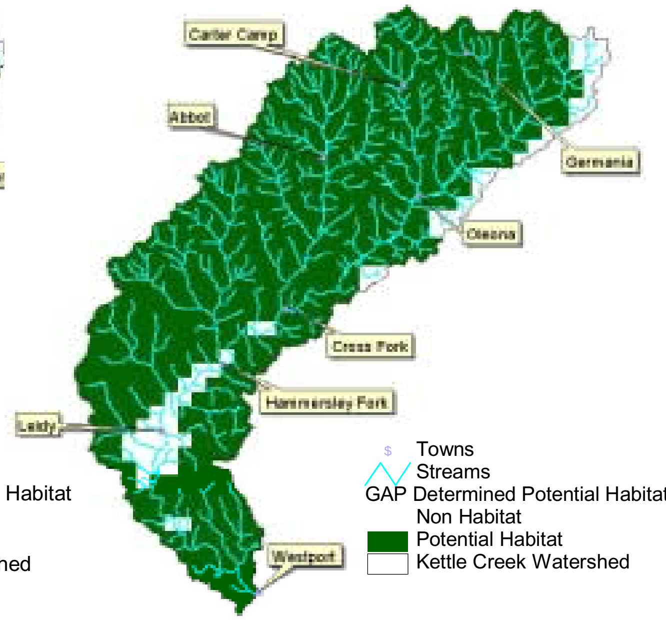
Potential habitat for the Marsh Wren



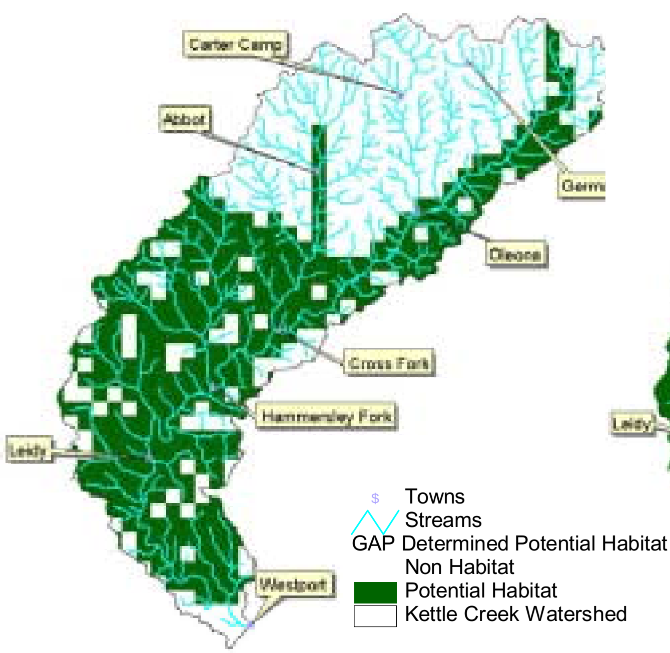
Potential habitat for the Northern Saw-Whet Owl



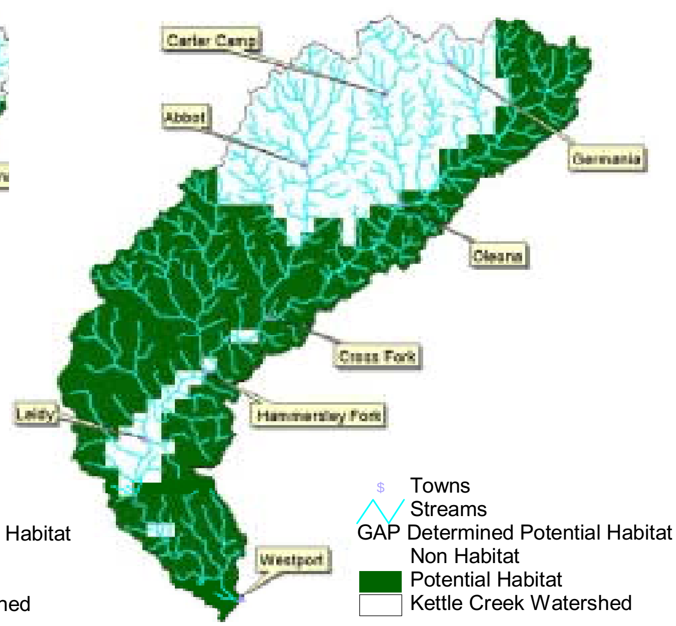
Potential habitat for the Osprey



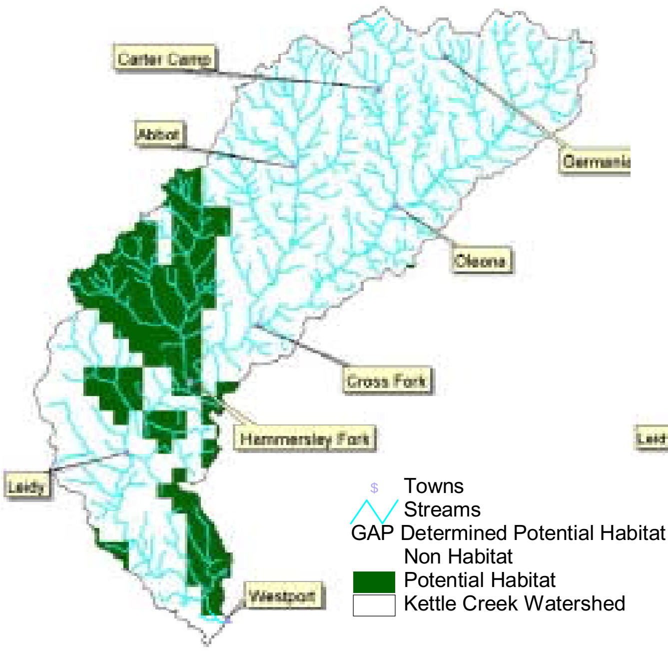
Potential habitat for the Appalachian Cottontail



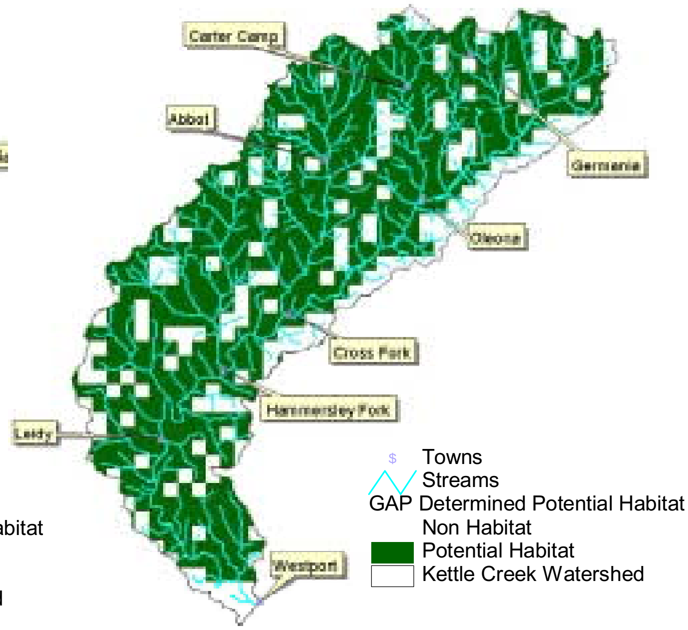
Potential habitat for the Porthonatory Warbler



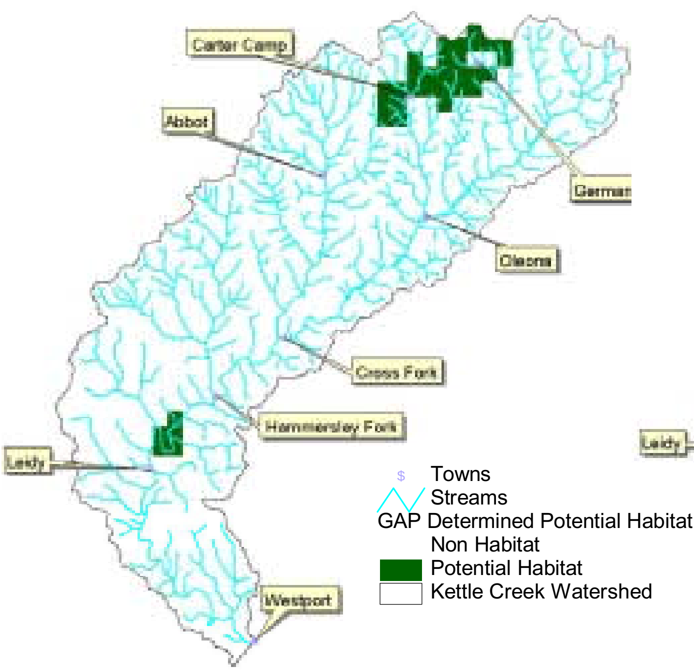
Potential habitat for the Coal Skink



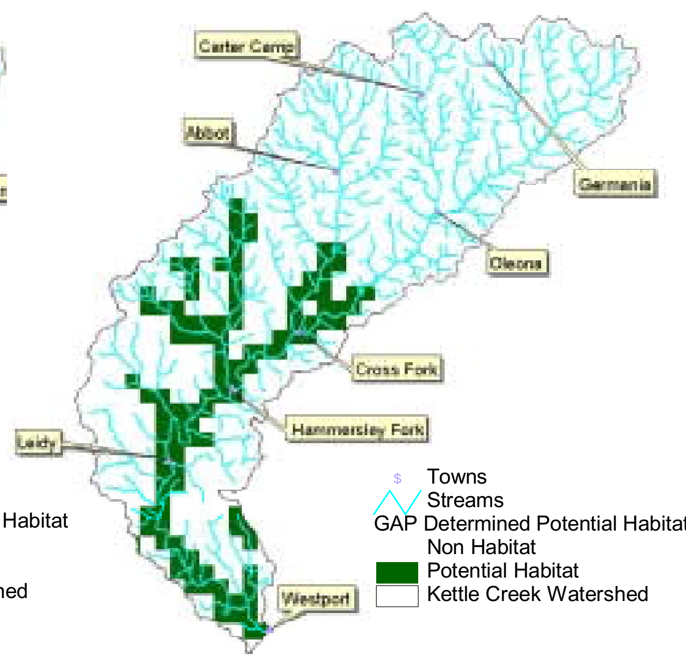
Potential habitat for the Longear Sunfish



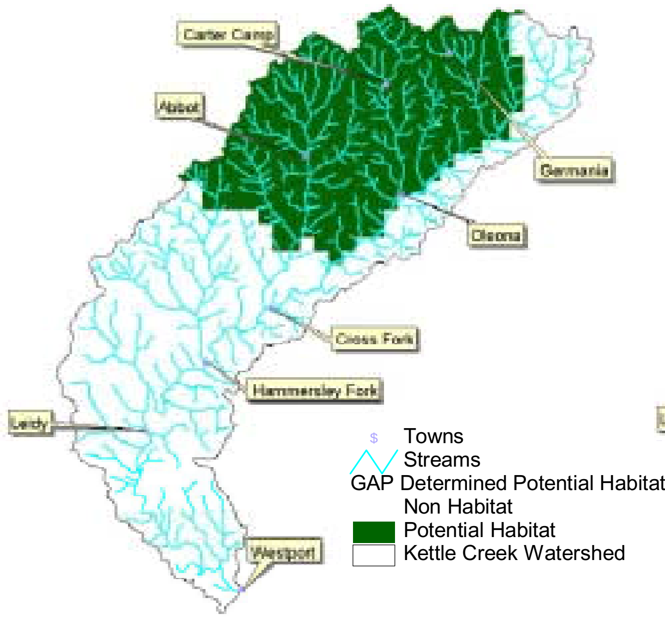
Potential habitat for the Northern River Otter



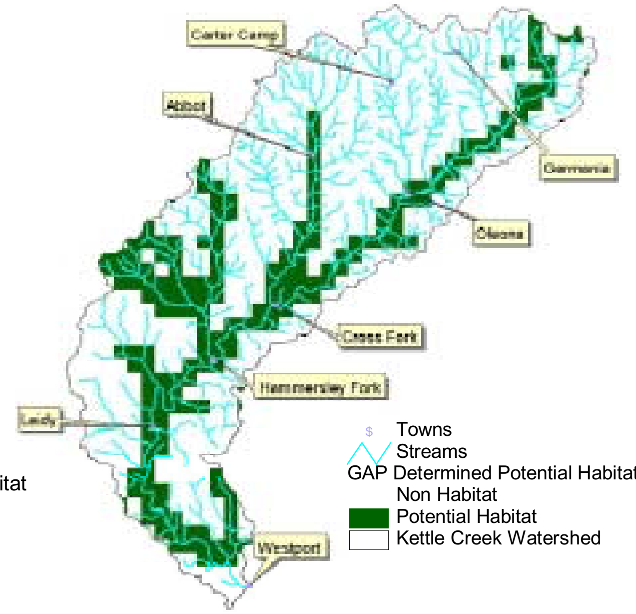
Potential habitat for the Northern Harrier



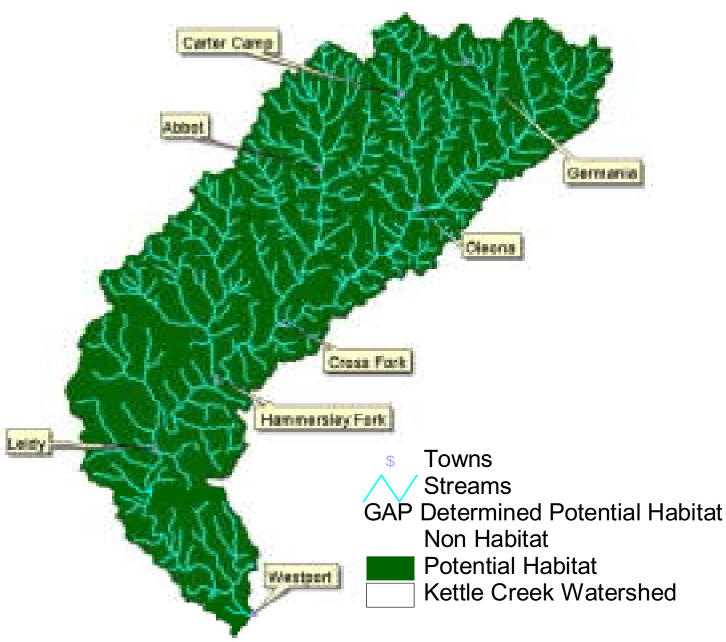
Potential habitat for the Redbelly Turtle



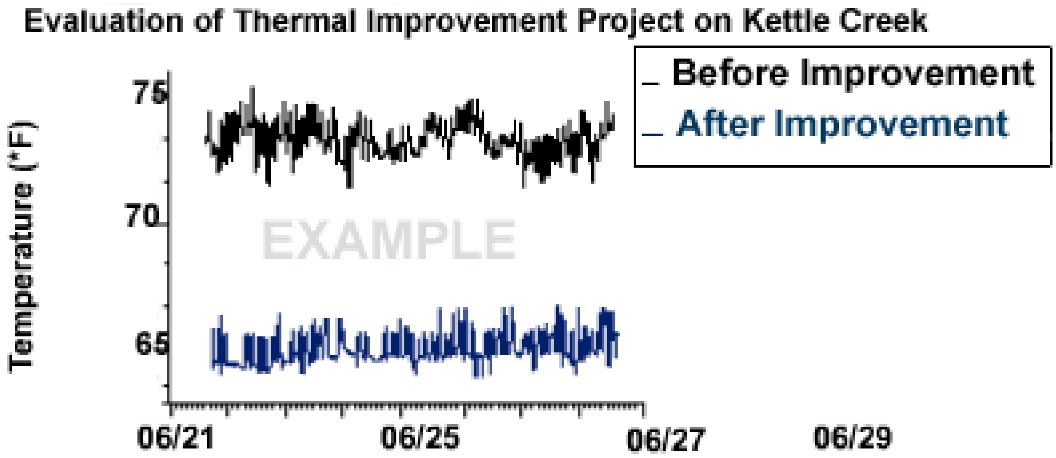
Potential Habitat for the Swainson's Thrush



Potential Habitat for the Bald Eagle



Potential habitat for the Eastern Footed Myotis, Northern Myotis, Northern Flying Squirrel, Silver Haired Bat, Timber Rattlesnake, Water Shrew, Fisher, Northern Goshawk



Example graphs that could be produced from HOBO temperature loggers

APPENDIX H
THERMAL ASSESSMENT

Average yearly nutrient and sediment loading on Kettle Creek (1976-1985)			
Subwatershed	lbs/acre/ year N	lbs/acre/ year P	lbs/acre/year Sediment
Billings Branch	0.71	0.06	0.08
Cross Fork	2.05	0.2	0.37
Germania Branch	3.83	0.22	0.37
Hammersley Fork	1.55	0.16	0.27
Little Kettle	4.46	0.37	0.7
Long Run	3.53	0.24	0.27
Sliders Branch	2.52	0.17	0.28
Two Mile Run	2.3	0.21	0.38

APPENDIX I
NPS POLLUTION

Methods used in the development of non-point pollution models

GWLF Background

The Generalized Watershed Loading Function (GWLF) model is a combined distributed/ lumped parameter watershed model based on land use/land cover source area characteristics. The GWLF models surface runoff using the Soil Conservation Service-Curve Number approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE). A sediment delivery ratio based on watershed size and transport capacity estimation based on average daily runoff is then applied to the calculated erosion to determine sediment yield. Streamflow consists of runoff and discharge from groundwater. The latter is obtained from a lumped parameter watershed water balance. Daily water balances are calculated for unsaturated and shallow saturated zones. Daily evapotranspiration is given by the product of a cover factor and potential evapotranspiration. The latter is estimated as a function of daylight hours, saturated water vapor pressure and daily temperature. The yield in any month is proportional to the total transport capacity of daily runoff during the month. Dissolved and solid-phase nitrogen and phosphorus in streamflow is derived from point sources, groundwater, rural runoff and urban runoff. Rural nutrient loads are transported in surface runoff and groundwater from numerous source areas. Dissolved loads from each source are obtained by multiplying runoff by dissolved concentrations. Nutrient loads from septic systems are calculated by estimating the per capita daily load from each type of system and the number of people in the watershed served by septic systems.

The ArcView version of the GWLF model was developed at Penn State and provides a user-friendly interface based on GIS technology and available data layers. The AVGWLF was used to model NPS sources on the Kettle Creek watershed.

Point source discharges can also be included in the model but are not applicable to Kettle Creek.

See Haith and others 1992 for additional information regarding this model.

The table above illustrates the average area loading values per year (1976-1985) as determined from the GWLF model. Subwatersheds selected for the modeling exercise had at least some agricultural or residential land-use characteristics. Billings Branch was selected as a reference watershed with predominately forest-land cover.

Water Quality Network Site Derived Area-Loading Estimation

Nutrient exports from the watershed were also modeled using the historic water quality data monitored by the US EPA at the Westport stream gage. Due to the location of this site below the Alvin Bush Reservoir only nitrogen was modeled.

A regression relationship was developed to predict the concentration of total nitrogen (mg/

l) from the daily stream flow (cfs). Mean daily flow data is then used to predict total nitrogen loads by day, month or year. These total load values divided by area above the gage provides an area loading rate that is comparable to the GWLF model. The following equation was obtained to predict concentration of total nitrogen from flow. Discharge values were square root transformed to improve the model.

Total N (mg/l) = 0.118289 + 3.05E-02 [Discharge(cfs)]- 3.65E-04 [Discharge (cfs)2] (R2 = .378 p = <.0001)

Some of the unpredicted variability in the model may be due to flow regulation by the Alvin Bush reservoir, but the area loading rate developed from the model was comparable with rates derived from the GWLF. (See page 180, for more on GWLF).

Dirt and Gravel Road Sediment Delivery Probability

Dirt and gravel roads are potentially contributing to excessive sediment loading on the Kettle Creek watershed. An ArcView-based model was developed in order to prioritize subwatersheds for road improvement options. The model examined all dirt and gravel roads within 30 meters of the stream as potential contributors of sediment. Township, state and other roads were included in the model. Forest management roads (i.e. skid roads, revegetated haul roads) were not included in the model. Roads within this 30m zone were converted to grid coverage and examined in relation to slope classes derived from the 30m digital elevation model of Kettle Creek. Slope classes were used as a measure of the probability of sediment delivery to a stream channel. Roads located on slopes greater than 40% were indicated as having a high probability of sediment delivery to the channel, 10-40% as moderate probability and roads on slopes less than 10% were listed as low probability. Additionally, roads that crossed streams were analyzed based on the slope of the road at the stream crossing. Road crossings of streams have the greatest potential for sediment delivery to the channel. The same slope classes were used to determine a probability of sediment delivery to the channel. Locations of crossings and road surfaces were ground-truthed in limited locations on the watershed for verification.

The actual delivery of sediment to the channel is based on a variety of factors that could not be included in the model and may affect the accuracy of the probability values, including ditch relief spacing, obstructions to flow below the road and others. It was our goal to provide an analysis that would begin to identify the potential delivery of sediment from dirt and gravel roads at the subwatershed scale. Site-specific problem sites in the watershed have been ground verified on township roads by the Dirt and Gravel Road program. These sites can now be viewed within the greater context of all dirt and gravel road sediment pollution potential at the subwatershed scale. Site-specific identification of problem areas can begin on non-township roads based on the locations identified in the potential sediment delivery model.

Subwatershed Sediment Impacts Ranking

A simple index was established for the sub-watersheds of Kettle Creek to determine the relative impacts of dirt and gravel road runoff to receiving streams. The index was based on the length of road segments with the potential for sediment delivery within each sub-watershed, the number of road crossings per subwatershed, the likelihood of runoff reaching a Class A trout stream and the location of the subwatershed in relation to naturally reproducing wild trout streams. Wild trout are particularly susceptible to siltation and road improvement projects should be identified in relation to these streams. High scores from the index indicate a greater likelihood and impact of sediment runoff from dirt and gravel roads.

Each of the parameters in the index received a score based on the relative importance as defined by the Kettle Creek Team. Road crossings, proximity to trout streams and the potential for sediment delivery were scored by importance in that order. These scores were then multiplied to receive a final ranking.

Roads that cross streams within subwatersheds were given scores based on the probability of sediment delivery at the site. Road crossings, as with other sections of road, were given relative probabilities of sediment delivery based on the slope of the landform in the vicinity of the road. Steeper slopes were given a higher score. This score was then multiplied by the number of road crossings. The PFBC trout stream classification provided a basis for scoring the subwatershed's streams. If streams were Class A or had the potential to be high quality wild trout streams they were given a higher score. Class D streams received a lower score. "Location in the watershed" was scored based on the class of the mainstem that the subwatershed drained into. If these downstream reaches had potential for wild trout reproduction the score was higher. This parameter was intended to account for the potential downstream affects of sediment delivery from the subwatershed and the connectivity of streams to other wild trout streams. High, moderate and low probability of sediment delivery was determined based on the sediment delivery model. The percent of roads within subwatersheds with the probability of sediment delivery to streams received scores proportional to the percent of stream length influenced by those road segments.

References:

Haith, Douglas A., Ross Mandel, Ray Shyan Wu. 1992. Generalized Watershed Loading Functions Version 2. Department of Agricultural and Biological Engineering, Cornell University.

Roads Prioritization Index

Stream	Road Sediment Production /Stream Length	High Potential	Moderate Potential	Low Potential	Stream Class	Location in Watershed	Road Crossings Low	Road Crossings Moderate	Ranking Score
Cross Fork	10.5%	0.1%	5.7%	4.6%	4.0	0.5	15.0	17.0	49.33
Upper Kettle Creek	15.5%	0.1%	8.3%	7.1%	4.0	2.0	6.0	8.0	23.91
Two Mile Run	36.9%	0.0%	15.1%	21.8%	4.0	0.5	12.0	5.0	23.04
Little Kettle Creek	9.0%	0.0%	5.4%	3.7%	2.0	1.0	7.0	7.0	21.29
Germania Branch	18.1%	0.0%	5.5%	12.6%	4.0	2.0	11.0	4.0	20.89
Hammersley Fork	2.5%	0.0%	1.7%	0.8%	4.0	0.5	2.0	3.0	8.08
Beaverdam Run	9.6%	0.3%	6.5%	2.8%	4.0	0.5	3.0	2.0	7.33
Trout Run	7.8%	0.5%	6.8%	0.6%	4.0	0.5	0.0	3.0	6.31
Hevner Run	4.5%	0.0%	3.0%	1.5%	4.0	0.5	0.0	2.0	4.15
Spicewood Run	17.7%	0.0%	16.7%	1.0%	4.0	0.5	1.0	1.0	3.69
Sliders Branch	5.2%	0.0%	1.6%	3.6%	4.0	2.0	1.0	1.0	3.55
Long Run	1.7%	0.0%	0.0%	1.7%	4.0	1.0	2.0	0.0	2.07
Walters Run	5.2%	0.0%	1.3%	3.9%	4.0	0.5	1.0	0.0	1.13
Billings Branch	0.0%	0.0%	0.0%	0.0%	4.0	2.0	0.0	0.0	0.00

This table shows the input data for the road prioritization index by subwatershed.

APPENDIX J
FUNDING SOURCES

Potential Funding Sources for Watershed Restoration and Protection

AMD Funding

Federal Abandoned Mine Land Reclamation Trust Fund: The Trust Fund was established by the federal Surface Mining Control and Reclamation Act (SMCRA). US Office of Surface Mining (OSM)

The Appalachian Clean Streams Initiative (ACSI) is a broad-based program to eliminate acid drainage from coal mines. The program was initiated by the US Office of Surface Mining (OSM) and the US E.P.A. Region 3

Rural Abandoned Mine Program(RAMP) is authorized by section 406 of the Surface Mining Control and Reclamation Act of 1977, as amended by the Abandoned Mine Reclamation Act of 1991. Eligibility: Individuals, groups, or units of government who own or control the surface or water rights of abandoned coal land or lands, and water affected by coal mining practices before August 3, 1977. These areas are not eligible if: (1) There is continuing reclamation responsibility on the part of the mine operator or the State; (2) the lands are in Federal ownerships; and (3) the surface rights are under easement or lease to be remained. (Source: http://www.cfda.gov/static/10910.asp).

Potential Funding Sources for Watershed Protection

Federal Watershed Protection Funding Sources (organized according to topic)

Agriculture

U.S. Department of Agriculture
Conservation Reserve Program (CRP)(FSA)

Environmental Quality Incentives Program (EQUIP)(NRCS)

Coastal Waters

(Kettle Creek is a part of the Cheasapeake Bay Watershed)

U.S. Environmental Protection Agency
Chesapeake Bay Program Grants (CBP)

Chesapeake Bay Small Watershed Grants (CBP)

Disaster Prevention and Relief

Federal Emergency Management Agency
Flood Mitigation Assistance Program

Hazard Mitigation Grant Program

Project Impact Grant Program

U.S. Army Corps of Engineers
Flood Hazard Mitigation and Riverine Ecosystem Restoration Program (Challenge 21) (USACE)

U.S. Department of Agriculture
Emergency Conservation Program (FSA)

U.S. Environmental Protection Agency
Superfund Technical Assistance Grants for Citizen Groups at Priority Site (OERR)

Economic Development

U.S. Department of Agriculture
Water and Waste Disposal Systems for Rural Communities (RUS)

U.S. Department of Commerce
Public Works and Development Facilities Program (EDA)

U.S. Department of Housing and Urban Development

Community Development Block Grant Program (CPD)

U.S. Environmental Protection Agency
Sustainable Development Challenge Grants (OA)

Education and Research

Corporation for National Service
Learn and Serve America Program

U.S. Department of Agriculture
Sustainable Agriculture Research and Education (CSREES)

Water Quality Special Research Grants Program (CSREES)

U.S. Environmental Protection Agency
Environmental Education Grants Program (OEE)

Science to Achieve Results (ORD)

Environmental Justice

U.S. Environmental Protection Agency
Environmental Justice Grants to Small Community Groups (OEJ)

Environmental Justice Through Pollution Prevention Grants Program (OEJ)

Forestry

U.S. Department of Agriculture
Cooperative Forestry Assistance Programs (FS)

Forestry Incentives Program (NRCS)

Mining

U.S. Department of the Interior
Abandoned Mine Land Reclamation Program (OSM)

Monitoring

U.S. Environmental Protection Agency
Environmental Monitoring for Public Access and Community Tracking (OEI)

Pollution Prevention and Control

Small Business Administration

Pollution Control Loans

U.S. Department of the Interior
Clean Vessel Act Grant Program (FWS)

U.S. Environmental Protection Agency

Chemical Emergency Preparedness and Prevention Technical Assistance Grants (CEPPO)

Pesticide Environmental Stewardship Grants (OPPTS)

Pollution Prevention Incentives for States (OPPTS)

Watershed and Drinking Water Source Protection

U.S. Department of Agriculture
Watershed Protection and Flood Prevention Program (NRCS)

U.S. Department of Transportation
Transportation Equity Act for the 21st Century Funding Programs (FHWA)

U.S. Department of the Interior
Land and Water Conservation Fund Grants to States (NPS)

U.S. Environmental Protection Agency

Capitalization Grants for Clean Water State Revolving Fund (OWM)

Nonpoint Source Implementation Grants (319 Program) (OWOW)

Water Quality Cooperative Agreements (OWM)

Watershed Assistance Grants (OWOW)

Wetlands

U.S. Department of Agriculture
Wetlands Reserve Program (NRCS)

U.S. Department of the Interior
North American Wetlands Conservation Act Grants Program (FWS)

U.S. Environmental Protection Agency
Five-Star Restoration Program (OWOW)

Wetlands Program Development Grants (OWOW)

Wildlife

National Fish and Wildlife Foundation
Bring Back the Natives Grant Program

U.S. Department of Agriculture
Wildlife Habitat Incentives Program (NRCS)

U.S. Department of Commerce
Community-Based Restoration Program (NOAA)

Fisheries Development and Utilization Research and Development Grants and Cooperative Agreements Program (NOAA)

U.S. Department of the Interior
Partners for Fish and Wildlife Program (FWS)

Wildlife Conservation and Appreciation Program (FWS)

Source
http://www.epa.gov/owow/watershed/wacademy/fund/sources.html

ATMOSPHERIC DEPOSITION METHODS

Episodic Acidification Sampling For Detailed Study

• Materials needed: clean water sampling bottles, access to stream hydrograph, flow meter, measuring tape.

• Three water samples are used to determine this. One sample is taken before the peak of the storm, one sample is taken at the peak of the storm, and the final sample is taken after the peak of the storm. To do this, much more than three samples are taken because it will not be known at what time the peak of the rain event occurs until after the rain event is over. In order to ensure that a sample is taken before, during, and after the peak of the storm, a water sample, flow, and depth measurements are taken every 6 hours during the entire storm length.

• The water sample is then analyzed for pH. Only three samples (before, during, and after peak) are needed for this analysis.

• Note: to determine which three samples are used, flow and depth measurements need to be graphed. The graph will look similar to the figure on the following page.

• If the pH becomes more acidic during the peak rain events, acidic deposition is affecting the watershed and may potentially cause problems with stream biota and general water quality in the future.

Episodic Acidification Sampling For Volunteers

• Materials needed: pH meter

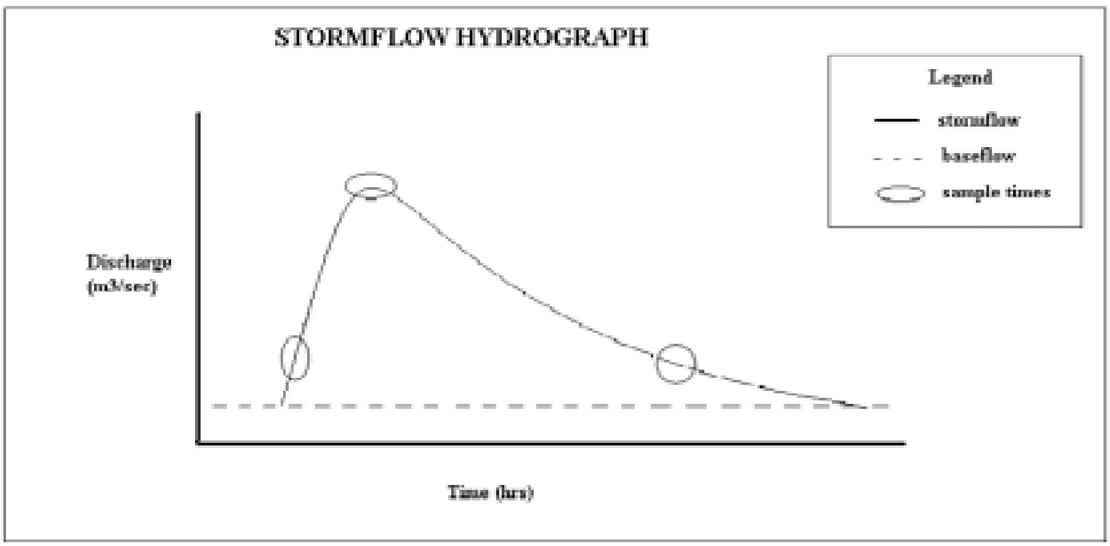
• Three pH readings are needed. One reading is taken before the peak of the storm, one reading is taken close to the peak of the storm, and the final pH reading is taken after the peak of the storm. Note: these samples do not have to be taken at exact times in the storm, estimations of high and low flow can be used to indicate the "peak", before, and after the peak of the storm.

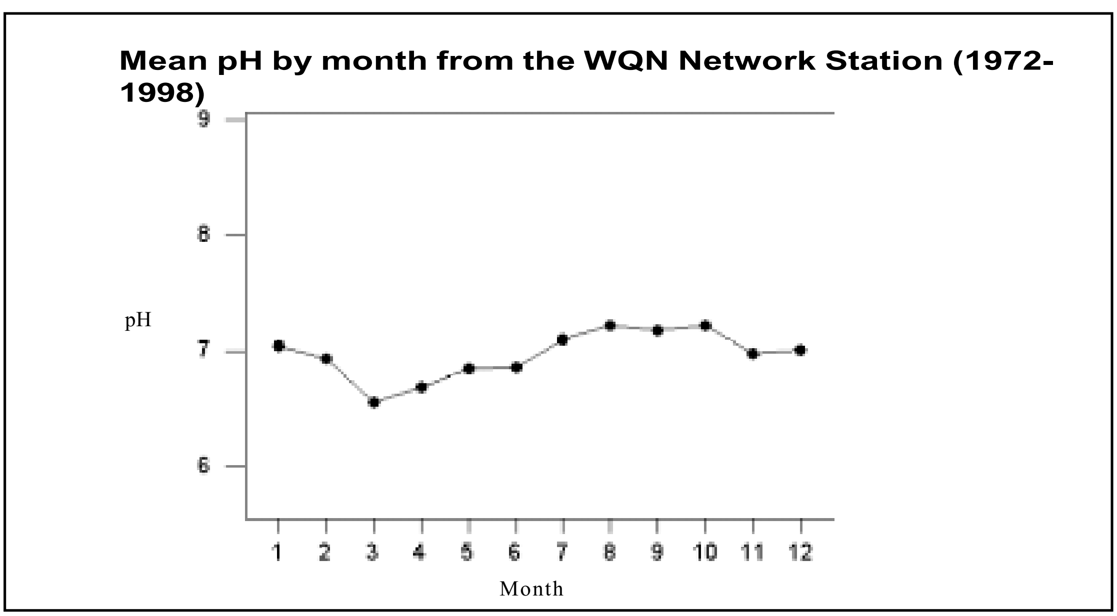
• Sample hydrograph of estimated times of pH reading are located on the graphs on the following page.

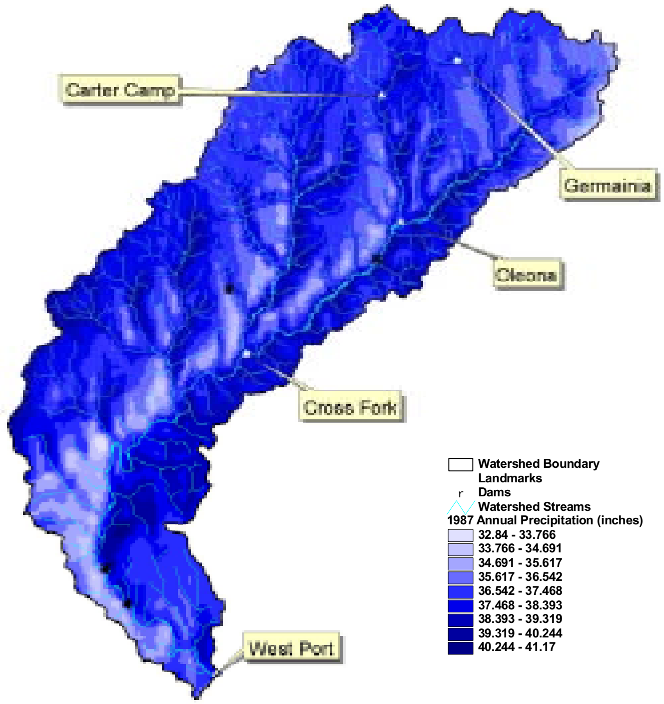
• If the pH becomes more acidic during the peak rain events, acidic deposition is affecting the watershed and may potentially cause problems with stream biota and general water quality in the future.

APPENDIX K
ATMOSPHERIC DEPOSITION

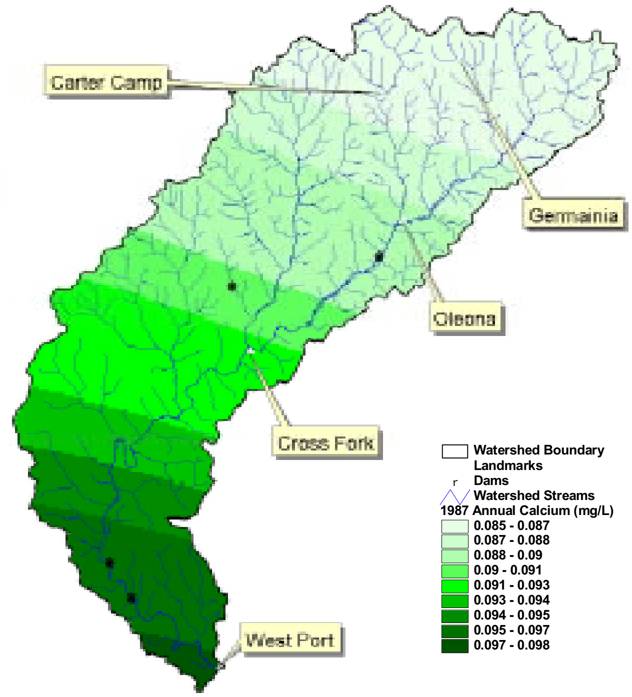
SUGGESTED EPISODIC ACIDIFICATION SAMPLING TIMES



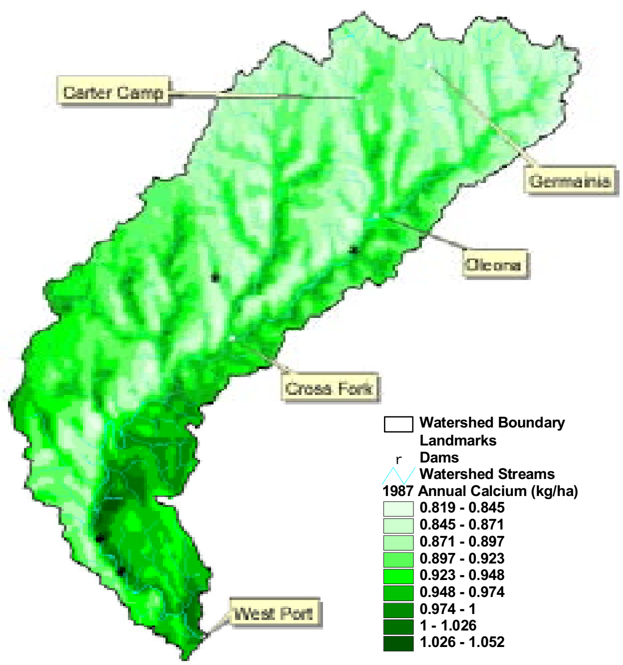




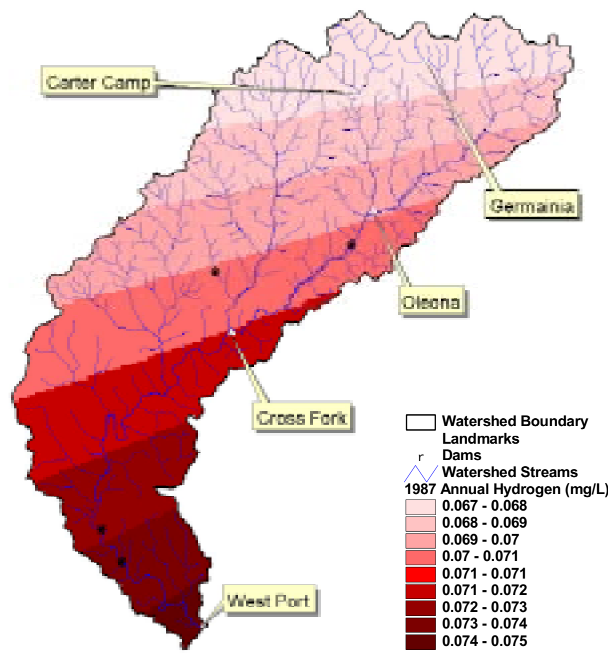
1987 Precipitation in the Kettle Creek Watershed



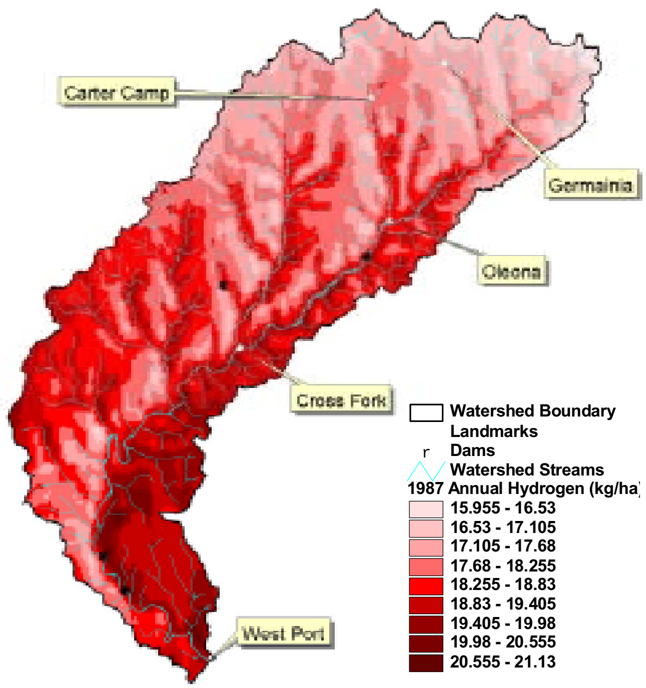
1987 Calcium Concentration in the Kettle Creek Watershed



1987 Calcium Deposition in the Kettle Creek Watershed



1987 Hydrogen Concentration in the Kettle Creek Watershed



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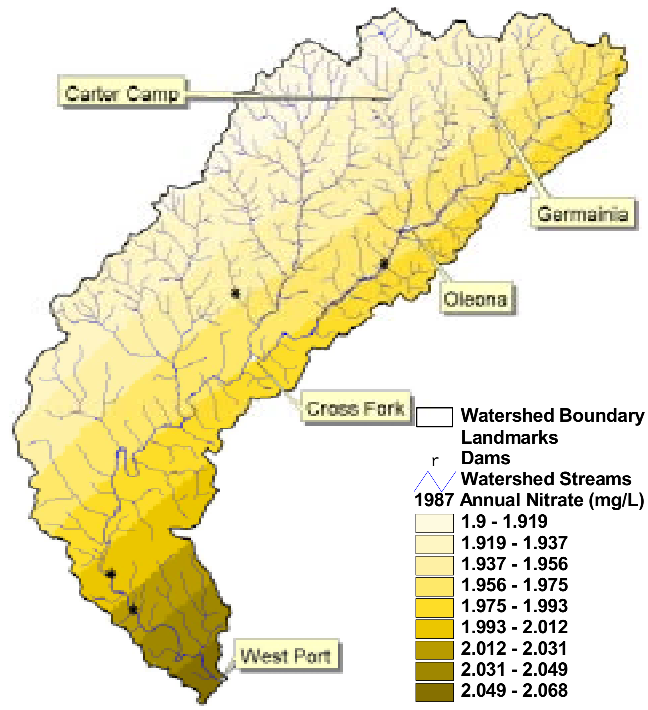
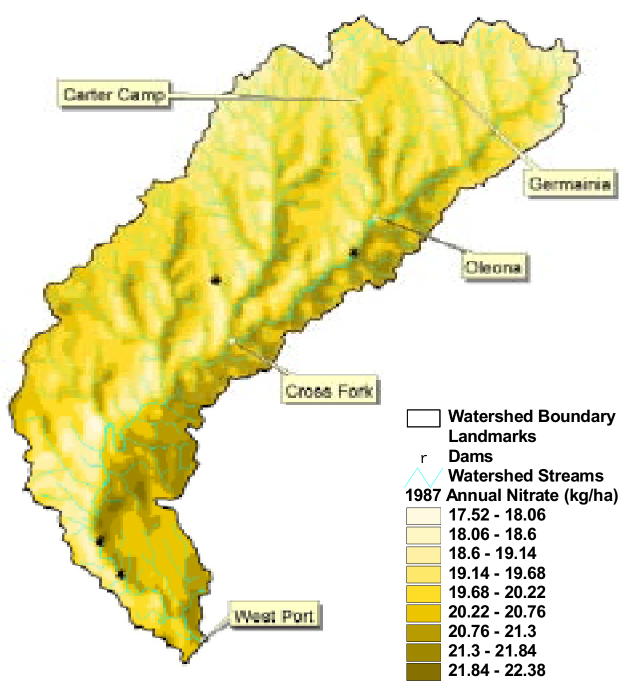
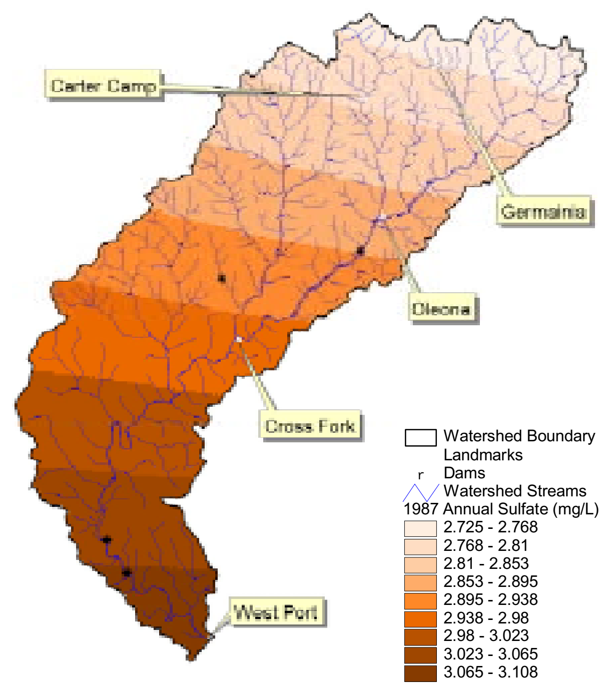


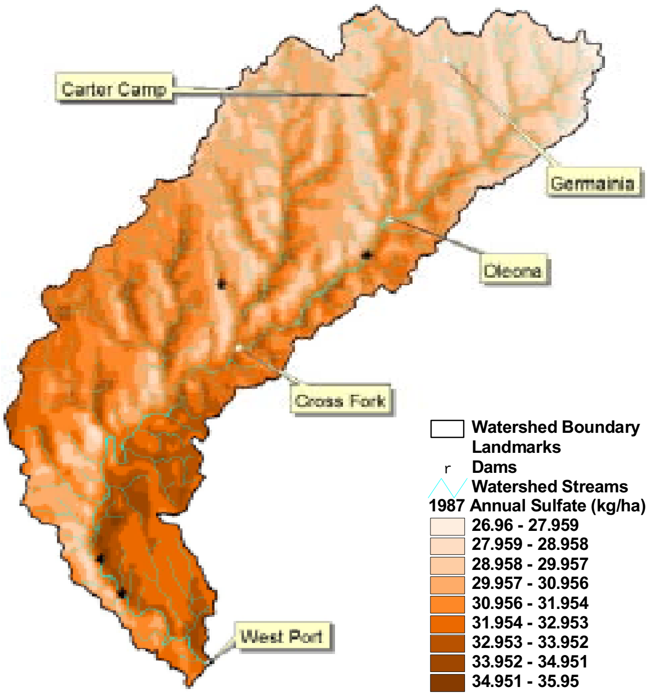
1987 Nitrate Concentration in the Kettle Creek Watershed



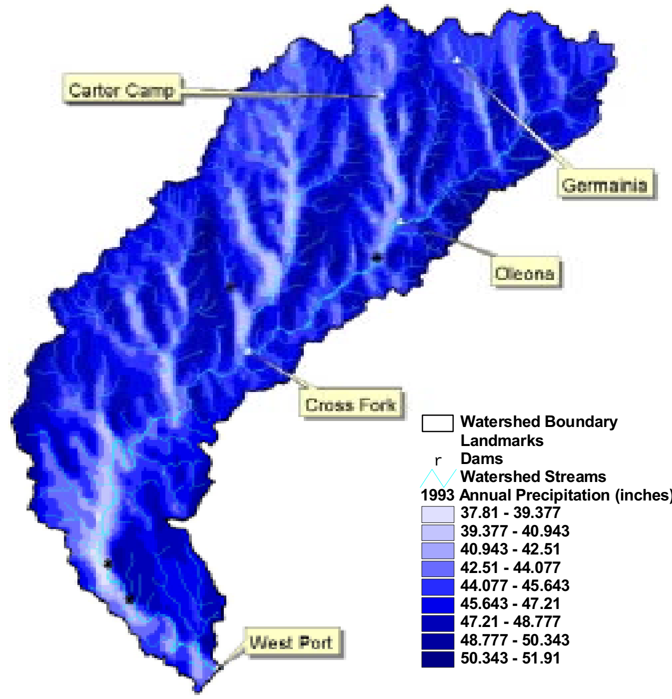
1987 Nitrate Deposition in the Kettle Creek Watershed



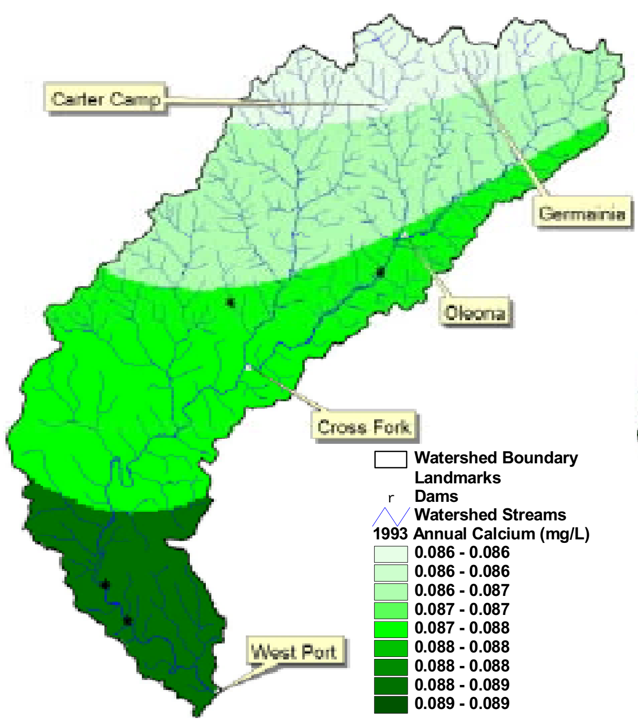
1987 Sulfate Concentration in the Kettle Creek Watershed



1987 Sulfate Deposition in the Kettle Creek Watershed



1993 Preciptation in the Kettle Creek Watershed



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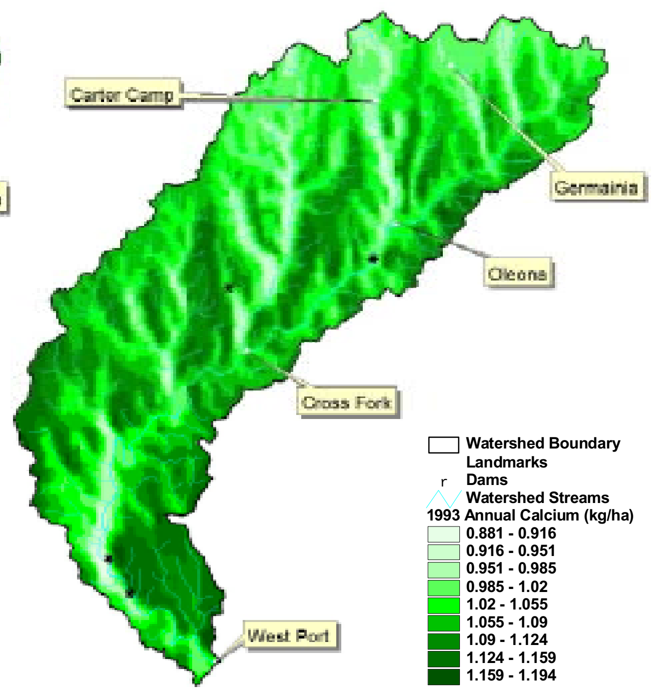

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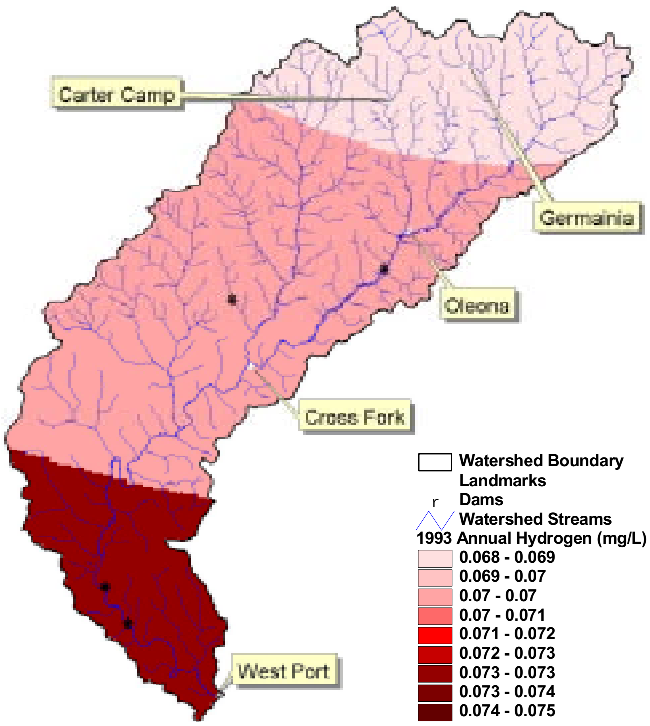

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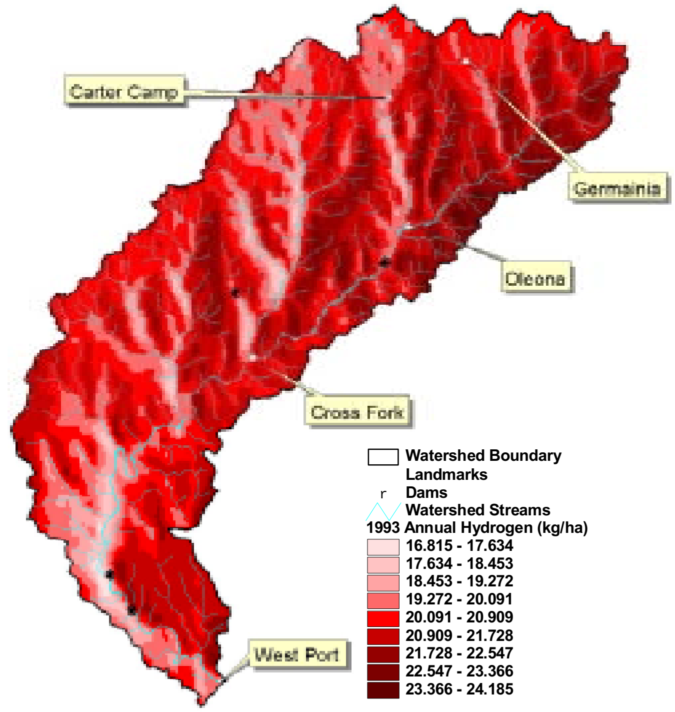

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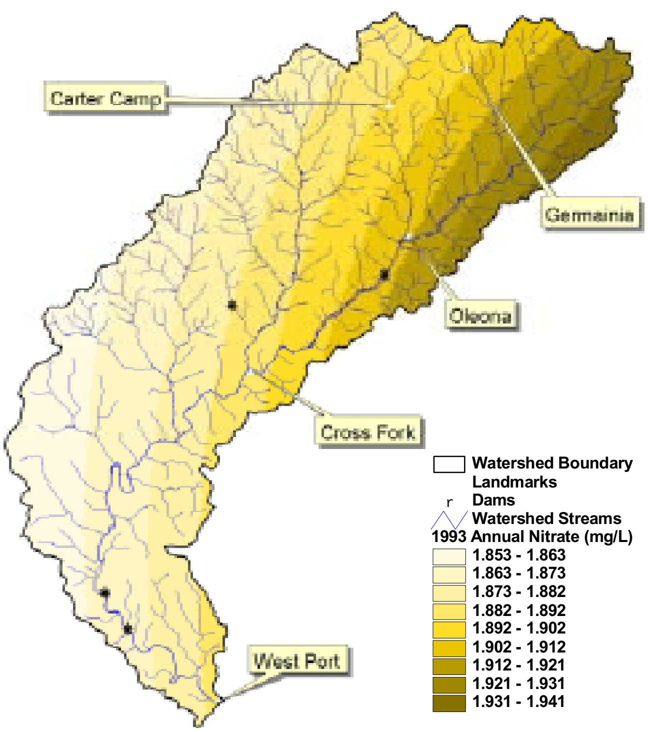

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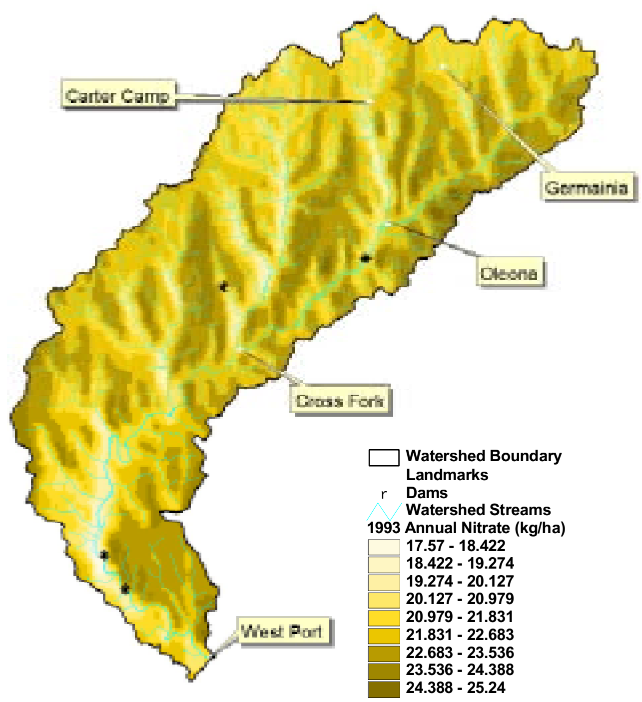
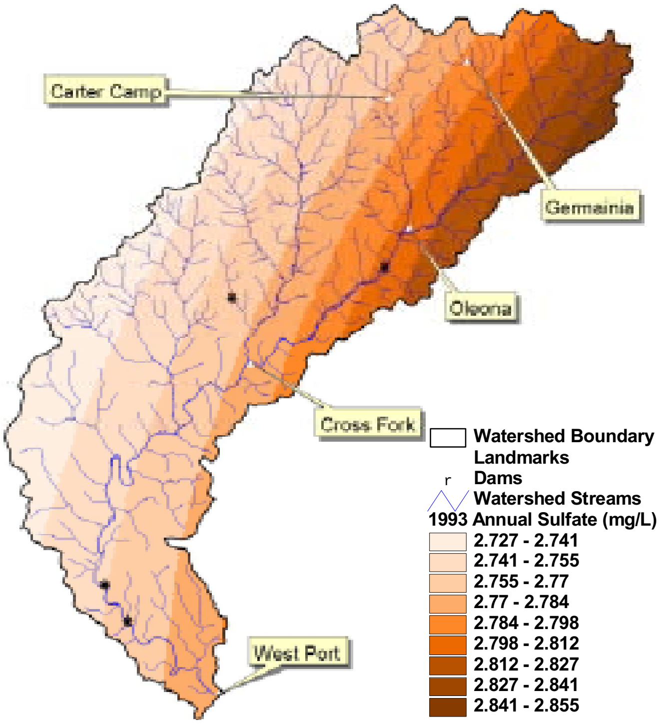
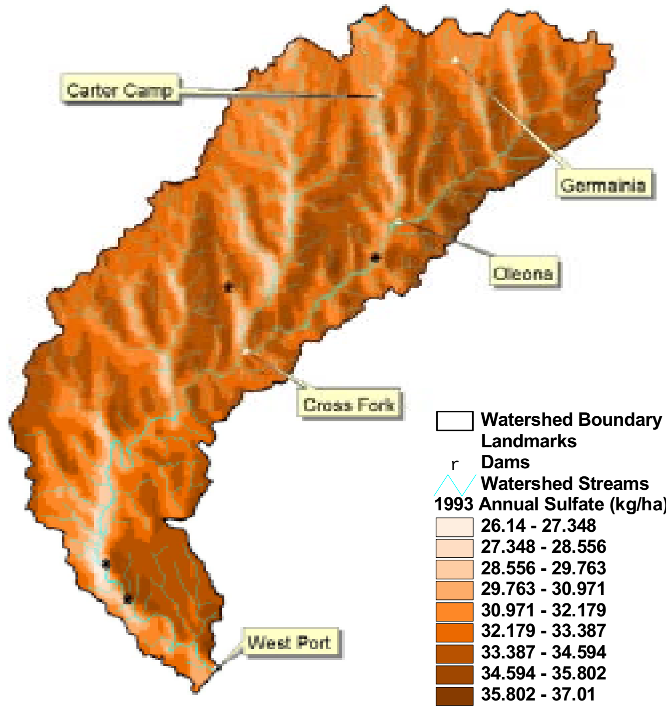


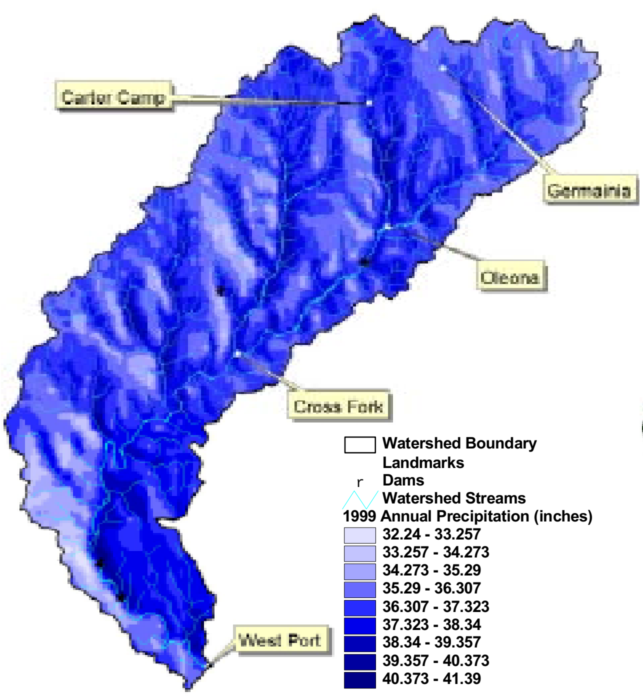
1993 Hydrogen Deposition in the Kettle Creek Watershed



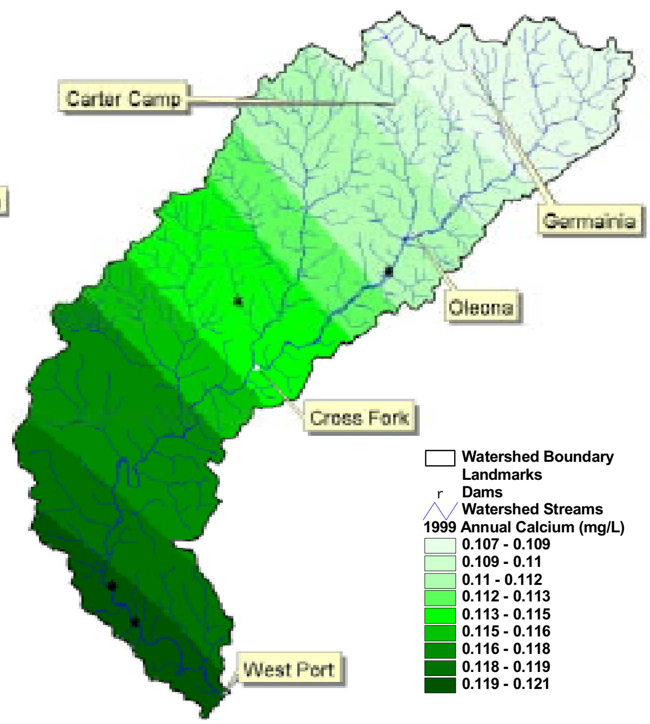
1993 Sulfate Concentration in the Kettle Creek Watershed



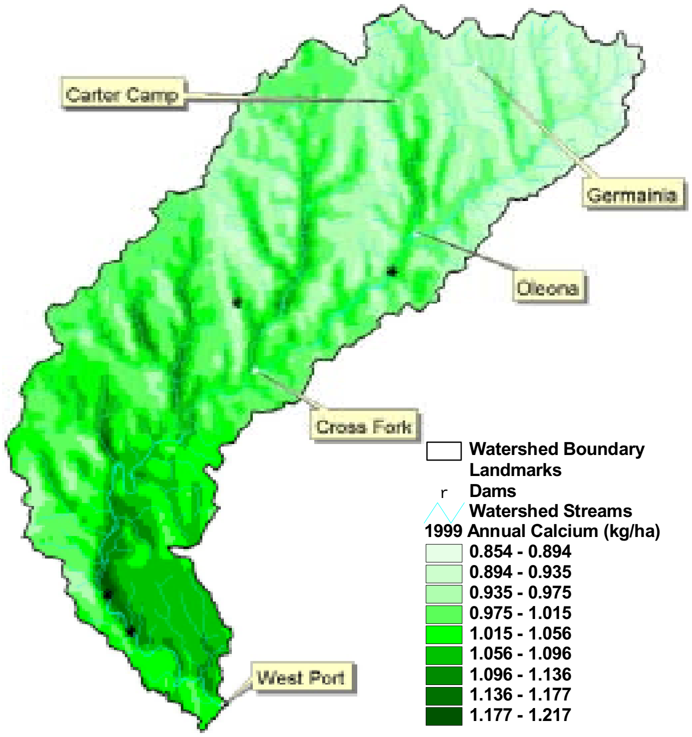
1993 Sulfate Deposition in the Kettle Creek Watershed



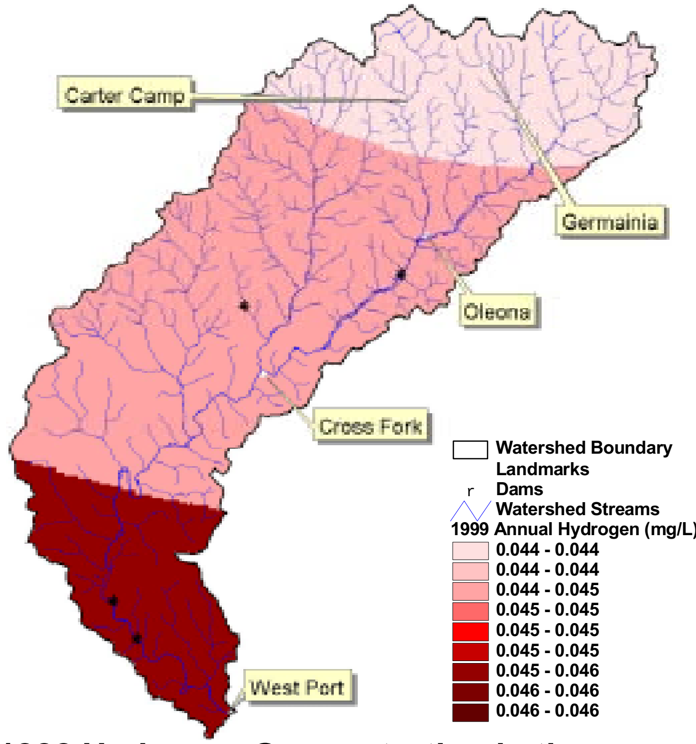
1999 Precipitation in the Kettle Creek Watershed



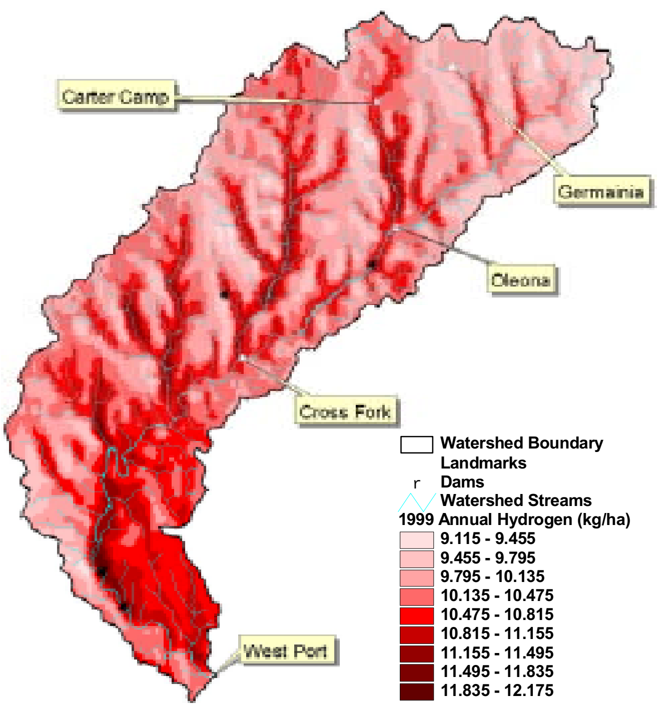
1999 Calcium Concentration in the Kettle Creek Watershed



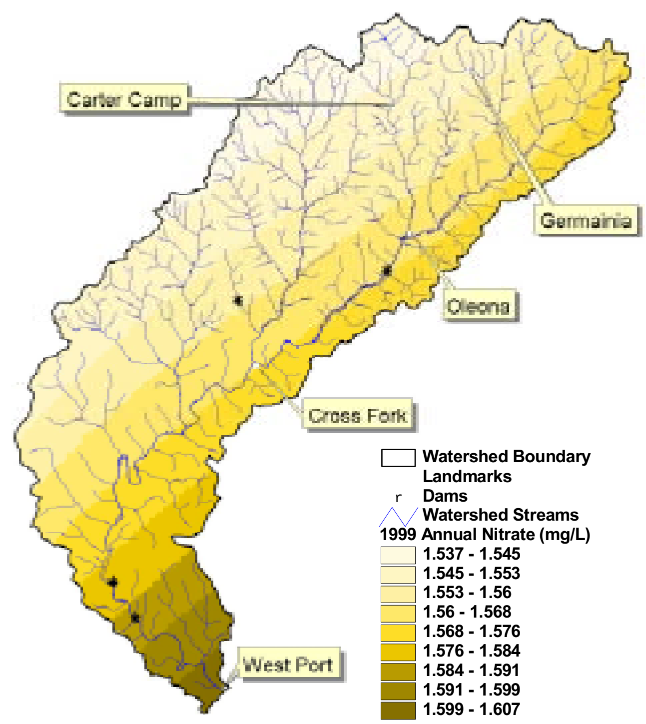
1999 Calcium Deposition in the Kettle Creek Watershed



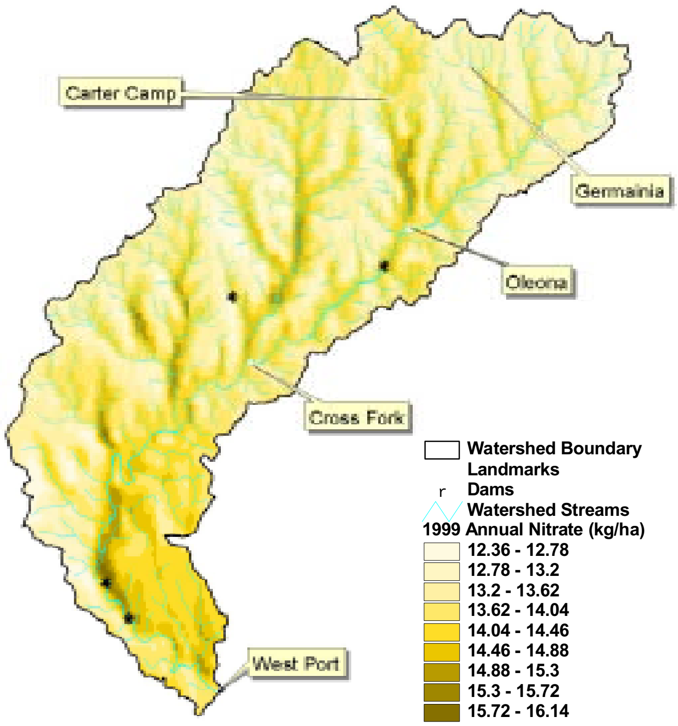
1999 Hydrogen Concentration in the Kettle Creek Watershed



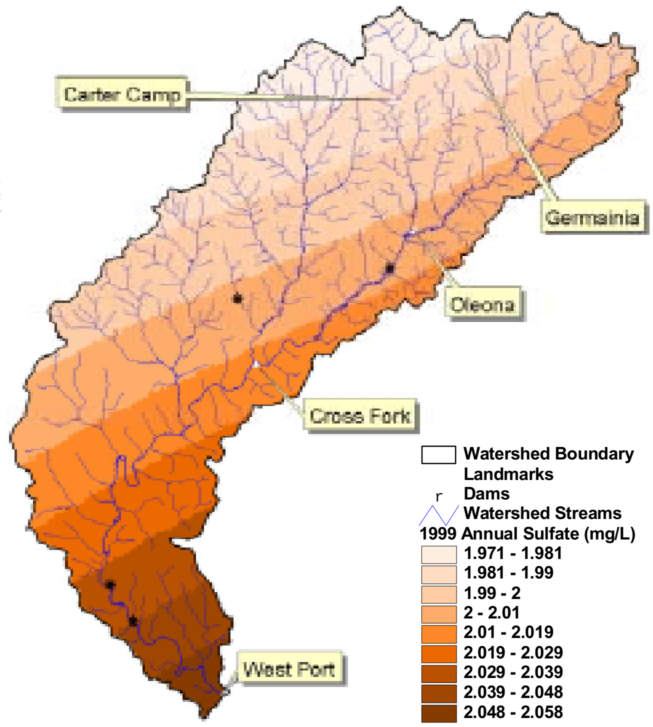
1999 Hydrogen Deposition in the Kettle Creek Watershed



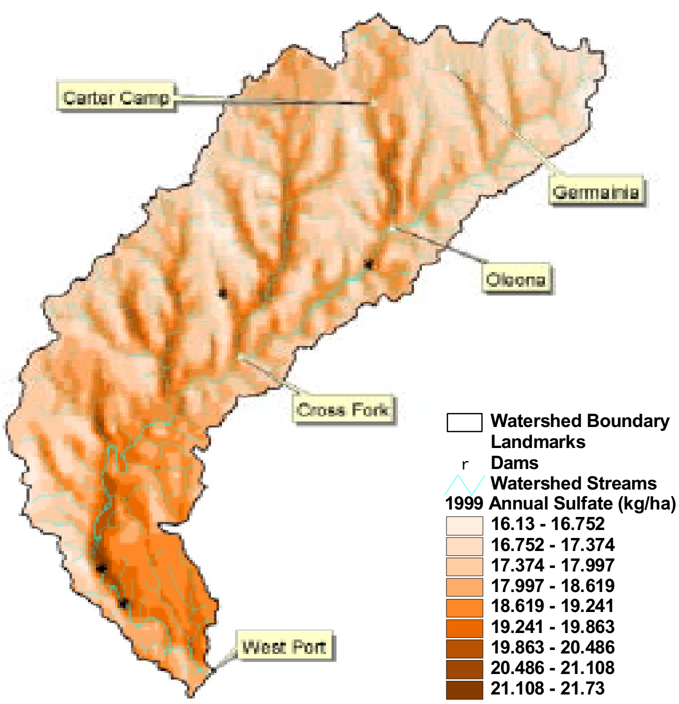
1999 Nitrate Concentration in the Kettle Creek Watershed



1999 Nitrate Deposition in the Kettle Creek Watershed



1999 Sulfate Concentration in the Kettle Creek Watershed



1999 Sulfate Deposition in the Kettle Creek Watershed

Water Quality Methods

Measuring Flow

• Materials needed: one orange, measuring tape and a watch.

• Measure 30 feet of stream length and mark where the measurement begins and ends.

• Take 3 width measurements in this 30-foot length of stream and note the average width.

• Take depth measurements across the width of the stream to obtain the average depth.

• Place orange in stream at beginning of 30-foot measurement and time how long it takes the orange to travel the measured 30 feet.

• Note: If orange becomes stuck or is stalled at any logs or rocks in the stream, the measurement is less valid. If stream is too shallow for an orange to flow, the orange peel will also work.

• Calculate flow as if a meter was used.

Creating a Rating Curve

After the staff gauges are installed throughout the watershed at the thermal project sample sites (summer 2001), a rating curve should be developed. This will enable anyone to estimate the flow of a given stream by checking the stage.

•To create a stage-discharge relationship, the discharge needs to be measured over a wide range of heights (low and high flows). The best way to do this would be to use potentiometer transducers that will measure stage continuously over varying flows. Finally, field volunteers will need to measure discharge periodically with flow meters.

•If transducers are not used, stage measurements need to be taken very frequently by field volunteers.

APPENDIX L
WATER QUALITY

Water Quality Field Data Sheet

STREAM NAME________________________	**LOCATION____________________________**
STATION #____________________________	**STREAM CLASS_______________________**
LAT_______________LONG______________	**RIVER BASIN_________________________**
DATE_________________________________	**TIME_______________am_____pm________**
FLOW/STAGE__________________________	**AGENCY/GROUP______________________**
INVESTIGATORS_______________________	**FORM COMPLETED BY_________________**
______________________________________	______________________________________
REASON FOR SURVEY____	

	CHEMICAL PARAMETER	MEASUREMENT	UNITS	SAMPLING METHOD/INSTRUMENT USED
standard	Temperature			
standard	Specific Conductance			
standard	Dissolved Oxygen			
standard	pH			
standard	Turbidity			
standard	Alkalinity			
standard	Fecal Coliform			
other				
other				
other				
other				
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other				
other				
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other				
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Standard Water Quality Field Quality Data Sheet

§ 93.7. Specific water quality criteria.

(a) Table 3 displays specific water quality criteria and associated critical uses. The criteria associated with the Statewide water uses listed in § 93.4, Table 2 apply to all surface waters, unless a specific exception is indicated in § § 93.9a-93.9z. Other specific water quality criteria apply to surface waters as specified in § § 93.9a-93.9z. All applicable criteria shall be applied in accordance with this chapter, Chapter 96 (relating to water quality standards implementation) and other applicable State and Federal laws and regulations.

*Critical use: The most sensitive designated or existing use the criteria are designed to protect.

(b) Table 4 contains specific water quality criteria that apply to the water uses to be protected.

Table 3

Symbol	*Criteria*	*Critical Use**
Alk	Minimum 20 mg/l as $CaCO_3$, except where natural conditions are less. Where discharges are to waters with 20 mg/l or less alkalinity, the discharge should not further reduce the alkalinity of the receiving waters.	CWF,WWF,TSF,MF
Am	The maximum total ammonia nitrogen concentration at all times shall be the numerical value given by: un-ionized ammonia nitrogen (NH_3-N) x ($\log^{-1}$[pK_T-pH] + 1), where: un-ionized ammonia nitrogen = 0.12 x f(T)/f(pH)f(pH) = 1 + 101.03(7.32-pH) f(T) = 1, T ›= 10°C f(T) = 1 + 10(9.73-pH) , T ‹ 10°C 1 + 10(pKT-pH) pKT =, the dissociation 0.090 + constant for ammonia in water. 2730 (T + 273.2) The pH and temperature used to derive the appropriate ammonia criteria shall be determined by one of the following methods: 1) Instream measurements, representative of median pH and temperature—July through September. 2) Estimates of median pH and temperature—July through September—based upon available data or values determined by the Department. For purposes of calculating effluent limitations based on this value the accepted design stream flow shall be the actual or estimated lowest 30-consecutive-day average flow that occurs once in 10 years.	1
Bac_1	(Fecal coliforms/ 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. For the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2,000 per 100 milliliters (ml) based on a minimum of five consecutive samples collected on different days during a 30-day period.	WC
Bac_2	(Coliforms/100 ml)—Maximum of 5,000/100 ml as a monthly average value, no more than this number in more than 20 of the samples collected during a month, nor more than 20,000/100 ml in more than 5% of the samples.	PWS
Ch	Maximum 250 mg/l.	PWS
Col	Maximum 75 units on the platinum-cobalt scale; no other colors perceptible to the human eye.	PWS
DO_1	Minimum daily average 6.0 mg/l; minimum 5.0 mg/l. For lakes, ponds and impoundments only, minimum 5.0 mg/l at any point.	CWF, HQ-WWF, HQ-TSF
DO_2	Minimum daily average 5.0 mg/l; minimum 4.0 mg/l. For the epilimnion of lakes, ponds and impoundments, minimum daily average of 5.0 mg/l, minimum 4.0 mg/l.	WWF
DO_3	For the period February 15 to 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. For lakes, ponds and impoundments, the criteria apply to the epilimnion.	TSF
DO_4	Minimum 7.0 mg/l.	HQ-CWF
F	Daily average 2.0 mg/l.	PWS
Fe_1	30-day average 1.5 mg/l as total recoverable.	CWF, WWF, TSF, MF
Fe_2	Maximum 0.3 mg/l as dissolved.	PWS
Mn	Maximum 1.0 mg/l, as total recoverable.	PWS
N	Maximum 10 mg/l as nitrogen.	PWS
OP	Maximum 50 milliosmoles per kilogram.	CWF, WWF, TSF, MF
pH	From 6.0 to 9.0 inclusive.	CWF, WWF, TSF, MF
Phen	Maximum 0.005 mg/l.	PWS
Sul	Maximum 250 mg/l.	PWS
	Maximum temperatures in the receiving water body resulting from heated waste sources regulated under Chapters 92, 96 and other sources where temperature limits are necessary to protect designated and existing uses. Additionally, these wastes may not result in a change by more than 2°F during a 1-hour period.	See the following table.

SYMBOL:	*TEMP 1*	*TEMP 2*	*TEMP 3*
CRITICAL USE:	*CWF*	*WWF*	*TSF*
PERIOD	*TEMPERATURE(°F)*		
January 1-31	38	40	40
February 1-29	38	40	40
March 1-31	42	46	46
April 1-15	48	52	52
April 16-30	52	58	58
May 1-15	54	64	64
May 16-31	58	72	68
June 1-15	60	80	70
June 16-30	64	84	72
July 1-31	66	87	74
August 1-15	66	87	80
August 16-30	66	87	87
September 1-15	64	84	84
September 16-30	60	78	78
October 1-15	54	72	72
October 16-31	50	66	66
November 1-15	46	58	58
November 16-30	42	50	50
December 1-31	40	42	42

Parameter	*Symbol*	*Criteria*	*Critical Use**
Total Dissolved Solids	TDS	500 mg/l as a monthly average value; maximum 750 mg/l.	PWS
Total Residual Chlorine	TRC	Four-day average 0.011 mg/l; 1-hour average 0.019 mg/l.	CWF,WWF, TSF,MF

	TABLE 4	
Symbol	*Water Uses Protected*	*Specific Criteria*
WWF	Statewide list	DO2 and Temp2
CWF	Statewide list plus Cold Water Fish	DO1 and Temp1
TSF	Statewide list plus Trout Stocking	DO3 and Temp3
HQ-WWF	Statewide list plus High Quality Waters	DO1 and Temp2
HQ-CWF	Statewide list plus High Quality Waters and Cold Water Fish	DO4 and Temp1
HQ-TSF	Statewide list plus High Quality Waters and Trout Stocking	DO1 and Temp3
EV	Statewide list plus **Exceptional Value** Waters	Existing quality

When the symbols listed in Table 4 appear in the Water Uses Protected column in § 93.9, they have the meaning listed in the second column of Table 4. Exceptions to these standardized groupings will be indicated on a stream-by-stream or segment-by-segment basis by the words "Add" or "Delete" followed by the appropriate symbols described elsewhere in this chapter.

Existing quality

(c) The list of specific water quality criteria does not include all possible substances that could cause pollution. For substances not listed, the general criterion that these substances may not be inimical or injurious to the existing or designated water uses applies. The Department will develop a criterion for any substance not listed in Table 3 that is determined to be inimical or injurious to existing or designated water uses using the best available scientific information, as determined by the Department.

(d) If the Department determines that natural quality of a surface water segment is of lower quality than the applicable aquatic life criteria in Table 3, the natural quality shall constitute the aquatic life criteria for that segment. All draft natural quality determinations shall be published in the Pennsylvania Bulletin and be subject to a minimum 30-day comment period. The Department will maintain a publicly available list of surface waters and parameters where this subsection applies, and shall, from time to time, submit appropriate amendments to § § 93.9a-93.9z.

Authority

The provisions of this § 93.7 amended under sections 5(b)(1) and 402 of The Clean Streams Law (35 P. S. § § 691.5(b)(1) and 691.402); and section 1920-A of The Administrative Code of 1929 (71 P. S. § 510-20).

Source

The provisions of this § 93.7 amended through March 8, 1985, effective February 16, 1985, 15 Pa.B. 907; amended March 10, 1989, effective March 11, 1989, 19 Pa.B. 968; amended February 11, 1994, effective February 12, 1994, 24 Pa.B. 832; amended April 3, 1998, effective November 4, 1995, 28 Pa.B. 1633; amended July 16, 1999, effective July 17, 1999, 29 Pa.B. 3720; amended November 17, 2000, effective November 18, 2000, 30 Pa.B. 6059. Immediately preceding text appears at serial pages (258062) to (258064), (243387) to (243392) and (258066) to (258067).

Notes of Decisions

The Department of Environmental Resources is not required to consider the economic consequences to a discharger in establishing water-quality based effluent limitations in a National Pollutant Discharge Elimination System (NPDES) Permit. Mathies Coal Company v. Department of Environmental Resources, 559 A.2d 506 (Pa. 1989).

The water quality standards in 25 Pa. Code § 93.7 are to be considered only as one of the major factors in developing discharge limitations, and neither these standards nor effluent limitations based on them in case-by-case DER determinations require a presumption of validity. Lucas v. Department of Environmental Resources, 420 A.2d 1 (Pa. Cmwlth. 1980).

Cross References

This section cited in 25 Pa. Code § 93.4b (relating to qualifying as High Quality or Exceptional Value Waters); 25 Pa. Code § 93.8 (relating to development of site-specific water quality criteria for the protection of aquatic life); and 25 Pa. Code § 96.3 (relating to water quality protection requirements).

§ 93.4b. Qualifying as High Quality or Exceptional Value Waters.

(a) Qualifying as a High Quality Water. A surface water that meets one or more of the following conditions is a High Quality Water.

(1) Chemistry.

(i) The water has long-term water quality, based on at least 1 year of data which exceeds levels necessary to support the propagation of fish, shellfish and wildlife and recreation in and on the water by being better than the water quality criteria in § 93.7, Table 3 (relating to specific water quality criteria) or otherwise authorized by § 93.8a(b) (relating to toxic substances), at least 99% of the time for the following parameters:

- dissolved oxygen
- aluminum
- iron
- dissolved nickel
- dissolved copper
- dissolved cadmium
- temperature
- pH
- dissolved arsenic
- ammonia nitrogen
- dissolved lead
- dissolved zinc

(ii) The Department may consider additional chemical and toxicity information, which characterizes or indicates the quality of a water, in making its determination.

(2) Biology. One or more of the following shall exist:

(i) Biological assessment qualifier.

(A) The surface water supports a high quality aquatic community based upon information gathered using peer-reviewed biological assessment procedures that consider physical habitat, benthic macroinvertebrates or fishes based on Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish, Plafkin, et al., (EPA/444/4-89-001), as updated and amended. The surface water is compared to a reference stream or watershed, and an integrated benthic macroinvertebrate score of at least 83% shall be attained by the referenced stream or watershed.

(B) The surface water supports a high quality aquatic community based upon information gathered using other widely accepted and published peer-reviewed biological assessment procedures that the Department may approve to determine the condition of the aquatic community of a surface water.

(C) The Department may consider additional biological information which characterizes or indicates the quality of a water in making its determination.

(ii) Class A wild trout stream qualifier. The surface water has been designated a Class A wild trout stream by the Fish and Boat Commission following public notice and comment.

(b) Qualifying as an Exceptional Value Water. A surface water that meets one or more of the following conditions is an Exceptional Value Water:

(1) The water meets the requirements of subsection (a) and one or more of the following:

(i) The water is located in a National wildlife refuge or a State game propagation and protection area.

(ii) The water is located in a designated State park natural area or State forest natural area, National natural landmark, Federal or State wild river, Federal wilderness area or National recreational area.

(iii) The water is an outstanding National, State, regional or local resource water.

(iv) The water is a surface water of exceptional recreational significance.

(v) The water achieves a score of at least 92% (or its equivalent) using the methods and procedures described in subsection (a)(2)(i)(A) or (B).

(vi) The water is designated as a "wilderness trout stream" by the Fish and Boat Commission following public notice and comment.

(2) The water is a surface water of exceptional ecological significance.

Authority

The provisions of this § 93.4b issued under sections 5(b)(1) and 402 of The Clean Streams Law (35 P. S. § § 691.5(b)(1) and 691.402); and section 1920-A of The Administrative Code of 1929 (71 P. S. § 510-20).

Source

The provisions of this § 93.4b adopted July 16, 1999, effective July 17, 1999, 29 Pa.B. 3720.

Cross References

This section cited in 25 Pa. Code § 93.1 (relating to definitions); and 25 Pa. Code § 96.3 (relating to water quality protection requirements).

PA Code Chapter § 109.713. Wellhead protection program.

For water suppliers seeking to obtain Department approval for a wellhead protection program, the wellhead protection program shall consist of the following:

(1) A steering committee composed of the necessary representatives, including, but not limited to, the water supplier, local government officials from the affected jurisdictions and potentially affected industry, to designate responsibilities for the planning and implementation of wellhead protection activities.

(2) Public participation and education activities to promote awareness and encourage local support of wellhead protection activities.

(3) Zone II and Zone III wellhead protection area delineation performed in accordance with methodology provided by the Department. Methods applicable to that hydrogeologic setting shall be utilized and site-specific hydraulic and hydrogeologic information shall include, but is not limited to, pumping rate or yield, aquifer properties, water table or potentiometric surface configuration and hydrogeologic mapping.

(4) Identification of existing and potential sources of contamination within each wellhead protection area.

(5) Development and implementation of wellhead protection area management approaches to protect the water supply source from activities that may contaminate the source. These approaches may include, but are not limited to, one or more of the following actions:

(i) Purchase of the wellhead protection area by the water system.

(ii) Adoption of municipal ordinances or regulations controlling, limiting or prohibiting future potential sources of contamination within the wellhead protection area.

(iii) Adoption of municipal ordinances or regulations establishing design and performance standards for potential sources of contamination within the wellhead protection area.

(iv) Transfer of development rights within the wellhead protection area to land outside of the wellhead protection area.

(v) A groundwater monitoring network that serves as an early warning system.

(vi) Public education programs.

(vii) Other methods approved by the Department which will ensure an adequate degree of protection for the source.

(6) Contingency planning for the provision of alternate water supplies in the event of contamination of a well, spring or infiltration gallery and emergency responses to incidents that may impact water supply source quality.

(7) New water supply source siting provisions to ensure the protection of new wells, springs or infiltration galleries.

Source

The provisions of this § 109.713 adopted October 7, 1994, effective October 8, 1994, 24 Pa.B. 5175.

APPENDIX M
ABOUT GIS

What is GIS?

A geographic information system is a facility for preparing, presenting, and interpreting facts that pertain the earth. This is a broad definition that can be applied to things ranging from hand drawn maps to computer systems to groups of people and animals. In common language, a geographic information systems or GIS is a configuration of computer hardware and software specifically designed for the acquisition, maintenance, and use of cartographic data (Tomlin, 1990, p. xi).

Vector

Vector is a form of representation, the boundaries or the course of the features are defined by a series of points that, when joined with straight lines, form the graphic representation of that feature. The attributes of features are then stored with a database system. For example, a vector property map of property parcels might be tied to an attribute database of information containing the address, owner's name, property valuation and land use. Vector systems tend to be database management oriented.

Raster

Raster is the second major form of representation. The graphic representation of features and the attributes they possess are merged into unified data files. The watershed is subdivided into a mesh of grid cells in which we record the condition or attribute of the geography. Raster systems are excellent for evaluating environmental models such are characterization of habitat.

Shape File

Shapefiles are a simple, non-topological format for storing the geometric location and attribute information of geographic features. The shapefile format defines the geometry and attributes of geographically-referenced features in as many with specific file extensions that must be stored in the same project workspace. They are:

.shp - the file that stores the feature geometry. Required.

.shx - the file that stores the index of the feature geometry. Required.

.dbf - the dBASE file that stores the attribute information of features. Required.

.sbn and .sbx - the files that store the spatial index of the features. Optional.These two files can be created in ArcView. See ArcView's online help for more information.

.fbn and .fbx - the files that store the spatial index of the features for shapefiles that are read-only. Optional.These two files can be created in ArcView. See ArcView's on-line help for more information.

.ain and .aih - the files that store the attribute index of the active fields in a table or a theme's attribute table. Optional.These two files can be created in ArcView. See ArcView's on-line help for more information.

.prj - the file that stores the coordinate system information. Optional.This file can be created with and is used by the ArcView Projection Utility. It is not used by ArcView GIS Version 3.x or older versions, or by ARC/INFO versions previous to version 8.0.

.xml - metadata for ArcInfo 8.0, for using shapefiles on the Internet. Optional.

Grid File

The GRID format is a proprietary ESRI format that supports 32-bit integer and 32-bit floating-point raster grids. Grids are especially suited to representing geographic phenomena that vary continuously over space, and for performing spatial modeling and analysis of flows, trends, and surfaces such as hydrology. With ArcView's Spatial Analyst Extension you can convert themes based on vector features to grids. You can also derive grids from various spatial analysis operations. Grids can be added to views as grid themes. You can classify the grid cells in various ways and choose different colors for each class.

TIN (Triangular Irregular Network)

A TIN is an object used to represent a surface. Since representation of a surface can be done in many different ways, TIN (Triangulated Irregular Network) also implies a specific storage structure of surface data. TIN partitions a surface into a set of contiguous, non-overlapping, triangles. A height value is recorded for each triangle node. Heights between nodes can be interpolated thus allowing for the definition of a continuous surface. TINs can accommodate irregularly distributed as well as selective data sets. This makes it possible to represent a complex and irregular surface with a small data set.

What is a DOQ?

http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/doq/doq.html

A Digital Orthophoto Quadrangle (DOQ) is a digital image of the earth's surface that has been digitally scanned and processed to remove the distortion inherent in aerial photography. Using a digital elevation model and advanced image processing techniques, radial and topographic distortion is removed from the image providing a true planimetric product. Basically the DOQ is manipulated to be able to be used with other types of maps and images.

A DOQQ image typically covers one-quarter of a 1:24,000 scale USGS topographic map plus a little overlap. This type of image is then tiled. The resolution of the image is quite high at one square meter per pixel. As a result of this fine cell size, these images consume large quantities of disk space. To conserve disk space the images are stored in JPEG image format which compresses the data very efficiently. These files can be potentially large and 45 megabytes is not uncommon.

What is a DRG?

http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/doq/doq.html#DRG

A digital raster graphic (DRG) is a scanned color image of a U.S. Geological Survey (USGS) standard series topographic map, including all map collar information. The image inside the map neatline is georeferenced to the surface of the earth and fit to the Albers Equal Area Conical projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map.

DRGs are created by scanning published paper maps on high-resolution scanners. The raster image is georeferenced and fit to the UTM projection. Colors are standardized to remove scanner limitations and artifacts. The average data set size is about 6 megabytes in Tagged Image File Format (TIFF) with PackBits compression.

DRGs are stored as rectified TIFF files in geoTIFF format. GeoTIFF is a relatively new TIFF image storage format that incorporates georeferencing information in the header. This allows software, such as ArcView, ARC/INFO, or EPPL7 to reference the image without an additional header or world file.

Much of the GIS information in this document was compiled specifically for the Kettle Creek Watershed from the Pennsylvania Spatial Data Access Internet Web Site at http://www.pasda.psu.edu on or before October 15,

2000. This project is relying on the metadata (data about data) that is available on PASDA. There were several pieces of data collected from other sources including the Pennsylvania Bureau of Forestry and Clinton County Planning. The sources are noted in the table of GIS data that is included with the compact disk set. In some cases, existing paper maps were digitally scanned for use as a image that is spatially registered with the watershed. For example, paper Platt Maps were digitally scanned to graphically show property ownership where actual shape themes were not available (e.g. Potter County).

One map projection standard was used to allow for displaying and analyzing the data about Kettle Creek. All spatial data were mapped or converted into the following projection:

Horizontal Coordinate System Definition:

Planar:

Map_Projection_Name: Albers Equal-Area Conic

Standard_Parallel: 40.000000

Standard_Parallel: 42.000000

Longitude_of_Central_Meridian: 78.000000

Latitude_of_Projection_Origin: 39.000000

False_Easting: 0.000000

False_Northing: 0.000000

Planar_Coordinate_Information:

Planar_Coordinate_Encoding_Method: Coordinate pair

Coordinate_Representation:

Abscissa_Resolution: unknown

Ordinate_Resolution: unknown

Planar_Distance_Units: Meters

Geodetic_Model:

Horizontal_Datum_Name: North American Datum of 1927

Ellipsoid_Name: Clarke 1866

Semi-major_Axis: 6378206.4000000

Denominator_of_Flattening_Ratio: 294.98

If the data were not in Albers Equal-Area Conic they were projected into this spatial reference using Arc/Info from Environmental Research Systems Institute, Inc.(ESRI) of Redlands, California. The relevant projection files have been provided on compact disk set in the aml directory and described on the table of all the GIS layers.

All the GIS files were used in ArcView 3.2a from ESRI, Inc. Additional extensions were used including 3D Analyst and Spatial Analyst.

There were additional extensions and patches used that are available from ESRI, Inc. and other web sites. These extentions are freely available from the ESRI web site. These extensions need to be copied into the localdrive/esri/av_gis30/arcview/ext32 directory in order to be available in ArcView.

GIS Themes and Legends

For a complete listing of all the GIS data with a brief description of what the theme is about please see the index that is included on the compact disk set. There is also a short PowerPoint presentation that describes what is gis from http://www.gis.com included in the compact disk set.