Cross Creek Watershed Assessment, Restoration, and Protection Plan Washington County, Pennsylvania

In accordance with

Pennsylvania is... Growing Greener — Growing Greener Program — DEP

Prepared For: Cross Creek Watershed Association

Prepared By:

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June 2003

Watershed Planning:

A grassroots movement-

In December of 2000, the Cross Creek Watershed Association (CCWA) was awarded a Growing Greener Grant from the Pennsylvania Department of Environmental Protection (PADEP) to conduct a Watershed Assessment, Restoration and Protection Plan (WARPP).

The Cross Creek Watershed Assessment, Restoration and Protection Plan was initiated by the Cross Creek Watershed Association to help the community better understand the natural, physical, and cultural resources of the Cross Creek Watershed, and how these resources are impacted by various factors. This information will assist concerned citizens to make informed decisions regarding potential improvements, and the protection of important features within the watershed.

Unlike other comprehensive planning documents that traditionally follow municipal boundaries, watershed planning encompasses areas that share a common surface water drainage pattern where various types of environmental processes occur and affect the lives of the area's residents. Therefore, it is important for the municipalities that share in this common resource to cooperate with each other and the local watershed group in order for the recommendations made in this plan to be implemented.

The area for the current study includes the area east of the Pennsylvania – West Virginia border upstream to the headwaters portion of the Cross Creek Watershed, near State Route 18. The size of the Pennsylvania portion of the Cross Creek Watershed is approximately 80 square miles (51,000 acres) and has approximately 165 total miles of streams.

The steering committee was formed and in April 2001 Skelly and Loy, Inc. was hired as the project's consultant. Skelly and Loy was hired to prepare the WARPP, which included the collection of existing data, providing an inventory of land, water, biological and cultural resources within the watershed, analysis of water quality sampling results over a twelve month period, a review of land use practices, and the encouragement of public participation via public meetings and public announcements.

The initial public meeting was held in November of 2001. This meeting provided local residents opportunity to voice their concerns. This information was implemented into the planning process. Early in 2003 the draft plan was open for public review and a second public meeting was held in February of 2003 in order for residents to voice their comments on the draft plan.

Funding for this project was provided by:

The Pennsylvania Department of Environmental Protection, Growing Greener Program

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- Hopewell Township
- Independence Township
- Jefferson Township
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And…

The volunteers that assisted in developing this plan-
Their participation in the public process facilitated and enabled completion of this vital step in the restoration of the Cross Creek Watershed.

List of Acronyms

ac	acre
AMD	Abandoned Mine Drainage
AML	Abandoned Mine Land
ALD	Anoxic Limestone Drains
BDA	Biological Diversity Area
BMP	Best Management Practice
CCRCP	Cross Creek Region Comprehensive Plan
CCWA	Cross Creek Watershed Association
CWA	Clean Water Act
DA	Dedicated Area
DOT	Department of Transportation
E&S	Erosion and Sedimentation
EIC	Environmental Improvement Compact
EPA	Environmental Protection Agency
ESA	Environmental Site Assessment
FEMA	Federal Emergency Management Agency
FGM	Fluvial Geomorphology
FHWA	Federal Highway Administration
GIS	Geographic Information System
ha	Hectare
LDW	Limestone Diversion Well
MCD	Municipal Code
MCL	Maximum Concentration Limit
MDE	Maryland Department of Environment
ML	Managed Land
mm	millimeters
MPC	Pennsylvania Municipalities Planning Code
MSA	Metropolitan Statistical Area
MU	Management Unit
NEPA	National Environmental Policy Act
NHI	Natural Heritage Inventory
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source
NRCS	Natural Resources Conservation Service
NRC	Nuclear Regulatory Commission
NWI	National Wetland Inventory
OLC	Open Limestone Channels
PA	Pennsylvania
PABAMR	Pennsylvania Bureau of Abandoned Mine Reclamation
PADCED	Pennsylvania Department of Community and Economic Development
PADCNR	Pennsylvania Department of Conservation and Natural Resources
PADEP	Pennsylvania Department of Environmental Protection
PADER	Pennsylvania Department of Environmental Resources
PASDA	Pennsylvania Spatial Data Access
PASDC	Pennsylvania State Data Center
PAWC	Pennsylvania American Water Company
PENNDOT	Pennsylvania Department of Transportation
PFBC	Pennsylvania Fish & Boat Commission
PGC	Pennsylvania Game Commission
PHMC	Pennsylvania Historic and Museum Commission
P.L.	Public Law
PNDI	Pennsylvania Natural Diversity Inventory
PRD	Planned Residential Development

List of Acronyms (continued)

PTC	Pennsylvania Turnpike Commission
PU	Planning Units
REI	Recycling Economic Information
SAPS	Successive Alkalinity Producing System
SDTDC	San Dimas Technology and Development and Center
SGL	State Game Land
SPC	Southwestern Pennsylvania Commission
SR	State Route
TDR	Transferable Development Rights
TEA	Transportation Equity Act
TIP	Transportation Improvement Plan
TMDL	Total Maximum Daily Load
UMWA	United Mine Workers of America
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WARPP	Watershed Assessment, Restoration and Protection Plan
WCCD	Washington County Conservation District
WCPC	Washington County Planning Commission
WCWA	Washington County Watershed Alliance
WHPP	Wellhead Protection Program
WPCAMR	Western Pennsylvania Coalition for Abandoned Mine Reclamation
WPWPP	Western Pennsylvania Watershed Protection Program
WV	West Virginia

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1 Introduction

1.1 Planning Process

The Pennsylvania Department of Environmental Protection, under its Growing Greener Program, provided funding for this project. The Steering Committee and the consultant initiated the planning process in the summer of 2001 in order to prepare the Cross Creek Watershed Assessment, Restoration and Protection Plan (WARPP). The approach for this plan involved collecting, analyzing, and evaluating data for natural, physical and cultural resources in the Cross Creek Watershed and correlating their impacts to land use activities and existing environmental conditions focusing on stream health. This approach has been further analyzed at the sub-basin level to assist in ranking implementation recommendations/goals/strategies. This gives the plan the flexibility to specifically direct improvements.

Natural, physical and cultural resource data collected includes information in hard copy and digital formats. This information has been collected from citizens groups, water/sanitary authorities, planning commissions, historical societies, and local, county, state, and federal governmental agencies. Data collected includes, but is not limited to: water quality sampling, aquatic surveys, soil surveys, biological studies, flood protection projects, geographical information systems data, surface and deep mining surveys/reports, regulations and laws, natural heritage inventories, park master plans, utility mapping/data, and zoning ordinance information.

After the data was collected, this information was analyzed and evaluated based on its importance in the planning process. The information was then evaluated to determine which specific resource items, activities, and/or processes correlated into issues, concerns, constraints, and opportunities to be addressed by this plan.

1.2 Planning Purpose

The purpose of this plan is to document the particular problems that are affecting the environmental health of the Cross Creek Watershed. Data used in assessing the holistic condition of the watershed will include visual interpretation, primary water quality data collected for this plan and previously documented secondary data that has been compiled by local watershed groups, the Washington County Conservation District, Pennsylvania state agencies and Federal agencies. After the initial empirical identification, water quality data for 20 sampling points located throughout the watershed were analyzed to, one; corroborate the visual assessment of the streams of the watershed and, two; to reveal any water impairments that were not empirically identified. After review of the previously compiled data, the findings determined by the visual interpretation and the water quality data were combined for the analysis portions of the plan. Following the analysis of the data, recommendations and best management practices have been suggested as well as examples of particular kinds of remediation techniques with cost estimates for each. Upon the completion of this plan, communities that lie within the Cross Creek Watershed are eligible for grant dollars made available through various programs, such as the Pennsylvania Growing Greener and Keystone Grant Programs, as well as other federal, state and private funds.

1.3 Goals and Objectives

The overall goals of the project, in no specific order, are to:

- Improve water quality
- Promote land development that is compatible with a healthy environment
- Enhance the recreational opportunities of the watershed
- Protect the natural resources, historic landscape and scenic beauty within the watershed
- Provide an environmental education program for adults and enhance existing school-based environmental education
- Provide a resource for municipal planning
- Prepare for future growth

The primary objectives of this plan are:

- To maintain the high water quality of the upper Cross Creek Watershed.
- To improve the water quality of the middle and lower Cross Creek Watershed.

2 Project Area Characteristics

2.1 Location

The Cross Creek Watershed is located in southwestern Pennsylvania and in the northern panhandle of West Virginia. Cross Creek flows west through Washington County, PA and through Brooke County, WV before it discharges into the Ohio River south of Follansbee and north of Wellsburg, WV. Cross Creek is not considered navigable by the U.S. Army Corps of Engineers (USACE) (USACE, 1995) (Refer to Map 1 & 2).

2.2 Size

The entire Cross Creek Watershed (in PA and WV) is approximately 80 square miles (51,000 acres) and the length of Cross Creek is 15 miles, excluding Cross Creek Lake. There are an approximate total of 165 stream miles in the entire Cross Creek Watershed.

The Pennsylvania portion of the Cross Creek Watershed is approximately 63 square miles (40,000 acres) and the length of the PA portion of Cross Creek is 12 miles, excluding Cross Creek Lake. There are an approximate total of 134 stream miles in the PA portion of the Cross Creek Watershed.

2.3 Topography

The Cross Creek Watershed ranges in elevation from nearly 1,300 feet above sea level at the eastern most portion of the watershed, near the headwater of Cross Creek in Mount Pleasant Township, to approximately 800 feet at the West Virginia border.

2.4 Major Tributaries

Table 2-1 below lists the major tributaries and accompanying stream with acres of the sub-basin land area and miles of the stream lengths. Please note that Table 2-1 only lists the Pennsylvania portion of Cross Creek Watershed.

Table 2-1
Major Tributaries and Sub-basins of the Cross Creek Watershed

Sub-basin Name	Sub-basin Area (acres)	Sub-basin Stream Length (miles)
Cross Creek Sub-basin	15,107	49
Coal Hollow Sub-basin	1,265	3
Haynan Run Sub-basin	799	3
Middle Fork Cross Creek Sub-basin	2,797	11
North Fork Cross Creek Sub-basin	7,392	28
Parmar Run Sub-basin	207 (PA)	Headwaters in PA
Scott Run Sub-basin	4,504	14
South Fork Cross Creek Sub-basin	8,091	27
TOTAL	40,162 acres	135 miles

Source: Skelly and Loy, after SPC

2.5 Land Use / Land Cover

Land use calculations were derived from satellite imagery captured from the LANDSAT satellite in spring of 1993. The classification of this data was performed by the SPC. The predominant land use within the watershed is agriculture at approximately 50% (20, 257 acres). Forestland ranks second with approximately 47% (18,996 acres) of the watershed. Together, agricultural and forested lands cover approximately 97% (39,253) of the watershed's area (Refer to Map 3).

Table 2-2
Major Land Use Types

Land Use Type	Acreage (est.)	Percent
Agriculture	20,257	50.4%
Forest	18,996	47.3%
Water	275	0.7%
Built-up Land	141	0.4%
Residential	184	0.5%
Strip Mines	296	0.7%
Wetlands	7	<0.5%
Total	40,159	100%

Source: Skelly and Loy, after SPC / Landsat (1993)

2.6 Climate

The Cross Creek Watershed has a humid continental climate. According to the United States Dept. of Agriculture, Natural Resources Conservation Service (USDA NRCS) 30 year data set (1961-1989) for the Burgettstown 2 W PA1105 weather station, the average winter (Nov. – April) temperature is 34.2ºF with an average maximum winter temperature of 46.9ºF (April) and the average minimum winter temperature is 24˚F (Jan.). The average summer (May-Oct.) temperature is 61.6ºF with an average maximum summer temperature is 69.3ºF and the average minimum summer temperature is 49.9ºF. Total average annual precipitation is 39.08 inches with a yearly summer average of 21.47 inches and a yearly winter average of 17.61 inches.

To properly analyze trends and/or shifts in precipitation patterns, a minimum of thirty years of rainfall data is necessary. Thirty years of rainfall data in conjunction with thirty years of stream flow data is also preferred when designing and engineering stream restoration projects. The thirty year benchmark was established in order to adequately provide a 'curve' that is the basis of designing such projects. The NRCS has established rain gauge stations in order to collect this data. The closest NRCS rain gauge is located in Burgettstown, PA. Below (Table 2-3) is an explanation of growing season beginnings, endings and lengths based on average temperature.

Table 2-3
Growing Season Dates (Calculated from the years 1948 to 1999)

	Temperature		
Probability*	**24 degrees F or Higher**	**28 degrees F or Higher**	**32 degrees F or Higher**
	Beginning and Ending Dates Growing Season Length		
50%	4/23 to 10/24 184 days	5/ 4 to 10/13 161 days	5/20 to 9/27 130 days
70%	4/20 to 10/28 191 days	4/30 to 10/17 170 days	5/16 to 10/ 2 139 days

*Percent chance of the growing season occurring between the Beginning and Ending dates.
Latitude: 40 23 / Longitude: 080 26
Averages determined from the NRCS Burgettstown 2 W PA1105 weather station.

2.7 Municipal Acreage of the Watershed

The municipal divisions included in the watershed are shown in Map 4 and Table 2-4. The Cross Creek Watershed stretches across Washington County, PA to the east and Brooke County, WV to the west. There are seven municipalities that are associated with the watershed in the PA portion of the watershed. Of these seven municipalities, two municipalities – Cross Creek Township and Jefferson Township -are over 70% of the watershed land area. The remaining 5 municipalities – Hopewell, Independence, Mount Pleasant and Smith Townships and West Middletown Borough – comprise the remaining 30% of the watershed land area.

If Cross Creek and Jefferson Townships are combined with Independence and Mount Pleasant Townships, the combined municipal area of these four municipalities results in a total of 92 (91.8)% of the total watershed area.

Table 2-4
Municipal Land Acreage in Watershed and % of Watershed

Column 1	2	3	4	5
Municipality	**Municipality Total Acres**	**Acres of Municipality In Watershed**	**% of Municipality in Watershed**	**% of Watershed in Municipality**
Cross Creek Township	17,672	16,833	95.3%	41.9%
Hopewell Township	13,137	2,775	21.1%	6.9%
Independence Township	16,487	4,608	28.0%	11.5%
Jefferson Township	14,496	11,480	79.2%	28.6%
Mount Pleasant Township	22,851	3,928	17.2%	9.8%
Smith Township	22,015	418	1.9%	1.0%
West Middletown Borough	260	109	42.0%	0.5%
Total	**106,918**	**40,150**		**100%**

Source: Skelly and Loy, after SPC, 2001

2.8 Transportation Facilities

2.8.1 Roads

The Cross Creek Watershed has a roadway network typical of a rural landscape. This network includes roadways from state highways to small gravel and dirt roads. The study area is nearly bisected by State Route (SR) 50, which runs the length of the study area in a east - west direction. This roadway serves as a major route for residents traveling east and west within the watershed. Additionally, SR 18 borders the eastern most portion of the study area running southeast and northwest. Other roads within the Cross Creek Watershed include SR 231 that runs north and south in the central portion of the watershed and SR 844 that connects' Washington, PA to Wellsburg, WV. In addition to these roadways, the overall existing travel network (smaller township roads) provides access to almost any area within the watershed (Refer to Map 4).

The present Pennsylvania Department of Transportation (PENNDOT) Transportation Improvement Plan (TIP) includes a few projects anticipated for study, design, and construction over the next four-year period, and one project for the next fourteen-year period. These projects are shown in Table 2-5 and 2-6. While these improvements are necessary to provide safe travel for the general public, they also increase access to areas that are prone to developmental pressure. The need to develop a strong conservation plan, as well as working with PENNDOT during development of their transportation plans, becomes essential in the long-term health of both the socioeconomic features and ecological aspects of the watershed. *While these projects are presently being planned, because of the extensive political and bureaucratic nature of roadway development, it is extremely difficult to detail exactly when or if these projects or others will actually be constructed.*

Table 2-5
Transportation Improvement Program Projects within the Cross Creek Watershed (2001-2004)

State Route	Project Name	Project Description	Township
Route 4018	Meadowcroft Bridge	**Bridge Replacement Completed March, 2003**	Jefferson/Independence
Route 4029	Avella Bridge	Bridge Replacement	Cross Creek
Route 4029	Patterson's Mill Bridge	Bridge Replacement	Cross Creek

Source: Southwestern Pennsylvania Commission, 2001-2004 Transportation Improvement Program for the Pittsburgh Transportation Management Area. (October 2001)

Table 2-6
Long Range Transportation Plan Projects in the PA Portion of the Cross Creek Watershed (1994-2015)

State Route	Section Limits	Miles	Project Description
Route 18	Interstate 70 to Route 22	20.7	Maintain/Upgrade

Source: Southwestern Pennsylvania Regional Planning Commission, A Region on the Move: A Transportation Investment Strategy for Growth and Renewal in Southwestern Pennsylvania, 2015 Long Range Transportation Plan (November, 1994)

2.8.2 Rail

Norfolk Southern and Norfolk and Western rail facilities and right-of-ways exist along various waterways and bisect in the project area (USGS, 1979). Norfolk Southern (previously Conrail) has an active rail line that follows along the Burgetts Fork of Raccoon Creek. However, the rail line spur that enters the Cross Creek Watershed via the North Fork Branch of Cross Creek is abandoned (Refer to Map 5). Norfolk and Western also has an active line that follows Cross Creek into Wellsburg, WV (Norfolk Southern Corporation, 2000).

2.8.3 Rail-to-Trail Facilities

The Panhandle Trail, rail-to-trail facility is now being developed on the Norfolk Southern (previously Conrail) right-of-way along Robinson Run to the north and east of the Cross Creek Watershed. The abandoned spur that runs along the North Fork of Cross Creek from Langloth to Studa is a potential rail-to-trail project (Refer to Map 5).

2.8.4 Traffic Studies

Personal correspondence between Skelly and Loy, Inc. and PENNDOT District 12 on the date of August 5, 2002, revealed that there are no specific traffic studies that have been conducted within the Cross Creek Watershed. Mr. Tom Ohurne of PENNDOT District 12's Uniontown office indicated that any traffic volumes used for projects within the watershed, including the Meadowcroft site bridge improvements, were taken from the annual publication of the PENNDOT Road Log, which indicates Average Daily Traffic Volumes (ADT) for all state road segments.

2.9 Development Issues in the Cross Creek Watershed

2.9.1 Historical Development

The rural character that the Cross Creek Watershed maintains today can be traced back to the areas historic ties with agriculture and self-sufficiency. According to Edward Hahn's study of Cross Creek Township entitled, "Social Changes in a Small Community: 1860-1880" (1974), as late as 1860, Cross Creek Township remained isolated from the major industrial and commercial markets of adjacent Pittsburgh, Wheeling and Washington. Hahn describes Cross Creek Township at that time as a self-sufficient economy where farms remained small and production was diversified. Much of the commerce and trade was conducted locally using cash and barter. While other, adjoining rural farming areas were steadily being 'brought into the fold' of industrial development and unequal access to wealth and services, the distribution of wealth among Cross Creek property owners was apparently not as unequal as it was in other increasingly commercialized rural communities of the county.

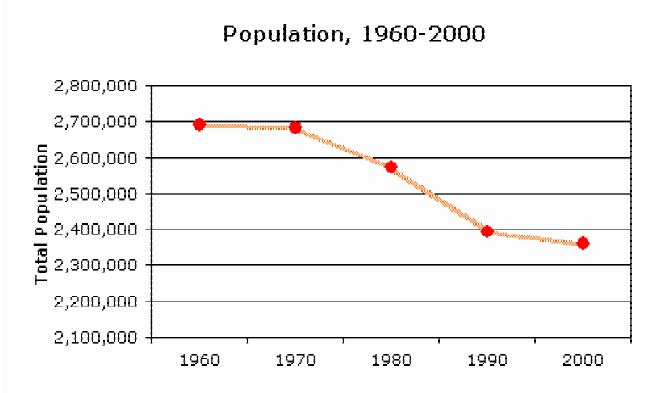
Migration from rural to urban areas was not only happening near and around Pittsburgh in the latter 1800's, it was pandemic in the industrializing world. Cross Creek Township, however, according to Hahn, was able to maintain it's population due to need to fuel Pittsburgh and the other surrounding industrial areas with agricultural products, wood, coal and other natural resources. While the number of farms between 1860-1880 declined and the ones that remained became larger, more men were able to find work within the township due to the new labor needs created from nearby industrialization. It was these new non-farm job opportunities that failed to spur the out-migration of local people that was common in other, similar townships at the time. Hahn remarks that Cross Creek Township remained family centered and almost entirely native born throughout this time period (Muller, 1989).

2.9.2 Current Development

The Cross Creek Watershed lies across two Metropolitan Statistical Areas (MSAs) in two different states. A MSA is a geographic entity designated by the federal Office of Management and Budget for use by federal statistical agencies. The Pennsylvania portion of the watershed is entirely within the Pittsburgh MSA while the West Virginia portion of the watershed is entirely within the Wheeling WV MSA. Therefore, it is important to recognize that while Cross Creek is locally perceived to be a rural area, the federal government views it as part of a metropolitan geography.

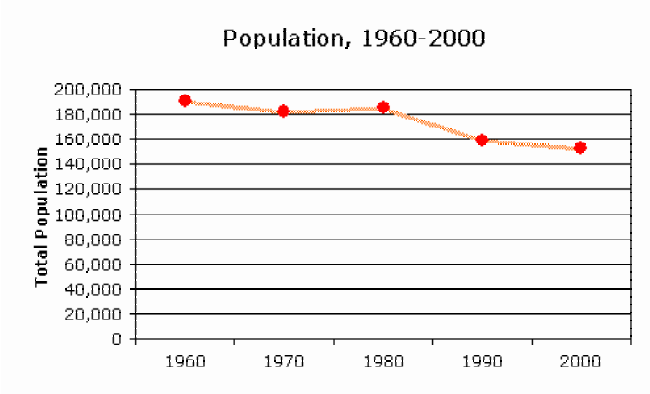
Regional Population Trends

Figure 2-1 Population Trends for Pittsburgh, PA Statistical Area (MSA)



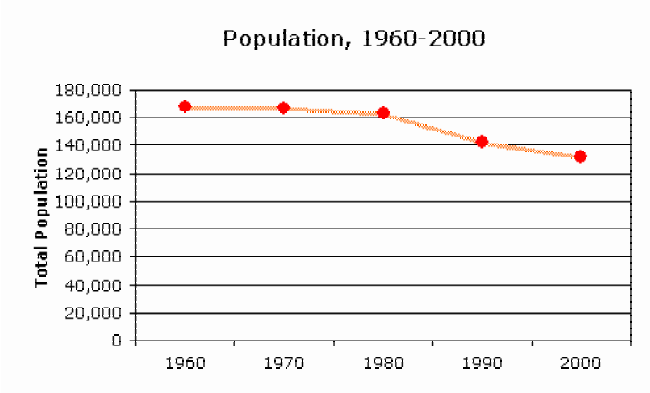
Source: www.censusscope.org

Figure 2-2 Population Trends for Wheeling, WV Metropolitan Statistical Area (MSA)



Source: www.censusscope.org

Figure 2-3 Population Trends for Steubenville, OH / Weirton, WV Statistical Area (MSA)



Source: www.censusscope.org

The population trend for both the Pittsburgh PA and Wheeling WV MSAs has been one of decline since the 1960's (Figures 2-1 & 2.3). The same trend is evident for the Steubenville / Weirton MSA located to the north of the Cross Creek Watershed (Figure 2-3).

Currently and historically, the growth of Pittsburgh is the most influential source of development pressures for the watershed. When comparing population decline, however, it is the Pittsburgh MSA that exhibits the most sever population loss.

According to the Governors Report on Land Use Trends, 2000, Pennsylvania has the highest degree of land development in the nation when compared to population growth numbers. What this indicates is that more Pennsylvanians are moving about internally within the state, developing more land than is necessary for sustainable development.

Please see the section 2.9.3 entitled 'Future Development Considerations' for more development issues concerning the Cross Creek Watershed.

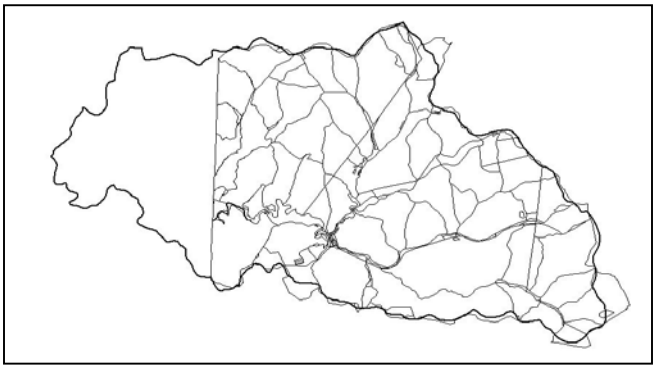
Local Population Trends

Populations within the Cross Creek Watershed have experienced slight declines, mirroring the population trend observed throughout Washington County. The most accurate measurement of populations within the rural Cross Creek Watershed is by investigating census data at the census block unit.

The US Bureau of the Census has demarked census blocks for the purposes of organizing population and housing data. Census blocks are areas bounded on all sides by visible features, such as streets, roads, county limits, property lines, and short, imaginary extensions of streets and roads. Generally, census blocks are small in area; for example, a block bounded by city streets. However, census blocks in remote areas may be large and irregular and contain many square miles. In the Cross Creek Watershed, two census block boundaries changed slightly but not significantly enough alter the population findings.

In 2000, there were 201 census blocks that were at least 50% within the Cross Creek Watershed (Refer to Figure 2-1). The population of these census blocks in 1990 was 4,378. In 2000, the same census blocks had a population of 4,121, revealing an assumed loss of 257 persons, or a negative 5.8%.

Figure 2-4 Census Blocks Within the Cross Creeks Watershed

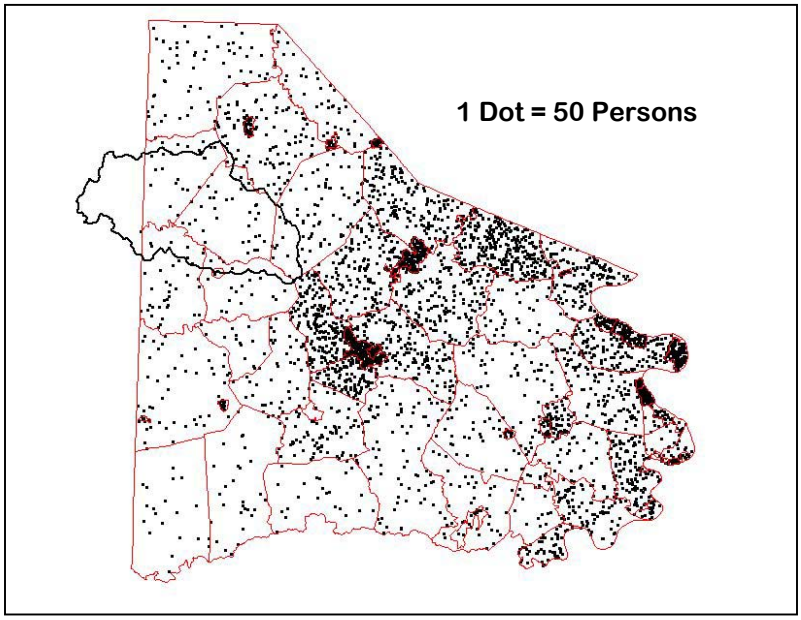


Source: SPC, 2001

Exploring the population of Washington County from 1990 to 2000 using the same census block data set reveals a similar, yet less severe, population loss countywide. Using the census block data for Washington County in 1990, the population of the county was 204,584. In 2000, census block data reveals a population of 202,897. Therefore, population loss in Washington County was only estimated to be 1,687 persons, or 0.8%. Acknowledging the limitations and margin of error in compiling census data, the countywide population loss can be interpreted as a zero loss/gain in population.

Figure 2-5 below is a population dot map, which depicts the populations and municipal boundaries in Washington County and also illustrates the Cross Creek Watershed boundary. Each dot in the map below represents 50 persons.

Figure 2-5 Population Density Map of Washington County



Source: SPC, 2001, 2002

Comprehensive Plan for Cross Creek, Independence, Hopewell and Mount Pleasant Townships

The 'Cross Creek Region Comprehensive Plan' (CCRCP) is an effort by the municipal members of the Cross Creek Regional Planning Group. This document is currently in the final stages of development. This document encompasses the area of each of these municipalities *entirely*, unlike this document, which plans for areas of each of these municipalities *that lie only within the Cross Creek Watershed.* (Please refer to Section 2-7, table 2-4 for an understanding of how many acres each municipality has within the watershed).

2.9.3 Future Development Considerations

The CCRCP has recognized the potential for development within the study area. The plan has identified 3 activities that may cause future development; they are-

- The Southern Beltway – The Southern Beltway will extend to the northeast of the watershed and may be a significant source of commercial and residential development in this area (Refer to Figure 2-6).

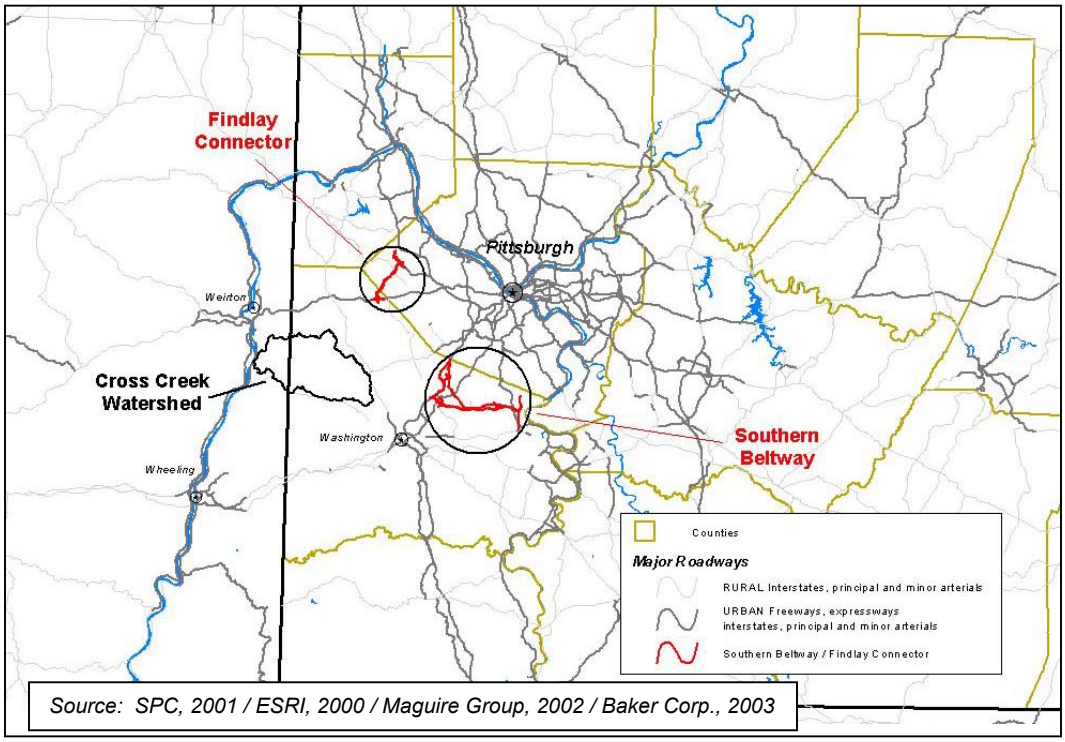
- Proposals to Improve State Route 50 – On more than one occasion, there have been proposals to widen SR 50 from its current two-lane capacity to a higher four-lane capacity through Washington County to Bethany, WV. Since SR 50 runs parallel with Cross Creek throughout the watershed, such a transportation improvement could significantly transform the current landscape (Refer to Map 4). However, this project is not listed on the Pittsburgh MSA metropolitan planning organization (Southwestern Pennsylvania Commission) 2001-2004 Transportation Improvement Project (TIPs) (See Section 2.8.1 and Table 2-5, 2-6).

- Pittsburgh's Urban Sprawl to the South – The CCRCP notes that portions of Washington County (i.e., Cecil and Mount Pleasant Townships) have experienced higher than average rates of development as a result of urbanization. For example, Mount Pleasant Township has seen an increase in the amount of building permit

applications and has recently approved the first phase of a three hundred and twenty unit planned residential development (PRD).

- The Findlay Connector – In addition to the 3 activities mentioned in the CCRCP, the Findlay Connector will extend the Southern Beltway to connect Route 60 at the Pittsburgh International Airport and Route 22 west of the McDonald exit, leading to potential commercial and residential development pressure for Cross Creek Watershed. Construction of the Findlay Connector began in Sept. 2002 and the project is scheduled for completion in fall 2005.

Figure 2-6 Regional Transportation Arteries



When comparing the figures depicting Cross Creek Watershed's proximity to urban arterial transportation routes (Refer to Figure 2-6), the water and sewage service extent in Washington County (Refer to Figure 2-7) and the location of Cross Creek Watershed in relation to urban population centers (Refer to Figure 2-8), it is evident that the Cross Creek Watershed is situated to experience development pressure in the future.

The Governors Report on Land Use Trends in Pennsylvania's 2000 indicates that Pennsylvania has lost a significant amount of farmland between 1992 and 1997. Unprecedented economic growth during the 1990's spurred this type of mostly suburban development. The continued pace of growth is uncertain, however, it is safe to say that development of land will continue at some rate in the Pittsburgh metropolitan region and that those areas prepared for growth will be able to benefit, not suffer, from such development.

Figure 2-7 Water & Sewage Service Extent in Washington County

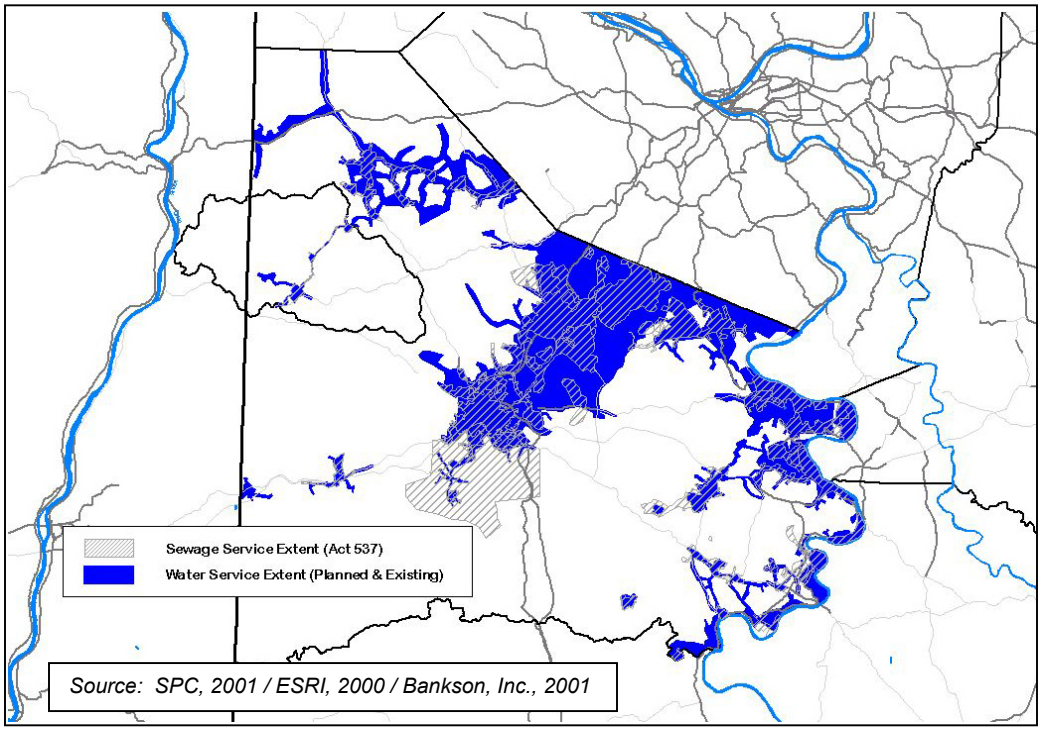
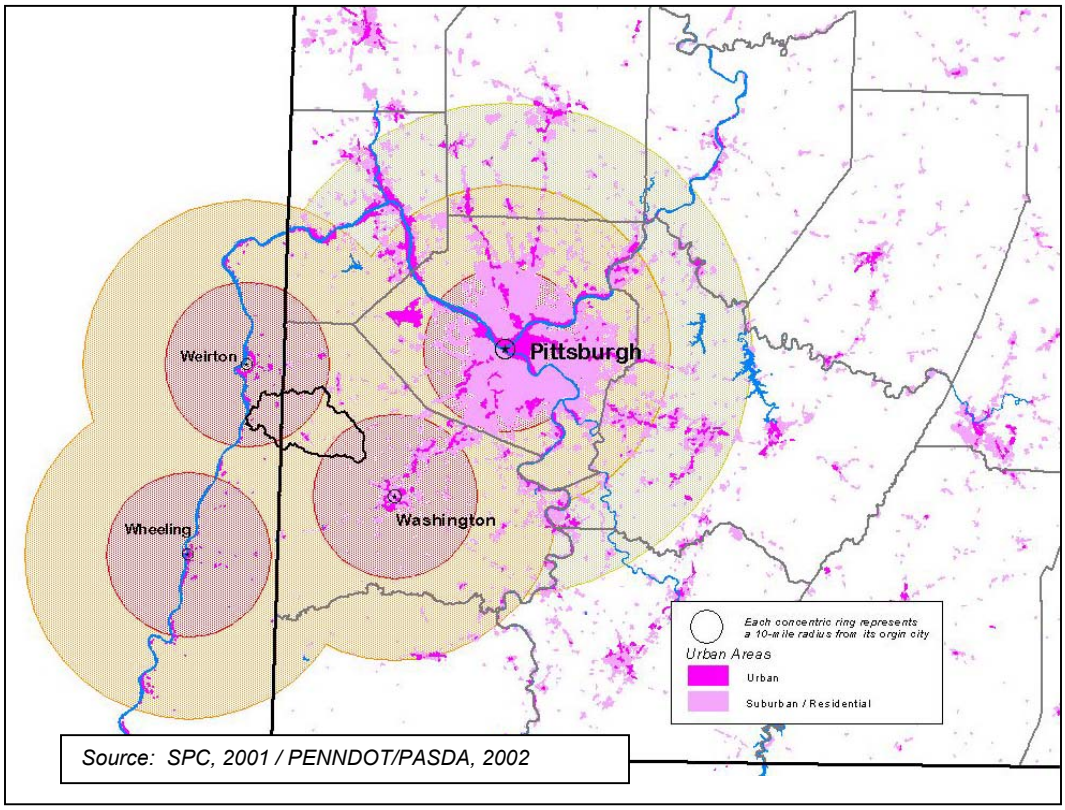


Figure 2-8 Location of Cross Creek Watershed in Relation to Population Centers



2.9.4 Intergovernmental Cooperation

One of the most important actions that must take place when planning for watersheds is for municipalities that share a common watershed to cooperate in the planning process. Seldom do municipal boundaries mirror watershed boundaries. However, what occurs upstream will affect the natural environment downstream. Therefore, it is important for local municipal officers and officials to recognize the common 'lifeline' the share and to engage in some kind of intergovernmental cooperation.

There are several kinds and degrees of intergovernmental cooperation promoted and recognized by the Commonwealth of Pennsylvania. The Pennsylvania Department of Community and Economic Development published the 'Intergovernmental Cooperation Handbook' (2002) to encourage and inform municipalities that share common resources and economic interests to work together. What follows is a reference of the various agreements and enabling legislation that municipalities can turn to in order to plan together.

Handshake Agreements – These are the most informal types of municipal cooperation. Handshake agreements are usually unwritten, informal and limited in scope.

Act 177 Agreements – Also known as the 'Intergovernmental Cooperation Law' (1996). Act 177 Agreements are also very broad in definition and must include; an enacted ordinance and must specify the details of the agreement.

Council of Governments (COGs) – COGs are a special kind of Act 177 agreements with additional, specific guidelines. COGs are general or multipurpose organizations established to enable a group of municipalities to work together on whatever programs are in their mutual interests.

Joint Authorities – The Municipality Authorities Act of 2001 (Act 22 of 2001) authorizes the creation of municipal authorities by tow or more local governments. Joint authorities are most often formed when major capital investments are required and were first enabled in the 1960's when the EPA began regionalizing municipal sewage treatment facilities. Joint authorities differ from Act 177 agreements mainly because joint authorities must be governed by authority board members appointed by the elected officials of the member municipalities.

Other Methods of Cooperation – The Commonwealth has enacted new legislations to augment intergovernmental cooperation in recent years. The two most relevant activities for the environmental protection of the Cross Creek Watershed are acts under the Pennsylvania Municipalities Planning Code (MPC) and the establishment of Environmental Improvement Compacts (EICs).

- *Planning* – Acts 67 and 68 (2000) of the MPC enable counties and municipalities to take more control of their local growth by planning together for both development and conservation of resources and the implementing of plans through cooperative agreements and consistent ordinances and actions. Article XI of the MPC 'Intergovernmental Cooperative Planning and Implementation Agreements' and Article XI-A 'Joint Municipal Zoning' also provide strong legislation for local communities to grow smarter and closer together. Some of the benefits municipalities can now share in enacted under Acts 67 and 68 (and Article XI) are;

    - Promoting the protection of rural resources
    - Promoting development in previously built-up areas
    - Taking advantage of funding incentives
    - Having greater input into state funding and permitting decisions
    - Addressing regional issues

- Allowing cost sharing
- Protecting against curative amendment lawsuits
- Authorizing Transfer of Development Rights across municipal boundaries
- Allowing Tax-base sharing across municipal boundaries
- Retaining local control

- *Environmental Improvement Compacts (EICs)* – Act 39 (1972) enables two or more municipalities to form an EIC in order to deliver one or more municipal functions. The advantages of an EIC over other types of cooperative agreements are;

    - An EIC must be created by referendum, not an acting governing body
    - The EIC board is elected by the citizens of the community, not participating municipalities
    - An EIC has corporate powers, including eminent domain
    - EICs have the power to fix and collect property taxes up to two mills.

As evident above, the Commonwealth now encourages and provides communities – whether within or across municipal boundaries – to plan together for their own future. If the rural character of the Cross Creek Watershed is valued by it's residents and is to be maintained, local residents and municipal officials should contact the PA Department of Community and Economic Development for technical assistance and funding opportunities.

3 Known Resources and Previous Studies

3.1 Water Resources

Available data regarding water resources in the Cross Creek Watershed were compiled and interpreted to formulate the following resource inventory. This inventory represents a snapshot of general and specific conditions occurring in the Cross Creek Watershed. By examining the resources and their limitations within the watershed, one can get a better perspective of the problems and opportunities that exist therein.

3.1.1 Wetlands

The wetlands in the watershed vary in size, complexity, and type depending on their location in the watershed. Palustrine wetlands include all nontidal wetlands dominated by trees, shrubs, persistent emergent plants, mosses, or lichens. Lacustrine wetlands include wetlands and deep-water habitats, which are depressional or dammed water bodies that are greater than 20 acres in size. Riverine wetlands include all wetlands and deep-water habitats contained within a channel, with two exceptions: 1) palustrine and 2) wetlands with ocean derived salts. Palustrine, lacustrine, and riverine wetlands are the dominant wetland type found within the project area. In order for an area to be considered a wetland, the area must satisfy three parameters. The area must have wetland hydrology (the presence of water), a dominance of hydrophytic (water-loving) vegetation, and hydric (wet/moist) soils.

The National Wetlands Inventory (NWI) is developed from aerial photography and denotes those wetlands that are either visible from aerial photography or can be classified from infrared photography as being a wetland. Limitations of the NWI, such as seasonal and weather variations, may leave many obvious and not-obvious wetlands from appearing in the inventory. There is not data presently available that is accurate or inclusive enough to determine the extent of the wetlands in the watershed. Natural wetland systems can be found throughout the project area along stream corridors. Wetlands serve many functions such as the passive treatment of AMD, sediment trapping, and nutrient filtering, providing wildlife and aquatic habitat, and controlling flood flows. There may be many wetlands not present on any published inventory.

Protection of wetlands is very important for the reasons listed above. When wetlands are eliminated, adverse results such as increased flooding downstream, increased stream pollution, erosion and sedimentation, and the elimination of fishing and other recreational activities may occur.

3.1.2 Floodplains and Flood Control Projects

The streams and waterways of the watershed contain numerous floodplains throughout the project area. GIS analysis indicates that approximately 1,278 acres of the watershed are flood prone. This data was acquired from the Federal Emergency Management Agency (FEMA) floodplain mapping and was analyzed by the consultant. These floodplains vary in size (width) and sinuosity (how much the stream and associated floodplain bends, turns, and meanders) as they relate to the specific stream and floodplain. The size and sinuosity of a floodplain is dependent on its relative location and proximity to the streams beginning, or headwaters. As a rule, the farther one travels up a streambed the smaller the size of the floodplain.

Floodplains are an important resource because they hold back storm flows, thus reducing destructive flooding downstream (Refer to Map 4). If development were to be restricted or eliminated from occurring within the floodplains, taxing capital investment costs due to expanding infrastructure (i.e., flood channels, levees, etc.) could be reduced or eliminated. This would also reduce the financial burden of maintaining the present structures located on

the floodplains. Additionally, floodplains are the areas along a stream where rich alluvial (stream placed) soils are to be found. Nutrients and organic matter are recycled and transformed into food by bacteria, fungi, and plants that then are passed on to animals. This is one reason why farmers utilize these floodplains as cropland. Floodplains also serve as fringe or buffer areas that transition from streams and rivers to upland areas. Floodplains provide important shading to stream habitat and connect these areas to wetland and upland areas. Much diversity in plant and animal life can be found here due to the amount of nutrient recycling. Floodplains are very fertile areas, thus, are an important resource to enhance and protect.

Flood protection studies completed by the Washington County Flood Control Commission in November 1995 and revised in January 2001, were reviewed for the Cross Creek Watershed. The flood protection studies noted two dams in the Cross Creek Watershed with Emergency Action Plans. These two dams are maintained by Washington County. Additionally, the two dams cost Washington County approximately $15,000 annually to maintain. The two dams are:

Dam PA 661, DEP # 63-83 - Dam PA 661 was designed and built under the Watershed Protection and Flood Prevention Act in 1979 (USDA, 1979). This 77 foot high and 855 foot long earthen dam is for Cross Creek Lake and it maintains a normal pool of 5,810 acre foot and has a maximum pool capacity of 11,200 acre foot. This dam is located along Cross Creek east of Avella, PA approximately 2 miles.

Benefits of this dam are related to flood control/protection and recreation. The flood control/protection benefits include the area between the Norfolk and Western Railroad and State Route 50. If a sudden dam failure were to occur, the area of inundation would include low-lying areas in Cross Creek and Independence Townships, thus the protection of these areas is a benefit. The potential for flooding exists from the dam downstream to Avella thru Browntown, and include other low-lying areas of Cross Creek to the Ohio River in WV. Additionally, flooding could cause a back up of flood waters in the North Fork of Cross Creek approximately 0.5 miles. This inundation area would affect approximately 635 residents, 250 homes, and 15 businesses at the time of the study in 2001. Recreational benefits of this dam include tens-of-thousands of visits by patrons annually (eco-tourism) in the form of boating, fishing, hunting, picnicking, nature observation, biking, and other passive activities. Wildlife habitat enhancement and preservation of local greenspace are additional benefits associated with this dam and the Cross Creek County Park (WCDPR, 2003).

Dam PA 662, DEP #63-87 - Dam PA 662 was designed and built under the Watershed Protection and Flood Prevention Act in 1983, is a single purpose structure, and is a dry dam (USDA, 1980). This 50 foot high and 470 foot long earthen dam maintains a normal pool of 599 acre foot and has a maximum pool capacity of 1,420 acre foot, and 79 acre feet of sediment storage. This dam is located along a tributary of the South Fork of Cross Creek east of Avella, PA north of Rae adjacent to Atlasburg Road.

Benefits of this dam are related to flood control/protection. The flood control/protection benefits include the area between the Norfolk and Western Railroad and State Route 50. If a sudden dam failure were to occur, the area of inundation would include low-lying areas in Cross Creek and Independence Townships, thus the protection of these areas is a benefit. The potential for flooding exists from the dam downstream to Avella thru Browntown, and include other low-lying areas of Cross Creek to the Ohio River in WV. Additionally, flooding could cause a back up of flood waters in the North Fork of Cross Creek approximately 0.5 miles. This inundation area would affect approximately 225 residents, 90 homes, and 8 businesses at the time of the study in 2001.

3.1.3 Lakes and Ponds

There are numerous ponds that are utilized mainly for cattle water supply, soil conservation practices, and fire insurance protection. One large lake, Cross Creek Lake, consists of 265 acres of the project area and is wholly within Cross Creek County Park. For more information on Cross Creek Lake, please refer to sections 3.1.4.1 and 3.4.1.2.

3.1.4 Water Quality

Most natural waters contain varying bicarbonate and carbonate compounds, originating from sedimentary rocks. The calcium bicarbonate content of freshwaters determines the pH or acidity/alkalinity balance (Allan, 1999). The more limestone that is associated with a stream, the better the stream is able to buffer against acidic water conditions. Thus, limestone geology can determine to what extent buffering to degraded streams occurs. The underlying geology of the watershed is made up of sandstone, shale, limestone, and coal.

The quality of water is important because it directly impacts chemical, physical, and biological processes that take place in streams. Human impacts to these parameters can indicate degraded water whereas conservation measures taken to make improvements can show the opposite. Surface water flows from land surfaces into drainage basins (via ephemeral, intermittent, and perennial streams) to the major tributaries until these streams meet Cross Creek. The quality of the water in these streams is directly related to the quality of the land from which it flows. Therefore, water coming from a commercial area will transport a different type of pollution versus water coming from a forested area.

3.1.4.1 Previous Studies

The Pennsylvania Fish and Boat Commission (PFBC) were consulted to review any environmental assessments of water resources within the Cross Creek Watershed that the PFBC may have completed. The PFBC has completed two assessments of water resources in the past decade. These include the *Cross Creek [820D] Management Report, Sections 02, 03* (December, 1993) and the *Water Quality and Fisheries Evaluation of Cross Creek Lake [820D]* (January, 1998).

Stream Assessment –
The *Cross Creek [820D] Management Report, Sections 02, 03* (December, 1993) noted that Cross Creek is a 37-kilometer (km) warm water stream flowing west to the Ohio River that flows through rolling farmland of western Washington County. The upper 24 km of Cross Creek is found in Pennsylvania before it passes into West Virginia. Land use in the watershed includes active and abandoned farmland, and extensive mining from Avella, PA downstream. Silt, acid, and metals from past land use activity was noted as negatively impacting the streams water quality. ***The purpose of this stream survey was to 1) update the Section 02 data from 1982, 2) conduct an initial survey of Section 03, and 3) update the management plan for each***.

Section 02:
The PFBC manages the 98.8-hectare (ha) Cross Creek Lake in the upper watershed, which is owned by the Washington County Department of Parks and Recreation. The lake is very productive and heavily utilized warm water fishery managed with Conservation Lake regulations. Section 02 of Cross Creek was initially surveyed by the PFBC in 1982 to document the status and develop a fish management plan for Section 02. This was to assist in determining the feasibility of a cold water draw from Cross Creek Lake to manage a salmonid (trout and salmon species) management plan. The recommendation was to maintain present water quality and the warm water fishery, and to work towards a cold-water release from the lake that would maintain salmonid species.

A total of twenty fish species were collected in 1993 from three sites in Section 02 utilizing a backpack electroshocker. The aquatic habitat at these two sites was noted as

good at site 01 and fair at site 02. Additionally, water quality was noted as being good in Section 02. The only recreational fishery noted in Section 02 is for suckers (White sucker [*Catostomus commersoni*] and Northern hog sucker [*Hypentelium nigricans*]) due to the transitional type of habitat (indicators included cold, cool, and warm water species). A final note was that water quality must be maintained and improved in Section 02 to sustain and protect the aquatic life and fishery in Section 03.

Section 03:
A total of nineteen fish species were collected with smallmouth bass (*Micropterus dolomieu*), sauger (*Stizostedion canadense*), rock bass (*Ambloplites rupestris*), and suckers (White sucker [*Catostomus commersoni*] and Northern hog sucker [*Hypentelium nigricans*]) available to provide angling recreational opportunities. The aquatic habitat in Section 03 was noted as good. Additionally, water quality was noted as being good, but AMD near Avella, PA was causing the pH to be lowered (7.4) in Section 03.

Stream Assessment Recommendations:

- Washington County Conservation District (WCCD) should continue to work with the community stakeholders to reduce turbidity and silt load from various land uses by utilizing streamside fencing and other Best Management Practices (BMPs).
- The elimination and/or reduction of AMD via abandoned mine land reclamation and passive treatment projects.
- Continued management of Cross Creek for improved water quality and naturally reproducing warm water fishery species listed above.
- Resurvey Cross Creek once water quality improvement measures have been completed.
- The PADEP Chapter 93 water use designation should be maintained as a High Quality – Warm Water Fishery for Section 02 and Warm Water Fishery for Section 03.

A copy of the report was to be provided to West Virginia Division of Natural Resources and Washington County Department of Parks and Recreation.

Cross Creek Lake Assessment -
The *Water Quality and Fisheries Evaluation of Cross Creek Lake [820D]* (January 1998) noted that the management of panfish populations and the panfish fishery was the focus of this evaluation. Cross Creek Lake is a productive, medium size, municipality owned (Washington County) reservoir that was constructed and filled with water in 1985. The study's evidence suggests that the high numbers of quality size panfish could be available for harvest from the fertile Cross Creek Lake environment. However, panfish abundance has apparently been suppressed possibly due to high exploitation. Creel surveys from 1986 to 1989 indicate that an over exploitation of the panfish fishery may have taken place. The creel survey data indicated that the majority of panfish species (Bluegill [*Lepomis macrochirus*], Redear sunfish [*Lepomis mcirolophis*], and Black crappie [*Pomoxis nigromaculatus*]) were harvested in a length range between 175 mm and 225 mm. A number of issues are related to panfish population suppression, which includes predation by a dense largemouth bass (*Micropterus salmoides*) population, exploitation by anglers, changes in fish production due to the reservoir's age, and panfish recruitment into the population. These issues are complex and inter-related.

Cross Creek Lake Assessment Recommendations:

- Panfish Special Regulations are deemed necessary to improve the panfish quality indices and fishery. The regulations are recommended for the species listed above. The regulations should have taken effect January 1, 1999.
- Conservation Regulations should remain in effect for all other fish populations at Cross Creek Lake.

- Redear sunfish should continue to be stocked on alternate years at 32/ha (80/ac).
- Continue stocking channel catfish annually at 8/ha (20/ac). It is imperative that channel catfish stocked be no longer than 200 mm due to the intense predator pressure exerted by bass.
- Saugeye should continue to be stocked annually at 16/ha (40/ac).
- Repeat trap net sampling to occur in 2000, 2002, and 2004 to evaluate the Panfish Special Regulations.
- A complete fish population, creel and angler opinion survey should be completed in 2004.

A copy of the Cross Creek Lake Assessment was to be given to the Washington County Department of Parks and Recreation.

Agricultural Non-Point Source Watershed Evaluation
The purpose of the Raccoon Creek and Cross Creek Watershed Assessment (1994) was to determine the extent and severity of agricultural non-point source pollution in these two watersheds. As a result of this assessment, nine (9) of the twenty-six (26) sub-watersheds in the project area were determined to be a high priority for conservation remediation activities (best management practices [BMPs]). The financial costs for remediating the identified problems were rendered as part of this assessment.

The Washington County Conservation District conducted the assessment with assistance from the Beaver County Conservation District, the U.S. Department of Agriculture, Soil Conservation Service (Washington and Beaver County offices), the U.S. Agriculture Stabilization and Conservation Service, and the Earth Systems lab located at the California University of Pennsylvania as authorized by the Bureau of Land and Water Conservation, Pennsylvania Department of Environmental Resources, with funding through the U.S. Environmental Protection Agency, Region III - Section 205 (j)(5) Clean Water Act program.

Assessment and Results
This assessment 1) Described the project area - location, major streams, population, topography and soils, geology, land use, agricultural land use, and stream corridor evaluation; and 2) Summarized Data – water quality records, on farm interviews, type of operation, water sources and water testing, types of conservation practices used, pesticide use, nutrient management plan(s), and livestock access to stream.

Analysis and Conclusions
Methodology for ranking and weighing sub-watersheds: Data collected from personal farmer interviews assisted in the ranking of priority sub-watersheds, along with the following four factors: 1) animal nutrient factor (25%), 2) watershed delivery factor (20%), 3) ground water delivery factor (15%), and 4) management factor (40%).

Authors of this assessment anticipated that sub-watersheds that had a higher amount of agriculture usage or activity would in the end receive a higher priority ranking. The results of the assessment held true to this anticipated result. Cross Creek Watershed's sub-basins received some of the highest priority ratings (Refer to Table 3-1). When comparing Cross and Raccoon Creek Watersheds, Cross Creek Watershed had three of the top four highest rated sub-watersheds, and four of the nine high priority sub-watersheds. Sub-watersheds that received a rating of 70 or higher were considered high priority areas, sub-watersheds with a rating of 48 to 69 were considered medium priority areas, and sub-watersheds with a rating of 47 or less were considered low priority areas. For this review of the assessment, only the high priority sub-watersheds have been discussed. Please review the actual assessment document for more specific information as related to the medium and low priority sub-watersheds.

Table 3-1
High Priority Rated Sub-Watersheds

Sub-basin	WD	AN	GD	MF	Total Score
Obney Run	15.26	25.00	11.69	31.02	82.97
North Fork	**17.76**	**18.00**	**14.57**	**32.20**	**82.53**
Cross Creek (Upper)	**20.00**	**16.00**	**14.50**	**31.19**	**81.69**
South Fork	**16.60**	**14.00**	**12.62**	**37.29**	**80.51**
Lower Cherry Valley	16.12	20.50	10.89	31.53	79.04
Burgetts Run	14.35	15.50	13.95	31.86	75.66
Upper Cherry Valley	14.21	11.00	14.70	33.56	73.47
Little Raccoon Run	11.86	11.00	15.91	34.24	73.01
Middle Fork	**16.38**	**11.00**	**11.30**	**33.56**	**72.24**

WD = Watershed Delivery AN = Animal Nutrient GD = Ground water delivery MF = Management Factor **NOTE: Cross Creek Watershed sub-basins are noted in bold** *Source: 'An Agriculutral Non-Point Source Pollution Watershed Evaluation For the Raccoon Creek and Cross Creek Watershed' prepared by the Washington County Conservation District*

The ranking of high priority streams indicate that conservation remediation activity efforts (i.e., BMPs – stream bank stabilization, pasture management plans, animal waste storage, stream bank fencing, etc.) in Cross Creek Watershed need to be concentrated initially in the headwater streams of the watershed. These streams are located in the eastern portion of the watershed. If these improvements were made, improved water quality would be observed through the length of Cross Creek and other tributary streams listed above.

Other Sources of Pollution

Other noted sources of non-point source pollution in the Cross Creek Watershed include abandoned mine drainage and municipal waste due to the lack of public sewage facilities.

Remediation and Implementation Plan

NOTE: In this section of the assessment (Section V), an error was noted during this review. Section V noted that eight high priority sub-watersheds needed to have a cost share program developed to institute nutrient/conservation plans in each. Section IV had noted nine high priority sub-watersheds. South Fork is the sub-watershed that is absent from Section V. It is presently not known if this error was carried through to the cost estimate and other areas of the assessment.

It was estimated that 7.6 staff years and $3+ million would be required to institute the recommended BMPs that include, but are not limited to.

- Nutrient management practices
- Erosion Controls
- Animal/pasture management practices and
- Stream bank stabilization practices.

Monitoring Program

A monitoring program was recommended after the completion of remediation activities to determine the effectiveness of the implementation program.

3.1.4.2 Macroinvertebrates in Cross Creek Watershed

Aquatic macroinvertabrates (aquatic insects) are collected in order to achieve various goals during research. Principally, these insects are used as bioindicators to assess the health of a stream. Maroinvertebrates can also be used in the research of ecological inquiry.

Macroinvertebrate samples were collected in three different locations in the Cross Creek Watershed. These samples were taken at each of these sites during the spring and fall of 2000, 2001, and 2002.

In order to analyze the macroinvertebrate data collected by the Cross Creek Watershed Association, a modified West Virginia Department of Environmental Protection (Save Our Streams) protocol was used. (Appendix A). Data constraints made this method the most appropriate mode of analysis. The data collected for the study allowed for limited analysis due to:

- Macros were not identified to the family and genus level which restricted the proper evaluation of taxa richness

- A reference stream-ranking site in the same or similar geological area was not established to set the ranking scale.

It should be noted that the diversity of macroinvertebrates is a major indicator of stream health. The data provided does provide a general indication of species diversity and creates a general indicator to monitor improvements or degradation to water quality in the watershed.

This system uses six different metrics to help assess water quality. These metrics are:

- Percent EPT: [(Ephemeroptera+Plecoptera+Trichoptera)/Total # insects]
- Taxa Richness: Total number of taxonomic groups found at a sample site
- EPT Richness: Total number of taxonomic groups falling under the orders EPT
- HBI Index: This is a modified version of the Hilsenhoff Biotic Index and is based on an organism's tolerance to organic pollution
- Percent tolerant taxa: This is the percent of organisms with an HBI value of eight or more
- Percent Dominance: Percent of the most numerically present organism

Please refer to Appendix A for the calculation of the above metrics.

After the metrics were calculated, a generic stream quality rating was calculated (Refer to Appendix A for the calculations). The rating levels used to describe a sample were: Excellent, Good, Marginal, and Poor. The results of this analysis are that, when considering aquatic macroinvertebrates, water quality is marginal to poor in the Cross Creek Watershed. This relatively low score is due mainly to the loss of macroinvertebrate habitat due to sediment inputs in the streams and nutrient enrichment. The concentrations of certain heavy metals (aluminum, iron, manganese) are high in all of the abandoned mine lands (AML) impacted stream reaches (Refer to Section 5 - Water Quality Results and Discussion). High concentrations of metals have been associated with a decrease in macroinvertebrate diversity. However, low macroinvertebrate counts can occur from other changes in the chemical and physical water quality of the streams, such as some of the other concerns documented throughout this plan. Refer to table 3-2 to view a summary of the index of biotic integrity results.

3.1.4.3 PADAP Title 25, Chapter 93 Designated Uses

According to the PADEP Title 25, Chapter 93 of the Pennsylvania Code, the streams in the Cross Creek Watershed are assigned the protected use of WWF downstream of the town of Avella and are HQWWF upstream of the water intake in the town of Avella (Refer to Maps 8 & 9).

The definition of the symbols and uses of Chapter 93 is broken down as follows:
Chapter 93.3 defines
'Protected Water Uses' (§93.3) as: "Water uses which shall be protected, and upon *which the development of water quality criteria shall be based*, or set forth…" (Emphasis added).

"Designated Uses" are defined as: Those uses specified in § 93.9a – 93.9z for each water body or segment *whether or not they are being attained*." (Emphasis added)

- The protected, or designated, uses for streams west of Avella Warm Water Fishes (WWF).

- The protected, or designated, use for streams east of Avella is High Quality Warm Water Fisheries (HQ-WWF).

In addition, the symbol HQ signifies the protected, or designated, use as on of High Quality Waters (HQ). HQ is Special Protection designated use, which means: "Surface waters having quality which exceeds levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water by satisfying §93.4b(a)".

§93.4b is titled 'Qualifying as A High Quality or Exceptional Value Waters'. In order to qualify as a High Quality Water, a surface water must meet one or more of the following conditions;
(1) Chemistry
(2) Biology

§93.4b(i) explains, "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

Management Unit 1 (MU1) exceeded the *minimum* standard concentration for aluminum 6 times during the 12-month sample period (6 occurrences out of 72 samples [6 sample sites @ 12 samples = 72], which is 8% of the time therefore exceeding the aluminum level in re: §93.4b). Manganese exceeded the *minimum* standard concentration 1 time during the 12-month sample period.

3.1.4.4 Point Sources

Point source forms of water pollution, those that discharge pollution directly into a stream or other water body, are regulated by state and federal environmental agencies. Anyone proposing to discharge industrial wastewater into surface waters (rivers, streams, and lakes) in Pennsylvania must receive an individual PADEP National Pollutants Discharge Elimination System (NPDES) permit or apply for coverage under an appropriate state-issued General Permit (PADEP, 1999).

The project area has five direct and indirect dischargers of state permitted treated wastewater into Cross Creek and its tributaries (PADEP, October 1998 and EPA EnviroFacts Website, 2001). These permitted facilities [www.epa.gov/enviro/html/ef_overview.html] (Refer to Table 3-2) industrial facilities, commercial businesses, and educational institutions. Please note that two sites from the PADEP Direct/Indirect Dischargers list (PADEP, October 1998) were not found on EPA's EnviroFacts website.

Table 3-2

PADEP Direct and Indirect Discharge NPDES Permit Sites

Facility (NPDES Permit #)
1. Narquini Service Station (PA0204633)
2. Mooney SR (PA0217263)
3. P and W Patch (PA0090913)
4. Avella School District – Junior High School (PA0029971)
5. Dorman SR (PA0216887)

***Bold** denotes those sites not listed on EPA Envirofacts Website

3.1.4.5 Total Maximum Daily Load

Numerous water bodies in Pennsylvania have been listed on the Clean Water Act (CWA) Section 303(d) list as impaired waters. Many of these water bodies will be required to have a Total Maximum Daily Load (TMDL) completed in order to identify and describe the cause of impairment. The objective of the TMDL program is to restore and maintain the beneficial uses (drinking water, recreation, aquatic life, etc.) of impaired or threatened water bodies. The program is authorized by and created to fulfill the requirements of Section 303(d) of the federal Clean Water Act. **The overall goal of a TMDL is to achieve the fishable and swimmable goal of the CWA**. A TMDL establishes the maximum amount of an impairing substance or stressor that a waterbody can absorb and still meet the water quality standards of the CWA, and allocates that load among pollution contributors. TMDLs are a tool for implementing State water quality standards. They are based on the relationship between pollution sources and in-stream water quality conditions (MDE, 2002)(www.mde.state.md.us/tmdl/index.html).

Cross Creek Watershed has not had a 303(d) assessment or a TMDL assessment completed.

At the time of this report, the PADEP has no scheduled timetable for the completion of a TMDL development or 303(d) assessment for the streams in the Cross Creek Watershed.

3.1.4.6 Non-point Sources

A non-point source form of water pollution is a source of water pollution that does not necessarily discharge water directly into a stream or other water body at one location or point. NPS water pollution is more difficult to regulate by state and federal environmental

agencies. This is because the source of pollution occurred prior to its regulation, or the problem is so widespread that regulators would have an impossible task trying to regulate it (e.g., abandoned mine discharges, nutrient effluent from farms, and pesticide residue from yards). Since the Cross Creek Watershed has not been assessed by PADEP in-regards to the 303(d) program, there is consequently no list of streams that have been found not to be in attainment (or meeting water quality standards for designated use) (PADEP, 2000).

3.1.4.7 Nutrient Enrichment

Nutrient Enrichment is a water quality problem that can be associated with the lack of agricultural conservation practices, leaking septic systems, and uncontrolled fertilizer application (e.g., golf courses, parkland, home gardens, etc.). Nutrient enrichment is a water quality problem in the Cross Creek Watershed. The dominant land cover type in the Cross Creek Watershed is agriculture at 50% and these areas, if not properly managed, can lead to increased nutrient enrichment problems. Streams impacted by nutrient enrichment exhibit eutrophic conditions. In these conditions, an increased amount of algae plant growth occurs until the algae die. The decomposition of the large amounts of algae biomass reduces oxygen levels in the stream and fish kills occur as a result. Nutrient enrichment problems can increase when agricultural conservation practices are not followed; buffers are not maintained along streams; no streambank fencing exists, or poorly planned/designed facilities are built; fertilizer/pesticides are not applied/used properly; and septic systems have not been built or maintained.

Both the lack of implementation of agricultural best management practices and the fact that a majority of the households have on-lot septic systems may lead or potentially cause increased nutrient enrichment of surface waters.

3.1.4.8 Habitat Modification

Habitat modification is a designation given to streams that are impacted due to one or more water quality parameters that alone or together degrade the habitat, stream structure, and the environment for benthic organisms and fish. Habitat modification is also one of the major water quality problems in the Cross Creek Watershed. Streams that exhibit habitat modification problems are affected by high stream flows, turbidity, erosion and sedimentation, residual chemical (e.g., road salts, oils, solvents, pesticides, etc.), and thermal pollution. The factors that lead to these types of water quality impacts are due primarily to areas with high developmental activities, high human population densities, high densities of residential/commercial/industrial structures, and transportation facilities. In general, habitat modifications occur due to a high degree of impervious surfaces (e.g., asphalt and concrete roads, structures, etc.).

Habitat modification problems increase when vegetated buffers are not maintained along streams, stormwater management facilities do not exist, or inadequately planned/designed facilities are built, stormwater and sanitary sewer discharges are mixed, and when stormwater flow comes from warm/hot surfaces and increases stream thermal temperatures. Model ordinances (i.e., stream buffer and forest resource ordinances) can assist a community in developing local planning tools that can reduce developmental pressures on natural resources, thus giving added protection to water quality and biological resources. Stormwater management involves the control of water that runs off the surface of the land from rain, melting ice, or snow (PADEP, 1997). High stream flows coming from developed areas only add to this water quality problem.

3.1.4.9 Sewage

Sewage is predominantly composed of wastewater, feces, and particulate matter. In a conventional sewage treatment plant, sewage is transported to treatment facilities via an underground network of sewage pipelines from residences and businesses. At the treatment plant the sewage is then put through primary and secondary (and in some cases tertiary)

treatment. This process removes solids, bacteria, viruses, and other waste material until the water is potable or drinkable for consumers. Thus, sewage or wastewater can be recycled for reuse by patrons of the water treatment authority.

On January 24, 1966, the Pennsylvania Sewage Facilities Act (Act 537, as amended) was enacted to correct existing sewage disposal problems and prevent future problems. To meet this objective, the Act requires proper planning in all types of sewage disposal situations. Local municipalities are largely responsible for administering the Act 537 sewage facilities program. To assist local municipalities in fulfilling this responsibility, the Department of Environmental Protection (DEP) provides technical assistance, financial assistance, and oversight.

Independence and Cross Creek Townships have initiated an Act 537 sewage facilities planning study undertaken by Bankson Engineering, Inc (Draft, 2001). This study area consists of the Cross Creek Valley Region of both townships, including the P & W Patch, Avella Heights, Avella, Browntown, Patterson's Mill, and Studa. The majority of the study area is found to be served by on-lot septic system. The Act 537 study noted that many of these on-lot systems are malfunctioning. On-lot septic systems are considered undesirable due to the soil quality, insufficient land, high water tables and population density.

This plan recommends the construction of a 537 municipal sanitary sewer system throughout the study area, with an anticipated completion date in the winter of 2004. Construction of a municipal sewage system is planned where there is pre-existing water service. Municipal water service and the new sewage service bisect the watershed. Starting at the southern portion of the watershed, water service runs parallel to SR 50, heading north through the town of Avella and continuing north on Cross Creek Road to the northern border of the watershed. Water service also extends west of Avella SR 4081 (Miller Road), where it ends near Meadowcroft Museum of Rural Life (Refer to Maps 3 & 5).

Table 3-3 lists the present implementation dates for all of the municipalities within the project area.

Table 3-3
Act 537 Municipal Plans Approval Status
for the Cross Creek Watershed

MCD Code	Municipalities	Plan Approval Date	Status
63925	Cross Creek Township	8/1/1992	–Updated 2001, currently under PADEP review
63936	Hopewell Township	3/10/1972	Plan Approval Date 1971 - 1976
63938	Independence Township	3/10/1972	–Updated 2001, currently under PADEP review
63939	Jefferson Township	3/10/1972	Plan Approval Date 1971 - 1976
63944	Mount Pleasant Township	6/27/1998	Plan Approval Date Less Than 5 Years Old
63953	Smith Township	6/27/1998	Plan Approval Date Less Than 5 Years Old
63953	Smith Township	6/27/1998	Plan Approval Date Less Than 5 Years Old

Source: http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqp_wm/537map/sw.htm

3.1.4.10 Abandoned Mine Drainage

Previous Studies:

Bureau of Abandoned Mine Reclamation (Richard Beam, primary author).
"Project Evaluation Report – Avella Southwest. Problem Area PA 0318, Independence Township, Washington County, PA". October 28, 1997.

The PA Bureau of Abandoned Mine Reclamation (PABAMR), under the direction of Rich Beam – hydrogeologist – produced a project evaluation report for the problem area known as PA 0318, southwest of the town of Avella. This problem area was assessed at the request of the Pennsylvania Fish and Boat Commission (PFBC) in order to determine if the problems could be addressed under the BAMR 10% Set Aside program.

Mr. Beam visited the site on two occasions in 1997 and collected water samples and flow measurements for analysis. The findings indicated that the majority of the discharges were associated with abandoned underground mining. The water quality analysis indicated that these discharges contained high concentrations of iron and aluminum and are net acidic. These indications revealed that surface restoration would provide little if any improvement to overall water quality.

A PABAMR engineer provided a conceptual solution to this problem area that involved reconstruction of the tributary as a series of ponds for the collection, retention, aeration and settling of the metal concentrations.

Another alternative discussed was the attempt of relocating the discharges with the construction of boreholes or excavations into the mine workings. This was concluded as not being a viable option. It appears that the geologic structure is not a significant controlling influence upon the location or quantity of the discharges, rather that the topography and condition of the abandoned underground mines are the predominate controls.

The conceptual solution posed by the PABAMR engineer was listed as best viable option in addressing this problem. The series of settling ponds within the channel would help in reducing metal loading into downstream portions of Cross Creek, but any discharges that exist beyond this proposed remediation would need to be addressed by other means.

Bureau of Abandoned Mine Reclamation. "Personal Correspondence between Pamela J. Milavec – Chief of BAMR Environmental Services Unit – and Mike Koryak of the US Army Corp of Engineers regarding a preliminary report on addressing problem area PA 0318, Avella Southwest". December 3, 1998.

P. Milavec and R. Beam of BAMR commented that the Cross Creek – Section 206 preliminary report discusses Priority 1 and 2 hazards at the subject site. BAMR identified only Priority 2 hazards and suggested any further reports should reflect this.

BAMR indicated that, while not opposing the USACE's feasibility study, it had not committed to being a local sponsor at this project site. BAMR's decision on any commitment would not be made until the completion of the preliminary feasibility study by the USACE. BAMR reiterated their concerns over the likelihood of success at addressing the acid mine drainage (AMD) problems at this site.

BAMR suggested preliminary feasibility investigations to be conducted concerning local landowner cooperation and potential resistance by regulatory agencies due to the stream relocation as a course of action for the USACE.

US Army Corp of Engineers. "Preliminary Restoration Plan, Section 206 Aquatic Ecosystem Restoration – Avella Southwest, Washington County, PA". March 2001.

The US Army Corp of Engineers produced a Preliminary Restoration Plan in March of 2001 to determine if further federal interest existed in remediation of the AMD at problem area 0318, Avella Southwest. This Preliminary Restoration Plan was supported by the PADEP, BAMR and the PFBC to determine if possible project funding could be provided by the Commonwealth's 10% Set Aside program or possibly under Title IV (the Abandoned Mine Land Trust Fund).

Five alternatives were considered in this preliminary investigation.

- Alternative 1 was the no action plan.
- Alternative 2 was one large project consisting of the construction of a large detention pond downstream with an adjacent passive system.
- Alternative 3 was a series of small detention ponds constructed within the stream channel designed to remove heavy metals from the stream via precipitation into the settling ponds.
- Alternative 4 suggested diverting the stream away from the discharges into a lined channel to bypass the AMD affected area.
- Alternative 5 considered a combination of alternatives 2, 3 and 4.

While conducting this assessment, it was discovered by the USACE that there existed a large network of Beaver Dams in the area. Apparently these natural settling ponds effectively capture a large percentage of the heavy metals associated with the AMD. As a result of this natural remediation, a surprisingly healthy and diverse biological community was discovered in Cross Creek; just 3.7 miles downstream of the Avella source, which suggests improved water quality.

Based on the discovery of the natural Beaver Dam network and the improved water quality evident by the aquatic invertebrate rapid assessment, this report concluded by recommending Alternative 1, the no action plan and that there is no federal interest in pursuing a project in this area.

3.2 Land Resources

Available data regarding land resources in the Cross Creek Watershed were compiled and interpreted to formulate the following resource inventory. By examining the resources and their limitations within the watershed, one can get a better perspective of the problems and opportunities that exist therein.

3.2.1 Geology

The Cross Creek Watershed is located in the Pittsburgh Low Plateaus section of the Appalachian Plateaus Physiographic Province. The Casselman, Greene, Monongahela, Washington, and Waynesburg Formations lie within the project area (Refer to Map 6). Cyclic sequences of sandstone, shale, claystone, limestone, dolomite, and coal are the exposed components of these geologic formations. The plateau is noted for its narrow and dissected, steep-sided valleys. These rocks are from the Permian and Pennsylvanian Age of the Paleozoic era. The headwaters of Cross Creek originate in rocks of the Washington Formation and then flow on the rocks of the Monongahela Formation (Ackenheil, 1968).

The Monongahela Group is a sedimentary sequence dominated by limestones and dolomitic limestones, calcareous mudstones, shales, and thin-bedded siltstones and laminates, all of which were deposited in a relatively low energy environment. Several coal beds are present. The only sandstone of significant thickness within the formation lies directly above the Pittsburgh coal complex. A major fluvial channel system, flowing north to northwest through what are now Greene and Washington Counties and extending directly through the Cross

Creek Watershed, deposited an elongated sandstone body up to 80 feet thick and several miles wide (Edmunds, et. al, 1999).

Water quality samples taken by the Washington County Conservation District throughout the Cross Creek Watershed and all of Washington County have indicated that the county experiences slightly elevated pH levels (alkaline), as well as recorded levels of elevated sulfates. This is due to the geology of the area that includes several formations of limestone and coal seams. Decades of human activity (such as mining), which further expose sulpher-containing rock strata, may contribute to the observed increased levels of sulfates

The overall geology of the Cross Creek Watershed consists of horizontal sedimentary rocks from the Pennsylvanian Period that were deposited between 286 and 320 million years ago. Throughout time, streams have dissected the area, eroding the plateau surface to the point that it is no longer evident, leaving hills, valleys and steep slopes (Refer to Map 6).

The surface geology revealed by this weathering consists of various types depending on elevation. The following groups and formations (from highest elevation to lowest) are:

- The Greene Formation
- The Washington Formation
- The Waynesburg Formation
- The Monongahela Group
- The Casselman Formation

3.2.2 Soils

The major soil associations found in the Cross Creek Watershed, as noted by General Soil Map for Greene and Washington Counties (USDA), indicate that there are three major soils in the study area. Table 3-4 below lists the soil names, their properties and relative location within the watershed.

Table 3-4

Soil Associations of the Cross Creek Watershed

Soil Association	Soil Description	Relative Soil Location
Dormont – Culleoka – Newark Association	Well drained to somewhat poorly drained, deep and moderately deep, nearly level to very steep soils, on hilltops, ridges, benches, hillsides, and flood plains.	Located along stream channel of Cross Creek from Cross Creek Lake to the WV border and extends slightly up the North and South Forks.
Guernsey – Dormont -- Culleoka Association	Moderately well drained and well drained, deep and moderately deep, gently sloping to moderately steep soils, on hill tops, ridges, benches, hillsides, and flood plains.	Located in the north – central portion of Cross Creek Township along the municipalities northeast border and in the southern portions of the watershed in both Hopewell and Mount Pleasant Township.
Dormont – Culleoka Association	Moderately well drained and well drained, deep and moderately deep, gently sloping to very steep soils, on hilltops, ridges, benches, and hillsides.	Located in all other portions of the watershed.

Source: USDA Soil Conservation Service (1980), WCCD Agricultural Study (1994)

3.2.3 Prime Agricultural Soils

There are 354 parcels of land considered to contain prime agricultural soils totaling 2,243 acres in the Cross Creek Watershed.

The types of prime agricultural soils found in Washington County are:

- Allegheny silt loam (AgB)
- Brooke silty clay loam (BoB)
- Culleoka silt loam (CaB)
- Culleoka-Upshur complex (CkB)
- Glenford silt loam (GdA and GdB)
- Huntington silt loam (Hu)

3.2.4 Agricultural Security Areas

The "Agricultural Area Security Law" (P.L. 128, no. 43 § 1) passed on June 30, 1981 is intended to protect and encourage the development and improvement of the Commonwealth's agricultural lands for the production of food and other agricultural products.

Agricultural Security Areas are land parcels of 250 or more acres used for the agricultural production of crops, livestock and livestock products under the ownership of one or more persons and designated as such by the procedures created by the Commonwealth. Once Agricultural Security Areas are established, farms may join with any size acreage.

Keeping agricultural security areas agriculturally productive benefits local residents by protecting and maintaining viable agricultural land for continued sustainability and maintaining a rural quality of life. Having a farm enrolled in an Agricultural Security Area protects the farmer from nuisance lawsuits; protect local governments from enacting ordinances, which would unreasonably restrict normal faming practice, normal farming practice not being defined as public nuisance, and eminent domain protection. The importance in maintaining agricultural security areas as agricultural land is also crucial to the agricultural economy of the Commonwealth. As Pittsburgh's urban influence expands into the countryside, it is vital that the residents of the Cross Creek Watershed recognize the importance of these resources. This means that local municipalities should critically evaluate any permits for non-agricultural development on lands protected under the Agricultural Security Area program and investigate any proposal to withdraw from the program by landowner in the hopes that a compromise can be reached.

Within the Cross Creek Watershed there are approximately 5,450 acres of land designated as Agricultural Security Areas. The municipal breakdown of these areas is in table 3-5 below (Refer to Map 8).

Table 3-5
Acres of Agricultural Security Areas by Municipality in the Cross Creek Watershed

Municipality	Acres of Ag. Sec/ Area by Municipality in Watershed (as of 2001)	Acres of Ag. Sec/ Area in Municipality	Acres of land under Farmland Protection in or intersecting Watershed
Cross Creek Township	2,871	3403.38	10.3
Hopewell Township	689	689	448
Independence Township	None in watershed	4458.2	162
Jefferson Township	820	820	85.8
Mount Pleasant Township	1,066	5132.53	207
Smith Township	5.5	4731.92	None
West Middleton Borough	None in watershed	None in Munic.	None
TOTAL	**5,451.5**	**19,235.03**	**913.1**

Source: Skelly and Loy, after SPC; CCWA

3.2.5 Farmland Preservation Areas

Farmland Preservation is a program where the Commonwealth of Pennsylvania purchases a permanent easement on agricultural lands to insure that the land stays in agriculture. This is a transfer of development right (TDR). The farmer receives a cash payment on a per-acre basis based on the different price between market value and agriculture production value.

In the Cross Creek Watershed, there are presently six farms enrolled in the farmland preservation program (Refer to Map 8).

3.2.6 Trash and Litter Problems

The Cross Creek Watershed has experienced illegal dumping and littering of trash in portions of the watershed. Like many rural areas in Pennsylvania, the watershed's remote settings and dirt road network provides many areas for people to dispose of their unwanted waste. Such waste varies from simple paper, metal, glass, plastic and demolition waste to automobiles tires and durable goods such as appliances.

Pennsylvania's 1988 Municipal Waste Planning, Recycling, and Waste Reduction Act (Act 101) established a goal of recycling at least 25 percent of the municipal solid waste stream by January 1, 1997. This goal has since been increased to 35 percent of the municipal solid waste stream by January 1, 2003. Act 101 also established curbside recycling mandates for municipalities according to population size. Initially, all municipalities with populations over 10,000 were required to provide curbside collection to their residents by 1991, and ultimately all municipalities with populations over 5,000, and a population density of greater that 300 persons/square mile, were required to provide curbside collection to their residents.

Act 101 established a recycling fund supported by a $2 per ton fee on all waste accepted at municipal waste landfills and resource recovery facilities in the State. The funds have been used for municipal recycling and planning grants, market development activities, education

and outreach, technical assistance, and waste processing and disposal feasibility studies. This fee, initially set to expire in 1997, has been extended until October 14, 2004.

3.2.6.1 Recycling Economic Study

The U.S. Recycling Economic Information (REI) Study is an unprecedented national study that demonstrates the importance of recycling and reuse to the U.S. economy. The REI study, commissioned by the U.S. Environmental Protection Agency and numerous states through a cooperative agreement with the National Recycling Coalition, used data from 1997-1999 and clearly shows what many have known for a long time, that "Recycling is Working."

In Pennsylvania, 3,247 recycling and reuse establishments employ 81,322 people, with a total annual payroll of nearly $2.9 billion. Total annual sales receipts for these industries were $18.4 billion (1999). The employment, payroll and sales numbers are more than any other state. Specifically, Pennsylvania leads in the glass, metals, paper, plastic and rubber industries.

In addition, Pennsylvania's recycling industries had an indirect effect on the economy, estimated at $1.8 billion, and had a direct impact on the tax base, contributing $305 million. The study also reports that 3.5 percent of Pennsylvania's jobs can be attributed to the recycling and reuse industry.

3.2.6.2 Recycling Programs

Pennsylvania recycled 32.6 percent of its municipal waste in 1999, diverting 3.8 million tons of reusable materials from the state's disposal facilities. Over 919 communities in Pennsylvania provide curbside collection programs, and including drop-off programs, Pennsylvania has 1,486 recycling programs, providing services to at least 85 percent of the state's residents. View the most recent (1999-2000) annual report of recycling activities at DEP's website.

3.2.6.3 Tire Recovery

In 1996, the State Legislature passed the Waste Tire Recycling Act (Act 190), establishing a system to survey and identify the Commonwealth's largest tire piles and providing $5 million over a five-year period for tire clean-up contracts, to be awarded through competitive bidding. Two million dollars of investment tax credits were also designated annually for companies investing in tire recycling equipment. This program expired in 2001.

DEP's goal is to remove and reuse all tires in the Commonwealth's abandoned scrap tire piles and to develop or expand markets for the continued reuse of newly generated tires. Over $3.2 million in Act 190 grants have been awarded to waste tire cleanup projects.

Also over $3.6 million in political subdivision grants, almost $1 million in waste tire recreation grants, and over $2.9 million in Waste Tire Industrial Market Development grants (no longer available) have been awarded.

Through the combination of these grant programs and targeted enforcement, the 36 million stockpiled tires identified in March 1997 have been reduced to 13 million tires. To see the most recent report (Winter 2000-2001) of DEPs waste tire activities visit DEP's waste tire website.

The Pennsylvania Department of Environmental Protection provided the above information regarding waste planning and state recycling efforts.

3.2.6.4 Junkyards

Automobile salvage yards, often referred to as 'junkyards' are not regulated as a land use that creates specific environmental hazards or sources of contamination. The exception to a junkyards land use regulation, at the state level, is if it is located within 1000 feet of a Federally funded highway (see 'Title 67' below). Therefore, it is important that local municipalities are proactive in zoning for the occurrence of junkyards. If municipalities anticipate the possibility of expanded junkyard land use in their jurisdiction, zoning regulations should explicitly address such land uses with measures and ordinances that encourage environmental monitoring and best management practices. Below are some Pennsylvania enabling legislations that regulate practices that may occur at junkyards.

The PADEP Wellhead Protection Program (WHPP) does list 'scrap and junkyards' as a commercial, potential source of ground water contamination (Section 5, Table 3 of the WHPP).

Title 67 (Transportation), Chapter 451 (Control of Junkyards and Automotive Dismantlers and Recyclers) of the Pennsylvania Code authorizes the control and/or maintenance of junkyards and automotive dismantler and recycler businesses and related activities within 1000 feet of the nearest edge of the right-of-way of any interstate or Federal aid primary highway.

Title 25 (Environmental Protection), Chapter 298 (Management of Waste Oil) does *not* explicitly regulate the junkyard as a land-use but does so implicitly by specifying general rules and procedures for 'persons or municipalities who generate, manage or handle waste oil that is being recycled' (§298.2) and defines one aspect of waste oil as '…waste oil generated by individuals who generate waste oil through the maintenance of their personal vehicles' (§298.1).

3.2.6.5 Washington County's Recycling Efforts

According to data published in Annual Act 101 Status Report for 1999-2000, Washington County ranks 21st among the 67 Pennsylvania counties in terms of recycling the basic standard materials (metals, paper, glass and plastic). This ranking correlates well with Washington County's ranking of 18th largest population among the 67 Pennsylvania counties. Together, these rankings are a good measurement of Washington County's recycling efforts.

According to the PADEP Recycled Materials Market Directory, Washington County has twelve listed facilities capable of receiving recyclable goods. Table 3-6 below is a list of these facilities with contact information and what types of materials each accept.

Table 3-6
Pennsylvania Recycled Materials Market Directory
for Washington County, PA

Facility	Address	Phone	Materials
Arden Landfill	P.O Box BC Washington, PA 15301	412-222-3272	Aluminum cans, glass (brown, clear, green) & steel cans
Brookman Auto Parts	4 Race Street Washington, PA 15301	724-222-4260	Aluminum cans, automotive batteries, ferrous metal & non-ferrous metal
Environmental Plastics	65 Hickory St. Washington, PA 15301	724-225-6610	HDPE (high density polyethylene), plastics (mixed, bottles/containers), PP (polypropylene) & PS (polystyrene)
General Alloys, Inc.	135 W. Wiley Ave. Washington, PA 15301	724-228-8654	Aluminum cans, aluminum scrap, AUTO PARTS: catalytic converters, radiators, brass, copper, non-ferrous metals
Penn-Pro Insulation	10 Wallace Lane Washington, PA 15301	724-222-6450	Old magazines, old newspaper
Polymer Grinding Recycling	Iron Street Canonsburg, PA 15317	724-228-6628	HDPE (high density polyenthylene), PET (polyethylene terephthalate), PP (polypropylene) & PS (polystyrene)
Riverside Iron and Steel Co.	770 E. Railroad St. Monongahela, PA 15063	724-258-9200	Aluminum cans, ferrous metal & non-ferrous metal
Simyaks Scrap Iron & Metals	131 Knob Road W. Brownsville, PA 15417	724-785-2990	Aluminum cans, ferrous metal, non-ferrous metal & steel cans
Washington City Mission	84 W. Wheeling St. Washington, PA 15301	724-222-8530	Clothing, computer print-out, old newspaper & white ledger
Westerns Recycling Center	333 Morganza Rd. Canonsburg, PA 15317	412-873-3200	Old newspaper

Source: PADEP, 2001

3.3 Biological Resources

Available data regarding terrestrial and aquatic biological resources in the Cross Creek Watershed were compiled and interpreted to formulate the following resource inventory. This inventory represents a snapshot of general and specific conditions occurring in the Cross Creek Watershed. By examining these biological resources and their limitations within the watershed, one can get a better perspective of the problems and opportunities that exist therein.

3.3.1 Wildlife

Available data regarding terrestrial and aquatic biological resources in the Cross Creek Watershed were compiled and interpreted to formulate the following resource inventory. This inventory represents a snapshot of general and specific conditions occurring in the Cross Creek Watershed. By examining these biological resources and their limitations within the watershed, one can get a better perspective of the problems and opportunities that exist therein.

3.3.1.1 Terrestrial

The Cross Creek Watershed contains a large variety of non-game (non-hunted) and game (hunted) wildlife species. The project area is generally located in a rural terrestrial habitat setting. In a rural setting, birds, mammals, amphibians, and reptiles generally inhabit and migrate between areas of large, wooded tracts, agricultural land, edge/fragmented habitat, riparian, and wetland habitat.

During the initial public meeting, a number of wildlife isssues were raised by stakeholders. These issues include the large population of white-tailed deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallopavo*), raccoon (*Procyon lotor*) and coyote (*Canis latrans*). In rural areas, white-tailed deer mostly cause crop damage. Wild turkey, coyote and raccoons can also cause problems for farmers in regards to crop damage or preying on livestock.

To assist in monitoring bird populations seasonally and annually, the Audubon Society established a Bird Circle centered in the Raccoon Creek Watershed. Bird circles assist in regional and national surveys of bird populations (both migratory and non-migratory species). With habitat fragmentation being a major cause in bird population decline, bird circles can assist in calculating increasing or decreasing populations of bird species.

3.3.1.2 Aquatic

Cross Creek and its tributaries are designated as a High Quality - Warm Water Fishery (Source to Avella Water Intake) and Warm Water Fishery (Basin – Avella Water Intake to PA/WV State border). The headwater area of Cross Creek has been designated as a High Quality Warm Water Fishery; this assignment designates this stream as one with “excellent quality waters…or other features that require special water quality protection” (Pennsylvania Code, Title 25, Chapter 93, 1994). The Pennsylvania Fish and Boat Commission lists Cross Creek Lake in Cross Creek and Hopewell Townships as being regulated under the Panfish Enhancement Special Regulations. These regulations are intended to increase the number, quality, and size of panfish through the use of minimum length limits on sunfish, crappie, and yellow perch. Additionally, the Big Bass Program – Special Regulations, regulates Cross Creek Lake. These regulations affect bass fishing on selected waters and apply to largemouth, small mouth, and spotted bass (PFBC, 2002).

3.3.1.3 Threatened and Endangered Species

Skelly and Loy submitted a request to the Pennsylvania Game Commission (PGC) to review the Cross Creek Watershed for any species of special concern. In a correspondence dated August 10, 2001, the PGC indicated that their office review of the project area determined

that, except for occasional transient individuals, **this project does not affect any endangered or threatened species of birds or mammals** recognized by the Pennsylvania Game Commission.

Skelly and Loy also submitted a request to the Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry to review the Cross Creek Watershed for any species of special concern in its Pennsylvania Natural Diversity Inventory (PNDI) information system. In a correspondence (PER NO: 11384) dated June 6, 2001, the Bureau of Forestry indicated that PNDI records show that **there are no occurrences of species of special concern known to exist within the project area**, including endangered, threatened, or rare species.

Also, according to correspondence dated May 14, 2001, the Pennsylvania Fish and Boat Commission (PFBC) conducted a Species Impact Review (SIR #6542) for rare, candidate, threatened and endangered species for the Cross Creek Watershed at the request of Skelly and Loy, Inc.

The SIR revealed that, at the time of the request, none of the fishes, amphibians or reptiles listed by the PFBC as threatened or endangered are known to occur at or in the immediate vicinity of the study area.

3.3.2 Vegetation

The Cross Creek Watershed is a part of the Western Allegheny Plateau (70) - Permian Hills (70a) and Monongahela Transition Zone (70b) Level III and VI Ecoregions of Environmental Protection Agency, Region 3. Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources; they are designated to serve as a spatial framework for research, assessment, management, and monitoring of ecosystems and their components. Ecoregions are directly applicable to the immediate needs of state agencies, including the development of biological criteria and water quality standards and the establishment of management goals for non-point source pollution (Woods et al., 1999).

The project area has a great diversity of vegetation, both native and exotic species. This diversity has occurred due to both natural (physiographic) and anthropogenic (man induced) reasons. The natural geology, soils, and climate support vegetation that survive and thrive in the region. In general, the Cross Creek Watershed area can be described as being located in the Cumberland and Allegheny Plateau Section of the original Mixed Mesophytic (medium moisture conditions) forest region.

The following are the dominant hardwood and softwood species in the region (Wagner, 1994):

- American Beech (*Fagus grandifolia*)
- Tuliptree (*Liriodendron tulipifera*)
- Basswood (*Tilia sp.*)
- Sugar Maple (*Acer saccharum*)
- Sweet Buckeye (*Aesculus octandra*)
- Red Oak (*Quercus rubra*)
- White Oak (*Quercus alba*)
- Eastern Hemlock (*Tsuga canadensis*)

The following is a list of some of the exotic invasive species in Washington County (Hart, East, and Wagner, 2002):

- Canada Thistle (*Cisium arvense*)
- Giant Hogweed (*Heracleum mantegazzianum*)
- Autumn-olive (*Eleagnus umbellate*)
- Common Reed (*Phragmaties australis*)
- Norway Maple (*Acer plantanoides*)
- Siltgrass (*Microstegium vimineum*)
- Japanese Barberry (*Berberis thunbergii*)
- Dames Rocket (*Hesperis matronalis*)
- Common Buckthorn (*Rhamnus cathartica*)
- Poison-hemlock (*Conium maculatum*)
- Multiflora Rose (*Rosa multiflora*)
- Tree-of-Heaven (*Ailanthus altissima*)
- Common Privet (*Ligustrum vulgare*)
- Purple Loosestrife (*Decodon verticillatus*)
- Japanese Knotweed (*Polygonum cuspidatum and sachaliense*)
- Japanese Honeysuckle (vine) (*Lonicera japonica*)
- Amur Honeysuckle (shrub) (*Lonicera mackii*)
- Morrow's Honeysuckle (shrub) (*Lonicera morrowii*)
- Tartarian Honeysuckle (shrub) (*Lonicera tartarica*)
- Garlic Mustard (*Alliaria officinalis*)
- Crown Vetch (*Coronilla varia*)
- Oriental Bittersweet (*Celastrus orbiculata*)The following are the dominant hardwood and softwood species in the region (Wagner, 1994):

An investigation performed by the Western Pennsylvania Conservancy (Wagner, 1994), produced a Natural Heritage Inventory for Washington County (Refer to section 3.4.1). The inventory describes the vegetative community as transitional in the Cross Creek Watershed. This is because many areas in Washington County are reverting from past land uses (e.g., agricultural use) to forest. However, this does not mean that these transitional areas are reverting to historical vegetative communities, instead a hybrid or mixed composition of species that includes native and exotic-ornamental species is developing.

3.4 Cultural Resources

Available data regarding natural, historical and recreational resources in the Cross Creek Watershed were compiled and interpreted to formulate the following resource inventory. This inventory represents the current status of these resources. By examining these cultural resources one can get a better perspective of the problems and opportunities that exist therein.

3.4.1 Natural Resources

The Natural Heritage Inventory (NHI) identifies natural heritage areas in order for the maintenance of their protection. The criteria for the continued maintenance of these biotic and ecological resources is based upon

1. The type of natural heritage site that the site is classified as
2. The ecological characteristics of each site
3. Evidence of past or present disturbance within the site
4. The potential effects of the land-use activities that surround the site.

According to the Washington County Natural Heritage Inventory (NHI), published January 1994 and the Southwestern Regional Commission's (SPC) geographic information system database, there are seven noteworthy natural features within the Cross Creek Watershed.

There are three types of features; one biological diversity area (BDA), 4 managed lands, and 2 geological features/ fossil locations (Refer to Map 5). Below is a brief description of each.

3.4.1.1 Biological Diversity Area (BDA)

Cross Creek Valley BDA

The Cross Creek Valley BDA is approximately 215 acres located 2.5 miles upstream of the Pennsylvania - West Virginia border (Refer to Map 5). Please refer to the following section (3.4.1.2 Managed Lands – State Game Lands 303) for some of the NHI's recommendations pertaining to the Cross Creek Valley BDA.

3.4.1.2 Managed Lands

State Game Lands 303

In total, SGL 303 are approximately 221 acres, with 86 acres of the game lands also being shared with the Meadowcroft Historic Area and 40 acres of the game lands being shared by the Cross Creek Valley BDA. Together, the Meadowcroft Historic Area and the Cross Creek Valley BDA intersect and share a combined 33 acres, leaving the total amount of state game lands that do not share any cultural or biologically sensitive area to be 128 acres. It has been recommended by the NHI that the shared 93 acres, especially the 40 acres of the game lands that is shared with the BDA, to be considered a Special Use Area where management would be limited to posting and hunting grounds. Any wildlife management pertaining to food plots or habitat modification could be practiced on those game lands located outside of the BDA (Refer to Map 5).

Cross Creek County Park

Cross Creek Park had its beginnings in 1967 when 2,500 acres of land were purchased during a four-year period. Since then Cross Creek Park has grown to become a 3,500-acre park facility that was officially designated a park in the mid-1980's after Cross Creek Lake was created as part of a local flood control project. The 60 foot deep, 258-acre Cross Creek Lake is the center of the park. Cross Creek Park is located between State Routes 50 and 844 in Cross Creek and Hopewell Townships east of Avella, PA (Refer to Map 5).

Land use adjacent to the park includes agricultural land, rangeland, and forestland. Cross Creek Park's activities center around a passive recreational theme as noted in the park master plan goal, *To develop a water-oriented park that supports fishing, hunting, boating, environmental education, multi-purpose trail use and camping, while maintaining a balance among the different types of park uses*. The center of these activities is located near the picnic and boat launch facilities. A number of primitive trails have been unofficially created by park users, and thus allow access to isolated areas. The park Master Plan (Pashek Associates, 2000) outlined potential park improvements that are listed below.

- Multi-purpose trails
- Camping/group reservation areas
- Additional shoreline fishing
- Nature center
- Expanded picnicking opportunities
- Improved boat launch
- Access to more areas of the park

These were then used to assist in creating the Cross Creek Park Master Site Development Plan four alternatives.

- The overall plan
- Nature Center and Picnic Area
- Boat Launch, Picnic Areas, and Trail Head
- Park Trail System and Signs

These four alternatives can be reviewed in more detail in the Washington County, Pennsylvania – Comprehensive Recreation, Park, and Open Space Plan with Master Plans for Mingo Creek and Cross Creek Parks (Pashek Associates, 2000).

Buffalo Creek Forest Game Project Lands
An Allegheny Power owned property consisting of 356 acres that is now managed under a cooperative agreement with the Pennsylvania Game Commission (Refer to Map 5).

Meadowcroft Museum of Rural Life
Meadowcroft Museum of Rural Life recreates the 1890s using historic structures relocated to the museum. Structures in the village include; the Pine Bank Covered Bridge, the one-room Miller Schoolhouse, a blacksmith shop, and the Fairview Southern Methodist Episcopal Church. Also located in Meadowcroft Museum of Rural Life are two log houses - the George Miller Log House and the Hamilton Log House (Refer to Map 5).

The goal of Meadowcroft Museum of Rural Life is to serve as an interpretive-education tool to inform visitors of local history through recreated 19th century rural Pennsylvania life.

3.4.1.3 Geological Features / Fossil Localities

Meadowcroft Rock Shelter
Considered by many to be one of the oldest known Native American archaeological sites in North America, the Meadowcroft Rock Shelter dates back 12,000 BP and may be as far as 17,000 BP. Re-discovered by Albert Miller in 1955, Meadowcroft Rock shelter was professionally excavated by Dr. James Adovasio from 1973 to 1978. Excavations continued under the direction of Dr. Adovasio (now of Mercyhurst College, Erie, PA) in 1994 (Refer to Map 5) (Donahue and Adovasio, 1990).

The site has yielded 20,000 artifacts including bone and stone tools, pottery shards and basketry fragments. The Meadowcroft excavation has also produced over 950,000 animal remains, 1.4 million plant remains and a remarkably complete archaeological record that spans all of North America's major cultural states.

The site is listed on the National Register of Historic Places (1978), has been designated as one of Pennsylvania's *Commonwealth Treasures* (1999) by the Pennsylvania Historical and Museum Commission, an *Official Save America's Treasures Project* (2001) by the National Trust for Historic Preservation, and has been nominated to become a National Historic Landmark (2002), and will eventually be nominated to become a World Heritage Site.

Currently, improvements are being made to the site to ensure the preservation of the archaeological resource and to make the site accessible to the general public. The adjacent Biologically Diverse Area (See Map 5 Cultural/Recreational) along Cross Creek will be maintained as a natural area to interpret the natural resources available to the first Americans. Efforts will be made to minimize stream bank erosion, littering and refuse dumping, damage from motorized vehicles and acid mine drainage. (Personal correspondence from Dave Scofield of Meadowcroft Museum of Rural Life to Richard Lehman of the Cross Creek Watershed Association).

The Meadowcroft Rock Shelter is located immediately to the north of State Route 4018 (SR4018) at a distance of less than a quarter of a mile from the roadside. According to the 2001 Annual Average Daily Traffic (ADT) volumes for the portion of SR 4018 extending west from the town of Avella to the West Virginia state line, it is estimated that 350 vehicles travel this section of road in front of the Meadowcroft Rock Shelter per day (PENNDOT, 2002).

Rea Block Field
This site includes a series of massive sandstone outcrops of the Greene Formation showing excellent examples of crossbedding of rock strata. Both the Meadowcroft Rock Shelter and the Rea Block Field were first noted by Geyer and Boles (1979, 1987) (Refer to Map 5).

3.4.2 Historic Resources

The Pennsylvania Historical and Museum Commission – Bureau for Historic Preservation publishes a list of eligible and listed properties for Historic Preservation. Washington County has 84 listed properties and 148 eligible properties. Within the Cross Creek Watershed there is one property listed on the National Register, that being Meadowcroft Rock Shelter in Cross Creek Township (listed 11/21/1978, key #001176). At this time, there are no properties listed as eligible for Historic Preservation and the Eldersville Historic District has been determined to be ineligible.

3.4.3 Recreational Resources

Recreational Resources in the Cross Creek Watershed include:

- The Cross Creek County Park and Lake
- Avella Sportsmen's Club
- Avella Library and Community Center
- Avella Train Station
- Avella School Complex
- Cross Creek Valley Senior Citizen Center
- Cross Creek fishery
- State Game Lands 303
- Raccoon Valley Sportsmen's Association
- Indian Run Golf Course
- Indian Springs Rod and Gun Club
- Polar Star Athletic Fields
  (Refer to Map 5)

4 Identification of Management Units

4.1 Rationale Used in Delineating Management Units

This plan divides the Cross Creek Watershed into three management units (Refer to Maps 7,8,9 & 10 and Figure 4-1 below). These units were determined by inspecting the land use practices (Refer to Maps 3 & 8), the recommendations put forth in the 'Washington County Conservation District Non-point Source Pollution Watershed Evaluation for the Raccoon and Cross Creek Watersheds' report, and the subsequent water quality problems identified by the water quality sampling analysis (Refer to section 5.3).

4.1.1 Three Sections of the Pennsylvania Portion of Cross Creek Watershed

4.1.1.1 Management Unit 1 - Upper Cross Creek Watershed (Eastern Portion)

Management Unit 1 is primarily agricultural and holds the largest portions of the agricultural security areas within the watershed.

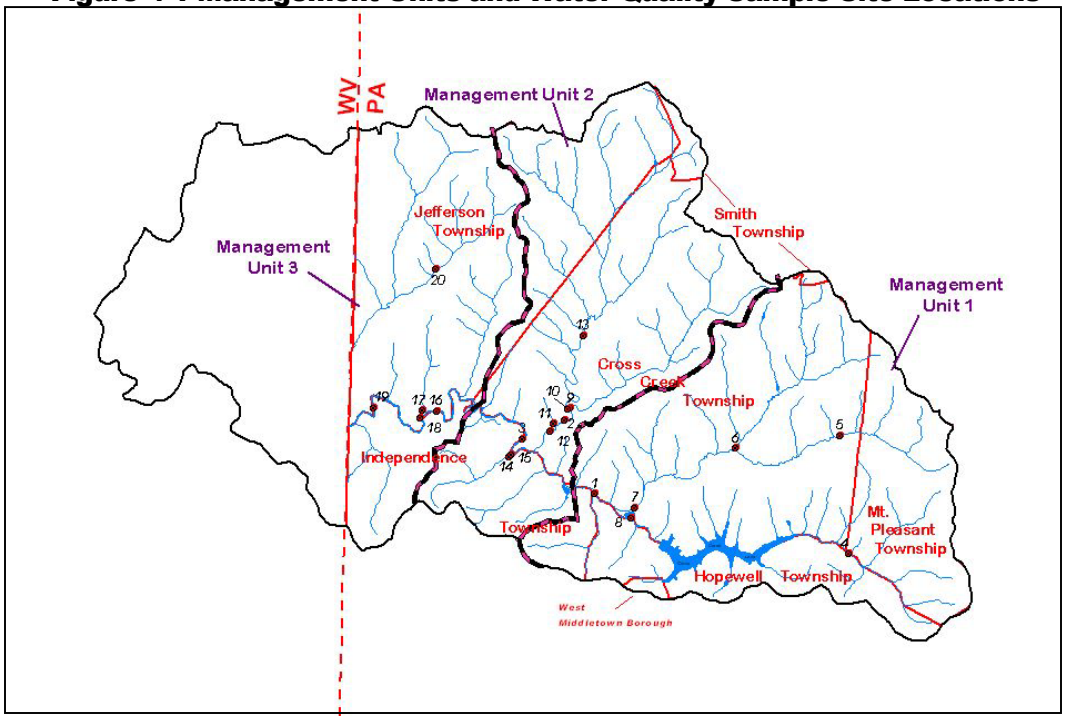
4.1.1.2 Management Unit 2 - Middle Cross Creek Watershed (Central Portion)

Management Unit 2 is also agriculturally active but is more developed, housing most of the population and infrastructure within the watershed. The North Fork sub-basin, primarily west of the creek, has been undermined for the Pittsburgh coal seam.

4.1.1.3 Management Unit 3 - Lower Cross Creek Watershed (Western Portion)

Management Unit 3 is forested and agriculturally active. This portion of the watershed has the largest concentration of steep slopes (>25%) and has historically been mined more than other portions of the watershed and continues to suffer from abandoned mine lands (Refer to Map 7).

Figure 4-1 Management Units and Water Quality Sample Site Locations



5 Water Quality Results / Discussion

5.1 Results of 12 Month Water Quality Sampling

In order to assist in the assessment of Cross Creek Watershed, the Cross Creek Watershed Association took water quality samples from several areas throughout the watershed. Twenty sampling sites (Refer to Figure 4-1 and Map 8) were designated using site association with problem areas in the watershed. Each sample site was tested monthly during twelve different months. The sampling season lasted for one year. The PADEP Bureau of Laboratories tested ten water quality parameters in each sample. These parameters are:

- Alkalinity
- Aluminum
- Hot acidity
- Iron
- Manganese
- Nitrates
- pH
- Phosphorus
- Sulfates
- Total suspended solids

The tested water quality parameters have a reporting limit associated with their specific chemical test. This reporting limit is the lowest limit to which the laboratory will report the results of a specific parameter. In the data set, when encountering these values, it should be noted that the true value of the sample might be less than the recorded value or not present. Refer to table 5-1 for the reporting limits. Because the reporting limit may signify that a chemical parameter is not present during a sample period, the occurrence values are only calculated using values both above the standard concentration (table 5-2) and above the reporting limits. The test for aluminum (Al) has a lower standard concentration than reporting limit. For this reason, Al will not be discussed in the results unless it is above this value (0.500 Mg/L). The reporting limits are general standards. Local geologic conditions may have an affect on particular readings. For a better understanding of the Cross Creek Watershed's geologic make-up, please refer to 'Section 3.2.1, Geology'

Table 5-1
Reporting Limits for Water Quality Parameters

Parameter	Reporting Limits Mg/L	Source
Total Aluminum	0.500	PADEP Bureau of Laboratories
Total Iron	0.300	PADEP Bureau of Laboratories
Total Manganese	0.050	PADEP Bureau of Laboratories
Nitrates	0.04	PADEP Bureau of Laboratories
Total Phosphates	0.01	PADEP Bureau of Laboratories
Sulfates	20.0	PADEP Bureau of Laboratories
Total Suspended Solids	3.0	PADEP Bureau of Laboratories

Water quality standards from various sources were used to call out specific parameters in the results section. Water quality standards were taken from 25 Pa. Code § 93.7 where applicable. When water quality standards for a particular parameter were not available in 25 Pa. Code § 93.7, EPA Water Quality Standards (1986) were used. Refer to table 5-2 for the standard concentrations and sources used for the results. Water quality data can be found in

Appendix A. *Italicized* data values signify results of tests that had exceeded time constraints before testing.

Table 5-2
Water Quality Standards

Parameter	Standard Concentration (Threshold) (Mg/L)	Source
Alkalinity	20< X <120	Pa. Code Title 25. Chapter 93.7
Aluminum	0.1	Pa. Code Title 25. Chapter 93.7 (1994)
Iron	1.5	Pa. Code Title 25. Chapter 93.7
Manganese	1.0	Pa. Code Title 25. Chapter 93.7
Nitrates	0.5	EPA Water Quality Standards
pH	6.0< X <8.5	Pa. Code Title 25. Chapter 93.7
Phosphate	0.1	EPA Water Quality Standards (1986)
Sulfates	250	Pa. Code Title 25. Chapter 93.7
Total Suspended Solids	No Criteria	----------

Sample Site CC-001 (SS1)

SS1 is located downstream of the intersection of the main branch of Cross Creek and South Fork. The rationale for the placement of this sample site is to observe the effect of the chemical condition in South Fork on main stem (downstream) water quality.

Nitrates in SS1 were found to be above the standard concentration (table 5-2) during 7 sample periods. The highest value for all of the sampling periods was 1.05 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Alkalinity at SS1 was found to be above the ideal range of 20 Mg/L to 120 Mg/L during 12 sample periods. The highest concentration for all of the sampling periods was 188 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-002 (SS2)

SS2 is located downstream from the intersection of Middle Fork and North Fork. The rationale for this sample site is to test water quality before the input of abandoned mine land (AML) discharge.

Nitrates in SS2 were found to be above the standard concentration (table 5-2) during 5 sampling periods. The highest value for all of the sampling periods was 0.88 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Alkalinity at SS2 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest concentration for all of the sampling periods was 202 Mg/L. This is causing a consistently basic pH within the sample area.

Sulfate concentrations at SS2 were found to be above the standard concentration (table 5-2) during 3 sample periods. The highest sulfate reading obtained was 272 Mg/L.

During 1 sample period, the concentration of manganese was found to be above the standard concentration of 1.0 Mg/L. This value was found at 117.0 Mg/L.

Sample Site CC-003 (SS3)

SS3 is located immediately downstream from the town of Avella and Browntown. The rationale for this sampling site is to test the water quality after the stream passes the area of the Browntown mine discharge.

Nitrates in SS3 were found to be above the standard concentration (table 5-2) during 4 sample periods. The highest value for all of the sampling periods was 0.85 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Alkalinity at SS3 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 194 Mg/L. This is causing a consistently basic pH within the sample area.

Sulfate concentrations at SS3 were found to be above the standard concentration (table 5-2) during 2 sample periods. The highest sulfate reading obtained was 286 Mg/L.

Iron concentrations at SS3 were found to be above the standard concentration (table 5-2) during 1 sample period. The highest Iron reading obtained was 1.7 Mg/L.

Sample Site CC-004 (SS4)

SS4 is located upstream of Cross Creek Lake. The rationale for this sampling site is to sample water quality conditions before the stream enters the lake.

Nitrates were found to be above the standard concentration (table 5-2) during 9 sample periods. The highest value for all of the sampling periods was 2.66 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Aluminum concentrations in SS4 were found to be above the standard concentration (table 5-2) during 3 sample periods. The highest value for all of the sampling periods was 0.873 Mg/L. Concentrations of aluminum that are greater than 0.1 Mg/L can cause an adverse effect on aquatic life.

Alkalinity at SS4 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 250 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-005 (SS5)

SS5 is located in the headwaters of South Fork. The rationale for this sample site was to assess the affects of land use practices before the stream enters the main stem of Cross Creek.

Nitrates in were found to be above the standard concentration (table 5-2) during 6 sample periods. The highest value for all of the sampling periods was 1.19 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Aluminum concentrations in SS4 were found to be above the standard concentration (table 5-2) during 2 sample periods. The highest value for all of the sampling periods was 0.708 Mg/L. Concentrations of aluminum that are greater than 0.1 Mg/L can cause an adverse effect on aquatic life.

Alkalinity at SS5 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 210 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-006 (SS6)

SS6 is located at the intersection of a major sub-basin of South Fork and South Fork itself. The rationale for this sample site is to determine the effects of the entire sub-basin on South Fork and its downstream components.

Nitrates in SS6 were found to be above the standard concentration (table 5-2) during 2 sample periods. The highest value for all of the sampling periods was 0.78 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Alkalinity at SS6 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 232 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-007 (SS7)

SS7 is located on South Fork downstream of Avella High School's treatment facility immediately upstream of the stream's intersection with the main branch. The rationale for this site is to determine impacts from the school on water quality in the area.

Nitrates in SS7 were found to be above the standard concentration (table 5-2) during 4 sample periods. The highest value for all of the sampling periods was 0.96 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Alkalinity at SS7 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 212 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-008 (SS8)

SS8 is located on the main branch downstream of Cross Creek Lake prior to its intersection with South Fork. The rationale for this sample site is to determine the effects of components of the watershed upstream of South Fork on water quality.

Nitrates in SS8 were found to be above the standard concentration (table 5-2) during 8 sample periods. The highest value for all of the sampling periods was 1.04Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse affect on aquatic life in a warm water fishery.

Manganese concentrations in SS8 were found to be above the standard concentration (table 5-2) during 1 sample period. The highest value for all of the sampling periods was 1.03 Mg/L. Concentrations of manganese that are greater than 1.0 Mg/L can have an adverse affect on an aquatic ecosystem.

Alkalinity at SS8 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 170 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-009 (SS9)

SS9 is located on Middle Fork prior to the streams intersection with North Fork. The rationale for this sample site is to test the water quality of Middle Fork before there are inputs from North Fork.

Nitrates in SS9 were found to be above the standard concentration (table 5-2) during 8 sample periods. The highest value for all of the sampling periods was 1.72 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse affect on aquatic life in a warm water fishery.

Aluminum concentrations in SS9 were found to be above the standard concentration (table 5-2) during 1 sample period. The highest value for all of the sampling periods was 0.9 Mg/L. Concentrations of aluminum that are greater than 0.1 Mg/L can cause an adverse effect on aquatic life.

Alkalinity at SS9 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 234 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-010 (SS10)

SS10 is located on North Fork, prior to the stream's intersection with Middle Fork. The rationale for this sample site is to test the water quality of North Fork and its associated streams.

Nitrates in SS10 were found to be above the standard concentration (table 5-2) during 3 sample periods. The highest value for all of the sampling periods was 0.78 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Sulfate in SS10 spiked above the recommended concentration of 250 Mg/L during four sampling periods. The other sampling periods remained below the threshold value; however, their sulfate values are consistently higher than the first nine sample sites in this section. The highest value for all of sampling periods was 400.8 Mg/L.

Alkalinity at SS10 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 234 Mg/L. This is causing a basic pH within the sample area.

Sample Site CC-011 (SS11)

SS11 is located on an unnamed tributary that is significantly impacted by mine drainage. This tributary empties into the North Branch of Cross Creek, downstream from the St. John the Baptist Church. The rationale for this sample site is to determine the effect of mine drainage seeps on water quality.

Sulfate concentrations in SS11 were found to be above the standard concentration (table 5-2) during 11 sample periods. The highest value for all of the sampling periods was 1147.8 Mg/L. Concentrations of sulfate should be no greater than 250 Mg/L.

Aluminum concentrations in were found to be above the standard concentration (table 5-2) during 9 sample periods. The highest value for all of the sampling periods was 2.37 Mg/L.

Concentrations of aluminum that are greater than 0.1 Mg/L can have an adverse effect on aquatic life.

Manganese concentrations in SS11 were found to be above the standard concentration (table 5-2) during 9 sample periods. The highest concentration found was 2.73 Mg/L. Concentrations of manganese should not exceed 1.0 Mg/L in order to maintain a healthy aquatic environment.

The concentration of iron in SS11 exceeded the standard concentration during 12 sample periods. The highest iron reading obtained was 22.9 Mg/L. Concentrations of iron should not exceed 1.5 Mg/L.

During 6 sample periods alkalinity levels were below the minimum standard concentration of 20 Mg/L. One sample period exhibited a concentration over the maximum range of 120 Mg/L. The lowest concentration of alkalinity was 5.4 Mg/L. The low alkalinity levels at this site are associated with dramatic decreases in pH levels. With an alkalinity concentration of 5.4 Mg/L, the pH during this sample period was 4.2. The lowest pH was 3.8 with an alkalinity of 0.00 Mg/L. High hot acidity levels were also noted during these periods of low alkalinity and acidic pH. The highest concentration of hot acidity at this site was recorded at 78.6 MG/L.

Sample Site CC-012 (SS12)

SS12 is located is located on the North Branch of Cross Creek downstream from where SS11 enters the North Branch. The rationale is to test water quality downstream from mine drainage discharges.

Nitrates in SS12 were found to be above the standard concentration (table 5-2) during 1 sample period. This value was 0.87 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Sulfate concentrations in SS12 were found to be above the standard concentration (table 5-2) during 8 sample periods. The highest value for all of the sampling periods was 884.3 Mg/L. Concentrations of sulfate should be no greater than 250 Mg/L.

Aluminum concentrations in SS12 were found to be above the standard concentration (table 5-2) during 5 sample periods. The highest value for all of the sampling periods was 12.8 Mg/L. Concentrations of aluminum that are greater than 0.1 Mg/L can have an adverse effect on aquatic life.

Manganese concentrations in SS12 were observed at high concentrations during 4 sampling periods. The highest concentration found was 2.72 Mg/L. Concentrations of manganese should not exceed 1.0 Mg/L in order to maintain a healthy aquatic environment.

Iron concentrations in SS12 exceeded the standard concentrations during 5 sample periods. The highest Iron reading obtained was 11.9 Mg/L. Concentrations of Iron should not exceed 1.5 Mg/L.

Alkalinity at SS12 was found to be above the ideal range of 20 Mg/L to 120 Mg/L in some samples and within the range for others. The highest value for all of the sampling periods was 194 Mg/L. In some instances, the alkalinity concentrations are 0.00 Mg/L and have very acidic pH concentrations. pH values at this sample site fluctuate between slightly basic to very acidic.

Sample Site CC-013 (SS13)

SS13 is located on North Fork near the headwaters at Cedar Grove.

Nitrates in SS13 were found to be above the standard concentration (table 5-2) during 3 sample periods. The highest concentration of nitrates observed in SS13 was 0.760. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Aluminum concentrations were found to be above the standard concentration (table 5-2) during 2 sample periods. The highest concentration of aluminum observed in SS13 was recorded at 0.59 Mg/L. Concentrations of aluminum that are greater than 0.1 Mg/L can have an adverse effect on aquatic life.

Alkalinity at SS13 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 238 Mg/L. This is causing a basic pH within the sample area.

Sample Site CC-014 (SS14)

SS14 is located downstream of several abandoned mine discharges at Browntown. The rationale for this sample site is to determine the effects of this cumulative discharge area on water quality before the intersection with Cross Creek.

Sulfate concentrations in SS14 were found to be above the standard concentration (table 5-2) during 12 sample periods. The highest value for all of the sampling periods was 2145 Mg/L. Concentrations of sulfate should be no greater than 250 Mg/L.

Aluminum concentrations in SS14 were found to be above the standard concentration (table 5-2) during 9 sample periods. The highest value for all of the sampling periods was 3.1 Mg/L. Concentrations of aluminum that are greater than 0.1 Mg/L can have an adverse effect on aquatic life.

Manganese concentrations in SS14 were found to be above the standard concentration (table 5-2) during 2 sample periods. The highest concentration found was 1.18 Mg/L. Concentrations of manganese should not exceed 1.0 Mg/L in order to maintain a healthy aquatic environment.

Iron concentrations in SS14 were found to be above the standard concentration (table 5-2) during 12 sample periods. The highest iron reading obtained was 60.5 Mg/L. Concentrations of iron should not exceed 1.5 Mg/L.

Alkalinity at SS14 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 222 Mg/L. The pH at this sample site remains consistently neutral throughout all of the sample periods.

Sample Site CC-015 (SS15)

SS15 is located on Cross Creek, upstream of the Browntown discharge. The sampling rationale was to test water quality before the stream runs through the AML discharge at Browntown.

Nitrates in SS15 were found to be above the standard concentration (table 5-2) during 4 sample periods. The highest concentration of nitrates observed in SS15 was 0.88 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Aluminum concentrations in SS15 were found to be above the standard concentration (table 5-2) during 1 sample period. The highest value for all of the sampling periods was 3.0 Mg/L.

Concentrations of aluminum that are greater than 0.1 Mg/L can have an adverse effect on aquatic life.

Sulfate concentrations were found to be above the standard concentration (table 5-2) during 1 sample period. The highest concentration of sulfate occurred at 263.5 Mg/L. Concentrations of sulfate should be no greater than 250 Mg/L.

Alkalinity at SS15 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The average alkalinity was 175.6 Mg/L and the highest value for all of the sampling periods was 190 Mg/L. This is causing a basic pH within the sample area.

Sample Site CC-016 (SS16)

SS16 is located on Cross Creek upstream of mine-impacted tributary at SS17. This site at Meadowcroft is testing the water quality of the stream before it runs through the AML discharge area.

Nitrates in SS16 were found to be above the standard concentration (table 5-2) during 3 sample periods. The highest concentration of nitrates observed in SS16 was 0.83 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Sulfate in SS16 spiked above the recommended concentration of 250 Mg/L during four sampling periods. The other sampling periods remained below threshold concentrations. The highest value for all of sampling periods was 304.4 Mg/L.

Alkalinity at SS16 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 182 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-017 (SS17)

SS17 is located in an AML impacted stream before it discharges into the Cross Creek main channel.

Nitrate concentrations were found to be above the standard concentration (table 5-2) during 1 sample period. The highest value recorded at SS17 was 0.61. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Sulfate concentrations were found to be above the standard concentration (table 5-2) during 9 sample periods. The highest value for all of the sampling periods was 501 Mg/L. Concentrations of sulfate should be no greater than 250 Mg/L.

Aluminum concentrations were found to be above the standard concentration (table 5-2) during 7 sample periods. The highest value for all of the sampling periods was 27.6 Mg/L. Concentrations of aluminum that are greater than 0.1 Mg/L can have an adverse effect on aquatic life.

Manganese concentrations were found to be above the standard concentration (table 5-2) during 2 sample periods. The highest concentration found was 3.17 Mg/L. Concentrations of manganese should not exceed 1.0 Mg/L in order to maintain a healthy aquatic environment.

Iron concentrations were found to be above the standard concentration (table 5-2) during 7 sample periods. The highest iron reading obtained was 78.4 Mg/L. Concentrations of iron should not exceed 1.5 Mg/L.

Sample Site CC-018 (SS18)

SS18 is located on Cross Creek. The rationale for this sample site is to determine the effect of the AML impacted stream from SS17 on water quality in the main branch.

Nitrates in SS18, during the majority of sampling periods, were below the threshold concentration of 0.5 Mg/L. However, two sampling period was found to be above a concentration that is conducive to maintaining the health of an aquatic ecosystem. The highest concentration of nitrates observed in SS18 was 0.84 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Sulfate in SS18 spiked above the recommended concentration of 250 Mg/L during 5 sample periods. The other sampling periods remained below threshold concentrations. The highest value for all of sampling periods was 338 Mg/L. Concentrations of sulfate should be no greater than 250 Mg/L.

Aluminum concentrations were found to be above the standard concentration (table 5-2) during 2 sample periods. The highest value for all of the sampling periods was 1.9 Mg/L. Concentrations of aluminum that are greater than 0.1 Mg/L can have an adverse effect on aquatic life.

Alkalinity at SS18 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 182 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-019 (SS19)

SS19 is located on Cross Creek upstream of the West Virginia border. The rationale for this sample site is to determine the cumulative effects of problem areas throughout the watershed on water quality.

Nitrates in SS19, during the majority of sampling periods, were below the threshold concentration of 0.5 Mg/L. However, two sampling periods were found to be above a concentration that is conducive to maintaining the health of an aquatic ecosystem. The highest concentration of nitrates observed in SS19 was 0.82 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Sulfate in SS19 spiked above the recommended concentration of 250 Mg/L during 4 sample periods. The other sampling periods remained below threshold concentrations. The highest value for all of sampling periods was 318 Mg/L.

Alkalinity at SS19 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The average alkalinity was 163 Mg/L and the highest value for all of the sampling periods was 176 Mg/L. This is causing a consistently basic pH within the sample area.

Sample Site CC-020 (SS20)

SS20 is located at the last easily accessible area in the Scott Run sub-basin. The sample site is the furthest site located upstream from the intersection with Cross Creek.

Nitrate concentrations were found to be above the standard concentration (table 5-2) during 6 sample periods. The highest value was recorded at 0.79 Mg/L. Concentrations of nitrates that are greater than 0.5 Mg/L can cause an adverse effect on aquatic life in a warm water fishery.

Alkalinity at SS20 was found to be above the ideal range of 20 Mg/L to 120 Mg/L. The highest value for all of the sampling periods was 234 Mg/L. This is causing a consistently basic pH within the sample area.

Cross Creek Watershed Chemical Water Quality Sampling Results

There are two evident impacts to chemical water quality in the Cross Creek Watershed. These impacts are eutrophication of streams (nutrient pollution), and high levels of heavy metals and sulfates in areas of high AML discharges. Nutrient loading is found frequently throughout the entire watershed; however, Management Unit 1 (MU1) exhibits the greatest amount of impacts due to heavy agricultural practices in the area. High concentrations of metals in the water are more significant when considering MU2. This is due to the abandoned mine lands in the area. The increased levels of heavy metals are cause for concern due to its detrimental effects on both aquatic life and humans (i.e. recreation, aesthetics, and health).

The following are sample sites with high concentrations of metals and/or sulfate due to AML impacts.

- SS11
- SS12
- SS14
- SS17
- SS18

Please refer to the water quality analysis section for further explanation of these water quality parameters.

5.2 Analysis of Water Quality Results

Explanation of Graphs

In order to assist in the understanding of the water quality data, two types of graphs (histograms) were used for each Management Unit. These graphs show the frequency, at which the water quality parameters discussed in the results section, occurred over the given standard concentrations as listed by Table 5-2. The first graph shows the frequency, at which, the entire Management Unit exceeds standard water quality concentrations, in essence, showing the "big picture". For example, Figure 5-1 represents MU1. When reading the bar labeled nitrates, the reader can see that nitrates occur above the standard concentration over 50% of the sample periods. This graph is using data from all of the sample sites in this Management Unit. The second graph shows this same information except that it shows this same frequency by sample site. Figure 5-2 shows all of the sample sites in MU1. If the reader wanted to visualize at which areas of MU1 high nitrate concentrations were most frequent, they would look to this graph to see that nitrates greater than the standard concentration occurred most frequently in SS1, SS4, and SS8.

Management Unit 1 (MU1)

The sample sites (SS) in this Management Unit are SS1, SS4, SS5, SS6, SS7, and SS8. Please refer to the results section and Appendix A for the concentrations of problematic water quality parameters at these individual sites. For specific standard water quality concentrations, refer to table 5-2.

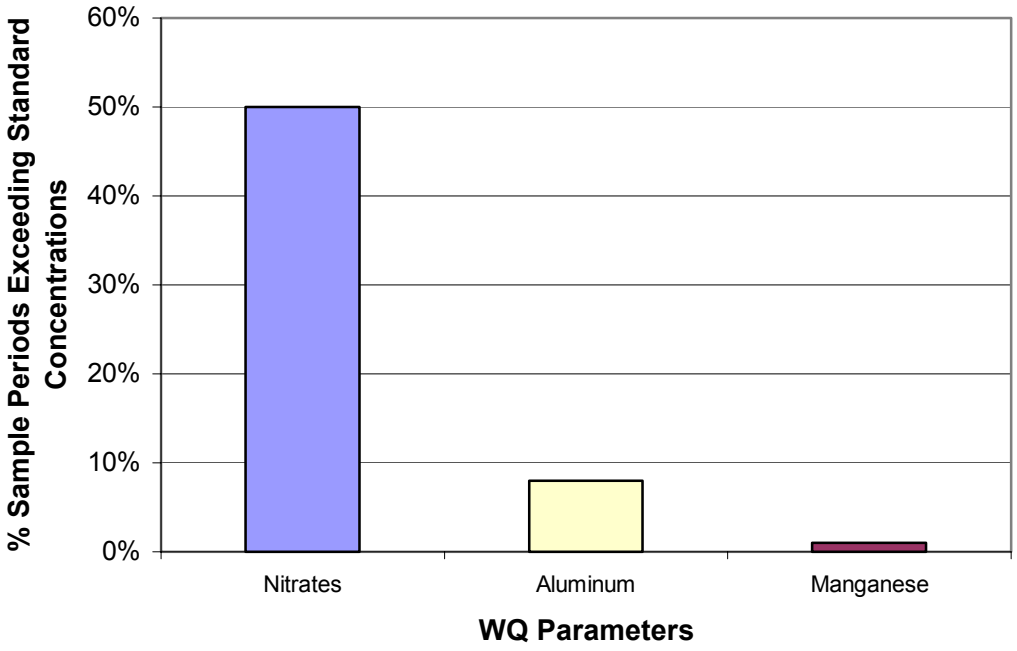
Most of the issues afflicting water quality in MU1 are resultant from agricultural practices in the area. The main issues in this Management Unit (in no particular order) are:

- Erosion
- Sedimentation

- Nutrient pollution (eutrophication)

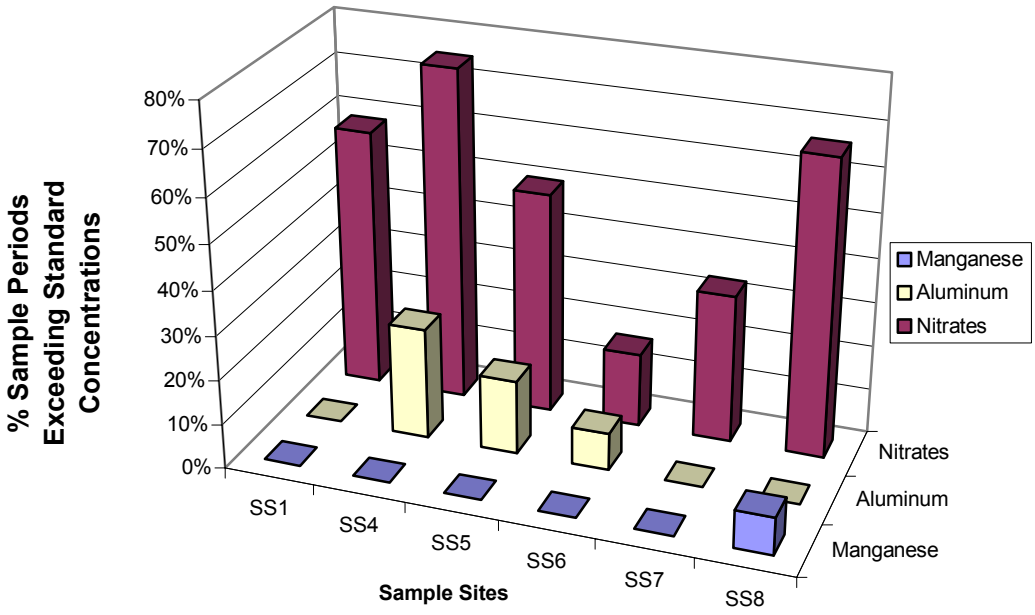
Figure 5-1 visually represents the number of sample periods, in which, the given standard concentration values for water quality in MU1 were exceeded. This figure was prepared by combining the results of the individual water quality parameters (for all of the sample sites) discussed in this section.

Figure 5-1 Frequency of Standard Water Quality Exceedence in MU1



This graph shows that nitrates, during more sample periods than any other parameter, exceed the standard concentration. This is possibly due to the agricultural land use and malfunctioning on-lot septic systems. Figure 5-2 shows this same information for individual sample sites within MU1.

Figure 5-2 Frequency of Standard Water Quality Concentration Exceedence for Individual Sample Sites in MU1



Concentrations of nitrates at all sample sites in this Management Unit demonstrated sample periods that were above the given standard concentration possibly due to agricultural activities and malfunctioning on-lot septic systems in this area of the watershed. This eutrophication of the streams in MU1 is causing an increase in phytoplankton (aquatic plant) activity in the water. This increase in photosynthetic activity is partially responsible for the high concentrations of alkalinity and basic pH in the streams. Nutrient pollution in MU1 can be attributed to direct nutrient inputs (manure) by livestock into streams, as well as, non-point agricultural nutrient inputs, including but not limited to manure and commercial fertilizer applications. Little to no vegetated riparian buffer zones amplify the runoff of nutrients into MU1 streams. SS1, SS4, and SS8 should be further evaluated because of their increased frequencies (in relation to the other sample sites) of above standard nitrate content (Figure 5-2).

Although heavy metals are not a primary concern in MU1, three of the sample sites exhibited above standard concentrations of metals in the streams at least once during the 12-month sampling period. SS4 (3 out of 12 samples), SS5 (2 out of 12 samples), and SS6 (one out of 12 samples) demonstrated episodes of increased total aluminum concentrations (Figure 5-2). Aluminum ions in the stream can come from industrial discharges, or from the wash water of water treatment facilities. Aluminum can also be found bound up in rocks and ores and released when disturbed by mining activities. Further investigation would be needed in order to ascertain the sources of this metal in the streams, as well as, its impacts on aquatic life.

SS8 yielded a concentration of manganese that was above the threshold limit during one sample period. Manganese is an important micronutrient to both plants and animals. The source of this manganese is undetermined and further inquiries should be made to pinpoint its source(s). Please see the personal correspondence from Mr. Dick Lehman in Appendix I.

Unregulated access of livestock to the stream results in stream bank erosion, which in turn generates considerable amounts of sediments that enter the stream channel. Shortages of

vegetated riparian buffer zones also contribute to the erosion of the stream banks, and increased sedimentation. Large amounts of fine sediments are, to a great extent, physically responsible for the loss of fish and macroinvertebrate habitat in the area.

Management Unit 2 (MU2)

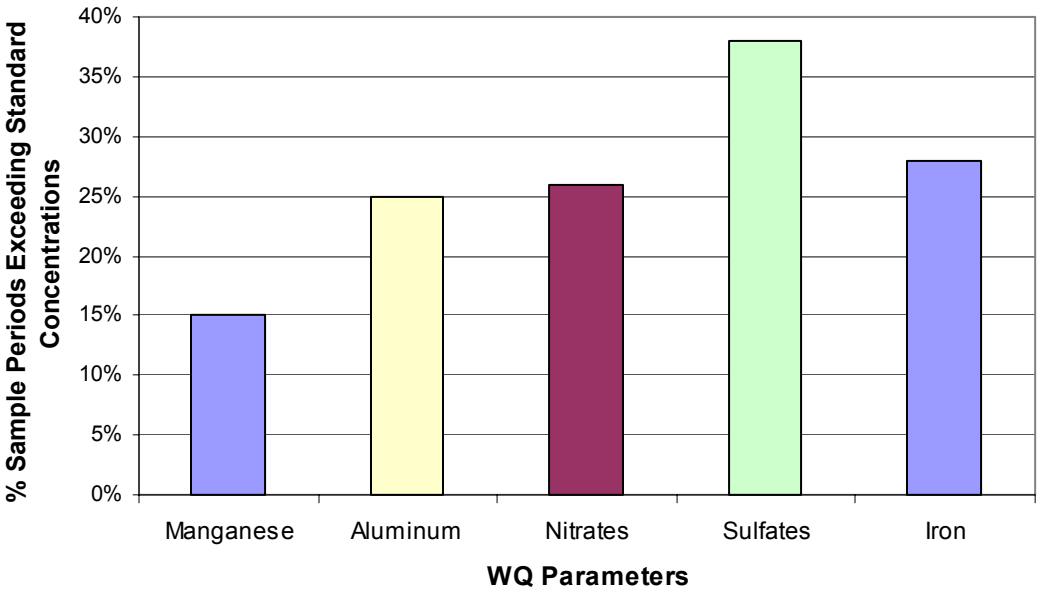
The sample sites (SS) in this Management Unit are SS2, SS3, SS9, SS10, SS11, SS12, SS13, SS14, and SS15. Please refer to the results section and appendix A for the concentrations of problematic water quality parameters at these individual sites. For specific standard water quality concentrations, refer to table 5-2.

The main water quality concerns in MU2 are those parameters associated with abandoned mine lands (AML), specifically acid mine drainage (AMD). There are five main issues of concern in this Management Unit (in no order of importance):

- Abandoned mine drainage (AMD) / AML
- Erosion
- Sedimentation
- Nutrient Pollution (eutrophication)
- Sewage

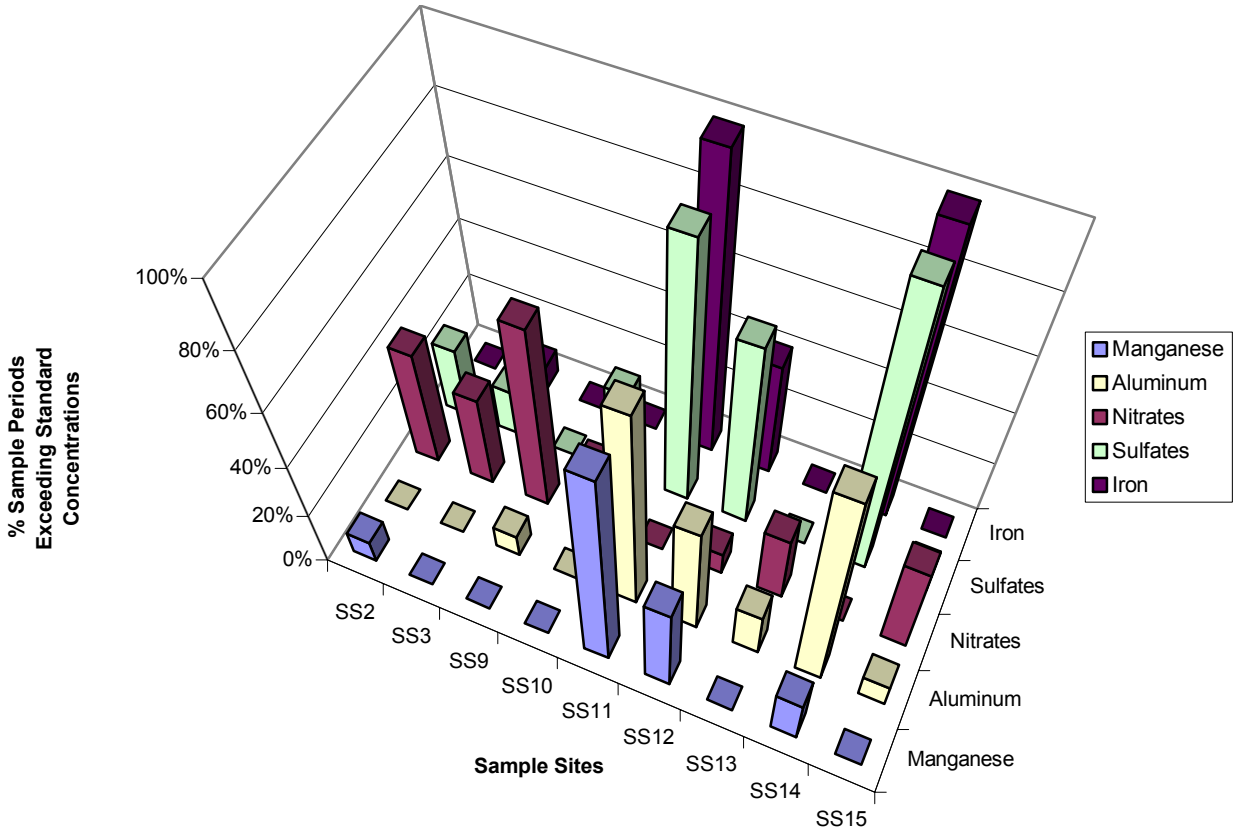
Figure 5-3 visually represents the number of sample periods, in which, the given standard concentration values for water quality in MU2 were exceeded. This figure was prepared by combining the results of the individual water quality parameters (for all of the sample sites) discussed in this section.

Figure 5-3 Frequency of Standard Water Quality Exceedence in MU2



This graph shows that AML impacts are much more significant in MU2 than in the previous Management Unit. Metals and sulfates from mine discharges are above the maximum allowable limits at much higher frequencies. Figure 5-4 shows this same information for individual sample sites within MU1.

Figure 5-4 Frequency of Standard Water Quality Concentration Exceedence for Individual Sample Sites in MU2



Because of past mining activities in MU2, there are above standard concentrations of certain heavy metals found at most sample sites in this MU. Concentrations of Iron (Fe), Aluminum (Al), and Manganese (Mn) were observed at high levels in some of the sample sites in this Management Unit. SS3, SS11, SS12, and SS14 had concentrations of Fe that were above the standard concentration. SS9, SS11, SS12, SS13, SS14, and SS15 had greater than standard concentrations of Al, while SS2, SS11, SS12, and SS14 exhibited greater than standard concentrations of Mn. The sample sites that had the most detrimental levels of heavy metals were those located downstream of mine discharge sites. These sample sites are: SS11, SS12, and SS14 (refer to the corresponding results section). The problems with heavy metals in SS12 stem mainly from upstream impacts from mine drainage - primarily, from the discharge documented from SS11 as well as other upstream discharges. SS12 is recording more impact from AMD than any other main stream sampling site. Additional monitoring would need to be completed to determine the intensity of affects from upstream discharges on SS12.

The presence of iron in the streams of MU2, especially at SS11, SS12, and SS14, can be problematic for both humans and aquatic life. Iron, when in contact with dissolved oxygen, will precipitate out of solution as a hydroxide ($Fe(OH)_3$) or occasionally as an oxide (Fe_2O_3). Both of these forms of iron will blanket the streambed and greatly decrease the amount of fish and bottom dwelling (benthic) macroinvertebrate habitat. Critically high concentrations of Fe can also be detrimental to cattle that may drink from these impacted streams. Iron also converts the stream water to an unattractive orange or red color, and gives the water a metallic smell and taste. This decreases the aesthetic and recreational values of streams in the area.

Levels of Manganese and Aluminum were highest in the sites near mine discharges. These metals are released into the streams when soil and rock materials are disturbed during mining related activities. Aluminum ions in the stream can also come from industrial discharges, or from the wash water of water treatment facilities. These metals can discolor stream water and cause an abnormal taste in drinking water. High concentrations of these metals in the drinking water can have possible adverse effects on human health.

The high alkalinity at the sample sites demonstrates the ability of these streams to buffer against change in pH by using carbonates. Normally, in areas impacted by AML, the pH of a stream will dramatically decrease causing acidic conditions. This buffering capacity can hide pH problems within the streams by maintaining a circumneutral pH. Gradually, the buffering capacity of a stream will diminish until the pH will remain at lethal levels for aquatic species. High flow events will also cause a temporary drop in pH downstream of mine discharge sites. SS12 demonstrates this drop in pH during a high flow event. This sample site exhibited episodes ranging from slightly basic pH levels to extremely acidic conditions. SS11 also had periods of acidic and circumneutral pH levels. During sample periods with high acidity concentrations and low buffer capacities the pH levels were very acidic. Please refer to the results section for SS11 and SS12 concentrations.

The sample sites where sulfate concentrations exceeded the standard concentration were SS2, SS3, SS10, SS11, SS12, and SS14. The concentrations in SS11, SS12, and SS14 were very high due to their proximity to mine discharge sites. The presence of sulfate in so many sites indicates the widespread impacts of AML throughout this management area.

Nitrate concentrations during most sample periods remained below the standard concentration in most of the sample sites. The spikes experienced by these sample sites are unexplainable in absence of flow-data measurements for each of the sample sites and periods. Further monitoring with flow measurements is recommended.

As in MU1, the unregulated access of livestock to the stream is a major cause of stream bank instability, erosion, and sedimentation. Urban buildup in this area also contributes to increased sedimentation of the streams. This area also lacks vegetated riparian buffer areas, thus increasing the aptitude for further stream bank erosion and nutrient runoff.

Management Unit 3 (MU3)

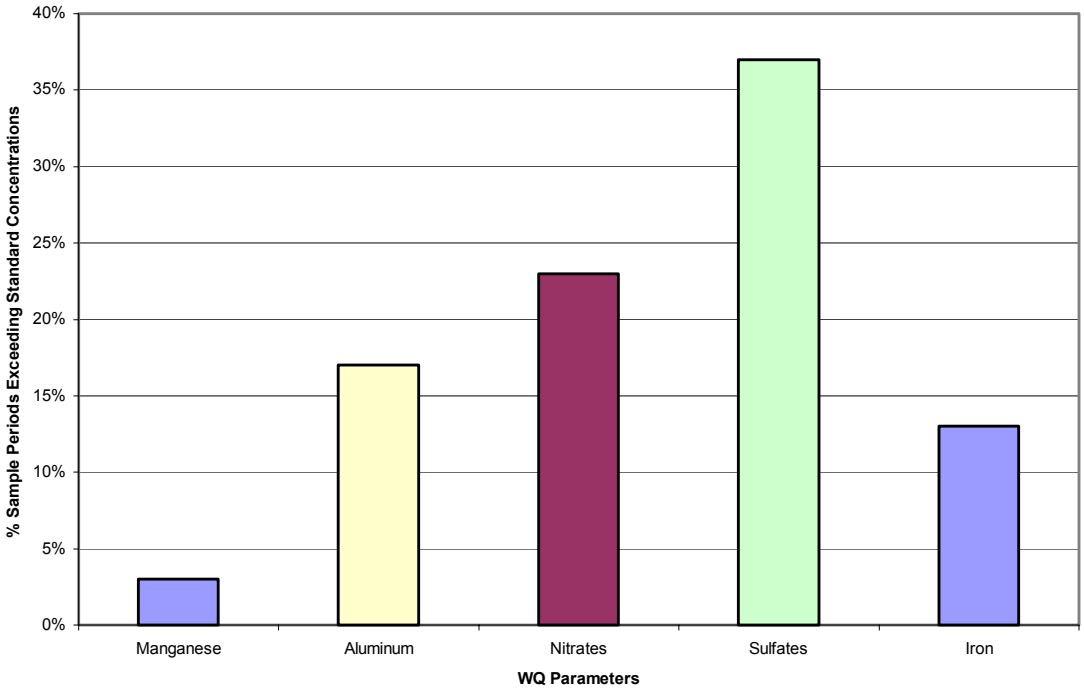
The sample sites (SS) in this Management Unit are SS16, SS17, SS18, SS19, and SS20. Please refer to the results section and appendix A for the concentrations of problematic water quality parameters at these individual sites. For specific standard water quality concentrations, refer to table 5-2.

MU3 has fewer serious concerns with water quality than do MU1 and MU2. The main concerns in this area are (in no particular order):

- Abandoned mine drainage (AMD) / AML
- Erosion
- Sedimentation

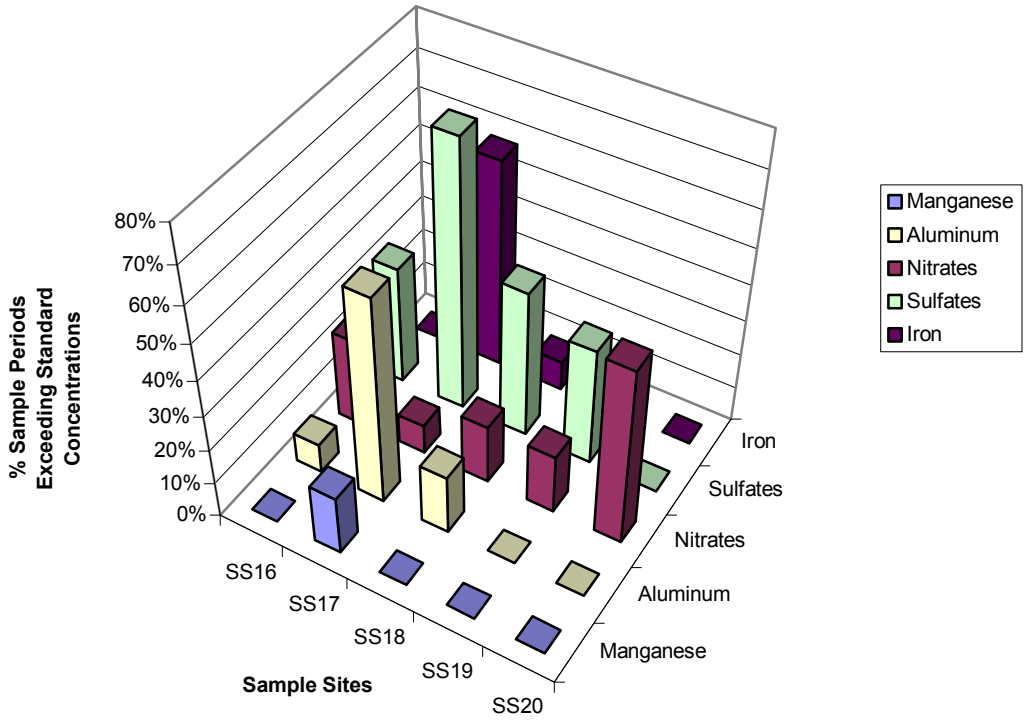
Figure 5-5 visually represents the number of sample periods, in which, the given standard concentration values for water quality in MU3 were exceeded. This figure was prepared by combining the results of the individual water quality parameters (for all of the sample sites) discussed in this section.

Figure 5-5 Frequency of Standard Water Quality Exceedence in MU3



This graph shows that heavy metals and nitrates occur at levels above the given standard concentration at similar frequencies in MU3. However, the results show that the concentrations of heavy metals occur at more damaging levels than the concentration of nitrate in the area. Figure 5-6 shows this same information for individual sample sites within MU1.

Figure 5-6 Frequency of Standard Water Quality Concentration Exceedence for Individual Sample Sites in MU3



The only 3 sample sites that showed greater than standard concentrations of heavy metals (aluminum and manganese) were SS16, SS17 and SS18, which are both located downstream of an AML impacted stream. These metals are released into the streams when soil and rock materials are disturbed during mining related activities. Aluminum ions in the stream can also come from industrial discharges, or from the wash water of water treatment facilities. These metals can discolor stream water and cause an abnormal taste in drinking water. High concentrations of these metals in the drinking water can have possible adverse effects on human health.

Sulfate concentrations were above the standard concentration in all of the sample sites except for SS20. These high concentrations of sulfate are caused by upstream AML inputs.

The pH in this management area remains slightly basic even with impacts of AML. This is because of the streams natural ability to buffer against fluctuations in pH as demonstrated by high alkaline concentrations in the stream.

6 Major Issues Affecting Water Quality in the Cross Creek Watershed

6.1 Introduction

The proposed remedial activities and cost estimates involve Best Management Practices (BMPs), Natural Stream Channel Design, and passive treatment technologies for the improvement of water quality from the above non-point source pollution sources.

Best Management Practices (BMPs) are a series of practices and management techniques designed to control point and non-point pollution. To rectify water quality pollution sources, BMPs can be utilized in a number of different ways in order to attain the desired effect.

Specific site remediation projects could utilize BMPs for corrective action. Many BMPs are relatively simple and inexpensive practice(s) and/or management techniques. BMPs involve conservation practices and management techniques that assist in improving water quality. The following issues are listed in no particular order and should be addressed equally, as each degrades water quality within the watershed.

6.2 Erosion and Sedimentation

6.2.1 Dirt and Gravel Roads

Cross Creek Watershed is a rural, agrarian area with many miles of dirt roads. There are approximately 183 miles of secondary roads in the watershed (SPC, 2001). According the Penn State Center for Dirt and Gravel Road Studies, of these 183 miles, over 27 are dirt or gravel roads (2001). This data is from the Annual Summary Report of the State Conservation Commission. The State Conservation Commission compiles the dirt and gravel road data from information provided by the county conservation districts.

Using this data in conjunction with the enabling legislation (Section 9106 of the PA Motor Vehicle Code) and all of the resources provided by the Dirt and Gravel Road Maintenance Program of 1997, Map 8 identifies all of the dirt and gravel roads in the watershed and all dirt and gravel roads currently earmarked for the Dirt and Gravel Road Maintenance Program.

The Dirt and Gravel Road Maintenance Program earmark those dirt and gravel roads that present a potential for sediment discharges to streams. The following BMPs (i.e., grade breaks) and cost estimate (Section 7.2.1) by linear foot provides for enhancement efforts as well as potential funding opportunities and grant applications. Also see Appendix for technical documentation provided by the Penn State Center for Dirt and Gravel Road Studies concerning the construction and maintenance of grade breaks and French mattresses (drains).

General Road Maintenance BMPs: Roads and their associated cut and fill surfaces are major sources of excess sediment discharge to channels in most watersheds. Fine sediments adversely affect aquatic ecosystems by increasing stream turbidity, by filling in fish-holding habitat, by covering or smothering fish-spawning gravels, disrupting macroinvertebrate communities, and by modifying the chemistry of streams by introducing nutrients and salts associated with the sediments. Excess sediment also contributes to lateral channel erosion and migration, which further impacts stream habitat.

Unpaved roads should be inspected on a regular basis and after large storms. Roadway surface maintenance procedures and drainage controls should be implemented to minimize sediment yield to adjacent streams. Basic surface maintenance procedures for unsurfaced

roads involve the use of proper grading or blading techniques, the stabilization of cut and fill slopes, the installation of improved road drainage facilities, culvert maintenance, and other techniques (SDTDC 2000, Weist 1998, and EPA 1992). Road fills at stream crossings should be well defended from erosion with stacked rock, rip rap, or vegetation. Proper management of roadside ditches and road runoff is also required for paved roadways. The preservation or creation of wide, vegetated riparian buffers can be very effective at protecting streams from road drainage and sediments. BMPs found below can be used to improve erosion and sedimentation problems associated with dirt and gravel roads.

Culvert Under Dirt Road

Stream Bank Erosion as a Result of Undersized Culvert

Left: Erosion and sedimentation is not only associated with the runoff from the dirt and gravel roads. Sometimes structural deficiencies, such as the diameter size of this culvert in relation to the stream width, can cause damage to streams (photo, top left).

On the top photo, the square highlights the culvert, which seems to be inadequate to support the high flows that occur in this stream. When high flows do occur, the water is not only compacted in a tighter area due to the size of the culvert, it's velocity increases due to this compacting and unrestricted passage.

What results is a rapid influx of water into a stream channel that is not able to handle the flow caused by this increased velocity and as a result, high-bank erosion occurs where the water strikes the outer bank (photo, bottom left).

Erosion and Sedimentation BMPs: The following permanent and temporary vegetative and structural BMPs can assist in reducing water pollution to developing areas (CH2MHill, 1998). The BMPs are described in further detail in Section 8 of the Pennsylvania Handbook of Best Management Practices for Developing Areas that can be purchased through the PA Association of Conservation District. http://www.pacd.org/products/bmp/bmp_orderform.htm, (CH2MHill, 1998).

- **Protection, Block and Gravel**
- **Inlet Protection, Excavated Drain**
- **Inlet Bioretention**
- **Constructed Treatment Wetland**
- **Critical-Area Planting**
- **Diversion**
- **Energy Dissipator**
- **Filter Bag**
- **Filter Strip (Level Spreader - Alternative BMP)**
- **Grass Swale**
- **Infiltration Trench & Dry Well (Dry Well, Below-Grade Detention**
- **Basin, Seepage Bed/Recharge Bed - Alternative BMP)**
- **Inlet Protection, Fabric Insert**
- **Interim Stabilization**
- **Lined Channel**
- **Outlet Stabilization Structure**
- **Permanent Vegetative Stabilization**
- **Permeable Paving System**
- **(Seepage Bed or Recharge Bed - Alternative BMP)**
- **Pond, Dry**
- **(Below-Grade Detention Basin, Dry Well or Detention Basin - Alternative BMP)**
- **Pond, Wet (Detention Basin - Alternative BMP)**
- **Portable Sediment Tank**
- **Riparian Corridor Management**
- **Riparian Forested Buffer**
- **Rooftop Runoff Management**
- **Sand Filter, Closed**
- **Sand Filter, Open**
- **Sediment Basin**
- **Sediment Trap**
- **Silt Curtain**
- **Silt Fence**
- **Slope Drain (Chute - Alternative BMP)**
- **Stabilized Construction Entrance (Tire Cleaning Strip – Alternative BMP)**
- **Straw Bale Barrier**
- **Stream Bank Stabilization**
- **Temporary Stream Crossing**
- **Tree Preservation and Protection**
- **Trench Plug**
- **Water Quality**
- **Inlet**

6.2.2 Open Stream Access to Livestock

Many of the streams within the watershed are adversely impacted by the unrestricted access by livestock. Problems include; high stream bank erosion, loss of productive soil and loss of real property, increased sediment loading and overall poor stream stability. Several areas in need of stream stabilization have been identified (Refer to Maps 8).

The Pennsylvania Department of Environmental Protection (PADEP) recommends that stream bank fencing should be installed allowing an average of 12 feet from the top of the stream bank. Livestock can drink from designated stream access points or from drinking cistern facilities located away from the streams. These areas should be reinforced to minimize erosion. A stream ramp can be built on both stream banks leading into the stream channel. To stabilize the channel, rocks should be placed in the stream. In order to build a stream crossing, a general permit from the PADEP will be required.

Electric fence is recommended for stream bank fencing. A high quality single or double strand fence may be used depending on the livestock present. In pastures where only cattle reside, single wire should be used. In pastures where both cattle and calves are present, double strand fencing should be used. The PADEP or the Washington County Conservation District can assist landowners by providing technical assistance and to obtain the necessary permits.

Best management practices (i.e., stream bank fencing, animal trails and walkways, and stream crossings) and cost estimates by linear foot are provided below for the enhancement of degraded stream bank area.

Left: When cattle are left unrestricted to streams, the fragile riparian area (the point at which the water and land meet) is almost always damaged. Understandably, the cattle must drink, but the damage done to the stream banks causes a much greater loss.

Erosion of stream banks, over years, results in the loss of productive soil and the loss of real property. It is not uncommon for some farmers in certain parts of the state to loose **acres** of productive land along streams during the course of a decade.

Stream bank fencing or the re-vegetation of stream banks to 'buffer' them are simple ways to combat the loss of property and the increase of erosion and sedimentation.

6.2.3 Lack of Stream-side Vegetation / Riparian Buffers

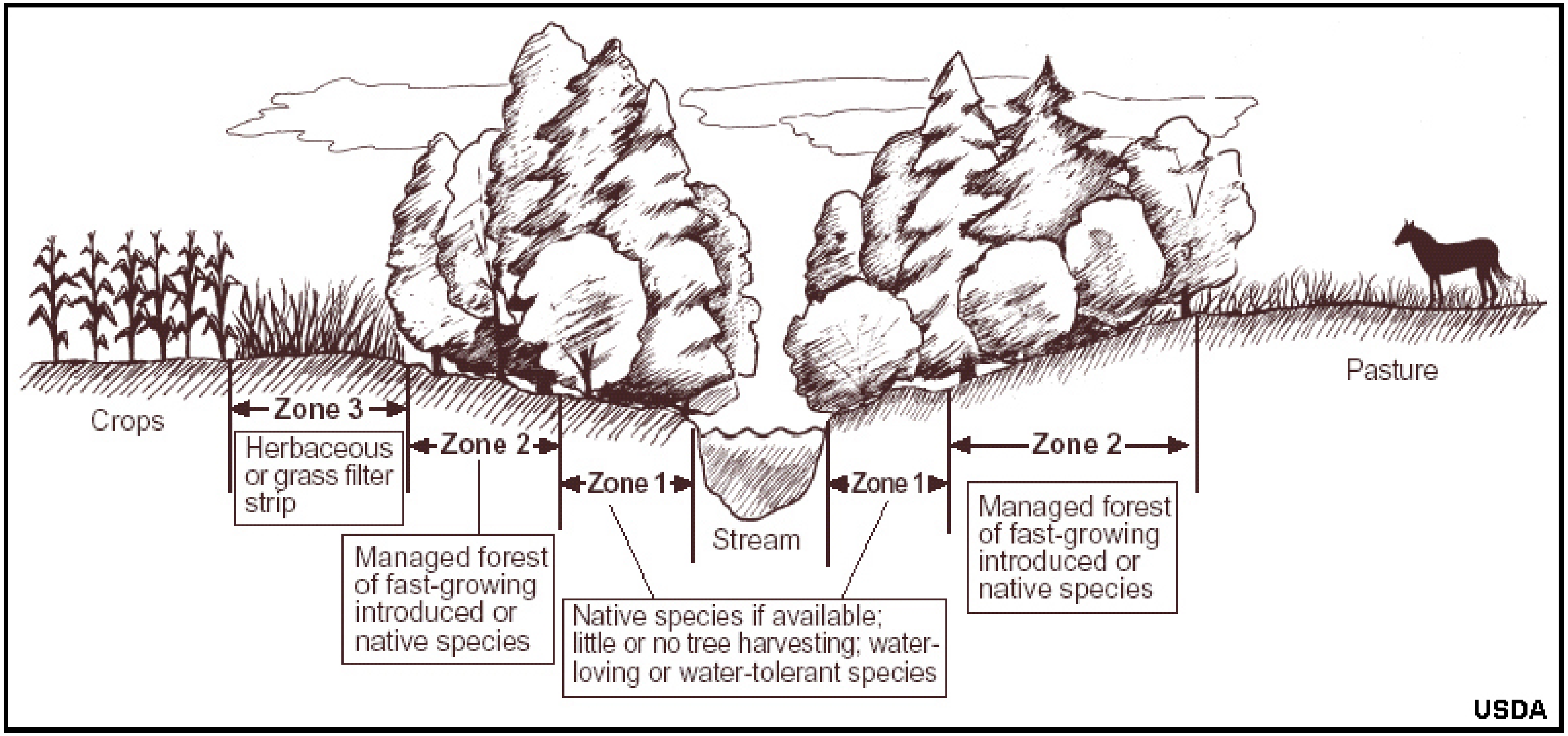
Re-vegetated stream banks would be the most beneficial and can be the least costly management practice for the entire watershed. Many of the riparian zones observed throughout the watershed were cleared to the stream banks. Lack of riparian vegetated buffers facilitates erosion and sedimentation, nutrient enrichment, loss of productive soil and loss of real property, unstable streams, and loss of aquatic habitat due to increased water temperatures, to name a few. Areas of critical concern have been identified based on the field survey, aerial photography and GIS (Refer to Maps 8).

Vegetated buffers do not necessarily mean wood herbaceous (trees and shrubs) cover. Riparian buffers can also be vegetated with grasses and still provide a strong defense against erosion and sedimentation, nutrient enrichment and soil and property loss. For those situations where trees and shrubs may be undesirable because of an increase in moisture in hay fields, or when trees and shrubs may provide unwanted habitat for predators and pests in livestock areas, grassed waterways may also be implemented.

Ideally, grassed waterways would be coupled with stream bank fencing and cattle crossings.

Left:
An aerial photo of fully functional streamside vegetated buffer.

There are several types of vegetated riparian buffer options. Choosing the best type for your need and landscape is a process that your local conservation district can assist you with. The photo above is an ideal example of how a buffer would function. The diagram on the following page describes the various components and zones recommended when adopting this practice.



A riparian forest buffer includes zone 1, the area closest to the waterbody or course, and zone 2, the area adjacent to and up gradient of zone 1. Trees and shrubs in zone 1 provide important wildlife habitat, litter fall for aquatic organisms, and shading to lower water temperature. This zone helps stabilize streambanks and shorelines. Trees and shrubs in zone 2 (along with zone 1) intercept sediment, nutrients, pesticides, and other pollutants in surface and subsurface water flows. Zone 2 can be managed to provide timber, wood fiber, and horticultural products. A third zone, zone 3, is established if periodic and excessive water flows, erosion, and sediment from upslope fields or tracts are anticipated. Zone 3 is generally of herbaceous plants or grass and a diversion or terrace, if needed. This zone provides a "first defense" to assure proper functioning of zones 1 and 2.

6.3 Nutrient Enrichment

6.3.1 Agricultural Practices

Data collected in 1994 for the *Agricultural Non-Point Source Pollution Watershed Evaluation For the Raccoon Creek and Cross Creek Watershed* indicate that analysis of five sample locations at three different periods (1 in Upper Cross Creek, 1 in Lower Cross Creek, 1 in South Fork, 1 in Middle Fork and 1 in North Fork) using field equipment during the data collection indicated that there were no concentration of nitrates above the EPA standard of 0.5 mg/L.

The analysis of laboratory data collected for this plan revealed that each of the Management Units (MU) experienced readings exceeding standard concentrations acceptable by those listed in Table 5-2. Aggregating the nitrate results for each sample site in each MU, the average exceedence percentage for each MU is as follows:

- MU1 – Nitrates exceeded standard concentrations 50% of the time.
- MU2 – Nitrates exceeded standard concentrations 21% of the time.
- MU3 – Nitrates exceeded standard concentrations 23% of the time.

For a breakdown of the percentage each sample site exceeded standard concentrations for nitrates, see Figures 5-1 and also 5-2.

A direct correlation cannot be established with the two data sets. Therefore, it is not possible to conclude that these waters have experienced and increase in nitrates, only that there were increased levels recorded at the sample site locations for this plan (See Map 10 and Fig. 4-1). However, due to the high degree of agriculture in this portion of the watershed, incidents of nitrates exceeding EPA standards may be caused by the lack of proper agricultural practices by certain individuals in select areas.

Analysis of the *Agricultural Non-Point Source Pollution Watershed Evaluation for the Raccoon Creek and Cross Creek Watershed (1994)* and water samples taken for this plan indicate that there are high concentrations of nitrogen and phosphate found in the streams (Refer to Section 5.2).

The U.S. Department of Agriculture - Natural Resources Conservation Service has completed Conservation Practice Standards for controlling non-point source pollution from agricultural activities. These Conservation Practice Standards include in part:

- *Code 322 – Channel Vegetation*
- *Code 327 – Conservation Cover*
- *Code 332 – Contour Buffer Strips*
- *Code 340 – Cover Crop*
- *Code 362 – Diversion*
- *Code 382 – Fence*
- *Code 412 – Grassed Waterway*
- *Code 500 – Obstruction Removal*
- *Code 512 – Pasture and Hay Planting*
- *Code 575 – Animal Trails and Walkways*
- *Code 580 – Streambank and Shoreline Protection*
- *Code 582 – Open Channel*
- *Code 584 – Channel Stabilization*
- *Code 590 – Nutrient Management*

Generally, the purpose of these conservation practices are to stabilize stream banks, reduce erosion and sedimentation, reduce nutrient enrichment (eutrophication) by nitrogen and phosphorus runoff, improve water quality, and maintain or enhance wildlife and aquatic

habitat. Additionally, the conservation practices are to be used to improve the quality and production of agricultural commodities by suppressing weeds, provide supplemental forage, promote biological use of nutrients by soil micro-organisms, improve or maintain livestock nutrition and health, and reduce runoff or flood damage from upland areas. *Therefore, a benefit is observed both in the improvement to livestock health and agricultural production, and in the environmental health of the land and water resources.*

Nutrient Enrichment BMPs:
The following is a list of BMPs promoted by the resource agencies.

BMP-1	**Permanent Vegetative Cover**
BMP-2	**Animal Waste Management System**
BMP-3	**Strip cropping and Contour Farming Systems**
BMP-4	**Terrace System**
BMP-5	**Diversion System**
BMP-6	**Grazing Land Protection System**
BMP-7	**Waterway System**
BMP-8	**Cropland Protection System**
BMP-9	**Cropland Tillage System**
BMP-10	**Stream Protection System**
BMP-11	**Permanent Vegetative Cover on Critical Areas**
BMP-12	**Sediment Retention, Erosion, or Water Control Structures**
BMP-13	**Soil and Manure Analysis**
BMP-14	**Management of Excess Manure**
BMP-15	**Fertilizer Management**
BMP-16	**Barnyard Runoff System**
BMP-17	**Composting**

http://www.pacd.org/products/bmp/bmp_orderform.htm, (CH2MHill, 1998).

6.3.2 Sewage

On-lot systems (OLS) and the lack of *any* sewage management apparatus is a general problem throughout southwestern Pennsylvania. With the knowledge that some of the most populated areas of the watershed are being addressed with an Act 537 Plan, we recognize those areas not being municipally served as potential areas of concern (Refer to Maps 4 & 8).

The Independence-Cross Creek Join Municipal Sewage Authority was formed in 2002. The Act 537 Plan (PA Sewage Facilities Act) was initiated by Independence Township in 2002. The draft 537 plan is completed and is presently under review by the PADEP. Presently, the Joint Authority has a long-range plan and target dates for the design and construction of an initial public sewage system.

It is acknowledged that municipal sewage service is not economically feasible or necessary in many portions of the Cross Creek Watershed. However, wastewater will undoubtedly become an issue within the watershed at some point in time. Unfortunately, the water samples taken for this study did not examine parameters usually investigated for human waste. It may become evident across the entire watershed, or it may arise as a very localized problem. If development spreads (Refer to Section 2.9) and sewage wastewater becomes an issue in the watershed, then action should be taken by municipalities to address such problems (Refer to Section 7.2). If wastewater problems arise as a localized, site-specific problem, then concerned stakeholders should explore other options that treat wastewater.

The Commonwealth of Pennsylvania specifies what types of alternative and experimental wastewater treatment mechanisms are approved by the PADEP. Chapter 25 of the Pa. Code (Standards for on-lot sewage treatment facilities) details all of the design principles for all of the approved types of wastewater facilities. Sections § 73.71 and § 73.72 address experimental and alternative on-lot systems, respectively. For a checklist of site requirements and a list of approved experimental and alternative on-lot systems, see Appendix C and for example diagrams of some more common alternative on-lot septic systems, see Appendix G.

6.4 Abandoned Mine Drainage (AMD)

AMD issues in the watershed are the legacy left by antiquated, failed or improper mining activities. Numerous AMD sites can be found throughout the watershed and have a variety of water pollution problems associated with them. These include acidity, aluminum, manganese, iron, sulfate, and pH problems. It should be noted that, according to the Washington County Conservation District, elevated levels of alkalinity are found in water quality samples throughout Washington County. This can be attributed to the underlying surface geology of streams throughout the region (Refer to Section 3.2.1 and Map 6). Generally, such elevated levels of alkalinity can buffer the fluctuations of pH caused by AMD, however it cannot counter the affects of inputs of metals attributed to AMD.

6.4.1 Management Unit 2

The Management Unit 2 has the most severe impacts from AMD. AMD found in the Browntown area has a higher volume of discharge than some of the other areas shown on Map7. However, based on investigations by federal and state agencies, the recommendation for no remediation to take place at the Browntown site was made (See Section 3.1.4.9).

6.4.1.1 Church Street Discharge (SS11)

The results of the water quality sampling over the study period for this project indicate that AMD discharges in this vicinity are having significant impacts on the north branch of Cross Creek. Refer to sampling results for SS12. Due to the water quality of the receiving stream and the location of the discharge, this particular problem area lends itself to having the greatest potential to being a successful remediation project.

Average Water Quality:

Aluminum	=	1.2 mg/l
Iron	=	12 mg/l
Manganese	=	2 mg/l
Sulfates	=	600 mg/l
Acidity	=	46 mg/l
Alkalinity	=	41 mg/l
pH	=	5.6

The recommended passive treatment system for this discharge is a settling basin to limestone channel to aerobic cell with a pond/wetland system for aeration, detention, and storage of metal sludge. Given adequate space to provide retention time, the metals will precipitate. Based upon the water quality data and general design criteria, approximately 1,000 tons of limestone may be required for the limestone channel. Based on typical sizing criteria for maximum flow (assumed to be 50 gpm), a treatment area of approximately three acres would be required, possibly consisting of one settling pond and a wetland (depending on topographic conditions and other constraints). Typical design criteria should be coupled with space limitations to optimize design. As appropriate, emerging technologies should be considered such as windmill or water wheel power for aeration.

Abandoned Mine Drainage (AMD) BMPs: The following example details some of the activities that may be needed to correct abandoned mine drainage.

Abandoned Mine Drainage Remediation Process: As part of the analysis of Abandoned Mine Drainage (AMD) issues for this project, AMD has been noted in this plan as being found in Management Units 2 and 3.

To correct a specific AMD discharge, a preliminary site investigation is needed to gather data for future activities. The investigation can include the measurement of water chemistry and flow parameters of the discharge(s), conceptual engineering and design constraints, determination of property ownership, consideration of other potential site constraints (i.e., wetland, stream, and floodplain impacts), and to calculate project costs.

Once these activities have been completed, attaining funding to complete project administration, draft and final engineering design of the passive treatment system, site permitting, construction, and construction surveillance must be performed. Possible sources of assistance can be found in the Potential Technical and Funding Assistance matrix located in Appendix E. This matrix includes both state and federal, and private endowment grant programs. Once funding is attained, the draft and final engineering design, site permitting, construction, and construction surveillance activities can be completed.

After the construction of the passive treatment facility, it is important for post construction monitoring to take place. This assists in determining how effective the treatment system is and is usually a requirement of the grant. It also assists in determining if new problems have occurred and need addressed. Another issue that needs to be addressed includes the facilities operations and maintenance (O&M). Passive treatment systems generally need little O&M on a daily basis. However, while completing post construction monitoring, O&M activities can also be completed. Most passive treatment facilities will be designed for a 25-year life. However, the life span of a site is site specific. Towards the end of the facilities life, it is important to prepare for the removal of metal precipitates (i.e., iron, aluminum, and manganese) and possibly the replenishment of limestone and organic mulch.

Abandoned Mine Drainage (AMD) BMPs (Continued): From the Draft Coal Remining BMP Guidance Manual, the following are the different BMPs that can be utilized to make improvements to problem situations involving AMD and AML sites (USEPA, 2000).

1.) Hydrologic and Sediment Control BMPs: *The following hydrologic and sediment control BMPs can assist in reducing groundwater, erosion and sedimentation pollution or both.*

Regrading of mine spoil – Utilized to establish positive drainage, facilitate revegetation, and reduce surface water infiltration of the mine spoil.

Revegetation - Utilized to revegetate areas that were previously mined and left devoid of vegetation thus exposing coal spoil material to the atmosphere. Bio-solids are often utilized to assist in fertilization of re-vegetated areas and to assist in soil formation.

Diversion ditch installation – Utilized to direct clean surface water away from contamination (mine spoil) sources.

Installation of low-permeability caps – Utilized on gob piles and other areas that need to have a synthetic or clay-lined cap placed over the material to reduce or eliminate ground and surface water pollution.

Stream sealing – Utilized to prevent clean surface water from entering an underground mine or surface mine spoil.

Underground mine daylighting (Remining) - Eliminates coal that had been partially mined by historic mining practices and left coal exposed underground. This exposed coal continues to degrade ground and surface waters, but if removed through daylighting activities, water pollution sources can be reduced or eliminated.

Mine entry and auger hole sealing – Refers to dry or wet seals. These seals prevent (dry seals) or control (wet seal) discharge of waters from mine entries.

Highwall and pit floor drains – Horizontal or vertical highwall drains and pit floor drains are used to collect groundwater entering the spoil and work to minimize contact with contaminants.

Grout curtains – Utilized to prevent or divert the flow of groundwater from one location to another. One example would be to utilize a grout curtain between a stream and an underground mine opening.

Ground water diversion wells - Utilized to intercept and collect groundwater prior to its entrance into a backfill area or underground mine where contaminants exist.

2.) Geochemical BMPs: *The following geochemical BMPs function to inhibit pyrite oxidation, reduce the contact of water with acid-producing materials, inhibit iron-oxidizing bacteria, or increase the amount of alkalinity generated within backfilled areas.*

Alkaline addition – Provides alkalinity to an acidic water source to enhance precipitation of metals.

Alkaline redistribution – Utilized to add alkalinity to one location (an area deficient of alkalinity) from another alkaline addition source.

Induced alkaline recharge – Utilized to add alkalinity to water prior to it entering a spoil area or underground mine.

Special handling of acid-forming materials – Segregate acid forming materials and handle them in a manner to minimize water contact. One example is to place acid forming materials (spoil) above the water table and then placing a cap over the reclaimed area.

Special handling of alkaline materials – Segregation of alkaline materials and encourage contact of these materials with water so dissolution takes place.

Use of bactericides – Use of bactericides is utilized to inhibit or eliminate certain bacteria from becoming established in a reclamation site. Some bacteria species can increase the acidic conditions thus reducing water quality.

3.) Passive Treatment Methods or BMPs: *The following passive treatment methods or BMPs entail a number of engineered treatment systems that require minimal maintenance after construction is completed and the systems become operational. These systems can be used by themselves and/or in combination to passively treat mine discharges. These systems vary in technical/engineering complexity and thus cost. This is because each site brings its own specific water quality (chemistry), discharge flow (gallons per minute, etc.), and engineering requirements (i.e., grading, materials, specific system type, permitting requirements, etc.). Thus it is impossible to give specific cost information to a general site, because each site can vary greatly.*

Successive Alkalinity Producing Systems (SAPS) – Utilized for sites with dissolved oxygen, iron (ferric or ferrous) and aluminum as components of the water quality.

Anoxic Limestone Drains (ALDs) – Utilized for sites with low dissolved oxygen, ferric iron and aluminum laden water quality.

Oxic Limestone Drains – Utilized for sites with a variety of AMD types, however, the dissolution of limestone and the generation of alkalinity is somewhat limited.

Limestone Diversion Wells (LDWs) - Utilized for sites that are relatively inaccessible and, therefore, difficult to treat. This type of system needs active (weekly to bi-weekly) maintenance to maintain treatment of the stream or discharge. This system can treat a variety of AMD types.

Open Limestone Channels (OLCs) – Is similar to oxic limestone drains and is utilized for a variety of AMD types too. However, they are found to be most effective on relatively steep slopes.

Limestone Sand – Utilized for treatment of marginally acidic streams. The sand is actually dumped along the stream bank and as flood flows wash the sand into the stream, the sand helps to increase stream alkalinity and can help to reduce dissolved metals. This treatment improves water quality in stream but does not treat the source of the AMD discharge.

Constructed Wetlands (Aerobic Wetlands and Compost Wetlands) – Utilized for treatment of sites with alkaline and acidic, laden with iron. These wetland systems can add alkalinity through sulfate reduction and in some cases dissolution of limestone that is present or added.

Pyrolusite® systems – This type of system is a patented biological process. It utilizes alkaline addition of limestone where the limestone bed is injected or inoculated with bacteria. This bacteria assists in increasing the oxidation process thereby reducing the metal concentration in AMD.

7 Recommendations and Cost Estimates

7.1 Recommendations

As was discussed earlier in this plan, three management units (MU1, MU2, and MU3) have been determined to assist in delineating the degradation of water quality from various sources. The water quality issues impacting the management units are, in no particular order, as follows:

Management Unit 1 (MU1)

- Erosion
- Sedimentation
- Nutrient pollution (eutrophication)

Management Unit 2 (MU2)

- Abandoned mine drainage (AMD) / AML
- Erosion
- Sedimentation
- Nutrient Pollution (eutrophication)
- Sewage

Management Unit 3 (MU3)

- Abandoned mine drainage (AMD) / AML
- Erosion
- Sedimentation

What follows is an iteration and reference of the recommendations made throughout this document.

7.1.1 Water Quality Monitoring

- Conduct further water quality sampling, specifically in Management Unit 1, to identify pollution sources. In order for streams in the Commonwealth of Pennsylvania to be considered a High Quality, conditions pertaining to (1) water chemistry and/or (2) water biology must be met. As a result of the chemical water quality monitoring performed for this plan, it was revealed that those waters east of Avella are not meeting High Quality water criteria (as specified in PA Code, Title 25, Chapter 93.4b(a) (Refer to section 3.1.4.3). Therefore, more effort should be made to ensure that these waters are protected from any present, continued or future uses that may further cause degradation.

  There was not sufficient biological water quality data collected for this plan to establish if the High Quality water criterion is being met in those streams east of Avella.

- Due to the geologic characteristics of Washington County, a County reference reach is recommended for both chemical and biological characteristics.

7.1.2 Stream Bank Erosion and Sedimentation

- <u>Stream Bank Fencing</u>

  The remediation cost estimates (Section 7.2) are for: 1) techniques and BMPs for low-cost stream bank restoration treatments and 2) the Natural Stream Channel Design

approach (Rosgen and other applicable methods), which is more expensive but provides a more stable and effective (long-term) solution to stream bank stability problems.

Any stream that runs through pasture land for livestock could benefit from stream bank fencing. The streams highlighted in red in Map 8 are recommended as being first investigated as candidate streams for stream bank fencing programs. Stream bank fencing can be obtained with very little to no cost whatsoever to the property owner. Consult with the Washington County Conservation District for more details (Refer to Appendix G).

- Vegetated Buffer and Grassways

  Best management practices (i.e., stream bank fencing, animal trails and walkways, and stream crossings) are recommended for most of the streams in agricultural lands and especially those streams of critical concern (Refer to Map 8 and Appendix H).

  Re-vegetated stream banks would be the most beneficial and can be the least costly management practice for the entire watershed. Many of the riparian zones observed throughout the watershed were cleared to the stream banks. Lack of riparian vegetated buffers facilitates erosion and sedimentation, nutrient enrichment, loss of productive soil and loss of real property, unstable streams, and loss of aquatic habitat due to increased water temperatures, to name a few.

  Land use practices, both upstream and around the lake are thought to be the significant source of erosion and sedimentation that affects Cross Creek Lake. Improper agricultural practices result in stream bank erosion relating to sediments in the lake, which acts as a settling basin.

- Stream Bank Stabilization Engineering

  Due to the widespread agricultural activity and evident problems with stream 'health', this plan recommends that the Cross Creek Watershed conduct a complete stream bank stabilization assessment that would study and identify how adverse human activity has altered the natural fluvial geomorphology.

  Applying practical principles of fluvial geomorphology to restore and re-channel streams is recommended for those stream reaches that have experienced massive degradation and cannot be remedied by less intrusive measures (i.e., stream bank fencing and vegetated buffers) (Refer to Appendix H, Section 6.2.2, 6.2.3 and Map 10).

- Dirt and Gravel Road Maintenance and Enhancement

  The Cross Creek Watershed is traversed with approximately 27 miles of dirt or gravel roads capable of automobile traffic according to the Penn State Center for Dirt and Gravel Road Studies (2001). In addition, there are many additional miles of undocumented off-road and all-terrain vehicle roads and trails. All of these types of transportation networks serve as an input source of sediment materials into the streams of the Cross Creek Watershed. The amount of sediment transported from untreated or poorly maintained dirt or gravel roads due to erosion from precipitation run-off is often ignored as a cause for stream bank sedimentation and instability.

  It is recommended that the local municipalities, county and Conservation District continue with the efforts and progress made via Pennsylvania's Dirt and Gravel Road Maintenance Program. Special attention should be directed towards 'Oak Ridge Road', which is a gravel road that crosses Cross Creek just as the creek is entering Cross

Creek Lake (Refer to Map 8 and Appendix B). Local residents contend that this road experiences high amounts of precipitation run-off and is a large contributor (in conjunction with upstream sources) to sediments in the eastern portion of Cross Creek.

7.1.3 Nutrient Enrichment

- Sewage

This plan recommends completing additional municipal sewage planning activities, extending municipal service throughout development zones in the watershed, and the use of alternative or experimental sewage treatments as regulated by 25 Pa. Code § 73.71 and § 73.72 for the less-developed areas that may be experiencing wastewater problems.

Additionally, it is suggested that local municipalities explore the capital investment opportunities available to them through the various types of intergovernmental cooperation frameworks (i.e., joint authorities, Act 177 agreements, EICs, etc.) (Refer to Section 2.9.4 and Appendix C).

7.1.4 Abandoned Mine Drainage (AMD)

- Church Street Discharge (SS 11)

The recommended passive treatment system for this discharge is a settling basin to limestone channel to aerobic cell with a pond/wetland system for aeration, detention, and storage of metal sludge. Given adequate space to provide retention time, the metals will precipitate. Based upon the water quality data and general design criteria, approximately 1,000 tons of limestone may be required for the limestone channel. Based on typical sizing criteria for maximum flow (assumed to be 50 gpm), a treatment area of approximately three acres would be required, possibly consisting of one settling pond and a wetland (depending on topographic conditions and other constraints). Typical design criteria should be coupled with space limitations to optimize design. As appropriate, emerging technologies should be considered such as windmill or water wheel power for aeration.

It is recommended that AMD site discharges be recommended after they have been evaluated as part of an AMD Assessment and Management Plan. Continue to complete remediation activities of AMD sites in Management Units 2 and 3. The recommended initial site to be remediated is the Church Street Discharge (SS 11). Remediation of SS11 would significantly reduce the amount of impairment recorded at SS12.

Abandoned mine lands (AMLs), which are often the source of abandoned mine drainage, should also be planned for remediation as part of a land use master plan.

7.1.5 Trash and Litter

The Cross Creek Watershed has experienced illegal dumping and littering of trash in portions of the watershed. Much of the trash found in dumps or as litter is recyclable. However, it is acknowledged that it is difficult to encourage people to separate and haul their trash to recycling centers. What follows are four measures that could alleviate the dumping and littering problems in the Cross Creek Watershed while encouraging more people to become involved in recycling programs.

1. Explore Developing Municipal Curb-side Recycling Programs under Act 101 – Bringing recycling service to the household would be the measure that is expected to reduce illegal dumping and encourage recycling within the watershed. In association with curbside recycling programs should also be a

periodic non-recyclable trash pick-up day that would help in reducing the rural dumping of non-recyclable items.

2. Establish a Recyclable Materials Drop-off Within the Watershed – Until municipal recycling services are available statewide, municipalities or local conservation groups should establish a recycling drop-off center within the watershed. None of the businesses listed in the PADEP Recycled Materials Market Directory for Washington County are located in the Cross Creek Watershed (Table 3-6).

3. Promote a PA Department of Transportation (PENNDOT) Adopt-A-Highway Program – This program encourages local civic or volunteer groups to 'adopt a highway' by adopting a two-mile portion of state highway and promising to pick-up litter at least four times a year. In return, PENNDOT will post signs along the highway giving you or your group full credit for your efforts.

   Anyone wishing to adopt a highway should contact the local Adopt-A-Highway coordinator, Mike Budzanoski of the Washington County PENNDOT District 12-4 office on Murtland Avenue in Washington.

4. Establish a 'PA CleanWays' chapter in Washington County – PA CleanWays mission is to encourage people to eliminate illegal dumping and littering in Pennsylvania. PA CleanWays not only picks up where the PENNDOT Adopt-a-Highway program leaves off by adopting local, non-state maintained roads, PA CleanWays also arranges outings of local residents to remove litter from streams and sorting and transporting of trash from illegal dumps.

   In addition to cleanups, PA CleanWays addresses problem disposal items, such as tires and appliances, by providing recycling opportunities and by educating the public on affordable and convenient disposal.

   PA CleanWays also offers an educational program complete with books and videos for children in order to introduce children to land and water stewardship and an early age.

   At the time of the writing of this report (March, 2003) Washington County was one of two counties in the Pittsburgh metro area that did not have a county chapter.

7.1.6 Nuisance Wildlife Management Options

During the initial public meeting, a number of wildlife issues were raised by stakeholders. These issues include the large population of white-tailed deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallopavo*), raccoon (*Procyon lotor*) and coyote (*Canis latrans*). In rural areas, white-tailed deer mostly cause crop damage. Wild turkey, coyote and raccoons can also cause problems for farmers in regards to crop damage or preying on livestock. Management options for nuisance wildlife include;

- No management
- Establishing designed habitat programs for farmland that manages the movement of wildlife using practices such as stream bank fencing and wildlife corridors
- Trapping and translocation of individuals
- Hunting

7.1.7 Rail-to-Trail Possibilities

The Panhandle Trail, rail-to-trail facility is now being developed on the Norfolk Southern (previously Conrail) right-of-way along Robinson Run to the north and east of the Cross Creek Watershed. The abandoned spur that runs along the North Fork of Cross Creek from Langloth to Studa is a potential rail-to-trail project. A Feasibility Study should be conducted on the current abandoned spur to make the case for a proposed construction of a rail-to-trail.

7.2 Cost Estimates

The proposed remedial activities and cost estimates have been compiled to assist local residents, conservation organizations (CCWA), and municipal and county governments in hopes of improving the environment and the quality of life within the Cross Creek Watershed in Washington County, Pennsylvania.

The cost estimations are based upon other projects of similar nature that have been completed to date by Skelly and Loy, Inc. Certain assumptions were made in regards to stream or AMD discharge flow, major bid items to complete cost estimations for the primary sites, and a variety of site-specific constraints. *Some costs may vary and additional specific site information will be needed to specifically estimate costs for recommended actions. The cost estimate information is provided to assist readers in gauging the approximate cost of each proposed remediation action and in prioritizing activities. The cost estimate information should not be inferred as the cost of completing each action.* These costs should not be used for detailed estimation of project costs, or funding. Each site should be evaluated on an individual basis. For a list of funding and technical assistance sources, please see Appendix F.

7.2.1 General Cost Estimate for Gravel Road Improvements and Maintenance

Gravel Road Improvements and Maintenance

MAJOR BID ITEM	QUANTITY	UNIT	UNIT PRICE	COST
Gravel Road Maintenance				
Pollution Control	200	Feet	$3.00	$600.00
Grading	1,000	Feet	$2.00	$2,000.00
Seeding	34.5	lbs	$15.00	$517.50
Gravel	100	Ton(s)	$20.00	$2,000.00
Construction Sub-Total				**$3,117.50**
Permitting	1		$500.00	$500.00
Project Administration	$3,117.50	8 Percent	$0.08	$249.40
Total				**$3,866.90**

Restoration or improvement costs for 1,000 linear feet of gravel road maintenance is $3.10 per linear foot for construction, and $00.70 per linear foot for permitting and administration.

7.2.2 General Cost Estimate for Stream Bank Fencing

Power Fence Cost Estimate				
Farmer's Name	Cross Creek W.A.			
Power Fence--2 Strands				
Fiberglass Post--20' Spacing				
Feet of Fence	2000	Feet		
Distance from Energizer to Fence	50	Feet		
Number of Corners Systems	4	Number		
Number of H Braces	4	Number		
Number of Gates	2	Number		
Number of Floodgates	4			
ESTIMATED COST OF MATERIALS				
	Units	Number	$/Unit	Total $
WIRE				
Power Fence (12 1/2 Gauge)	Rolls	1.0	78.00	78.00
Smooth Wire	Rolls	0.1	78.00	7.80
POST				
Fiberglass Line Post	Number	92	2.30	211.60
Wood Line Post (3" minimum diameter)	Number	0	2.40	0.00
Metal Line Post	Number	0	2.30	0.00
Insul-timber Post	Number	0	4.00	0.00
Brace (4" minimum diameter)	Number	40	6.00	240.00
Corner (5" minimum diameter)	Number	4	12.00	48.00
OTHER MATERIALS				
Ground Rod and Clamp	Number	7	7.00	51.65
Lightening Arrestor	Number	0	7.00	0.00
Energizer	Number	1	400.00	400.00
Insulated Cable	Feet	98	0.90	88.20
In-Line Strainer	Number	22	3.50	77.00
Cut-off Switch	Number	2	7.00	10.61
Gate Handles	Number	2	2.75	5.50
Gate (14')	Number	2	80.00	160.00
Flood Gate Controller	Number	4	20.00	80.00
Ties	Number	184	0.10	18.40
Insulators	Number	10	0.50	5.00
Concrete (bag)	Number	4	2.00	8.00
		Total Materials =		$1,481.76
Labor	Hrs.	26.6	8.00	212.53
Equipment	Hrs.	5.3	25.00	132.00
		Total Cost =		1,826.29
		Cost/Foot =		$0.91

7.2.3 General Cost Estimates for Streambank Restoration / Enhancement

The following remediation action involves the improvement of 1,000 linear feet of perennial stream channel located in a pasture. It assumes that no clearing or grubbing of woody vegetation is needed and allows for the construction of a stream crossing for cattle across a 20-foot wide channel. It also includes minimal cost for the preparation of erosion and sedimentation control permitting.

Streambank Restoration / Riparian Buffer Enhancement

MAJOR BID ITEM	QUANTITY	UNIT	UNIT PRICE	COST
Pollution Control	800	Feet	$3.00	$2,400.00
Herbaceous Seeding	34.5	lbs	$15.00	$517.50
Shrubs	400	Shrub	$50.00	$20,000.00
Trees	150	Tree	$150.00	$22,500.00
Access	100	Feet	$28.00	$2,800.00
Construction Sub-Total				**$25,717.50**
Construction Cost Contingencies	$25,717.50	20 Percent	$0.20	$5,143.50
Design	1000	$10 per linear foot	$10.00	$10,000.00
Permitting	1		$4,000.00	$4,000.00
Project Administration = % of Construction	$25,717.50	8 Percent	$0.08	$2,057.40
Mobilization/Demobilization = % of Construction	$25,717.50	10 Percent	$0.10	$2,571.75
Land Rights	2.3	Acre(s)	$2,000.00	$4,600.00
Total				**$54,090.15**

Restoration costs for 1,000 linear feet of stream are $37.50 per linear foot for construction, and $16.00 per linear foot for design, permitting and administration.

7.2.4 General Cost Estimates for Streambank Stabilization / Enhancement

Streambank Stabilization and Riparian Buffer Enhancement
(Rosgen Style / Natural Stream Channel Design)

MAJOR BID ITEM	QUANTITY	UNIT	UNIT PRICE	COST
Clearing/Grubbing	2.3	Acre(s)	$500.00	$1,150.00
Pollution Control	2,200	Feet	$3.00	$6,600.00
Herbaceous Seeding	34.5	lbs.	$15.00	$517.50
Shrubs	400	Shrub	$50.00	$20,000.00
Trees	150	Tree	$150.00	$22,500.00
Grading - Streambank Restoration	1	Acre(s)	$15,000.00	$15,000.00
Rock Structures	6	Each	$7,000.00	$42,000.00
Access	100	Feet	$28.00	$2,800.00
Construction Sub-Total				**$88,067.50**
Construction Cost Contingencies	$88,067.50	20 Percent	$0.20	$17,613.50
Engineering/Design	1000	$45 per linear foot	$45.00	$45,000.00
Permitting	1		$5,500.00	$5,500.00
Project Administration = % of Construction	$88,067.50	8 Percent	$0.08	$7,045.40
Mobilization/Demobilization = % of Construction	$88,067.50	10 Percent	$0.10	$8,806.75
Land Rights	2.3	Acre(s)	$2,000.00	$4,600.00
Total				**$176,633.15**

Restoration costs for 1,000 linear feet of stream are $118.00 per linear foot for construction, and $57.00 per linear foot for design, permitting and administration.

7.2.5 General Cost Estimates for Grassed Waterway Treatment (NRCS BMP 412)

Grassed Waterway Treatment

MAJOR BID ITEM	QUANTITY	UNIT	UNIT PRICE	COST
Grassed Waterway				
Grading	1.15	Acre(s)	$2,500.00	$2,875.00
Seeding	17.25	lbs.	$25.00	$431.25
Streambank Fencing & Crossing	2400	Feet	$1.80	$4,320.00
Crossing Stone	4	Tons	$25.00	$100.00
Access	100	Feet	$28.00	$2,800.00
Construction Sub-Total				**$10,526.25**
Construction Cost Contingencies	$10,526.25	20 Percent	$0.20	$2,105.25
E&S Permitting	1		$500.00	$500.00
Mobilization/Demobilization = % of Construction	$10,526.25	10 Percent	$0.10	$1,052.63
Total				**$13,684.13**

Restoration costs for 1,000 linear feet of stream are $13.00 per linear foot for construction, and $2.00 per linear foot for permitting.

7.2.6 General Cost Estimate for Treatment of Abandoned Mine Drainage at SS11 (Church Street)

Treatment of Abandoned Mine Drainage at SS11

MAJOR BID ITEM	QUANTITY	UNIT	UNIT PRICE	COST
Clearing/Grubbing	1	Acre(s)	$500.00	$500.00
Pollution Control	600	Feet	$3.00	$1,800.00
Seeding	3	Acre(s)	$1,500.00	$4,500.00
Access	1	Job	$5,000.00	$5,000.00
Excavation & Fill Settling Basin	1	Each	$15,000.00	$15,000.00
Excavation & Fill Wetland	1	Each	$5,000.00	$5,000.00
Limestone Channel Excavation	1000	Cubic yards	$5.00	$5,000.00
Limestone	1000	Tons	$20.00	$20,000.00
Construction Sub-Total				**$56,800.00**
Construction Cost Contingencies	$56,800.00	20 Percent	$0.20	$11,360.00
Engineering = % of Construction	$56,800.00	10 Percent	$0.10	$5,680.00
Permitting	1		$5,500.00	$5,500.00
Project Administration = % of Construction	$56,800.00	8 Percent	$0.08	$4,544.00
Mobilization/Demobilization = % of Construction	$56,800.00	10 Percent	$0.10	$5,680.00
Land Rights	3	Acre(s)	$2,000.00	$6,000.00
Total				**$95,564.00**

The treatment of AMD in this estimate employs assumed site conditions (i.e., discharge flow was not provided and was assumed to be 50 gpm, landownership, etc.). The cost estimate to complete engineering design, permitting, and construction activities for the AMD discharge site (SS11) was based on the assumed conditions.

Appendix A

Water Quality Results

Notes:

PADEP Bureau of Laboratories Water Quality Results

1. The State Watershed Code for all sites is 20D.
2. See Section 5 and Table 5-1 & Table 5-2 for water quality criteria.
3. U indicates concentrations below the PADEP Bureau of Laboratories' reporting limit (reporting limits shown).
4. A blank space indicates no analysis
5. All results are MG/L except for Temperture and pH
6. *Italicized* data values indicate results of tests that had exceeded time constraints before testing

Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-001	8/12/2001		7.6	172.0	0.579		0.150		0.500	U	4.0		71.6		*0.86*		*0.055*		0.0
CC-001	9/9/2001	18.0	7.8	168.0	0.300	U	0.093		0.500	U	3.0	U	29.4		1.05		*0.057*		0.0
CC-001	10/14/2001	15.0	7.7	176.0	0.300	U	0.065		0.500	U	3.0	U	60.2		0.70		0.039		0.0
CC-001	11/11/2001		8.2	176.0	0.300	U	0.014		0.500	U	3.0	U	66.3		*0.86*		*0.046*		0.0
CC-001	12/9/2001		7.9	188.0	0.300	U	0.158		0.500	U	3.0	U	54.1		0.77		*0.028*		0.0
CC-001	1/13/2002	3.0	8.0	174.0	0.300	U	0.050	U	0.500	U	3.0	U	77.5		*0.90*		*0.019*		0.0
CC-001	2/10/2002		8.0	164.0	0.300	U	0.054		0.500	U	3.0	U	101.3		*0.45*		*0.010*	U	0.0
CC-001	3/10/2002		8.3	158.0	0.300	U	0.050	U	0.500	U	4.0		106.0		0.35		0.011		0.0
CC-001	4/14/2002		8.3	164.0	0.300	U	0.062		0.500	U	6.0		77.2		*0.45*		*0.017*		0.0
CC-001	5/12/2002		8.4	158.0	0.300	U	0.065		0.500	U	3.0	U	131.2		*0.21*		*0.013*		0.0
CC-001	6/9/2002		8.1	154.0	0.325		0.111		0.500	U	4.0		54.3		*0.35*		*0.017*		0.0
CC-001	7/14/2002		8.1	172.0	0.300	U	0.135		0.500	U	3.0	U	34.2		*0.87*		*0.029*		0.0
CC-002	8/12/2001		8.0	194.0	0.500		0.050	U	0.500	U	3.0	U	255.7		*0.68*		*0.020*		0.0
CC-002	9/9/2001	24.0	8.2	192.0	0.674		0.052		0.500	U	3.0	U	127.0		0.12		*0.015*		0.0
CC-002	10/14/2001	16.0	7.9	202.0	0.300	U	0.050		0.500	U	3.0	U	282.0		0.04	U	0.013		0.0
CC-002	11/11/2001		8.4	194.0	0.300	U	0.050	U	0.500	U	4.0		272.0		*0.04*	U	*0.012*		0.0
CC-002	12/9/2001		8.3	202.0	0.308		0.110		0.500	U	3.0	U	83.4		0.53		*0.018*		0.0
CC-002	1/13/2002	4.0	8.1	190.0	0.302		0.162		0.500	U	3.0	U	91.0		*0.88*		*0.015*		0.0
CC-002	2/10/2002		8.3	198.0	0.343		0.115		0.500	U	3.0	U	97.0		*0.56*		0.010	U	0.0
CC-002	3/10/2002		8.3	194.0	0.394		0.105		0.500	U	6.0		131.0		0.46		0.011		0.0
CC-002	4/14/2002		8.2	196.0	0.382		0.108		0.500	U	8.0		97.5		*0.39*		*0.015*		0.0
CC-002	5/12/2002		8.4	194.0	0.487		0.113		0.500	U	3.0	U	106.1		0.30		*0.013*		0.0
CC-002	6/9/2002		8.2	202.0	0.601		117.000		0.500	U	14.0		61.8		*0.53*		*0.025*		0.0
CC-002	7/14/2002		8.3	190.0	0.300	U	0.061		0.500	U	6.0		248.3		*0.38*		*0.015*		0.0

Notes:

PADEP Bureau of Laboratories Water Quality Results

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2. See Section 5 and Table 5-1 & Table 5-2 for water quality criteria.
3. U indicates concentrations below the PADEP Bureau of Laboratories' reporting limit (reporting limits shown).
4. A blank space indicates no analysis
5. All results are MG/L except for Temperture and pH
6. *Italicized* data values indicate results of tests that had exceeded time constraints before testing

Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-003	8/12/2001		7.7	176.0	1.320		0.132		0.500	U	6.0		223.4		*0.56*		*0.027*		0.0
CC-003	9/9/2001	25.0	8.2	172.0	1.720		0.103		0.500	U	3.0	U	248.0		0.44		*0.022*		0.0
CC-003	10/14/2001	14.0	7.6	176.0	1.150		0.139		0.500	U	12.0		276.0		0.37		0.047		0.0
CC-003	11/11/2001		8.4	178.0	1.400		0.088		0.500	U	4.0		286.8		*0.40*		*0.026*		0.0
CC-003	12/9/2001		8.1	194.0	0.845		0.092		0.500	U	3.0	U	128.6		0.59		*0.036*		0.0
CC-003	1/13/2002	4.0	8.0	176.0	0.796		0.121		0.500	U	4.0		120.8		*0.85*		*0.019*		0.0
CC-003	2/10/2002		8.1	178.0	0.577		0.082		0.500	U	3.0	U	101.2		*0.48*		*0.014*		0.0
CC-003	3/10/2002		8.3	172.0	0.690		0.064		0.500	U	8.0		64.0		0.36		0.011		0.0
CC-003	4/14/2002		8.2	176.0	0.474		0.079		0.500	U	3.0	U	94.1		*0.37*		*0.015*		0.0
CC-003	5/12/2002		8.3	174.0	0.531		0.076		0.500	U	3.0	U	154.8		0.22		0.015		0.0
CC-003	6/9/2002		8.0	170.0	0.650		0.103		0.500	U	12.0		62.7		*0.42*		*0.019*		0.0
CC-003	7/14/2002		8.1	170.0	1.020		0.091		0.500	U	12.0		249.2		*0.61*		*0.010*	U	0.0
CC-004	8/12/2001		7.9	236.0	1.070		0.518		0.521		14.0		134.3		*0.62*		*0.055*		0.0
CC-004	9/9/2001	22.0	7.9	222.0	1.150		0.557		0.873		16.0		42.5		0.75		*0.063*		0.0
CC-004	10/14/2001	18.0	7.6	250.0	1.020		0.477		0.500	U	10.0		60.3		*0.26*		*0.032*		0.0
CC-004	11/11/2001		8.2	212.0	0.369		0.192		0.500	U	4.0		86.4		*0.26*		*0.035*		0.0
CC-004	12/9/2001		8.0	186.0	0.569		0.176		0.500	U	8.0		50.2		0.64		*0.039*		0.0
CC-004	1/13/2002	5.0	8.0	168.0	0.397		0.098		0.500	U	3.0	U	62.3		*1.12*		*0.017*		0.0
CC-004	2/10/2002		8.0	184.0	0.478		0.077		0.500	U	3.0	U	121.9		*0.96*		*0.016*		0.0
CC-004	3/10/2002		8.3	178.0	0.333		0.058		0.500	U	8.0		93.6		*0.61*		*0.018*		0.0
CC-004	4/14/2002		8.2	194.0	0.658		0.099		0.500	U	44.0		59.9		*0.68*		*0.027*		0.0
CC-004	5/12/2002		8.3	198.0	0.793		0.126		0.500	U	12.0		78.0		0.43		*0.010*	U	0.0
CC-004	6/9/2002		8.0	198.0	1.330		0.136		0.775		42.0		30.5		*2.66*		*0.031*		0.0
CC-004	7/14/2002		8.1	238.0	1.030		0.116		0.500	U	8.0		47.0		*0.73*		*0.011*		0.0

Notes:

PADEP Bureau of Laboratories Water Quality Results

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3. U indicates concentrations below the PADEP Bureau of Laboratories' reporting limit (reporting limits shown).
4. A blank space indicates no analysis
5. All results are MG/L except for Temperture and pH
6. *Italicized* data values indicate results of tests that had exceeded time constraints before testing

Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-005	8/12/2001		7.6	176.0	0.666		0.339		0.500	U	8.0		75.7		*0.26*		*0.059*		0.0
CC-005	9/9/2001	21.0	7.5	190.0	1.070		0.567		0.708		22.0		41.8		*0.35*		*0.049*		0.0
CC-005	10/14/2001	17.0	7.4	210.0	0.479		0.453		0.500	U	8.0		71.7		*0.04*	*U*	*0.047*		0.0
CC-005	11/11/2001		8.0	194.0	0.445		0.183		0.500	U	12.0		67.5		*0.04*	*U*	*0.022*		0.0
CC-005	12/9/2001		7.8	164.0	0.408		0.122		0.500	U	3.0	U	47.3		0.58		*0.025*		0.0
CC-005	1/13/2002	3.0	7.8	140.0	0.300	U	0.081		0.500	U	3.0	U	49.0		*1.19*		*0.014*		0.0
CC-005	2/10/2002		7.9	158.0	0.300	U	0.050	U	0.500	U	3.0	U	67.0		*0.87*		*0.010*	U	0.0
CC-005	3/10/2002		8.2	148.0	0.300	U	0.050	U	0.500	U	4.0		68.3		*0.63*		*0.010*	U	0.0
CC-005	4/14/2002		8.0	152.0	0.300	U	0.066		0.500	U	4.0		69.6		*0.65*		*0.016*		0.0
CC-005	5/12/2002		8.1	166.0	0.300	U	0.126		0.500	U	3.0	U	49.5		*0.46*		*0.015*		0.0
CC-005	6/9/2002		7.9	154.0	0.300	U	0.095		0.500	U	4.0		23.3		*0.81*		*0.020*		0.0
CC-005	7/14/2002		8.0	192.0	0.670		0.246		0.506		12.0		20.0	U	*0.40*		*0.011*		0.0
CC-006	8/12/2001		7.7	186.0	0.775		0.120		0.500	U	10.0		63.8		*0.23*		*0.046*		0.0
CC-006	9/9/2001	20.0	8.0	220.0	0.563		0.154		0.500	U	34.0		34.0		*0.24*		*0.023*		0.0
CC-006	10/14/2001	17.0	7.9	232.0	0.350		0.075		0.500	U	10.0		58.7		*0.04*	*U*	*0.031*		0.0
CC-006	11/11/2001		8.3	214.0	0.300		0.050	U	0.500	U	8.0		58.3		*0.04*	*U*	*0.010*	U	0.0
CC-006	12/9/2001		8.1	204.0	0.534		0.058		0.500	U	3.0	U	65.8		0.42		*0.030*		0.0
CC-006	1/13/2002	4.0	8.1	186.0	0.300	U	0.050	U	0.500	U	3.0	U	50.7		*0.78*		*0.014*		0.0
CC-006	2/10/2002		8.1	198.0	0.300	U	0.050	U	0.500	U	3.0	U	74.6		*0.53*		*0.013*		0.0
CC-006	3/10/2002		8.3	188.0	0.325		0.050	U	0.500	U	14.0		62.4		*0.29*		*0.014*		0.0
CC-006	4/14/2002		8.2	192.0	0.520		0.082		0.500	U	14.0		82.2		*0.37*		*0.026*		0.0
CC-006	5/12/2002		8.3	190.0	0.573		0.090		0.500	U	10.0		47.1		*0.18*		*0.022*		0.0
CC-006	6/9/2002		7.9	202.0	1.020		0.132		0.548		30.0		34.0		*0.40*		*0.029*		0.0
CC-006	7/14/2002		8.0	200.0	0.340		0.080		0.500	U	3.0	U	20.0	U	*0.27*		*0.016*		0.0

Notes:

PADEP Bureau of Laboratories Water Quality Results

1. The State Watershed Code for all sites is 20D.
2. See Section 5 and Table 5-1 & Table 5-2 for water quality criteria.
3. U indicates concentrations below the PADEP Bureau of Laboratories' reporting limit (reporting limits shown).
4. A blank space indicates no analysis
5. All results are MG/L except for Temperture and pH
6. *Italicized* data values indicate results of tests that had exceeded time constraints before testing

Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-007	8/12/2001		7.9	200.0	0.617		0.050	U	0.500	U	8.0		65.5		*0.31*		*0.048*		0.0
CC-007	9/9/2001	21.0	7.9	202.0	0.349		0.070		0.500	U	10.0		36.7		*0.49*		*0.040*		0.0
CC-007	10/14/2001	16.0	7.7	212.0	0.435		0.055		0.500	U	3.0	U	63.6		*0.04*	*U*	*0.092*		0.0
CC-007	11/11/2001		8.3	212.0	0.300		0.050	U	0.500	U	6.0		60.6		*0.04*	*U*	*0.010*	U	0.0
CC-007	12/9/2001		8.1	196.0	0.300		0.050	U	0.500	U	3.0	U	52.8		0.52		*0.026*		0.0
CC-007	1/13/2002	3.0	8.1	174.0	0.300		0.050	U	0.500	U	3.0	U	58.6		*0.96*		*0.015*		0.0
CC-007	2/10/2002		8.2	184.0	0.300	U	0.050	U	0.500	U	3.0	U	62.7		*0.53*		*0.011*		0.0
CC-007	3/10/2002		8.3	170.0	0.300	U	0.050	U	0.500	U	12.0		59.5		*0.34*		*0.012*		0.0
CC-007	4/14/2002		8.3	184.0	0.300	U	0.050	U	0.500	U	10.0		80.1		*0.34*		*0.020*		0.0
CC-007	5/12/2002		8.4	184.0	0.300	U	0.050	U	0.500	U	3.0	U	48.1		*0.13*		*0.014*		0.0
CC-007	6/9/2002		8.0	192.0	0.451		0.050	U	0.500	U	12.0		34.5		*0.63*		*0.026*		0.0
CC-007	7/14/2002		8.1	198.0	0.420		0.050	U	0.500	U	12.0		20.0	U	*0.22*		*0.050*		0.0
CC-008	8/12/2001		7.5	160.0	0.300		0.473		0.500	U	3.0	U	52.6		*0.83*		*0.062*		0.0
CC-008	9/9/2001	15.0	7.7	162.0	0.300	U	0.424		0.500	U	3.0	U	22.9		*0.89*		*0.080*		0.0
CC-008	10/14/2001	13.0	7.4	166.0	0.300	U	0.372		0.500	U	3.0	U	49.6		*0.84*		0.082		0.0
CC-008	11/11/2001		7.9	170.0	0.300	U	0.885		0.500	U	3.0	U	53.1		*0.88*		*0.099*		0.0
CC-008	12/9/2001		7.6	164.0	0.300	U	1.030		0.500	U	3.0	U	34.0		1.04		*0.129*		0.0
CC-008	1/13/2002	4.0	7.9	170.0	0.300	U	0.217		0.500	U	3.0	U	70.8		*0.75*		*0.017*		0.0
CC-008	2/10/2002		8.0	144.0	0.300	U	0.130		0.500	U	3.0	U	45.8		*0.36*		*0.010*	U	0.0
CC-008	3/10/2002		8.3	140.0	0.300	U	0.056		0.500	U	3.0	U	50.6		*0.35*		*0.010*	U	0.0
CC-008	4/14/2002		8.2	148.0	0.300	U	0.182		0.500	U	4.0		64.8		*0.54*		*0.022*		0.0
CC-008	5/12/2002		8.4	136.0	0.300	U	0.194		0.500	U	3.0	U	40.2		*0.31*		*0.015*		0.0
CC-008	6/9/2002		8.0	134.0	0.300	U	0.213		0.500	U	8.0		20.0	U	*0.19*		*0.015*		0.0
CC-008	7/14/2002		7.9	158.0	0.300	U	0.769		0.500	U	4.0		20.0	U	*0.72*		*0.048*		0.0

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PADEP Bureau of Laboratories Water Quality Results

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Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-009	8/12/2001		8.0	234.0	1.200		0.060		0.852		16.0		64.6		*1.72*		*0.057*		0.0
CC-009	9/9/2001	24.0	8.0	232.0	0.420		0.068		0.500	U	10.0		31.7		*0.31*		*0.042*		0.0
CC-009	10/14/2001	16.0	7.9	234.0	0.300	U	0.050	U	0.500	U	8.0		77.1		0.04	U	0.062		0.0
CC-009	11/11/2001		8.1	228.0	0.314		0.050	U	0.500	U	3.0	U	184.0		*0.04*	*U*	*0.014*		0.0
CC-009	12/9/2001		8.1	194.0	0.433		0.183		0.500	U	3.0	U	87.5		0.50		*0.017*		0.0
CC-009	1/13/2002	4.0	8.4	208.0	0.300	U	0.050	U	0.500	U	6.0		60.5		*1.17*		*0.014*		0.0
CC-009	2/10/2002		8.5	226.0	0.330		0.050	U	0.500	U	4.0		70.2		0.95		0.014		0.0
CC-009	3/10/2002		8.3	216.0	0.300	U	0.050	U	0.500	U	12.0		58.2		0.72		0.019		0.0
CC-009	4/14/2002		8.2	212.0	0.435		0.050	U	0.500	U	14.0		104.9		*0.57*		*0.031*		0.0
CC-009	5/12/2002		8.4	216.0	0.300	U	0.050	U	0.500	U	12.0		50.4		0.51		0.017		0.0
CC-009	6/9/2002		8.3	234.0	0.300	U	0.065		0.500	U	18.0		47.0		*0.79*		*0.024*		0.0
CC-009	7/14/2002		8.3	224.0	0.300	U	0.050	U	0.500	U	3.0	U	20.0	U	*0.37*		*0.030*		0.0
CC-010	8/12/2001		8.0	184.0	0.313		0.112		0.500	U	3.0	U	267.0		*0.56*		*0.019*		0.0
CC-010	9/9/2001	24.0	8.2	194.0	0.900		0.140		0.500	U	20.0		146.0		*0.18*		*0.011*		0.0
CC-010	10/14/2001	14.0	7.8	188.0	0.300		0.127		0.500	U	6.0		345.0		0.04	U	0.013		0.0
CC-010	11/11/2001		8.1	184.0	0.300		0.191		0.500	U	3.0	U	400.8		*0.09*		*0.010*	U	0.0
CC-010	12/9/2001		8.3	234.0	0.300		0.050	U	0.500	U	3.0	U	41.1		0.65		*0.023*		0.0
CC-010	1/13/2002	5.0	8.3	178.0	0.438		0.243		0.500	U	3.0	U	89.2		*0.78*		*0.010*	U	0.0
CC-010	2/10/2002		8.4	192.0	0.415		0.183		0.500	U	4.0		104.9		0.45		0.010	U	0.0
CC-010	3/10/2002		8.2	188.0	0.522		0.154		0.500	U	3.0	U	88.0		0.38		0.010	U	0.0
CC-010	4/14/2002		8.1	186.0	0.508		0.168		0.500	U	3.0	U	91.1		*0.31*		*0.014*		0.0
CC-010	5/12/2002		8.3	184.0	0.483		0.160		0.500	U	3.0	U	82.7		0.26		0.013		0.0
CC-010	6/9/2002		8.2	190.0	0.640		0.180		0.500	U	6.0		56.3		*0.41*		*0.017*		0.0
CC-010	7/14/2002		8.3	184.0	0.300	U	0.158		0.500	U	3.0	U	275.8		*0.43*		*0.010*	U	0.0

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Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)	Nitrates		Phosphates		Hot Acidity
CC-011	8/12/2001		6.00	30.00	22.00		2.44		1.00		3.00	U	649.00	*0.04*	*U*	*0.012*		62.0
CC-011	9/9/2001	20.0	5.3	13.2	22.900		2.730		1.270		16.0		640.2	*0.08*		*0.010*	U	73.6
CC-011	10/14/2001	15.0	5.0	12.4	13.700		2.510		1.260		4.0		586.0	0.04	U	0.010	U	62.2
CC-011	11/11/2001		3.8		14.400		2.710		1.780		14.0		1147.8	*0.04*	*U*	*0.010*	U	64.8
CC-011	12/9/2001		4.2	5.4	14.300		2.530		1.890		10.0		561.9	0.06		0.010	U	78.6
CC-011	1/13/2002	7.0	4.2	5.2	16.700		2.450		2.350		12.0		619.5	*0.04*	*U*	*0.012*		70.6
CC-011	2/10/2002	5.5	3.9	17.6	16.000		2.100		2.160		10.0		736.1	0.08		0.010	U	66.6
CC-011	3/10/2002		6.0	20.0	13.700		1.690		2.140				443.2	0.11		0.021		0.0
CC-011	4/14/2002		6.4	52.0	9.510		0.991		2.370		116.0		307.2	*0.12*		*0.010*	U	0.0
CC-011	5/12/2002		7.0	112.0	1.770		0.450		0.500	U	3.0	U	272.1	*0.04*	*U*	*0.010*	U	0.0
CC-011	6/9/2002		7.2	140.0	1.510		0.432		0.500	U	3.0	U	185.6	*0.11*		*0.010*	U	0.0
CC-011	7/14/2002		6.3	42.0	13.500		2.020		0.500	U	3.0	U	623.8	*0.41*		*0.010*	U	50.6
CC-012	8/12/2001		8.0	182.0	0.315		0.069		0.500	U	3.0	U	327.3	*0.49*		*0.019*		0.0
CC-012	9/9/2001	21.0	8.1	190.0	0.696		0.087		0.500	U	4.0		181.0	*0.14*		*0.020*		0.0
CC-012	10/14/2001	12.0	3.9	0.0	3.280		1.990		9.860		10.0		467.0	0.27		0.010	U	102.2
CC-012	11/11/2001		8.3	184.0	0.300	U	0.050	U	0.500	U	3.0	U	375.5	*0.04*	*U*	*0.010*	U	0.0
CC-012	12/9/2001		3.4	0.0	4.220		2.720		12.800		6.0		655.3	0.15		0.010	U	136.4
CC-012	1/13/2002	4.0	8.3	186.0	0.300	U	0.155		0.500	U	3.0	U	89.6	*0.87*		*0.012*		0.0
CC-012	2/10/2002		3.7	0.0	5.960		2.560		10.700		8.0		884.3	0.27		*0.010*	U	114.4
CC-012	3/10/2002		8.3	192.0	0.382		0.079		0.500	U	4.0		100.4	0.45		0.023		0.0
CC-012	4/14/2002		6.6	80.0	27.400		1.340		9.140		90.0		493.2	*0.17*		*0.016*		0.0
CC-012	5/12/2002		8.3	194.0	0.382		0.078		0.500	U	3.0	U	117.6	*0.30*		*0.015*		0.0
CC-012	6/9/2002		7.0	164.0	11.900		0.773		5.880		74.0		291.0	*0.17*		*0.010*	U	0.0
CC-012	7/14/2002		8.2	180.0	0.300	U	0.050		0.500	U	4.0		259.5	0.31		0.010	U	0.0

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Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-013	8/12/2001		7.7	218.0	1.230		0.399		0.584		28.0		126.6		*0.23*		*0.043*		0.0
CC-013	9/9/2001	25.0	8.0	216.0	0.821		0.148		0.500	U	10.0		32.3		*0.04*	*U*	*0.042*		0.0
CC-013	10/14/2001	16.0	7.6	238.0	0.718		0.446		0.500	U	4.0		163.0		0.04	U	0.047		0.0
CC-013	11/11/2001		8.0	226.0	0.632		0.314		0.500	U	12.0		122.5		*0.04*	*U*	*0.017*		0.0
CC-013	12/9/2001		8.0	204.0	0.364		0.117		0.500	U	3.0	U	116.3		0.52		0.033		0.0
CC-013	1/13/2002	4.0	8.3	186.0	0.334		0.113		0.500	U	3.0	U	57.2		*0.76*		*0.014*		0.0
CC-013	2/10/2002		8.4	204.0	0.334		0.094		0.500	U	6.0		107.1		0.51		0.010	U	0.0
CC-013	3/10/2002		8.3	198.0	0.316		0.064		0.500	U	6.0		75.1		0.38		0.012		0.0
CC-013	4/14/2002		8.1	192.0	0.638		0.130		0.500	U	10.0		101.3		*0.30*		*0.022*		0.0
CC-013	5/12/2002		8.2	196.0	0.504		0.147		0.500	U	3.0	U	59.5		0.24		*0.017*		0.0
CC-013	6/9/2002		8.0	202.0	0.859		0.134		0.590		24.0		55.3		*0.35*		*0.024*		0.0
CC-013	7/14/2002		8.1	234.0	0.619		0.190		0.500	U	10.0		45.0		*0.21*		*0.010*	U	0.0
CC-014	8/12/2001		6.9	190.0	23.500		0.932		1.040		50.0		1710.0		*0.21*		*0.018*		0.0
CC-014	9/9/2001	20.0	6.9	212.0	23.500		1.020		0.509		78.0		1990.0		*0.15*		*0.024*		0.0
CC-014	10/14/2001	15.0	6.9	202.0	60.500		1.180		3.100		134.0		1479.0		0.05		0.010	U	0.0
CC-014	11/11/2001		6.8	222.0	24.700		0.961		0.759		70.0		2145.0		*0.08*		*0.017*		0.0
CC-014	12/9/2001		6.9	220.0	22.400		0.843		0.775		40.0		1409.9		0.15		0.010	U	0.0
CC-014	1/13/2002	7.0	7.2	194.0	20.800		0.735		0.748		44.0		1427.0		*0.24*		*0.010*	U	0.0
CC-014	2/10/2002		7.1	200.0	15.500		0.504		0.540		30.0		964.7		*0.34*		*0.010*	U	0.0
CC-014	3/10/2002		7.1	190.0	16.100		0.461		0.500	U	44.0		682.2		0.23		0.012		0.0
CC-014	4/14/2002		7.1	190.0	10.100		0.365		0.500	U	28.0		568.3		*0.29*		*0.010*	U	0.0
CC-014	5/12/2002		7.4	196.0	8.560		0.329		0.500	U	16.0		726.0		0.19		0.010	U	0.0
CC-014	6/9/2002		7.3	186.0	6.800		0.264		0.586		22.0		437.3		*0.45*		*0.010*	U	0.0
CC-014	7/14/2002		7.1	194.0	23.600		0.815		1.900		60.0		1346.4		*0.14*		*0.010*	U	0.0

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Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-015	8/12/2001		7.8	176.0	0.646		0.115		0.500	U	12.0		263.5		*0.61*		*0.030*		0.0
CC-015	9/9/2001	24.0	7.9	170.0	0.670		0.080		0.500	U	8.0		116.0		*0.47*		*0.028*		0.0
CC-015	10/14/2001	17.0	7.4	178.0	0.515		0.109		0.500	U	6.0		194.0		0.40		0.051		0.0
CC-015	11/11/2001		8.5	174.0	0.415		0.053		3.000		3.0	U	209.6		*0.41*		*0.031*		0.0
CC-015	12/9/2001		8.0	190.0	0.369		0.091		0.500	U	3.0	U	104.7		0.61		0.035		0.0
CC-015	1/13/2002	7.0	8.2	176.0	0.336		0.112		0.500	U	4.0		93.0		*0.88*		*0.019*		0.0
CC-015	2/10/2002		8.3	182.0	0.320		0.091		0.500	U	3.0	U	115.4		*0.48*		*0.013*		0.0
CC-015	3/10/2002		8.2	170.0	0.319		0.051		0.500	U	3.0	U	99.0		0.37		0.011		0.0
CC-015	4/14/2002		8.0	176.0	0.300		0.079		0.500	U	4.0		100.7		*0.40*		*0.017*		0.0
CC-015	5/12/2002		8.3	174.0	0.341		0.079		0.500	U	3.0	U	151.6		0.23		0.013		0.0
CC-015	6/9/2002		8.0	168.0			0.116		0.500	U	14.0		112.7		*0.40*		*0.026*		0.0
CC-015	7/14/2002		8.0	168.0			0.069		0.500	U	4.0		183.3		*0.61*		*0.019*		0.0
CC-016	8/12/2001		8.0	168.0			0.050	U	0.500	U	4.0		279.6		*0.49*		*0.018*		0.0
CC-016	9/9/2001	26.0	8.1	170.0	0.339		0.050	U	0.500	U	6.0		246.0		*0.27*		*0.011*		0.0
CC-016	10/14/2001	16.0	7.7	166.0	0.300	U	0.050	U	0.500	U	3.0	U	256.0		0.20		0.015		0.0
CC-016	11/11/2001		8.5	168.0	0.300	U	0.050	U	0.500	U	3.0	U	287.6		*0.24*		*0.015*		0.0
CC-016	12/9/2001		8.3	182.0	0.353		0.050	U	0.500	U	3.0	U	142.9		0.59		0.019		0.0
CC-016	1/13/2002	3.0	8.3	170.0	0.416		0.108		0.500	U	3.0	U	111.3		*0.83*		*0.013*		0.0
CC-016	2/10/2002		8.5	176.0	0.341		0.067		0.500	U	3.0	U	127.7		0.44		0.010	U	0.0
CC-016	3/10/2002		8.3	170.0	0.411		0.050	U	0.500	U	12.0		114.0		0.34		0.010	U	0.0
CC-016	4/14/2002		8.2	170.0	0.405		0.063		0.500	U	4.0		161.9		0.35		0.015		0.0
CC-016	5/12/2002		8.3	166.0	0.585		0.057		0.500	U	10.0		94.0		0.19		0.013		0.0
CC-016	6/9/2002		8.1	168.0	0.684		0.094		0.561		35.9		67.3		*0.43*		*0.014*		0.0
CC-016	7/14/2002		8.2	160.0	0.300		0.050		0.500	U	3.0	U	304.4		*0.50*		*0.010*	U	0.0

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Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-017	8/12/2001		7.4	104.0	8.960		0.677		1.780		58.0		430.9		*0.24*		*0.018*		0.0
CC-017	9/9/2001	20.0	7.1	100.0	3.570		0.342		0.906		16.0		464.1		*0.22*		*0.018*		0.0
CC-017	10/14/2001	14.0	7.3	104.0	1.930		0.259		0.539		16.0		501.0		0.04	U	0.014		0.0
CC-017	11/11/2001		7.7	104.0	0.553		0.135		0.500	U	10.0		491.0		*0.08*		*0.010*		0.0
CC-017	12/9/2001		7.2	104.0	0.790		0.190		0.500	U	4.0		385.1		0.17		0.010	U	0.0
CC-017	1/13/2002	5.0	7.6	116.0	0.661		0.279		0.500	U	3.0	U	441.2		0.34		*0.010*	U	0.0
CC-017	2/10/2002		7.9	130.0	0.852		0.232		0.500	U	4.0		82.4		0.48		0.010	U	0.0
CC-017	3/10/2002		7.8	124.0	1.050		0.272		0.500	U	20.1		69.4		0.31		0.010	U	0.0
CC-017	4/14/2002		7.9	122.0	7.310		0.653		1.510		42.0		20.0	U	0.33		0.020		0.0
CC-017	5/12/2002		7.1	76.0	78.400		3.170		27.600		790.0		258.8		0.61		0.015		0.0
CC-017	6/9/2002		7.8	130.0	11.900		1.080		3.190		96.0		286.7		*0.39*		*0.010*	U	0.0
CC-017	7/14/2002		7.8	102.0	5.920		0.607		0.963		28.0		425.5		*0.19*		0.020		0.0
CC-018	8/12/2001		8.0	160.0	0.532		0.050	U	0.500	U	8.0		262.0		*0.45*		*0.015*		0.0
CC-018	9/9/2001	25.0	8.0	168.0	0.432		0.050	U	0.500	U	3.0	U	270.4		*0.24*		*0.010*	U	0.0
CC-018	10/14/2001	16.0	7.8	162.0	0.300	U	0.050	U	0.500	U	3.0	U	338.0		0.12		0.011		0.0
CC-018	11/11/2001		8.4	168.0	0.300	U	0.050	U	0.500	U	3.0	U	318.9		*0.20*		*0.011*		0.0
CC-018	12/9/2001		8.3	182.0	0.344		0.050	U	0.500	U	3.0	U	179.3		0.57		0.017		0.0
CC-018	1/13/2002	8.0	8.1	172.0	0.384		0.099		0.500	U	3.0	U	117.1		0.84		*0.013*		0.0
CC-018	2/10/2002		8.4	178.0	0.300		0.050	U	0.500	U	3.0	U	131.9		0.45		0.010	U	0.0
CC-018	3/10/2002		8.3	168.0	0.390		0.076		0.500	U	8.0		132.6		0.33		0.010	U	0.0
CC-018	4/14/2002		8.3	168.0	0.584		0.074		0.500	U	10.0		128.7		0.35		0.014		0.0
CC-018	5/12/2002		8.2	160.0	4.070		0.176		1.980		272.0		134.8		0.21		0.010	U	0.0
CC-018	6/9/2002		8.2	164.0	1.140		0.135		0.664		18.0		85.5		*0.42*		*0.015*		0.0
CC-018	7/14/2002		8.2	154.0	0.389		0.060		0.500	U	3.0	U	300.1		*0.45*		*0.010*	U	0.0

Notes:

PADEP Bureau of Laboratories Water Quality Results

1. The State Watershed Code for all sites is 20D.
2. See Section 5 and Table 5-1 & Table 5-2 for water quality criteria.
3. U indicates concentrations below the PADEP Bureau of Laboratories' reporting limit (reporting limits shown).
4. A blank space indicates no analysis
5. All results are MG/L except for Temperture and pH
6. *Italicized* data values indicate results of tests that had exceeded time constraints before testing

Site #	Study Date	Temp C	PH	Alkalinity	Iron (Total)		Manganese (Total)		Aluminum (Total)		Total Susp. Solids		Sulfates (Total)		Nitrates		Phosphates		Hot Acidity
CC-019	8/12/2001		7.8	150.0	0.692		0.082		0.500	U	64.0		181.9		*0.42*		*0.024*		0.0
CC-019	9/9/2001	25.0	7.8	162.0	0.300	U	0.050	U	0.500	U	4.0		256.5		*0.24*		*0.010*	U	0.0
CC-019	10/14/2001	14.0	7.6	154.0	0.300	U	0.050	U	0.500	U	4.0		318.0		0.10		0.011		0.0
CC-019	11/11/2001		8.2	164.0	0.300	U	0.050	U	0.500	U	8.0		279.3		*0.10*		*0.011*		0.0
CC-019	12/9/2001		8.2	176.0	0.300	U	0.050	U	0.500	U	3.0	U	176.2		0.55		0.021		0.0
CC-019	1/13/2002	2.0	8.1	166.0	0.300	U	0.071		0.500	U	3.0	U	133.7		*0.82*		*0.013*		0.0
CC-019	2/10/2002		8.3	174.0	0.300	U	0.050	U	0.500	U	3.0	U	113.4		0.47		0.010	U	0.0
CC-019	3/10/2002		8.2	170.0	0.321		0.054		0.500	U	4.0		127.6		0.32		0.010	U	0.0
CC-019	4/14/2002		8.3	166.0	0.362		0.051		0.500	U	8.0		125.8		0.34		0.016		0.0
CC-019	5/12/2002		8.2	164.0	0.441		0.050	U	0.500	U	3.0	U	139.2		0.17		0.013		0.0
CC-019	6/9/2002		8.2	168.0	0.617		0.089		0.500	U	12.0		70.5		*0.42*		*0.014*		0.0
CC-019	7/14/2002		8.1	152.0	0.300	U	0.050	U	0.500	U	3.0		270.4		*0.32*		*0.010*	U	0.0
CC-020	8/12/2001		8.0	206.0	0.478		0.050	U	0.500	U	6.0		120.6		*0.33*		*0.038*		0.0
CC-020	9/9/2001	22.0	8.3	222.0	0.300	U	0.050	U	0.500	U	8.0		56.5		*0.19*		*0.041*		0.0
CC-020	10/14/2001	12.0	7.8	220.0	0.300	U	0.050	U	0.500	U	3.0	U	79.8		0.04	U	*0.040*		0.0
CC-020	11/11/2001		8.2	214.0	0.300	U	0.050	U	0.500	U	3.0	U	103.2		*0.04*	*U*	*0.011*		0.0
CC-020	12/9/2001		8.2	192.0	0.300	U	0.050	U	0.500	U	3.0	U	50.4		0.42		0.017		0.0
CC-020	1/13/2002	3.0	8.1	192.0	0.300	U	0.500	U	0.500	U	3.0	U	56.0		*0.79*		*0.013*		0.0
CC-020	2/10/2002		8.3	200.0	0.300	U	0.050	U	0.500	U	3.0	U	149.5		0.79		0.010	U	0.0
CC-020	3/10/2002		8.3	194.0	0.300	U	0.050	U	0.500	U	3.0	U	84.9		0.60		0.010	U	0.0
CC-020	4/14/2002		8.4	194.0	0.300	U	0.050	U	0.500	U	4.0		83.6		0.55		0.017		0.0
CC-020	5/12/2002		8.3	186.0	0.309		0.050	U	0.500	U	4.0		59.5		0.41		0.012		0.0
CC-020	6/9/2002		8.3	210.0	0.300	U	0.050	U	0.500	U	8.0		27.6		*0.68*		*0.014*		0.0
CC-020	7/14/2002		8.3	234.0	0.300	U	0.050	U	0.500	U	8.0		52.3		*0.50*		*0.020*		

				CROSS CREEK WATERSHED WATER QUALITY FIELD ANALYSIS			
Site	DATE	TIME (Hours)	TEMP. (Celsius)	pH	Specific Conductivity	Dissolved Oxygen	Comments
CC-001	7/8/2001	1330	22	8.1	349	13.5	
CC-002	7/8/2001	1430	25	8.2	429	16.5 (limit)	
CC-003	7/8/2001	1610	25	8.1	450	16.5 (limit)	
CC-004	7/8/2001	1015	18	8.1	420	8.5	
CC-005	7/8/2001	1105	22	8.0	383	9.1	
CC-006	7/8/2001	1135	22	8.0	327	9.2	
CC-007	7/8/2001	1155	22	8.1	319	9.5	
CC-008	7/8/2001	1250	20	8.1	365	9.5	
CC-009	7/8/2001	1500	25	8.2	403	11.6	
CC-010	7/8/2001	1450	25	8.2	422	8.8	
CC-011	7/8/2001	1415	22	6.7	951	9.4	
CC-012	7/8/2001	1400	25	8.2	437	9.2	
CC-013	7/8/2001	1515	25	8.1	396	8.8	
CC-014	7/8/2001	1545	25	7.3	1690	11.8	
CC-015	7/8/2001	1600	25	8.2	397	12.6	
CC-016	7/8/2001	1630	24	8.2	416	12.9	
CC-017	7/8/2001	1645	21	8.0	858	12.5	
CC-018	7/8/2001	1705	23	8.2	448	13	
CC-019	7/8/2001	1730	24	8.2	448	10	
CC-020	7/8/2001	1750	23	8.3	428	11.1	
							07/08/01 ~1" of rain from 0100 to 0600 hrs. All day very hot and humid. No rain during sampling. Air temperature from 70f to 88f. All water samples very turbid (except CC-008) because of previous night's rain.
CC-001	8/12/2001	816	18	8.1	425	7.7	
CC-002	8/12/2001	1107	22	8.2	740	7.2	
CC-003	8/12/2001	1220	21	7.9	812	7.8	
CC-004	8/12/2001	1003	24	8.0	571	5.6	
CC-005	8/12/2001	951	22	7.9	468	5.6	
CC-006	8/12/2001	935	21	8.0	400	7.5	
CC-007	8/12/2001	840	21	8.1	494	7.7	
CC-008	8/12/2001	912	13	9.1	385	7.8	
CC-009	8/12/2001	1050	21	8.2	523	7.4	
CC-010	8/12/2001	1100	21	8.2	778	8.7	
CC-011	8/12/2001	1139	11	6.2	1194	8.2	
CC-012	8/12/2001	1128	22	8.1	764	8.1	
CC-013	8/12/2001	1036	24	7.8	507	4.8	
CC-014	8/12/2001	1200	18	7.2	>2000	7.5	
CC-015	8/12/2001	1207	21	8.0	602	8	
CC-016	8/12/2001	1233	22	8.2	739	8.1	

				CROSS CREEK WATERSHED WATER QUALITY FIELD ANALYSIS			
Site	DATE	TIME (Hours)	TEMP. (Celsius)	pH	Specific Conductivity	Dissolved Oxygen	Comments
CC-017	8/12/2001	1245	18	7.8	753	9.1	
CC-018	8/12/2001	1258	21	8.2	760	8.5	
CC-019	8/12/2001	1308	22	8.0	713	7.7	
CC-020	8/12/2001	1345	20	8.2	454	7.5	
							8/12/01 - Weather: Cloudy, rain starting and continuous. A lot of rain.
CC-001	9/9/2001	1145	18	8.0	379	11.5	
CC-002	9/9/2001	1250	24	8.2	589	8.1	
CC-003	9/9/2001	1445	25	8.2	788	16.5 (limit)	
CC-004	9/9/2001	930	22	8.2	577	7.9	
CC-005	9/9/2001	1000	21	7.7	488	9.7	
CC-006	9/9/2001	1025	20	8.0	470	9.1	
CC-007	9/9/2001	1045	21	8.0	497	8.1	
CC-008	9/9/2001	1115	15	7.8	363	10.3	
CC-009	9/9/2001	1305	24	8.0	476	9.6	
CC-010	9/9/2001	1325	24	8.2	605	9.3	
CC-011	9/9/2001	1230	20	5.5	1148	7.6	
CC-012	9/9/2001	1215	21	8.2	645	9.8	
CC-013	9/9/2001	1345	25	8.0	445	8.6	
CC-014	9/9/2001	1415	20	7.0	3750	8.3	
CC-015	9/9/2001	1425	24	8.2	545	9.1	
CC-016	9/9/2001	1510	26	8.3	726	12.1	
CC-017	9/9/2001	1525	20	7.8	996	10.5	
CC-018	9/9/2001	1535	25	8.3	725	12.7	
CC-019	9/9/2001	1550	25	8.0	780	9.4	
CC-020	9/9/2001	1615	22	8.2	455	8.4	
							9/9/01 - No rain for several days, creek levels low.
CC-001	10/14/2001	1230	15	8.1	412	9.2	
CC-002	10/14/2001	1435	16	7.8	769	10.1	
CC-003	10/14/2001	1335	14	7.9	847	9	
CC-004	10/14/2001	1000	18	8.2	573	5.6	
CC-005	10/14/2001	1030	17	7.9	535	5.1	
CC-006	10/14/2001	1055	17	8.0	486	8.2	
CC-007	10/14/2001	1120	16	8.0	519	7.5	
CC-008	10/14/2001	1145	13	7.9	385	8.7	
CC-009	10/14/2001	1445	16	8.0	488	8.3	
CC-010	10/14/2001	1450	14	7.9	865	9.3	
CC-011	10/14/2001	1425	15	5.7	1143	10.1	
CC-012	10/14/2001	1355	12	7.9	1220	15	
CC-013	10/14/2001	1515	16	7.7	510	10.8	

				CROSS CREEK WATERSHED WATER QUALITY FIELD ANALYSIS			
Site	DATE	TIME (Hours)	TEMP. (Celsius)	pH	Specific Conductivity	Dissolved Oxygen	Comments
CC-014	10/14/2001	1300	15	7.2	NA*	9.8	*Not Analylized, Not Diluted, probably greater than 2000
CC-015	10/14/2001	1310	17	7.8	731	8.9	
CC-016	10/14/2001	1525	16	8.0	805	9.5	
CC-017	10/14/2001	1535	14	7.6	855	4.8	
CC-018	10/14/2001	1545	16	8.1	783	10.7	
CC-019	10/14/2001	1605	14	7.9	795	3	
CC-020	10/14/2001	1625	12	8.0	425	8.3	
							10/14/01 Raining
CC-001	11/11/2001	1235	9	8.2	449	15.2	Clear
CC-002	11/11/2001	1320	9	8.2	722	14.8	Clear, low
CC-003	11/11/2001	1450	11	8.2	793	16.5 (limit)	
CC-004	11/11/2001	1015	10	8.3	690	13.9	Clear, low, slow
CC-005	11/11/2001	1055	8	8.0	728	11.4	Some turbidity, fairly high
CC-006	11/11/2001	1125	8	8.4	613	16.2	Clear
CC-007	11/11/2001	1140	8	8.2	602	14.8	Clear
CC-008	11/11/2001	1205	8	7.7	433	12.4	Clear, new beaver dam ~100' upstream
CC-009	11/11/2001	1350	10	8.3	492	13	Clear
CC-010	11/11/2001	1355	9	8.2	859	14.2	
CC-011	11/11/2001	1300	12	4.3	1305	11	Clear, Acid stains
CC-012	11/11/2001	1245	9	8.3	723	16.5 (limit)	Clear, sewage smell in air
CC-013	11/11/2001	1410	10	7.8	515	14.3	
CC-014	11/11/2001	1425	11	7.0	4800	11.4	
CC-015	11/11/2001	1440	9	8.4	596	16.5 (limit)	
CC-016	11/11/2001	1505	9	8.3	783	14.8	
CC-017	11/11/2001	1515	9	7.6	922	13.9	
CC-018	11/11/2001	1525	9	8.2	806	15.1	
CC-019	11/11/2001	1540	9	8	782	15.6	
CC-020	11/11/2001	1600	8	8	443	13.3	
							11/11/01 - No rain last 48 hours.
CC-001	12/9/2001	1140	6	8	442	11.2	
CC-002	12/9/2001	1305	7	8.2	542	12.7	
CC-003	12/9/2001	1245	7	8.1	616	13.6	
CC-004	12/9/2001	1000	6	8.6	416	12.8	
CC-005	12/9/2001	1015	5	7.9	436	11.7	
CC-006	12/9/2001	1035	6	8.1	433	12.3	
CC-007	12/9/2001	1100	6	8.1	471	12.4	
CC-008	12/9/2001	1130	7	7.7	383	11.3	
CC-009	12/9/2001	1350	7	7	556	12.2	
CC-010	12/9/2001	1400	7	8.2	484	13	
CC-011	12/9/2001	1325	9	5	1324	15.4	

				CROSS CREEK WATERSHED WATER QUALITY FIELD ANALYSIS			
Site	DATE	TIME (Hours)	TEMP. (Celsius)	pH	Specific Conductivity	Dissolved Oxygen	Comments
CC-012	12/9/2001	1335	9	6.7	1643	9.4	
CC-013	12/9/2001	1415	6	8	444	11.8	
CC-014	12/9/2001	1200	9	7.3	4320	9.6	
CC-015	12/9/2001	1220	7	8.2	517	12.5	
CC-016	12/9/2001	1430	7	8.3	608	12.5	
CC-017	12/9/2001	1440	7	7.8	993	16.5(limit)	
CC-018	12/9/2001	1450	7	8.3	620	12.6	
CC-019	12/9/2001	1500	7	8.3	638	13.1	
CC-020	12/9/2001	1520	7	8.2	429	11.2	
							12/09/01 - Air Temp ~35-40 F, creeks med. High
CC-001	1/13/2002	1255	3	7.9	417	16.4	Clear, normal Flow
CC-002	1/13/2002	1335	4	7.5	487	13.5	
CC-003	1/13/2002	1410	4	7.6	538	16.5(limit)	
CC-004	1/13/2002	1100	5	8.3	702	15.7	Clear, normal flow
CC-005	1/13/2002	1125	3	7.8	426	14.9	Clear, normal flow, frozen on top
CC-006	1/13/2002	1145	4	8.1	449	15.7	Clear, normal flow
CC-007	1/13/2002	1205	3	8	409	16.5(limit)	Clear, normal flow, some ice
CC-008	1/13/2002	1225	4	7.9	420	14.8	Clear, normal flow, black staining
CC-009	1/13/2002	1405	4	8	451	13.9	Clear, normal flow
CC-010	1/13/2002	1415	5	7.9	503	14.3	
CC-011	1/13/2002	1320	7	5.4	1221	10.7	Clear, orange stained, normal flow
CC-012	1/13/2002	1305	4	8	499	14.5	Clear, normal flow
CC-013	1/13/2002	1325	4	7.9	430	16	
CC-014	1/13/2002	1340	7	7.2	2946	11.8	
CC-015	1/13/2002	1400	4	7.9	475	15.3	
CC-016	1/13/2002	1435	3	8.2	501	15.7	
CC-017	1/13/2002	1445	5	7.7	937	16.5(limit)	
CC-018	1/13/2002	1455	8	7.4	515	15.4	
CC-019	1/13/2002	1515	2	7.8	538	16.5(limit)	
CC-020	1/13/2002	1540	3	7.9	410	14.4	
CC-001	2/10/2002	1030	5	8	382	13.2	
CC-002	2/10/2002	1235	6	8.3	486	14.9	
CC-003	2/10/2002	1115	4	7.9	513	14.1	
CC-004	2/10/2002	900	5	8.4	501	13.2	
CC-005	2/10/2002	915	4	7.8	471	14.5	
CC-006	2/10/2002	930	3	8	561	13.5	
CC-007	2/10/2002	945	4	8.1	420	13.8	
CC-008	2/10/2002	1015	4	7.8	347	12.3	
CC-009	2/10/2002	1210	5	8.2	458	16.5 (Limit)	

				CROSS CREEK WATERSHED WATER QUALITY FIELD ANALYSIS			
Site	DATE	TIME (Hours)	TEMP. (Celsius)	pH	Specific Conductivity	Dissolved Oxygen	Comments
CC-010	2/10/2002	1200	6	7.7	494	13.7	
CC-011	2/10/2002	1145	7	5.5	1110	9.7	
CC-012	2/10/2002	1130	7	3.8	1559	10.5	
CC-013	2/10/2002	1225	5	8.1	441	14.2	
CC-014	2/10/2002	1045	6	7.3	2488	10.3	
CC-015	2/10/2002	1050	4	8.2	464	14.3	
CC-016	2/10/2002	1300	5	8.3	499	16.5 (Limit)	
CC-017	2/10/2002	1315	6	7.8	951	12.4	
CC-018	2/10/2002	1330	5	8.3	517	14.4	
CC-019	2/10/2002	1320	6	8.2	519	13.8	
CC-020	2/10/2002	1400	6	8.2	441	12.4	
							2/10/02 - Air Temp ~45 f, water average
CC-001	3/10/2002	1215	4	7.9	395	15.6	Clear, normal flow
CC-002	3/10/2002	1235	4	7.8	495	15.1	Clear, normal flow
CC-003	3/10/2002	1440	4	7.7	520	14.9	
CC-004	3/10/2002	1035	4	8.5	575	16.5(limit)	Clear, normal flow
CC-005	3/10/2002	1055	2	7.9	402	15.7	Clear, normal flow
CC-006	3/10/2002	1115	4	7.9	410	15.3	Clear, normal flow
CC-007	3/10/2002	1125	4	8	416	15.9	Clear, normal flow
CC-008	3/10/2002	1145	5	8	353	14.7	Clear, normal flow. Black staining, algea growth
CC-009	3/10/2002	1325	3	7.8	462	13.8	Clear, normal flow
CC-010	3/10/2002	1315	4	7.7	508	15.2	Clear, normal flow
CC-011	3/10/2002	1245	7	6.7	1010	13.5	Clear, normal flow, orange staining
CC-012	3/10/2002	1230	5	7.9	497	16.5(limit)	Clear, normal flow
CC-013	3/10/2002	1340	4	7.7	445	16.3	Clear, normal flow
CC-014	3/10/2002	1410	2	6.9	1869	10.8	
CC-015	3/10/2002	1420	4	7.5	471	16	
CC-016	3/10/2002	1450	5	7.7	509	16.5(limit)	
CC-017	3/10/2002	1500	5	7.4	963	15	
CC-018	3/10/2002	1510	5	7.7	532	15.4	
CC-019	3/10/2002	1525	5	7.7	532	16.5(limit)	
CC-020	3/10/2002	1545	4	7.9	432	16.5(limit)	
CC-001	4/14/2002	1040	13	8.2	387	10.7	
CC-002	4/14/2002	1215	14	7.9	476	10	
CC-003	4/14/2002	1135	7	8	467	11.5	
CC-004	4/14/2002	919	8	8.3	666	11	
CC-005	4/14/2002	930	12	7.8	406	11.2	
CC-006	4/14/2002	945	14	7.9	447	12.3	
CC-007	4/14/2002	1000	7	8.2	445	11.6	

				CROSS CREEK WATERSHED WATER QUALITY FIELD ANALYSIS			
Site	DATE	TIME (Hours)	TEMP. (Celsius)	pH	Specific Conductivity	Dissolved Oxygen	Comments
CC-008	4/14/2002	1025	14	8	369	10.2	
CC-009	4/14/2002	1240	12	8.1	444	10.8	
CC-010	4/14/2002	1235	14	8	486	10.8	
CC-011	4/14/2002	1200	13	6.5	693	9.7	
CC-012	4/14/2002	1150	14	6.9	985	9	
CC-013	4/14/2002	1300	13	8	438	11.6	
CC-014	4/14/2002	1100	14	7.5	1704	9.5	
CC-015	4/14/2002	1115	14	8	457	10.9	
CC-016	4/14/2002	1320	14	8.1	485	10.9	
CC-017	4/14/2002	1330	14	7.8	818	10.4	
CC-018	4/14/2002	1345	15	8.2	485	11.2	
CC-019	4/14/2002	1400	14	8.1	499	10.8	
CC-020	4/14/2002	1445	15	8.4	416	10.7	
							4/14/02 - Creek flow med-high, fast moving. Weather cloudy, first part of day light rain. Heavy rain at locations 008-018. Rained previous 2 days. Temp ~68
CC-001	5/12/2002	1135	20	8.2	396	12.8	Water level normal, clear, fast flow
CC-002	5/12/2002	1227	19	8	466	11.6	Water level bit high, clear, good flow
CC-003	5/12/2002	1355	19	8	474	13.2	
CC-004	5/12/2002	945	18	7.7	513	11.7	Water level bit high, clear, good flow
CC-005	5/12/2002	1005	16	7.8	457	11	Water level bit high, cloudy, good flow
CC-006	5/12/2002	1025	18	8	434	12.8	Water level bit high, clear, fast flow
CC-007	5/12/2002	1045	18	8.1	459	12.6	Water level normal, clear, normal flow
CC-008	5/12/2002	1112	19	8	424	12	Water level normal, clear, fast flow
CC-009	5/12/2002	1235	20	8.2	460	12	Water level normal, clear, fast flow
CC-010	5/12/2002	1240	19	8.2	480	11.6	Water level normal, clear, fast flow
CC-011	5/12/2002	1210	17	6.8	591	11.2	Water level normal/high, clear, fast flow,
CC-012	5/12/2002	1155	19	8.1	483	12.4	Water level normal, clear, fast flow
CC-013	5/12/2002	1255	20	7.9	451	12	Water level normal, clear, fast flow
CC-014	5/12/2002	1325	18	7.5	1320	10.2	Water level normal/high, clear, fast flow
CC-015	5/12/2002	1345	19	8.1	461	11.6	Water level normal/high, clear, fast flow
CC-016	5/12/2002	1415	19	8	474	11	
CC-017	5/12/2002	1425	19	7.4	656	10.6	
CC-018	5/12/2002	1445	18	8	491	12.8	
CC-019	5/12/2002	1520	17	8.1	402	9.9	
CC-020	5/12/2002	1430	18	7.9	487	13.9	
CC-001	6/9/2002	1125	22	7.9	378	10.6	
CC-002	6/9/2002	1245	22	7.8	479	10.1	
CC-003	6/9/2002	1205	22	7.8	452	11.1	

				CROSS CREEK WATERSHED WATER QUALITY FIELD ANALYSIS			
Site	DATE	TIME (Hours)	TEMP. (Celsius)	pH	Specific Conductivity	Dissolved Oxygen	Comments
CC-004	6/9/2002	1005	20	7.9	438	9.6	
CC-005	6/9/2002	1030	19	7.6	392	9.9	
CC-006	6/9/2002	940	21	7.9	430	10.7	
CC-007	6/9/2002	1045	19	7.7	426	13.9	
CC-008	6/9/2002	1110	24	8.1	346	11.7	
CC-009	6/9/2002	1315	22	8.1	481	11.5	
CC-010	6/9/2002	1300	22	8	445	10.4	
CC-011	6/9/2002	1230	19	7	598	9.8	
CC-012	6/9/2002	1220	18	7	560	8.9	
CC-013	6/9/2002	1325	22	7.9	450	9.7	
CC-014	6/9/2002	1145	20	7.3	1010	10.9	
CC-015	6/9/2002	1200	22	7.9	424	10.1	
CC-016	6/9/2002	1350	23	8.1	464	10.1	Due to construction sample taken at the temporary pipes placed for stream crossing
CC-017	6/9/2002	1400	22	7.7	758	16.5	
CC-018	6/9/2002	1415	23	8.1	484	9.2	
CC-019	6/9/2002	1440	22	8.1	461	8.5	
CC-020	6/9/2002	1500	21	8.2	439	8.5	
CC-001	7/14/2002	1105	19	7.5	411	12.1	low, and clear
CC-002	7/14/2002	1205	22	7.4	716	9.8	low, and clear
CC-003	7/14/2002	1325	23	7.4	802	13.8	low, and clear
CC-004	7/14/2002	915	22	8.1	590	10.3	low, and clear
CC-005	7/14/2002	935	20	7.4	450	7.1	slow, average depth, cloudy
CC-006	7/14/2002	955	21	7.5	441	8.9	low, and clear
CC-007	7/14/2002	1010	20	7.8	453	13.7	low, and clear
CC-008	7/14/2002	1045	17	7.2	398	10.5	low, and clear, black staining
CC-009	7/14/2002	1210	22	7.3	476	14.4	low, and clear
CC-010	7/14/2002	1205	23	7.6	788	11.8	low, and clear
CC-011	7/14/2002	1145	20	6.5	1038	13.9	red stained, clear
CC-012	7/14/2002	1125	22	7.4	748	10.4	low, and clear
CC-013	7/14/2002	1220	23	7.3	488	8.3	low, and clear
CC-014	7/14/2002	1250	21	6.8	2830	9.1	low, and clear, red staining
CC-015	7/14/2002	1305	24	7.2	602	14.2	low, and clear, and septic sewage
CC-016	7/14/2002	1350	24	7.6	809	10.1	low, and clear
CC-017	7/14/2002	1405	20	7.3	840	11.1	low, cloudy, red staining
CC-018	7/14/2002	1415	24	7.6	789	11.7	very low, but clear
CC-019	7/14/2002	1435	24	7.4	746	10.7	very low, but clear
CC-020	7/14/2002	1455	21	7.7	483	9.8	very low, but clear

WVSOS Bioassessment Calculations

Macroinvertebrate Score Sheet – Use this score sheet to calculate each of the biotic indexes that will be used to determine the stream's condition.

Major Group	Total #	Types	Tolerance	HBI value
Stonefly			2.0	
Mayfly			3.0	
Most Caddisflies			3.0	
Water penny			4.0	
Riffle beetle			4.0	
Hellgrammite			4.0	
Fishfly			4.0	
Watersnipe			4.0	
Netspinning Caddisfly			5.0	
Cranefly			5.0	
Alderfly			5.0	
Other beetle larva			5.0	
Dragonfly			6.0	
Damselfly			6.0	
Clams & mussels			6.0	
Water bugs			6.0	
Crayfish			7.0	
Sowbugs			7.0	
Scuds			7.0	
Other crustaceans			7.0	
Snails			7.0	
Blackfly larva			7.0	
Midge larva			8.0	
Other fly larva			8.0	
Flatworms			8.0	
Aquatic worms			10.0	
Leeches			10.0	
Totals			Total HBI	

Biotic Indexes	Value	**Comments**
% EPT Abundance		
Taxa Richness		
EPT Richness		
HBI Index		
% Tolerant		
% Dominance		

Bioassessment Integration – Based upon your calculated values, circle the appropriate range and determine your overall biotic index by adding the totals from each column.

Index	Value	**6**	**4**	**2**	**1**
% EPT		> 75	75 - 50	50 - 25	< 25
Taxa Richness		> 20	20 - 10	10 – 6	< 6
EPT Richness		> 10	10 - 7	7 – 4	< 4
HBI Index		< 4.0	4.0 – 6.0	6.0 – 7.0	> 7.0
% Tolerant		< 10	10 - 20	20 – 40	> 40
% Dominance		< 20	20 - 40	40 – 60	> 60
Totals					
Stream Index					

Rating Scale	Excellent	Good	Marginal	Poor
	> 30	30 - 24	23 - 12	< 12

Bioassessment Instructions

Use the score sheet to the left, or the excel spreadsheet, which is available from WVSOS, to complete the table above. The indexes listed are calculated as follows:

% EPT – This index is the % of the 3 most pollution sensitive groups, the mayflies "**E**", stoneflies "**P**" and the caddisflies "**T**". To calculate the index, divide the total number of organisms by the total number of EPT's. Multiply by 100 to obtain your percentage.
Taxa Richness – This index is the number of types found in the samples. To calculate the index, add the total number of types.
EPT Richness – This index is the number of EPT types. To calculate the index, add the number of EPT types.
HBI Index – This index is a modified version of the Hilsenhoff Biotic Index (HBI) and is based upon the organism's tolerance to organic pollution. To calculate the index multiply the number of organisms by their pollution tolerance value (HBI value), sum all HBIs (Total HBI), and divide the Total HBI by the total number of organisms collected.
% Tolerant – This index is the % of the most pollution tolerant organisms, organisms with an HBI value of 8 or more. To calculate the index, add all tolerant organisms and divide that total by the total number of organisms. Multiply by 100 to obtain your percentage.
% Dominance – This index is the % contribution of the most numerically dominant organism. To calculate the index, find the most numerically dominant organism (the one with the highest number) and divide that number by the total number of organisms. Multiply by 100 to obtain your percentage.

If you have questions, or would like a copy of the excel spreadsheet (you will still need the table above), send e-mail to tcraddock@mail.dep.state.wv.us.

WVSOS Bioassessment Calculations

Why Biological Monitoring?

Traditional measures of water quality such as levels of dissolved oxygen or concentrations of toxic contaminants in water (performance based standards) are indirect ways to determine the health of a waterbody. They allow one to draw inferences concerning expected effects on aquatic life but do not look directly at biological responses in the stream. By inventorying the makeup of invertebrate communities and comparing results to those found in reference reaches (relatively undisturbed areas), it is possible to determine whether or not pollution is causing ecological effects such as the loss of sensitive groups of organisms.

Section 101 of the Federal Clean Water Act states that "it is the objective of the Act to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Of the three characteristics, biological integrity may be the most important since organisms not only integrate the full range of environmental influences (chemical, physical, and biological), but also complete their life cycles in the water and, as such, are continuous monitors of environmental quality.

How do you make any sense of all those macroinvertebrates?

Biologists use metrics to analyze samples of benthic invertebrates taken from a stream. Metrics are measures that summarize the numbers of organisms, the types of organisms, and the pollution tolerance of organisms. Taxa Richness, EPT Abundance and HBI are a few of the more commonly used metrics.

Taxa richness is a measure of the number of distinct families (types) of critters in the stream. For example, a healthy stream has many different organisms. A healthy stream often has 20 or more families of different organisms. An impacted stream tends to have fewer types of organisms, and most of those present most often are pollution tolerant and can live in poor habitat. As stream health improves, the number of different organisms increases and taxa richness generally increases. Taxa richness is also seasonal. The number of different organisms usually peaks in the spring, before the first hatch of mature insects occurs.

Mayflies, stoneflies and caddisflies are sensitive to changes in water quality and habitat. The Latin names for the orders of these insects are Ephemeroptera, Plecoptera and Trichoptera. The number of different families, genera or species in these three orders can be counted and summarized into another common index, the number of **E**phemeroptera, **P**lecoptera and **T**richoptera, or simply **%EPT**. Healthy streams often have 10-15 different families of mayflies, stoneflies and caddisflies present. EPT is a subset of total taxa richness, and it also peaks in the spring.

The Hilsenhoff Biotic Index, or **HBI**, is another common index that is designed to summarize the organic pollution tolerance of stream critters. This index was designed when raw sewage in streams and rivers was still a widespread concern. However, it is still useful today since many activities add organic pollution to the water (treated waste water, septic tanks, agriculture, etc.). Each family (type) is assigned a tolerance value of 0 - 10. The most sensitive organisms are lower on the scale. The more tolerant organisms are on the higher end of the scale. The index value ranges from 0 - 10, increasing as water quality decreases. Common values for healthy streams are often less than 4.0. This means that the average tolerance value of all the critters in the stream is 4.0. Slow-moving, lower gradient streams, like those found in the coastal plain, will have higher values for this index than fast-moving higher gradient streams. The slower-moving streams should not be considered impaired or polluted, just naturally different.

Measuring Integrity: **The Integration of Biotic Indexes**

"Our ability to protect biological resources depends on our ability to identify and predict the effects of human actions on biological systems, especially our ability to distinguish between natural and human-induced variability in biological condition".

We use an integration process; also know as an Index of Biotic Integrity (IBI) as a synthesis of diverse biological information, which depicts associations between human influence and biological attributes. It is normally composed of several biological attributes or **metrics** (indexes) that are sensitive to changes in conditions caused by human activities. This multi-metric (integration of indexes) approach compares what is found at a monitoring site to what is expected using a baseline condition that reflects little or no human impact. Just as doctors use data from a check-up (e.g., blood samples, temperature, weight, blood pressure, etc.) to compare against what is considered healthy in humans, multimetric indexes utilize a variety of measurements to assess the biological condition of our streams. The multiple index approach uses the following benthic macro-invertebrate information: Pollution tolerance or intolerance taxa (%EPT, %Tolerant); Taxonomic composition (Taxa Richness, EPT Richness, %Dominance); and Population attributes (HBI and other indexes).

The IBI is a measure of a stream's biological condition (i.e., health). Each of the individual metrics reflects the condition of important biological components. These components provide insight and clues about the types of degradation responsible for changes within the biological community of benthic macro-invertebrates. It is important to not only look at the final score, but to look at the individual metric scores for clues to the types of impacts affecting the final score. Knowing the stream ecology of the different taxa associated with streams in your region will aid in the interpretation of your data and the resulting IBI scores.

4/16/2000 CC001

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly	36	1	3.0	108
Most Caddisflies	36	1	3.0	108
Water penny	22	1	4.0	88
Riffle beetle	7	1	4.0	28
Hellgramite			4.0	0
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	9	1	5.0	45
Alderfly			5.0	0
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish	1	1	7.0	7
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae	2	1	7.0	14
Midge larvae			8.0	0
Other fly larvae	24	1	8.0	192
Flatworms			8.0	0
Aquatic worms	1	1	10.0	10
Leeches			10.0	0
Totals	**138**	**9**	**Total HBI**	**600**
Biotic indices	*Value*			
%EPT abundance	52.173913			
Taxa richness	9			
EPT Richness	2			
HBI index	4.3478261			
% tolerant	18.1			
% dominance	26			

4/16/00 CC002

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly	2	1	2.0	4
Mayfly	8	1	3.0	24
Most Caddisflies	25	1	3.0	75
Water penny			4.0	0
Riffle beetle			4.0	0
Hellgramite	39	1	4.0	156
fishfly			4.0	0
Watersnipe	1	1	4.0	4
Netspinning Caddisfly			5.0	0
Cranefly	11	1	5.0	55
Alderfly	11	1	5.0	55
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly	7	1	6.0	42
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish	2	1	7.0	14
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae	1	1	7.0	7
Midge larvae	43	1	8.0	344
Other fly larvae	1	1	8.0	8
Flatworms			8.0	0
Aquatic worms			10.0	0
Leeches			10.0	0
Totals	**151**	**12**	**Total HBI**	**788**
Biotic indices	*Value*			
%EPT abundance	23.178808			
Taxa richness	12			
EPT Richness	3			
HBI index	5.218543			
% tolerant	29			
% dominance	28			

4/16/00 CC003

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly	2	1	2.0	4
Mayfly	1	1	3.0	3
Most Caddisflies			3.0	0
Water penny	1	1	4.0	4
Riffle beetle			4.0	0
Hellgramite			4.0	0
fishfly			4.0	0
Watersnipe	3	1	4.0	12
Netspinning Caddisfly			5.0	0
Cranefly			5.0	0
Alderfly			5.0	0
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish	1	1	7.0	7
Sowbugs			7.0	0
Scuds	2	1	7.0	14
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae	3	1	7.0	21
Midge larvae	2	1	8.0	16
Other fly larvae	3		8.0	24
Flatworms			8.0	0
Aquatic worms	1	1	10.0	10
Leeches			10.0	0
Totals	**19**	**9**	**Total HBI**	**115**
Biotic indices	*Value*			
%EPT abundance	15.78947368			
Taxa richness	9			
EPT Richness	2			
HBI index	6.052631579			
% tolerant	32			
% dominance	16			

10/08/00 CC001

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly	15	1	2.0	30
Mayfly	18	1	3.0	54
Most Caddisflies	16	1	3.0	48
Water penny	65	1	4.0	260
Riffle beetle	2	1	4.0	8
Hellgramite	1	1	4.0	4
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	3	1	5.0	15
Alderfly	18	1	5.0	90
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly	12	1	6.0	72
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish	4	1	7.0	28
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails	1	1	7.0	7
Black fly larvae	3	1	7.0	21
Midge larvae	1	1	8.0	8
Other fly larvae			8.0	0
Flatworms	3	1	8.0	24
Aquatic worms			10.0	0
Leeches			10.0	0
Totals	**162**	**14**	**Total HBI**	**669**
Biotic indices	*Value*			
%EPT abundance	30.2469136			
Taxa richness	14			
EPT Richness	3			
HBI index	4.12962963			
% tolerant	2.5			
% dominance	40			

10/08/00 CC002

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly	1	1	2.0	2
Mayfly	7	1	3.0	21
Most Caddisflies	25	1	3.0	75
Water penny			4.0	0
Riffle beetle			4.0	0
Hellgramite	5	1	4.0	20
fishfly			4.0	0
Watersnipe	1	1	4.0	4
Netspinning Caddisfly			5.0	0
Cranefly	6	1	5.0	30
Alderfly	8	1	5.0	40
Other beetle larva			5.0	0
Dragonfly	1	1	6.0	6
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs	1	1	6.0	6
Crayfish	7	1	7.0	49
Sowbugs			7.0	0
Scuds	1	1	7.0	7
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae	5	1	7.0	35
Midge larvae			8.0	0
Other fly larvae	2	1	8.0	16
Flatworms			8.0	0
Aquatic worms	9	1	10.0	90
Leeches			10.0	0
Totals	**79**	**14**	**Total HBI**	**401**
Biotic indices	*Value*			
%EPT abundance	41.772152			
Taxa richness	14			
EPT Richness	3			
HBI index	5.0759494			
% tolerant	14			
% dominance	32			

10/08/00 CC003

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly	12	1	3.0	36
Most Caddisflies	18	1	3.0	54
Water penny	1	1	4.0	4
Riffle beetle	1	1	4.0	4
Hellgramite	1	1	4.0	4
fishfly			4.0	0
Watersnipe	2	1	4.0	8
Netspinning Caddisfly			5.0	0
Cranefly	3	1	5.0	15
Alderfly	4	1	5.0	20
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish	2	1	7.0	14
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae	3	1	8.0	24
Other fly larvae	5	2	8.0	40
Flatworms	1	1	8.0	8
Aquatic worms			10.0	0
Leeches	1	1	10.0	10
Totals	**54**	**14**	**Total HBI**	**241**
Biotic indices	*Value*			
%EPT abundance	55.555556			
Taxa richness	14			
EPT Richness	2			
HBI index	4.462963			
% tolerant	13			
% dominance	33			

4/29/2001 CC001

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly	1	1	3.0	3
Most Caddisflies	15	1	3.0	45
Water penny	35	1	4.0	140
Riffle beetle			4.0	0
Hellgramite	16	1	4.0	64
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	2	1	5.0	10
Alderfly	8	1	5.0	40
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae	24	1	8.0	192
Other fly larvae			8.0	0
Flatworms			8.0	0
Aquatic worms			10.0	0
Leeches			10.0	0
Totals	**101**	**7**	**Total HBI**	**494**
Biotic indices	*Value*			
%EPT abundance	15.841584			
Taxa richness	7			
EPT Richness	2			
HBI index	4.8910891			
% tolerant	24			
% dominance	35			

4/29/2001 CC002

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly			3.0	0
Most Caddisflies			3.0	0
Water penny			4.0	0
Riffle beetle			4.0	0
Hellgramite	2	1	4.0	8
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	2	1	5.0	10
Alderfly			5.0	0
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish	4	1	7.0	28
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae	7	1	7.0	49
Midge larvae	8	1	8.0	64
Other fly larvae			8.0	0
Flatworms			8.0	0
Aquatic worms	2	1	10.0	20
Leeches			10.0	0
Totals	**25**	**6**	**Total HBI**	**179**
Biotic indices	*Value*			
%EPT abundance	0			
Taxa richness	6			
EPT Richness	0			
HBI index	7.16			
% tolerant	40			
% dominance	32			

4/29/2001 CC003

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly	1	1	3.0	3
Most Caddisflies	17	1	3.0	51
Water penny	1	1	4.0	4
Riffle beetle			4.0	0
Hellgramite			4.0	0
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	4	1	5.0	20
Alderfly			5.0	0
Other beetle larva	4	1	5.0	20
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae	22	1	8.0	176
Other fly larvae			8.0	0
Flatworms			8.0	0
Aquatic worms	7	1	10.0	70
Leeches			10.0	0
Totals	**56**	**7**	**Total HBI**	**344**
Biotic indices	*Value*			
%EPT abundance	32.1428571			
Taxa richness	7			
EPT Richness	2			
HBI index	6.14285714			
% tolerant	52			
% dominance	39			

10/7/2001 CC001

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly	9	1	3.0	27
Most Caddisflies	15	1	3.0	45
Water penny	6	1	4.0	24
Riffle beetle			4.0	0
Hellgramite	4	1	4.0	16
fishfly	4	1	4.0	16
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	30	1	5.0	150
Alderfly	4	1	5.0	20
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae	7	1	7.0	49
Midge larvae			8.0	0
Other fly larvae	2	1	8.0	16
Flatworms			8.0	0
Aquatic worms	6	1	10.0	60
Leeches			10.0	0
Totals	**87**	**10**	**Total HBI**	**423**
Biotic indices	*Value*			
%EPT abundance	27.586207			
Taxa richness	10			
EPT Richness	2			
HBI index	4.862069			
% tolerant	9			
% dominance	35			

10/7/2001 CC002

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly	30	1	3.0	90
Most Caddisflies	129	1	3.0	387
Water penny	19	1	4.0	76
Riffle beetle			4.0	0
Hellgramite	13	1	4.0	52
fishfly	3	1	4.0	12
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	2	1	5.0	10
Alderfly	2	1	5.0	10
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly	2	1	6.0	12
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae	32	1	8.0	256
Other fly larvae	21	1	8.0	168
Flatworms			8.0	0
Aquatic worms			10.0	0
Leeches			10.0	0
Totals	**253**	**10**	**Total HBI**	**1073**
Biotic indices	*Value*			
%EPT abundance	62.84585			
Taxa richness	10			
EPT Richness	2			
HBI index	4.2411067			
% tolerant	21			
% dominance	51			

10/7/2001 CC003

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly			3.0	0
Most Caddisflies	25	1	3.0	75
Water penny			4.0	0
Riffle beetle	3	1	4.0	12
Hellgramite	2	1	4.0	8
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	2	1	5.0	10
Alderfly			5.0	0
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae			8.0	0
Other fly larvae			8.0	0
Flatworms			8.0	0
Aquatic worms	3	1	10.0	30
Leeches			10.0	0
Totals	**35**	**5**	**Total HBI**	**135**
Biotic indices	*Value*			
%EPT abundance	71.428571			
Taxa richness	5			
EPT Richness	1			
HBI index	3.8571429			
% tolerant	8.6			
% dominance	71			

Year 2002 WVDEP Bioassessment Worksheets

4/21/02 CC001

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly	1	1	3.0	3
Most Caddisflies	30	1	3.0	90
Water penny	15	1	4.0	60
Riffle beetle			4.0	0
Hellgramite			4.0	0
fishfly			4.0	0
Watersnipe	2	1	4.0	8
Netspinning Caddisfly			5.0	0
Cranefly	6	1	5.0	30
Alderfly			5.0	0
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae	6	1	8.0	48
Other fly larvae	6	1	8.0	48
Flatworms			8.0	0
Aquatic worms	6	1	10.0	60
Leeches			10.0	0
Totals	**72**	**8**	**Total HBI**	**347**
Biotic indices	*Value*			
%EPT abundance	43.055556			
Taxa richness	8			
EPT Richness	2			
HBI index	4.8194444			
% tolerant	25			
% dominance	42			

4/21/02 CC002

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly			3.0	0
Most Caddisflies	8	1	3.0	24
Water penny			4.0	0
Riffle beetle			4.0	0
Hellgramite			4.0	0
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	1	1	5.0	5
Alderfly	1	1	5.0	5
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae	5	1	8.0	40
Other fly larvae	6	2	8.0	48
Flatworms			8.0	0
Aquatic worms	10	2	10.0	100
Leeches			10.0	0
Totals	**31**	**8**	**Total HBI**	**222**
Biotic indices	*Value*			
%EPT abundance	25.806452			
Taxa richness	8			
EPT Richness	1			
HBI index	7.1612903			
% tolerant	68			
% dominance	32			

4/21/02 CC003

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly			3.0	0
Most Caddisflies	4	1	3.0	12
Water penny			4.0	0
Riffle beetle			4.0	0
Hellgramite			4.0	0
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	1	1	5.0	5
Alderfly	2	1	5.0	10
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs	1	1	7.0	7
Scuds	1	1	7.0	7
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae	10	1	8.0	80
Other fly larvae	2	1	8.0	16
Flatworms	1	1	8.0	8
Aquatic worms	20	1	10.0	200
Leeches			10.0	0
Totals	**42**	**9**	**Total HBI**	**345**
Biotic indices	*Value*			
%EPT abundance	9.5238095			
Taxa richness	9			
EPT Richness	1			
HBI index	8.2142857			
% tolerant	79			
% dominance	48			

10/13/2002 CC001

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly	15	1	2.0	30
Mayfly	60	1	3.0	180
Most Caddisflies	92	1	3.0	276
Water penny	14	1	4.0	56
Riffle beetle	14	1	4.0	56
Hellgramite	8	1	4.0	32
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	13	1	5.0	65
Alderfly	8	1	5.0	40
Other beetle larva	42	1	5.0	210
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels	4	1	6.0	24
Waterbugs	1	1	6.0	6
Crayfish	7	1	7.0	49
Sowbugs	25	1	7.0	175
Scuds	29	1	7.0	203
Other Crustaceans			7.0	0
Snails	2	1	7.0	14
Black fly larvae			7.0	0
Midge larvae	28	1	8.0	224
Other fly larvae	11	1	8.0	88
Flatworms	2	1	8.0	16
Aquatic worms	6	1	10.0	60
Leeches			10.0	0
Totals	**381**	**19**	**Total HBI**	**1804**
Biotic indices	*Value*			
%EPT abundance	43.832021			
Taxa richness	19			
EPT Richness	3			
HBI index	4.734908136			
% tolerant	25			
% dominance	42			

Year 2002 WVDEP Bioassessment Worksheets

10/13/2002 CC002

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly			3.0	0
Most Caddisflies	6		3.0	18
Water penny			4.0	0
Riffle beetle			4.0	0
Hellgramite			4.0	0
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly	13		5.0	65
Alderfly			5.0	0
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs	4		6.0	24
Crayfish	3		7.0	21
Sowbugs	3		7.0	21
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae	1		7.0	7
Midge larvae	44		8.0	352
Other fly larvae	20		8.0	160
Flatworms			8.0	0
Aquatic worms	4		10.0	40
Leeches			10.0	0
Totals	**98**	**0**	**Total HBI**	**708**
Biotic indices	*Value*			
%EPT abundance	6.122449			
Taxa richness	0			
EPT Richness	0			
HBI index	7.2244898			
% tolerant	25			
% dominance	42			

10/13/2002 CC003

General grouping	*Total #*	*# Taxa*	*Tolerance*	*HBI Value*
Stonefly			2.0	0
Mayfly			3.0	0
Most Caddisflies			3.0	0
Water penny			4.0	0
Riffle beetle			4.0	0
Hellgramite			4.0	0
fishfly			4.0	0
Watersnipe			4.0	0
Netspinning Caddisfly			5.0	0
Cranefly			5.0	0
Alderfly			5.0	0
Other beetle larva			5.0	0
Dragonfly			6.0	0
damselfly			6.0	0
Clams&mussels			6.0	0
Waterbugs			6.0	0
Crayfish			7.0	0
Sowbugs			7.0	0
Scuds			7.0	0
Other Crustaceans			7.0	0
Snails			7.0	0
Black fly larvae			7.0	0
Midge larvae			8.0	0
Other fly larvae			8.0	0
Flatworms			8.0	0
Aquatic worms			10.0	0
Leeches			10.0	0
Totals	**0**	**0**	**Total HBI**	**0**
Biotic indices	*Value*			
%EPT abundance	#DIV/0!			
Taxa richness	0			
EPT Richness	0			
HBI index	#DIV/0!			
% tolerant	25			
% dominance	42			

Appendix B

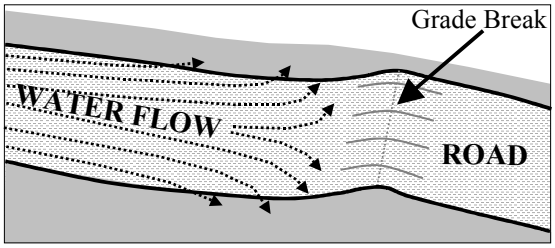
Dirt & Gravel Road Technical Documentation

Technical Bulletin # D-001

Version 1.0 5/09/01

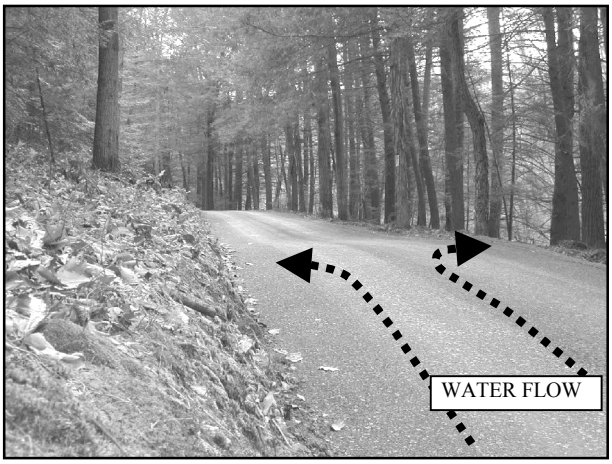
GRADE BREAKS

GRADE BREAK – A small intentional increase in road elevation on a downhill slope, which causes water to flow off of the road surface to both sides into ditches or dispersal areas.



PURPOSES – The main purpose of a *grade break* is to prevent erosion of road material caused by build up of water volume and velocity in the travel lanes. They also calm traffic speeds.

NO GRADE BREAK – Water flows on road causing excess erosion and aggregate loss.



GRADE BREAK – Interruption in slope redirects flow and causes water to leave road area.

BENEFITS OF *GRADE BREAKS*:

- *Grade breaks* conserve road material and prevent eroded road surfaces
- *Grade breaks* reduce road maintenance expenses
- *Grade breaks* conserve aggregate by removing the water's erosive force from the road
- *Grade breaks* calm traffic by inducing lower driving speeds

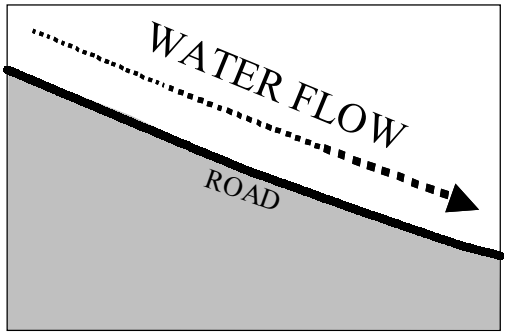
WHERE TO USE *GRADE BREAKS*:

- On any sloping section of road that has evidence of water velocity damage to the surface.
- Before stream crossings to force road surface drainage into turnouts or vegetative filters.
- At intervals frequent enough to prevent a concentration of water to cause erosion of the road surface or of the discharge area. If ruts are forming on the driving surface or stones 1 inch or larger are being moved by concentrated water flow, some correction is needed.
- Prior to cross pipes to cause water to flow into the inlet side ditch. Discharge to the side ditches should not be located where it can erode cover off of the end of the pipe.

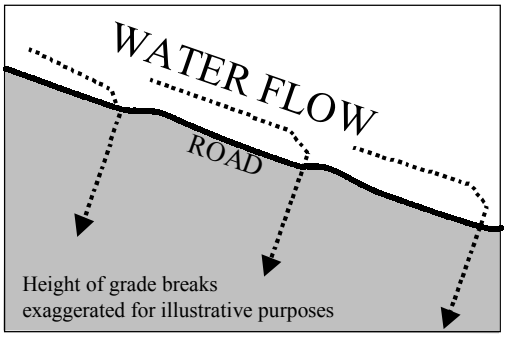
Grade breaks are easy to build with normal machinery. They are inexpensive, but highly effective structures to reduce and prevent erosion of dirt and gravel roads!

The publishers of this publication gratefully acknowledge the financial support of the Pennsylvania State Conservation Commission. For additional information or assistance, contact: Center for Dirt & Gravel Roads Studies, Penn State University, 105 MRL, University Park, PA 16802 (Phone: 814-865-5355, Fax: 814-863-7039, Email: Dirtandgravel@psu.edu). Copies available at www.mri.psu.edu/cdgrs.

PENNSTATE



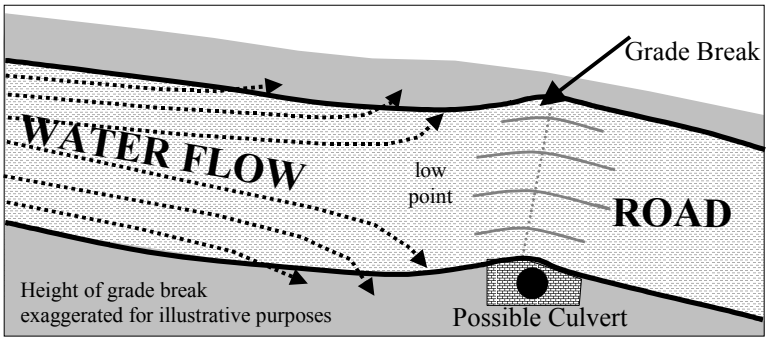
NO *GRADE BREAKS* – Water flows on road causing excess erosion and aggregate loss.



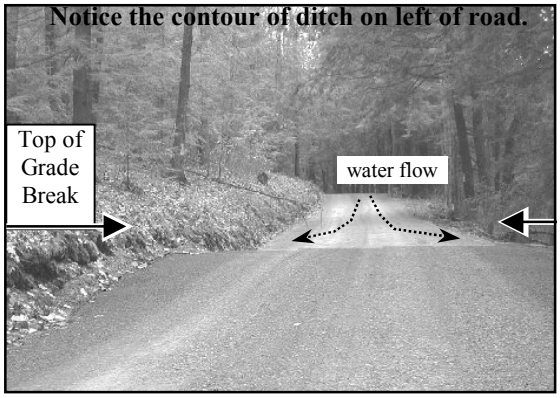
***GRADE BREAKS* – Increase in slope disrupts flow and causes water to leave road area.**

IMPORTANT CONSIDERATIONS:

- Spacing: On a long sloped road, multiple g*rade breaks* may be used in succession to bleed water from the road and prevent the buildup of erosive volume and velocity. The degree of slope is the determining factor in *grade break* spacing. Steeper slopes require g*rade breaks* to be constructed closer together because water will build volume and velocity more rapidly.
- Equipment: Most municipalities can make a *grade break* with their own equipment. A bulldozer is preferred, but in most cases, a grader can be used.
- Transitions: It is important to gradually taper the edges of a *grade break* back into the road grade. Driving through the finished *grade break* in a car at a reasonable speed is one test of this structure. If the ride is too rough or the car "bottoms-out", the structure needs to be tapered more. The iron clad test of a *grade break* is the ability to plow snow. The plow should ride into and out of the *grade break* without cutting the road surface. A good *grade break* is very subtle.
- Maintenance: Grader operators need to be instructed to maintain crown through a *grade break* without eliminating it. Traditional grading operations strive to eliminate surface deviations. Uninformed operators may see g*rade breaks* as a source of road material for use in other areas.



Compressed illustration showing road surface water drainage patterns at grade break. (Height is Exaggerated)



BROAD BASED DIPS:

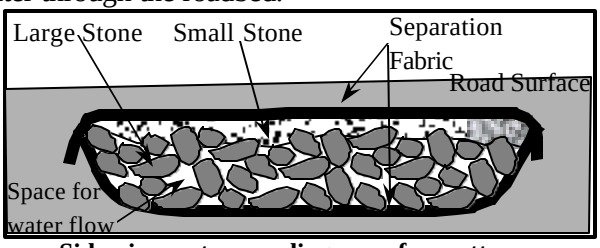
A "*Broad Based Dip*" is somewhat like a *grade break* except it conveys water from the uphill road ditch and road surface across the road and to a discharge area. *Broad based dips* are also effective structures in diverting water and will be the subject of a future technical bulletin.

PENNSTATE

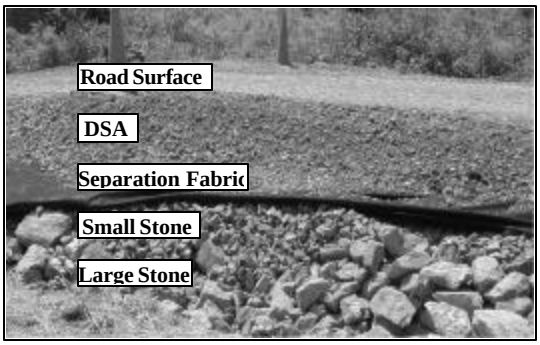
Technical Bulletin # D-002
Version 1.0 8/24/01

FRENCH MATTRESS

FRENCH MATTRESS –A structure under a road consisting of coarse rock wrapped in fabric through which water can freely pass. A *French mattress* is basically a French drain that is used similar to a culvert to allow water through the roadbed.



Side view cut-away diagram of a mattress



Side view of an actual mattress.

PURPOSES: The primary function of a *French mattress* is to provide road support, and to establish, maintain, or equalize the subsurface water on both sides of the road. The use of *French mattresses* in road maintenance is a relatively new concept, and therefore the use of a *French mattress* should be approached with caution. Please contact the Center for Dirt & Gravel Road Studies for assistance.

HOW THEY WORK:
Support strength is provided by large rocks in the lower portions and by spreading the load with layers of progressively smaller rock near the top. Water moves into the *French mattress* from any direction through the protective fabric, which functions to stop the fine material. The water collects in the voids provided by the larger rock and moves by gravity either into the soil or subsurface drainpipes, if provided, or as a gentle seep outlet on the downhill end of the structure.

BENEFITS:
- Correct road support problems in areas where the road base has been weakened by water saturation caused when the road acts as a dam to natural water flow
- Allows for natural equalization of subsurface water on both sides of a road
- Requires little, if any, maintenance compared to cross-drainage culverts
- May eliminate the need for additional cross pipes in some instances
- Allows a gentle, non-erosive water discharge rather than concentrated flow
- An indefinite service life provided they are not plugged

WHERE TO USE A *FRENCH MATTRESS*:
- Areas where concentrated outlet flow through a pipe may be undesired, impractical, or regulated.
- On low-lying areas near streams or wetlands where installing cross drains would be difficult.
- Where a road is acting as an impoundment, or dam, to the natural water flow by isolating the new subsurface water on one side of the road from the other.
- Where placement of a pipe at the depth necessary to provide structural cover would lower the natural water table of the area and require long term maintenance.

The publishers of this publication gratefully acknowledge the financial support of the Pennsylvania State Conservation Commission. For additional information or assistance, contact: Center for Dirt & Gravel Roads Studies, Penn State University, 105 MRL, University Park, PA 16802 (Phone: 814-865-5355, Fax: 814-863-7039, Email: dirtandgravel@psu.edu). Additional copies available on our website at: www.mri.psu.edu/cdgrs.

IMPORTANT CONSIDERATIONS:

- Materials: The core material for the mattress should be large clean stone, typically referred to as R4[1]. A general rule is that the depth of the mattress needs to be at least three times the diameter of the largest stone used. Smaller stone, such as #3's[1] should be placed on top of the large stone. Progressively smaller stone should be place on top to prevent tearing of the fabric. The structure should be wrapped in heavy-duty, non-woven separation fabric.
- Dimensions: The length of the mattress must at least extend to the width of the road, but can be extended out of the road area and under adjacent ground if necessary. Mattress width depends on the amount of water that will need to pass through. In wetland settings, the mattress should be as wide as possible to allow slow lateral flow and avoid concentrating the outlet drainage. Mattress depth depends on stone size, depth available, and desired drainage patterns.
- Openings: May be covered or uncovered depending on the situation.
- Equipment: Most mattresses can be installed easily with a backhoe and a truck to haul stone.

CONSTRUCTION: *Refer to numbered pictures on right.*

1. Excavate the section of the road where the mattress will be located to desired depth. Lay heavy-duty separation fabric in the bottom of the area after excavation and leveling. Use bedding material if necessary to protect fabric. Leave enough fabric on the ends to wrap around and overlap with top fabric later.

2. Place large stone, typically R4[1], on top of the fabric and spread out into a uniform bed.

3. Place a layer of smaller stone such as #3's[1] on top of the R4[1]. Be careful not to intermix the two stone sizes. The empty space between the large stones, and therefore water capacity, will be reduced if the small stone is intermixed. Spread increasingly smaller stone on top to create layer that will not puncture fabric.

4. Wrap ends of lower fabric up on top of structure. Place a piece of fabric on the top if existing fabric does not completely cover mattress. All fabric "joints" should overlap by at least 18".

5. Place bedding material and fill over the mattress if necessary. Place sufficient driving surface aggregate over the structure according to normal specifications and procedures.

TYPICAL REQUIREMENTS:

While these figures will vary with the size of structure and individual site conditions, here is what was required for the 20´ x 12´ x 1.5´ mattress illustrated on the right:

- 3 Hours of work with a Case 580 Backhoe
- 20 tons of clean R4[1] rock (large rock)
- 8 tons of clean #3[1] rock (small rock on top)
- 85 Square yards of heavy-duty geo-textile (fabric)
- Sufficient fill and aggregate over fabric as driving surface (at least 6 inches recommended after compaction)

[1] **R4 and #3 size rock refer to PA Department of Transportation Section 408 Specifications. #3 rock ranges from 1" to 2 ½". R4 rock ranges from 3" to 18".**

Appendix C

Sewage Options

WASTEWATER OPTIONS CHECKLIST

STANDARD ON-LOT SEWAGE SYSTEMS (SEO-PERMITTED)

SS-1: In-Ground Bed
SS-2: In-Ground Trenches
SS-3: Elevated Sand Mound (ESM) Bed
SS-4: Elevated Sand Mound (ESM) Trenches
SS-5: Subsurface Sand Filters
SS-6: Permit-Exempt System (a.k.a., A10-acre exempt@)
SS-7: Bonded Disposal Systems
SS-8: Retaining Systems ('73.62, holding tank; '73.63 privy)
SS-9: Individual Residential Spray Irrigation (IRSIS) (trained SEO or PA DEP)
SS-10: Recycling, Incinerating, or Composting Toilet
Note: Primary Treatment Component Options:
- ! Septic Tank
- ! Aerobic Treatment (e.g., Cromaglass, etc.)

ALTERNATE ON-LOT SEWAGE SYSTEMS (SEO- AND, IN SOME CASES, PA DEP-PERMITTED)

AS-1: Composting Toilet (e.g., Bio-Sun)
AS-2: At-Grade Bed
AS-3: Drip Irrigation (American Manufacturing)
AS-4: Modified Subsurface Sand Filter (fast percolation/shallow rock)
AS-5: Shallow Placement Pressure-Dosed System
AS-6: Steep Slope ESM (12-15%, 3-30 min./in.)
AS-7: Evapo-transpiration (Non-infiltration greenhouse, e.g., Sundrive)
AS-8: Co-Op RSF III Recirculating Sand Filter (PREA)
AS-9: A/B Soil System
Note: Alternate System Components:
- ! Flow Equalization
- ! De-nitrification Units (ADenite@, e.g., Cromaglass, Biomicrobics FAST)
- ! Alternate Peat-Based Treatment (e.g., Eco Flow) (AS-10a, b, c)
- ! Free-Access Sand Filter (gravity option/re-circulating option)
- ! Leaching Chambers (e.g., Infiltrator Systems, ADS BioDiffuser)
- ! Alternate Coarse Aggregate (e.g., tire chips, crushed glass, slag)
- ! Gray Water Separation System

EXPERIMENTAL ON-LOT SEWAGE SYSTEMS (PA DEP-PERMITTED)

ES-1: Experimental Peat-Based treatment/disposal (ES-1a, b, c)
ES-2: Eljen Type-B In-Drain Absorption Area
ES-3: Experimental Drip Irrigation
ES-4: Steep Slope Slow-Perc ESM (12-15%, 30-90 min./in.)
ES-5: ESM or Drip Irrigation (AMicroMound@) on Shallow Limiting Zone
ES-6: Experimental Controlled Fill

CLEAN STREAMS PERMIT (PA DEP-PERMITTED)

CS-1: General, Anaerobic Treatment/Sand Filtration
CS-2: Individual, Aerobic Treatment/Sand Filtration
CS-3: Experimental Wetland Treatment System
CS-4: Land Application (e.g., community spray field, rapid infiltration, etc.)

STANDARD SYSTEMS SITING CRITERIA

SS-1: In-Ground Bed B '73.53	
Soil Depth	$72"
Depth to Water Table	$72"
Slope	0-8%
Percolation Rate	6-90 min./in.
Other	As slope increases, effective depth decreases.
SS-2: In-Ground Trenches B '73.52	
Soil Depth	$72"
Depth to Water Table	$72"
Slope	#25% (for slopes $15%, elevation design relationship must be shown)
Percolation Rate	6-90 min./in.
Other	As slope increases, effective depth decreases.
SS-3: Elevated Sand Mound Bed B '73.55	
Soil Depth	$20"
Depth to Water Table	$20"
Slope	0-12%
Percolation Rate	3-180 min./in.
SS-4: Elevated Sand Mound Trench B '73.55, '73.52(b)	
Soil Depth	$20"
Depth to Water Table	$20"
Slope	0-12%
Percolation Rate	3-180 min./in.
SS-5: Subsurface Sand Filter Bed/Trench B '73.54	
Soil Depth	Site Specific (>72")
Depth to Water Table	Site Specific (>72")
Slope	0-25%
Percolation Rate	Measured at depth of installation, 3-90 min./in.
Other	As slope increases, effective depth decreases.
SS-6: Permit Exempt (Ten-Acre) B '72.22	
Soil Depth	Not Measured

Depth to Water Table	Not Measured
Slope	Not Measured
Percolation Rate	Not Measured
Other	10-acre exemption can be prohibited by local ordinance; single-family residential use; ownership/subdivision prior to January 10, 1987; 200-foot horizontal isolation distance from property lines and water features; 10 feet from utility right-of-way
SS-7: Bonded Disposal System B '73.77	
Soil Depth	$20"
Depth to Water Table	$20"
Slope	Depends on System
Percolation Rate	Depends on System
Other	Soil scientist evaluation required
SS-8a: Retaining System - Privy B '73.61, 63	
Soil Depth	Not Measured
Depth to Water Table	Not Measured
Slope	Not Measured
Percolation Rate	Not Measured
Other	No running water in dwelling or separate gray water disposal system required
SS-8b: Retaining System - Holding Tank B '73.61, 62	
Soil Depth	Not Measured
Depth to Water Table	Not Measured
Slope	Not Measured
Percolation Rate	Not Measured
Other	Local ordinance required in order to be permitted; generally requires maintenance contract and escrow
SS-9: Individual Residential Spray Irrigation System (AIRSIS@) B '73.161 through 167	
Soil Depth	$16"
Depth to Water Table	$10"
Slope	0-25%
Percolation Rate	Not Measured
Other	Sizing '73.16(e); testing '73.14(b)
SS-10: Recycling, Incinerating, or Composting Toilet B '73.65, '72.22	

Soil Depth	Not Measured
Depth to Water Table	Not Measured
Slope	Not Measured
Percolation Rate	Not Measured
Other	Separate gray water disposal system or retaining tank for wash water; otherwise, may be permit-exempt

ALTERNATE SYSTEMS SITING CRITERIA B '73.72, ASG 362-0300-007

AS-1: Individually Designed Alternate Composting Toilet	
Soil Depth	Not Measured
Depth to Water Table	Not Measured
Slope	Not Measured
Percolation Rate	Not Measured
AS-2: At-Grade Bed System	
Soil Depth	$48 inches
Depth to Water Table	$48 inches
Slope	0-12%
Percolation Rate	3-180 min/in
Other	#600 gpd
AS-3: Drip Irrigation System (e.g., American Manufacturing)	
Soil Depth	$20 inches
Depth to Water Table	$20 inches
Slope	0-25%
Percolation Rate	Not measured unless soil scientist requests
Other	Need certified professional soil scientist to confirm soils
AS-4: Modified Subsurface Sand Filter	
Soil Depth	$72 inches and additional criteria
Depth to Water Table	N/A
Slope	#8%
Percolation Rates	<3 min/in at 12-36 inches 3-180 min/in at 36-60 inches
AS-5: Shallow Placement Pressure Dosed Systems	
Soil Depth	$58 inches
Depth to Water Table	$58 inches
Slope	0-25%
Percolation Rate	3-180 min/in
AS-6: Steep Slope ESM	
Soil Depth	$20 inches

Depth to Water Table	$20 inches
Slope	>12% and #15%
Percolation Rate	3-180 min/in
Other	#600 gpd
AS-7: Evapotranspiration Bed (a.k.a., Greenhouse; e.g., Sundrive)	
Soil Depth	Any (noninfiltration system)
Depth to Water Table	Any (noninfiltration system)
Slope	Any (noninfiltration system)
Percolation Rate	Any (noninfiltration system)
AS-8: Co-Op RSF III System	
Soil Depth	$20 inches ($16 inches for IRSIS)
Depth to Water Table	$20 inches ($10 inches for IRSIS)
Slope	0-25%
Percolation Rate	3-180 min/in
Other	Conditions dependent on final treatment options chosen
AS-9: A/B Soil System	
Soil Depth	$16 inches
Depth to Water Table	$10 inches
Slope	0-12%
Percolation Rate	Not Measured
Other	Soil scientist evaluation required; specific filter performance standards also apply (BOD, TSS, bacteria)
AS-10a: Alternate Peat Based System Option 1	
Soil Depth	$20 inches
Depth to Water Table	$20 inches
Slope	0-12%
Percolation Rate	3 - 180 min/in
Other	Size reduction of absorption area due to primary treatment
AS-10b: Alternate Peat Based System Option 2 (IRSIS)	
Soil Depth	$10 inches
Depth to Water Table	$16 inches
Slope	0-25%

Percolation Rate	None
Other	Use in place of sand filter in IRSIS
AS-10c: Alternate Peat Based System Option 3	
Soil Depth	$72 inches
Depth to Water Table	$72 inches
Slope	0-12%
Percolation Rate	<3 min/in @ 12-36 inches 3-180 min/in @ 36-60 inches
Other	For use in place of 12 inches of sand

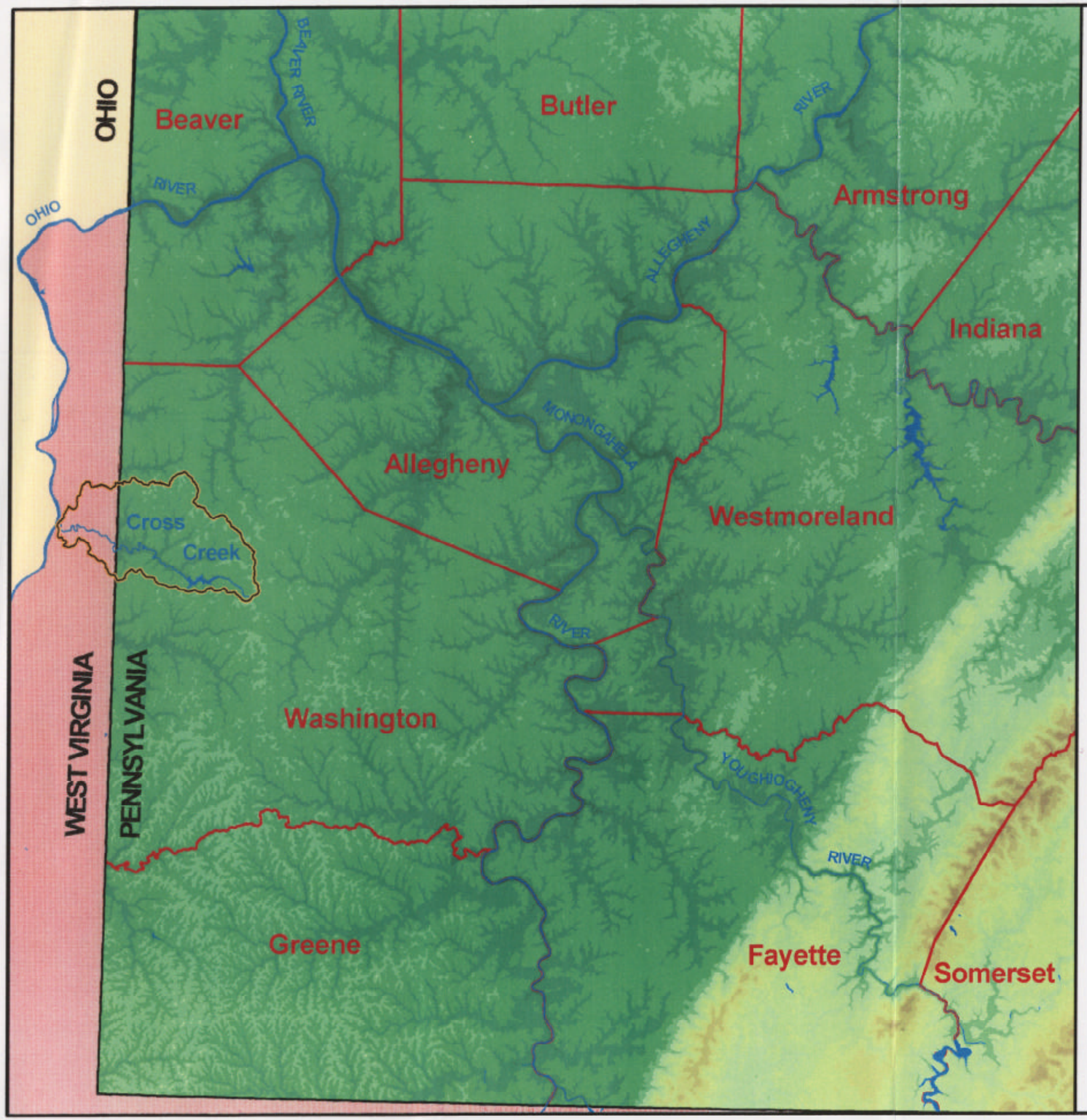
EXPERIMENTAL SYSTEMS SITING CRITERIA B '73.71

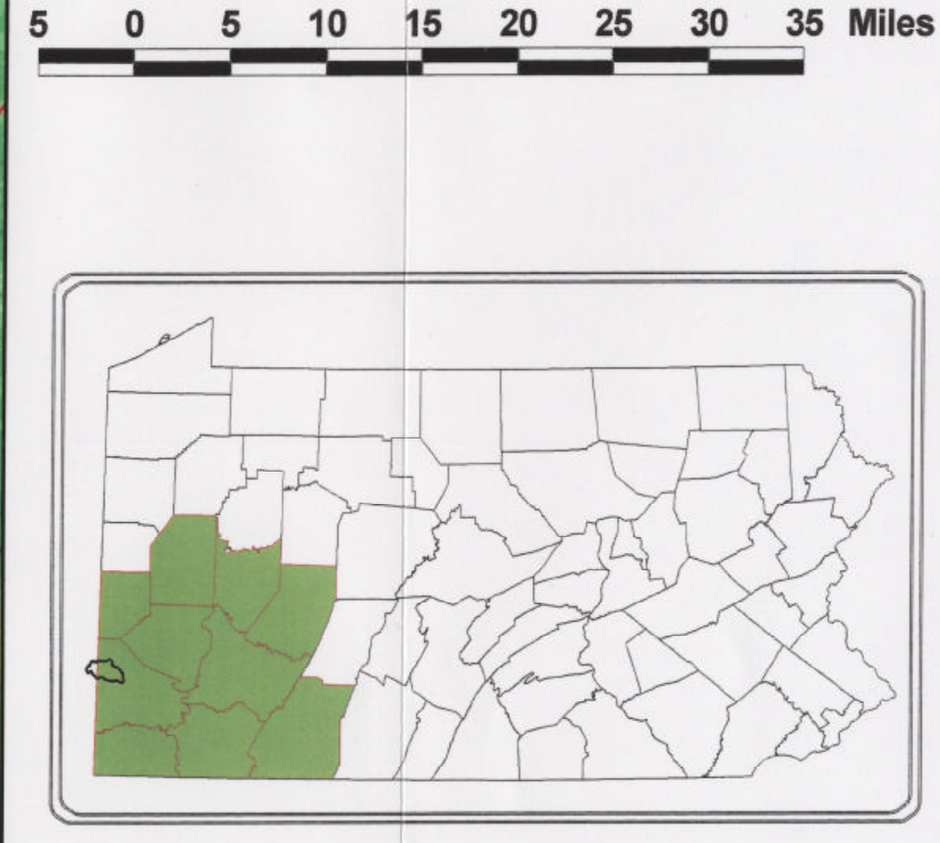
ES-1a: Experimental Peat Based System Option 1	
Soil Depth	$20 inches
Depth to Water Table	$20 inches
Slope	12-15%
Percolation Rate	3-180 min/in
Other	May reduce size of absorption area by up to 40%
ES-1b: Experimental Peat Based System Option 2	
Soil Depth	$10 inches to water table $16 inches to rock
Slope	0-15 %
Percolation Rate	3-180 min/in (with sealed filter) 3-75 min/in (with open-bottom filter)
ES-1c: Experimental Peat Based System Option 3	
Soil Depth	$16 inches, #20 inches
Depth to Water Table	$16 inches, #20 inches
Slope	0-15%
Percolation Rate	3-180 min/in (with sealed filter) 3-75 min/in (with open-bottom filter)
Other	Replaces 24 inches of sand in ESM
ES-2: Eljen Type B In-Drain	
Soil Depth	$20 inches
Depth to Water Table	$20 inches
Slope	0-8%
Percolation Rate	3-60 min/in
Other	May reduce size of absorption area by up to 60%
ES-3: Drip Irrigation on Shallow Limiting Zone (e.g., Micro Mound)	
Soil Depth	$10 inches to water table $16 inches to rock
Slope	0-25%
Percolation Rate	Not measured unless soil scientist requests

Other	Need certified professional soil scientist to confirm soils
ES-4: ESM Bed Systems on Steep Slopes with Slow Perc Rates	
Soil Depth	$20 inches
Depth to Water Table	$20 inches
Slope	$12% #15%
Percolation Rate	3-90 min/in
Other	May not be placed on sites with well-developed fragipan; #400 gpd residential flows
ES-5: ESM on Shallow Limiting Zone	
Soil Depth	$17 inches - #20 inches
Depth to Water Table	$17 inches - #20 inches
Slope	0-25%
Percolation Rates	3-180 min/in
Other	Only used as BTG Repair
ES-6: Experimental Controlled Fill B '73.12(b)	
Soil Depth	Selected by DEP
Depth to Water Table	$20 inches
Slope	#12%
Percolation Rates	3-180 min/in
Other	Soil scientist, PA DEP, and SEO must confirm site

Appendix D

Maps





Coordinate System: PA South, NAD 1927
Date: 07/23/2003
-Digital Elevation Models: PASDA
-All other data: SPC 2001

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan
Washington County, PA

Project Region

SKELLY AND LOY, INC.
ENGINEERS-CONSULTANTS

MAP - 1

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan,
Washington County, PA

Sub - basins

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS

MAP - 2

Parmar Run Sub-basin

WV

PA

North Fork Sub-basin

Scott Run Sub-basin

Middle Fork Sub-basin

South Fork Sub-basin

Coal Hollow Sub-basin

Haynan Run Sub-basin

Cross Creek Sub-basin

Cross Creek Lake

-USGS Digital Raster Graphs (7.5' topographic map): PASDA
-All other data: SPC 2001

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan,
Washington County, PA

Land Cover

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS | MAP - 3

RIVER

OHIO

WV

PA

Eldersville

Cross Creek

Studa

Cedar Grove

Meadowcroft

Browntown

Avella

Rea

Woodrow

Independence

Cross Creek Lake

18

50

231

Legend

Cross Creek Watershed

Land Use Classes

- Agriculture
- Forest
- Water
- Built-Up Land
- Residential - Low Density
- Barren Land / Strip Mines
- Transportation
- Streams
- Roads

SOURCES:
-All data: SPC 2001, land cover classification derived from Landsat TM - 1992

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Cross Creek Watershed Association

Cross Creek Watershed Assessment, Restoration and Protection Plan, Washington County, PA

Infrastructure

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS

MAP - 4

RIVER

OHIO

WV

PA

Jefferson Township

Smith Township

Cross Creek Township

Independence

Township

Hopewell Township

Mt. Pleasant Township

West Middletown Borough

Eldersville

Cross Creek

Studa

Cedar Grove

Meadwocroft

Browntown

Avella

Rea

Woodrow

Dam PA 662 (DEP 63-87)

Dam PA 661 (DEP 63-83)

Independence

18

50

231

Legend

- Cross Creek Watershed
- Municipalities
- Sub-basins
- Sewage Service Extent *(Areas covered under Act 537 Draft Plan - 2002)*
- Water Service Extent
- Secondary Roads
- Railroads *(Active as of Jan. 2003)*
- Streams
- Dams
- Towns

SOURCES:
-Sewage Service Extent: Cross Creek and Independence Act 537 Draft Plan
-All data: SPC 2001

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan,
Washington County, PA

Cultural / Recreational

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS

MAP - 5

RIVER

OHIO

WV

PA

Burgettstown Area

Avella Area

Bethel Church Cemetery

Cross Creek Cemetery

Meadowcroft Museum of Rural Life

Meadowcroft Rock Shelter

Cross Creek Valley Biological Diversity Area

Polar Star Athletic Fields

West End Cemetery

Indian Springs Rod & Gun Club

Raccoon Valley Sportsman Assoc.

Avella Sportsmen's Association

Avella Library & Community Center

Avella Elementary Jr. / Sr. High

Rea Block Field

Agape Bible Camp

Indian Run Golf Course

Buffalo Creek Forest Game Project Lands

Cross Creek County Park

Cross Creek Lake

West Middletown Cemetery

Ft. Cherry

303

18

50

Cross Creek Watershed

Cross Creek Valley Biological Diversity Area

Campground

Cemetery

Meadowcroft Musuem of Rural Life

Golf Course

Buffalo Creek Forest Project (Allegheny Pittsburgh Coal Co.)

Indian Springs Rod and Gun Club

Polar Star Athletic Fields

Raccoon Valley Sportsman Assoc.

Cross Creek County Park

State Game Land

Inactive Railroads

Streams

Secondary Roads

School Districts

Avella Area

Burgettstown Area

Fort Cherry

Public Schools

Community Center / Library

SOURCES:
-PA inactive railroads: PADEP / PASDA (1996)
-All other data: SPC 2001

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan,
Washington County, PA

Surface Geology

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS

MAP - 6

RIVER

OHIO

WV

PA

Parmar Run Sub-basin

North Fork Sub-basin

Scott Run Sub-basin

Middle Fork Sub-basin

South Fork Sub-basin

Coal Hollow Sub-basin

Haynan Run Sub-basin

Cross Creek Sub-basin

18

50

50

50

18

Legend

Cross Creek Watershed

Sub-basins

Surface Geology

- Monongahela Group
- Casselman Formation
- Greene Formatiion
- Washington Formation
- Waynesburg Formation
- Secondary Roads

Please Note:

The Surface Geology data set used for this map was produced at a scale of 1 : 250,000. Ordinarily, it is not reccommended to use large and small scale data sets together to produce a map. However, the use of the surface geology data does provide an adequate representation of the surface geology of the area. As a result of the scale discrepancy, the surface geology data may not be spatialy accurate in relation to the streams and watershed boundary.

Surface Geology Data Source: USGS/PADER/PASDA (1994)

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan,
Washington County, PA

Mining Impacts

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS | MAP - 7

RIVER
OHIO
WV
PA
Management Unit 2
Management Unit 3
Management Unit 1
18
50
Cross Creek Lake
STEUBENVILLE EAST
BETHANY
AVELLA
MIDWAY
WEST MIDDLETOWN
WASHINGTON WEST

Cross Creek Watershed

Abandoned Mine Lands (AMLs)
- Coal Processing Settling Basin
- Dry Strip Mine
- Flooded Strip Mine
- Refuse Pile
- Spoil Pile
- Suspected Subsidence Prone Area
- AML 'Problem Areas'
- AMD Discharge Area
- Abandoned Structure
- Mine Entry
- Open Shaft/Mine Entry
- Vertical Mine Shaft

Deep Mining of the Pittsburgh Coal Seam
- Deep Mining Extent *(PA permitted)*
- Sub-basins
- USGS 1:24,000 Quadrangle Boundaries
- Management Units
- Roads

PA Code Title 25, Chapter 93 Designated Prtected Use / Stream Designation
- WWF *(warm water fishery)*
- HQ-WWF *(high-quality warm water fishery)*
- Sub-basins affecting HQ-WWF

(for a description of Chapter 93 and 'protected use', see Section 3.1.4.3)

SOURCES:
- *Mining data: USGS open file report 96-280 (1997)*
- *AML data: PADEP / BAMR (NALIS database)*
- *All other data: SPC 2001*

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan,
Washington County, PA

Agricultural & Other Impacts or Constraints

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS

MAP - 8

RIVER

OHIO

WV

PA

Management Unit 2

Management Unit 3

Management Unit 1

18

50

Meadowcroft Museum of Rural Life

Cross Creek Valley Biological Diversity Area

Meadowcroft Rock Shelter

Rea Block Field

Cross Creek County Park

Buffalo Creek Forest Game Project Lands

Legend

Cross Creek Watershed

- Agricultural Security Areas
- Farmland Preservation Area
- Prime Agricultural Soils
- Flood Prone Areas
- Slope >25%
- Cross Creek Valley BDA
- Cross Creek County Park
- Buffalo Creek Forest Reserve
- State Game Land
- Cemeteries
- Meadowcroft Musuem of Rural Life
- Dams
- Streams
- Railroads
- Roads
- Management Units
- NHI Geologic / Fossil Locations
- Sub-basins affecting HQ-WWF

SOURCES:
- *Management units & wq sample locations: CCWA*
- *Dams: WA County Planning Dept.*
- *All other data: SPC 2001*

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan,
Washington County, PA

Dirt & Gravel Roads

(w/ Water Quality Sample Site Locations)

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS | MAP - 9

OHIO RIVER

WV / PA

Management Unit 1

Management Unit 2

Management Unit 3

Scott Run

North Fork Cross Creek

Middle Fork Cross Creek

South Fork Cross Creek

Lower Cross Creek

Middle Cross Creek

Upper Cross Creek

Cross Creek Lake

20 13 19 17 16 18 10 9 11 2 3 12 15 14 1 7 8 6 5 4

50 231 50 50 18

Legend

- Cross Creek Watershed
- Sub-basins
- Built-Up Land
- Management Units
- Secondary Roads
- Dirt or Gravel Road
- Dirt Roads Currently Under D & G Program
- Roads
- Streams
- Water Quality Sample Site Locations

SOURCES:
- *Dirt & Gravel Roads: Penn State Center for Dirt and Gravel Road Studies*
- *Built-Up Land: PENNDOT / PASDA*
- *All other data: SPC 2001*

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Cross Creek Watershed Association

Cross Creek Watershed Assessment,
Restoration and Protection Plan,
Washington County, PA

Stream Sedimentation

SKELLY AND LOY, INC. ENGINEERS-CONSULTANTS | MAP - 10

OHIO RIVER

WV
PA

Management Unit 2

Management Unit 3

Management Unit 1

18

50

Cross Creek County Park

Legend

- Cross Creek Watershed
- Pasture
- Cropland
- Disturbed / Strip Mines
- Agricultural Security Areas
- Farmland Preservation Areas
- Prime Agricultural Soils
- Streams Impacted by Sedimentation
- Streams
- Management Units
- Roads
- Water Quality Sample Site Locations

SOURCES:
-Stream sediment data: CCWA
-Farmland preservation areas: WA County Planning - Not Spatially Accurate
-All other data: SPC 2001

Coordinate System: PA South, NAD 1927
Date: 07/23/2003

1 0 1 2 3 4 5 6 7 8 9 Miles

Appendix E

Recommendation Matrix and Funding and Technical Assistance Sources

Management Recommendations Matrix

Management Issue	Management Recommendations	Responsible Entity	Potential Assistance Sources	Implementation Schedule
Resources				
Water Quality Monitoring and Assessment (Refer to Section 7.1.1)	Water Quality Monitoring – Conduct further water quality sampling, specifically in Management Unit 1, to identify pollution sources. The water quality sampling needs to include: 1. Chemical 2. Biological (macroinvertebrate and fish) parameters and 3. Physical parameters Determine county reference reach(s) for the above parameters Watershed Assessment – Complete a watershed assessment on Management Unit 1 to determine the stability of the stream located in this area and to locate unstable and eroding streambanks/reaches.	Cross Creek Watershed Association (CCWA) and PADEP.	PADEP (Growing Greener Program), EPA (319 Program), and WCCD.	2003+
Stream Bank Erosion and Sedimentation (Refer to Section 7.1.2)	1. Stream Bank Fencing - Install stream bank fencing to a broader area of the watershed to prevent access to streams by livestock. Various techniques and Best Management Practices (BMPs) for low-cost stream bank restoration. 4. Complete stream restoration activities utilizing the Natural Stream Channel Design approach (Rosgen and other applicable methods). This approach is more expensive but provides a more stable and effective (long-term) solution. 5. Vegetated Buffer and Grassways – BMPs are recommended for most streams in agricultural lands and those streams of critical concern. Re-vegetated stream banks would be the most beneficial and can be the least costly management practice for the entire watershed. 6. Stream Bank Engineering - Complete stream stability assessments in the watershed or the sub-basins that are currently the most impacted by high stormwater flows, agricultural activities, and higher developmental activities. Priority areas in the watershed include Management Units 1, 2, and 3.	CCWA, municipal governments, Washington County government and PADEP.	EPA (319 program), USGS, PADCNR: Keystone Funds, PADEP (Growing Greener and ReLeaf Programs), PENNDOT/PTC stream/wetland mitigation funds, WPWPP, McKenna Foundation, Pittsburgh Foundation, Mellon Foundation, CVI, etc.	2004
Nutrient Enrichment - Sewage (Refer to Section 7.1.3)	1. Encourage municipalities and municipal authorities to complete additional municipal sewage planning activities to make corrections to faulty sewer systems or to expand systems. This includes sewer upgrades and septic system correction plans to make improvement to antiquated facilities of the watershed that include Management Unit 1. 2. Local municipalities explore the capital investment opportunities available through various types of intergovernmental cooperation frameworks (Refer to Section 2.9.4).	Washington County, municipal governments, CCWA, local citizens, PADEP, and EPA.	Washington County, PADEP (PA Act 537 program), PADCNR: Keystone Funds, and EPA.	Present - 2006

Management Recommendations Matrix

Management Issue	Management Recommendations	Responsible Entity	Potential Assistance Sources	Implementation Schedule
Resources				
Abandoned Mine Drainage (AMD) and Abandoned Mine Land (AML) (Refer to Section 7.1.4)	1. Development of a strategic plan that assists in prioritizing restoration activities to make improvement to the watershed that includes Management Units 2 and 3. 2. Remediate AMD site discharges that have been evaluated as part of a AMD Assessment and Management Plan. Complete remediation activities of AMD sites in Management Units 2 and 3. The initial site to be remediated is the Church Street Discharge (SS 11). 3. Complete the remediation of AML sites. This activity could assist with the re-development activities in local communities.	CCWA and the municipalities working with PADEP.	EPA (104 & 319 programs), PADCNR: Keystone Funds, PADEP (Growing Greener, Reclaim PA, Bond Forfeiture Program, etc.), Pennsylvania Department of Transportation (PENNDOT) / Pennsylvania Turnpike Commission (PTC) mitigation funds, WPCAMR, and Western PA Watershed Protection Program. PADEP (Abandoned Mine Land [AML] 10% Set Aside, Growing Greener, and WRAP Programs), PADCNR: Keystone Funds, US Environmental Protection Agency (EPA) 104 and 319 Programs, and Western Pennsylvania Coalition for Abandoned Mine Reclamation (WPCAMR) Funds.	2003+
Trash and Litter (Refer to Section 7.1.5)	1. Continue to develop municipal curbside recycling programs under Act 101. 2. Establish a recyclable materials drop-off site(s) within the watershed. 3. Promote a PA Department of Transportation (PENNDOT) Adopt-a-Highway program. 4. Establish a “PA Cleanways” Chapter in Washington County. Control unregulated waste sites at the local level by implementing proper zoning ordinances that address the optimal placement of such activities. By completing an inventory of unregulated waste sites for potential reclamation and development opportunities (e.g., dump sites). This can be accomplished through an inter-municipal framework (Refer to Section 2.9.4). 5. Participation in the “Ohio River Sweep Program”.	PADEP, CCWA, and local municipal officials.	PADEP, PENNDOT, PADCNR: Keystone Funds, and EPA.	2003+
Nuisance Wildlife Management Options (Refer to Section 7.1.6)	Stakeholders in the Cross Creek Watershed identified white-tailed deer, wild turkey, raccoon, and coyote as nuisance animals, because of crop damage and/or preying on livestock by these species. The following are recommended management options: 1. No management 2. Establishing designed habitat programs for farmland that manage the movement of wildlife using practices such as stream bank fencing and wildlife corridors 3. Trapping and translocation of individuals 4. Hunting	PGC, CCWA, and local municipal officials.	PGC, USFWS, and local sportsmen’s clubs.	2003+
Rail-to-Trail Possibilities (Refer to Section 7.1.7)	Complete needed feasibility studies and construction activities for Rail-to-Trail opportunities (i.e., the Panhandle Trail).	Washington County, CCWA, school districts, and local municipalities.	PADCNR: Keystone Funds, PADEP: Growing Greener, PENNDOT TEA-21 funds, and NPS - Rivers, Trails, and Conservation Assistance program.	2004+

POTENTIAL TECHNICAL & FUNDING ASSISTANCE FOR WATERSHED PROJECTS IN PENNSYLVANIA

Source of Assistance	Phone	Contact Information	Assistance Information	Planning	Const.	Other
Farm Service Agency	(T) 724-222-3060 Ms. Linda Barnett	2800 North Main Street Extension PO Box 329 Meadowlands, PA 15347 www.fsa.usda.gov www.fs.fed.us	FSA offers financial assistance for streambank fencing and crossings for farmers.	NO	YES	YES
Allegheny Co. Conservation District	(412) 241-7645 Mr. Ed Feigel	Lexington Tech Park Building Room 1 102-400 North Lexington Street Pittsburgh, PA 15208-2521	Provides technical assistance for conservation activities Small grants to non-profit organizations for clean water projects.	YES	YES	YES
Appalachian Clean Streams Initiative	(T) 412-937-2863 Mr. Milton Allen (T) 717-782-4036 Mr. David Hamilton	Office of Surface Mining 1951 Constitution Ave. NW Washington, DC 20240 mallen@osmre.gov	Assists with restoration activities involving abandoned mine drainage issues throughout Appalachia.	YES	YES	YES
DCNR: Rivers Conservation Program	(T) 717-788-8526 Mr. Jim Mays (T) 412-880-0486 Ms. Tracey Robinson	1405 State Office Building 300 Liberty Avenue Pittsburgh, PA 15222 www.dcnr.state.pa.us	Offer technical and financial assistance for planning, implementation, development, and acquisition grants. Applications: Late August Proposals: Early February	YES	YES	YES
DEP: Stormwater Management Program	(T) 717-772-4048 Mr. Durla Lathia	400 Market Street Harrisburg, PA 17105 www.dep.state.pa.us	Watershed planning for stormwater control and implementation of programs at local levels.	YES	YES	YES
Dirt and Gravel Road Maintenance State Conservation Commission	(T) 717-787-8821 Mr. Woody Colbert	2301 North Cameron Street Harrisburg, PA 17110-9408	Financial assistance through participating conservation districts.	YES	YES	YES
PA Association of Conservation Districts: Educational Mini-Projects Program	(T) 717-545-8878 Education Specialist	4999 Jonestown Road Suite 203 Harrisburg, PA 17109	Small grants for PA based grassroots educational projects that address non-point source watershed concepts.	NO	NO	YES

POTENTIAL TECHNICAL & FUNDING ASSISTANCE FOR WATERSHED PROJECTS IN PENNSYLVANIA

Source of Assistance	Phone	Contact Information	Assistance Information	Planning	Const.	Other
Environmental Protection Agency: Region III	(T) 215-814-5756 Mr. Bernie Sarnoski	Water Protection Division 3WP10, 1650 Arch Street Philadelphia, PA 19103-2029 www.epa.gov	Grants awarded to small non-profit groups for various projects in Region III	YES	YES	YES
EPA - Region III Environmental Education Grants	(T) 215-814-5546 Ms. Nan Ides	3G00, 16th Floor 1651 Arch Street Philadelphia, PA 19103 www.epa.gov	Grants awarded to small non-profit groups for various projects in Region III	YES	YES	YES
Natural Resources Conservation Service (NRCS)	(T) 724-222-3060 Mr. Tom Sierzega (T) 724-774-7090 Mr. Robin Moyer (T) 814-445-8979 Mr. Dan Seibert	2800 North Main Street Extension PO Box 329 Meadowlands, PA 15347 www.nrcs.usda.gov	Technical and funding assistance to farmers for planning, design, construction, and maintenance activities. These involve many programs (i.e., fencing and stream crossings, farmland protection).	YES	YES	YES
NRCS PL 83-566, Watershed Protection and Flood Prevention Act	(T) 717-782-4429 (T) 814-445-8979 Mr. Dan Seibert	North Ridge Building, Suite 105 1590 North Center Avenue Somerset, PA 15501	Plan development for natural resource concerns within a watershed area: cost-sharing available to carry out plan.	YES	YES	YES
Office of Surface Mining Reclamation and Enforcement	(T) 717-782-4473 Mr. David Hamilton	415 Market Street Transportation Building Suite 3C Harrisburg, PA 17101	Provides funds to Appalachian Clean Streams Initiative for Abandoned Mine related activities.	YES	YES	YES
PA - Growing Greener	(T) 717- 705-5400 1-877-PAGREEN Ms. Patricia Grim	Rachel Carson St. Office Bldg. 9th Floor, 400 Market Street PO Box 8776 Harrisburg, PA 17109-8776 www.dep.state.pa.us	Funds for PennVest, PA Department of Agriculture, Department of Environmental Protection and Department of Conservation and Natural Resource activities.	YES	YES	YES
PA DEP - Nonpoint Source Management Program (Section 319 & WRAP)	(T) 717- 787-5259 Ms. Jane Earle	400 Market Street PO Box 8555 Harrisburg, PA 17105-8555 www.dep.state.pa.us	Provide funding for improving Non-point source water pollution.	YES	YES	YES

POTENTIAL TECHNICAL & FUNDING ASSISTANCE FOR WATERSHED PROJECTS IN PENNSYLVANIA

Source of Assistance	Phone	Contact Information	Assistance Information	Planning	Const.	Other
PA Organization for Watersheds and Rivers	(T) 717-234-7910 Mr. Walt Pomeroy wpomeroy@aol.com	PO Box 765 Harrisburg, PA 17108	POWR assists river and watershed organizations in Pennsylvania.	YES	NO	YES
PADEP Southwest Regional Office	(T) 412-442-4149 (F) 412-442-4194 Ms. Rita Coleman (T) 412-442-4049 Ms. Karen Crowley	400 Waterfront Drive Pittsburgh, PA 15222-4745 www.dep.state.pa.us	Grants for various environmental, conservation, and educational activities.	YES	YES	YES
PA Stream ReLeaf Program	(T) 717-236-8825 Ms. Susan Richards	Alliance for the Chesapeake Bay 600 North Second Street Harrisburg, PA 17101	Grants for riparian buffers along streams. For the purchase of trees, seed and planting mats. Grants between $500-$1000.00 Application: January Begin: Spring Complete: July	YES	YES	YES
Penn's Corner RC&D	(T) 724-834-9063 Mr. Nevin Ulery	Donhoe Center RD 12, Box 202B Greensburg, PA 15601	Provides technical assistance and small financial grants to non-profit organizations in 9 southwestern PA counties.	YES	YES	YES
Pennsylvania Fish and Boat Commission	(T) 814-359-5185 (T) 412-341-0370 Mr. Bob Wheeler	Adopt-A-Stream Program 450 Robinson Lane Bellefonte, PA 16823 www.fish.state.pa.us	Offers technical assistance on design and construction of stabilized stream crossings.	YES	YES	YES
Pennsylvania Game Commission	(T) 717-787-6400 Mr. Dennis Neideigh	2001 Elmerton Avenue Harrisburg, PA 17110-9797 www.pgc.state.pa.us	Streambank fencing financial and technical assistance to farmers who participate in one of the commission's cooperative public-access programs.	YES	YES	YES
Pennsylvania Senior Environment Corps: Environmental Alliance for Senior Involvement	(T) 717-787-9580 Mr. Christopher Allen	400 Market Street Harrisburg, PA 17105 www.dep.state.pa.us	EASI provides technical assistance numerous environmental and education issues amongst many more.	YES	NO	YES

POTENTIAL TECHNICAL & FUNDING ASSISTANCE FOR WATERSHED PROJECTS IN PENNSYLVANIA

Source of Assistance	Phone	Contact Information	Funding Information	Planning	Const.	Other
The Leo Model Foundation	(T) 215-546-8058 Extension 3021 Ms. Margaret Stridick	ICO - Model Entities 310 South Juniper Street Philadelphia, PA 19107-5818	Grants for habitat, conservation, watershed conservation, and species preservation.	YES	YES	YES
The Pittsburgh Foundation	(T) 412-391-5122 Mr. Alfred Wishart, Jr.	The Pittsburgh Foundation One PPG Place - 30 th Floor Pittsburgh, PA 15222-5401	Funding grants to organizations located in Allegheny County for special projects, seed money for new programs, or grants which would leverage additional funding. Submit proposals Jan. 1, March 15, June 1, and Sept. 15	YES	YES	YES
The William Penn Foundation	(T) 215-988-1830 Ms. Hollister Knowlton	Two Logan Square 11th Floor 100 North 18 Street Philadelphia, PA 19103-2757	Grants to preserve natural areas, including environmental education and planning, within the foundation's geographic area.	YES	YES	YES
US Army Corps of Engineers	(T) 412-395-7210 Dr. Ed Smith	1928 Federal Building 1000 Liberty Avenue Pittsburgh, PA 15222 www.usace.army.mil/	Provides funding and technical assistance through a variety of planning and construction programs for environmental improvement, flood protection, and other projects.	YES	YES	YES
US Geological Survey	(T) 717-730-6916 Mr. John Nantz jmnantz@usgs.gov	840 Market Street Lemoyne, PA 17043 http://pa.water.usgs.gov	Provides technical assistance through planning programs for environmental improvement, flood protection, and other projects.	YES	YES	YES
Vira I. Heinz Endowment	(T) 412-281-5777 (F) 412-281-5788 Mr. Andrew McElwaine	30 CNG Tower 625 Liberty Avenue Pittsburgh, PA 15222-3115 www.heinz.org/low/environment/	Funds to implement ecosystem programs in selected western PA watersheds. Small matching grants are provided to the DCNR for the Coldwater Heritage program.	YES	YES	YES
Washington Co. Conservation District	(T) 724-228-6774 Mr. Gary Stokum	602 Courthouse Square 100 West Beau Street Washington, PA 15301-4402 WCCD@COBWEB.NET	Provides technical and financial assistance to farmers, developers, and conservation organizations.	YES	YES	YES

POTENTIAL TECHNICAL & FUNDING ASSISTANCE FOR WATERSHED PROJECTS IN PENNSYLVANIA

Source of Assistance	Phone	Contact Information	Assistance Information	Planning	Const.	Other
Waterways Conservation Grant Program (Conserve 2000 Fund) Commonwealth of PA PA Fish and Boat Commission	(T) 717-657-4515 717-657-4540 (F) 717-657-4033 (T) 814-445-3454 Mr. Rick Lorson	PA Fish and Boat Commission PO Box 67000 Harrisburg, PA 17160-7000 www.fish.state.pa.us	Grants support activities directed at restoring and protecting watersheds; including acquisition, and enhancing riparian habitat. Application Deadline: June.	YES	YES	YES
Western PA Watershed Protection Program	(T) 814-869-4847 Mr. John Dawes	RD #1, Box 152 Alexandria, PA 16611	Provides funding to grassroot organizations and watershed associations for site specific watershed remediation in western PA.	YES	YES	YES
WPCAMR: Western PA Coalition For Abandoned Mine Reclamation	(T) 724-837-5271 (F) 724-837-4127 Mr. Mark Killar	Donohoe Center RD # 12 - Box 202-B Greensburg, PA 15601 wpcamr@westol.com	Grants through the Regional Watershed Support Initiative Applications -December Received - January Complete - June	YES	YES	YES
Canaan Valley Institute	(T) 814-768-9584 Ms. Janie French (T) 304-866-4739 1-800-922-3601 Ms. Emily Grafton	650 Leonard Street Clearfield, PA 16830 www.canaanvi.org	Promotes the development and growth of local organizations committed to improving or maintaining the natural resources of their watersheds, in the Mid-Atlantic Highlands portions of PA. MD. VA and all of WV.	YES	YES	YES
Penn State Cooperative Extension	(T) 412-473-2540 Mr. Dino De Ciantis	400 North Lexington Street Pittsburgh, PA 15208 www.allegheny.extension.psu.edu	Provide technical assistance to homeowners, farmers, and others concerning agricultural issues.	YES	NO	YES
League of Women Voters: Citizen Education Fund and Water Resources Education Network	(T) 724-465-2595 (T) 724-465-4687 1-800-692-7281 Ms. Sherene Hess	226 Forester Street Harrisburg, PA 17102 http://www.pa/lwv.org/wren	Grants up to $3000.00 Application: January Begin: Spring Grants are available for community education or outreach projects pertaining to water resource issues.	YES	YES	NO

POTENTIAL TECHNICAL & FUNDING ASSISTANCE FOR WATERSHED PROJECTS IN PENNSYLVANIA

Source of Assistance	Phone	Contact Information	Assistance Information	Planning	Const.	Other
PennVest (Pennsylvania Infrastructure Investment Authority): V.A. Johnson. 1997. *A Water, Sewer and Stormwater Utility's Guide to Financial and Technical Assistance Programs*. Harrisburg, PA. A 56 page guidance document that provides telephone numbers, addresses, Internet and email addresses, and contacts for a variety of infrastructure grant programs. These include sewer, septic, and water systems, stormwater, floodplain management, community planning, municipal training, Appalachian Regional activities, and rural development activities. For assistance and to receive a copy of this guidance document, please call Ms. Vickie Johnson at 717-783-8618.						
Pennsylvania Department of Community and Economic Development (DCED): *DCED Funding Source Directory*. 2000. A 15 page guidance document that provides sources of information concerning a variety of funding programs to assist in community and economic development. Please contact the DCED for assistance in attaining this guidance document at 1-800-379-7448.						

POTENTIAL TECHNICAL & FUNDING ASSISTANCE FOR WATERSHED PROJECTS
NATIONAL ORGANIZATIONS

Source of Assistance	Phone	Address	Assistance Information	Planning	Const.	Other
American Canoe Association	(T) 703-451-0141 Mr. David Jenkins	7432 Alban Station Boulevard Suite B232 Springfield, VA 22150	May provide funding for various watershed related projects including starting groups and lobbying.	YES	NO	YES
National Park Service: Rivers, Trails, and Conservation Assistance Program	(T) 215-597-1581 Mr. Jody Bellows	200 Chestnut Street, 3rd Floor Philadelphia, PA 19106	Provide technical, administrative, public facilitation and other services for a variety of projects.	YES	NO	YES
Charles A. and Anne Morrow Lindburgh Foundation	(T) 763-576-1596	2150 Third Avenue North, Suite 310 Anoka, MN 55303-2200 www.lindberghfoundation.org	Grants awarded fro the conservation of natural resources and water resource management.	YES	NO	YES
American Sportfish Association and Foundation	(T) 703-519-9691 Mr. Thomas Marshall	1033 North Fairfax Street, #200 Alexandria, VA 22314 www.fishamerica.org www.asafishing.org	Grants awarded for: stream bank stabilization materials, instream habitat improvements, contracted heavy equipment, and stream morphology work.	NO	YES	NO
Scenic America	(T) 202-543-6200 Ms. Debra Myerson	801 Pennsylvania Avenue, SE Suite 300 Washington, DC 20003 www.scenic.org	Technical assistance for improving community visual quality assessments, sign control, cellualr tower location, amonst other visual pollution issues.	YES	YES	YES
Wildlife Forever	(T) 612-936-0605 (F) 612-936-0915 Ms. Andrea Stoffregen	12301 Whitewater Drive Suite 210 PO Box 3404 Minnetonka, MN 55343 www.wildlife forever.org	Provides technical and financial assistance for habitat enhancement projects.	YES	YES	YES
USEPA: Five Star Restoration Program	(T) 202-260-8076 Mr. John Pai	Office of Wetlands, Oceans, and Watersheds (4502F) Ariel Rios Building 1200 Pennsylvania Avenue Washington, DC 20460 www.epa.gov/owow/wetlands/restore/5star/	Clean Water Act Section 104 (b)(3) Program Applications - Jan./Feb.	YES	YES	YES

POTENTIAL TECHNICAL & FUNDING ASSISTANCE FOR WATERSHED PROJECTS
NATIONAL ORGANIZATIONS

Source of Assistance	Phone	Contact Information	Assistance Information	Planning	Const.	Other
North American Wetlands Conservation Council	(T) 413-253-8269 Attention: Small Grants Coordinator	Atlantic Coast Joint Venture US Fish and Wildlife Service 300 Westgate Center Drive Hadley, MA 01035-9589 www.fws.gov/r9nawwo	Program promotes long-term wetland activities through encouraging participation by new partners who may not be able to compete in the standard grant program. Grants no larger than $50,000. Application: December	YES	YES	YES
WalMart/Sam's Club: Environmental Clean Air and Water Grant	See Local WalMart/Sam's Club	Grants are administered through the local stores. Talk with Store Manager for applications. Washington and Robinson Town Center, PA Stores.	Funding distributed on a first come first serve basis. Funding Distribution: February	YES	YES	YES
National Tree Trust	(T) 202-628-8733 Ms. Joanne Miller	1120 G Street, NW Suite 770 Washington, DC 20005 www.nationaltreetrust.org/	Grants awarded: Tree plantings, education, administration, and national/regional programs.	YES	YES	YES
The Foundation Center	(T) 212-620-4230 (T) 412-622-1917	4400 Forbes Avenue Pittsburgh, PA 15213 http://fdncenter.org	An independent national service organization established by foundations to provide an authoritative source of information about private philanthropic giving.	NO	NO	YES
National Audubon Society	(T) 412-963-6100	614 Dorseyville Road Pittsburgh, PA 15238 www.audubon.org	Inspire and educate people of southwestern PA to be respectful of the natural world.	NO	NO	YES
Wildlife Habitat Council	(T) 301-588-8994 (T) 412-433-5900 Ms. Marsh Mazlavic	1010 Wayne Avenue, Suite 920 Silver Springs, MD 2-910 http://www.wildlifehc.org	Provide technical assistance to corporate and community organizations to improve wildlife habitat.	YES	NO	YES
National Wildlife Federation: Community and Backyard Wildlife Habitat Programs	(T) 703-790-4434 1-800-822-9919	8925 Leesburg Pike Viena, VA 22184-0001 http://www.nwf.org/habitats	Provide technical assistance to corporate, communities, and organizations to improve wildlife habitat.	YES	NO	YES

Appendix F

Examples of Alternative On-lot Septic Systems Diagrams

The following onsite wastewater treatment and disposal system fact sheets provide efficient and cost effective alternatives for local homeowners to implement in the Cross Creek Watershed.

This material was originally published in:

Onsite Wastewater Treatment Systems Manual (2002 edition)

EPA/625/R-00/008

February 2002

Office of Water
Office of Research and Development
U.S. Environmental Protection Agency

Onsite Wastewater Treatment Systems Technology Fact Sheet 5

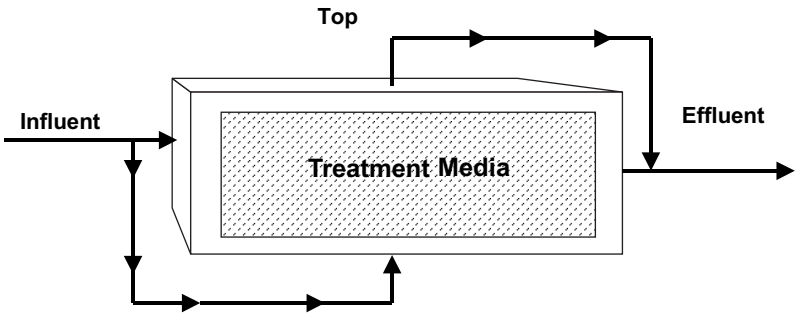
Vegetated Submerged Beds and Other High-Specific-Surface Anaerobic Reactors

Description

A high-specific-surface anaerobic reactor (figure 1) is any tank or cavity filled with solid media through which wastewater flows with a high hydraulic retention time (HRT). In onsite treatment the two primary types are vegetated submerged beds (VSBs) and anaerobic upflow filters (AUFs). The first is characterized by horizontal flow and prolific growth of macrophytes on the surface. The second comes in a variety of forms from upflow sludge blanket systems and fixed media anaerobic filters to partially fluidized beds of fine media. Both have long HRTs, produce anaerobic effluents, generally treat either high-strength or minimally pretreated wastewater, and usually require some form of posttreatment to meet surface discharge or water reuse requirements.

The primary removal mechanisms in all of these systems are physical, that is, floculation, sedimentation, and adsorption. Anaerobic biological reactions are extremely slow and do not have a significant impact on soluble BOD until HRTs become quite long. Some toxic organic compounds may be reduced through these mechanisms and chemical precipitation (e.g., sulfides) at shorter HRTs.

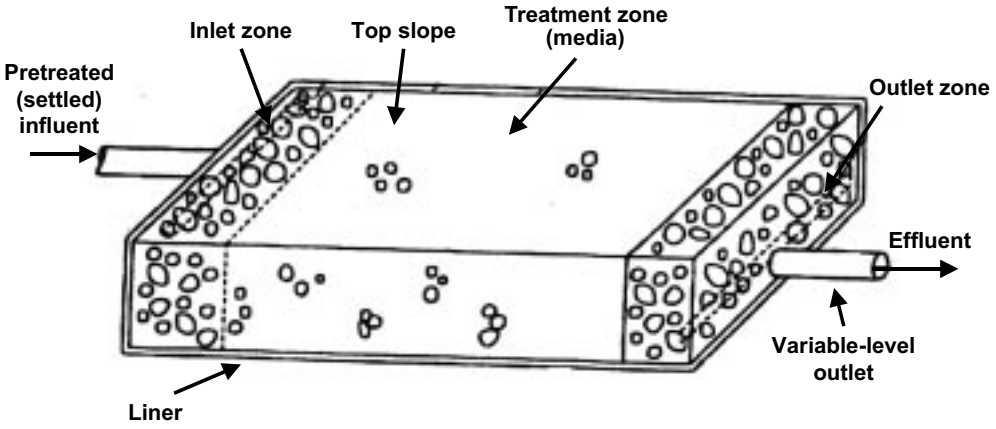
Figure 1. Generic high-specific surface anaerobic reactor

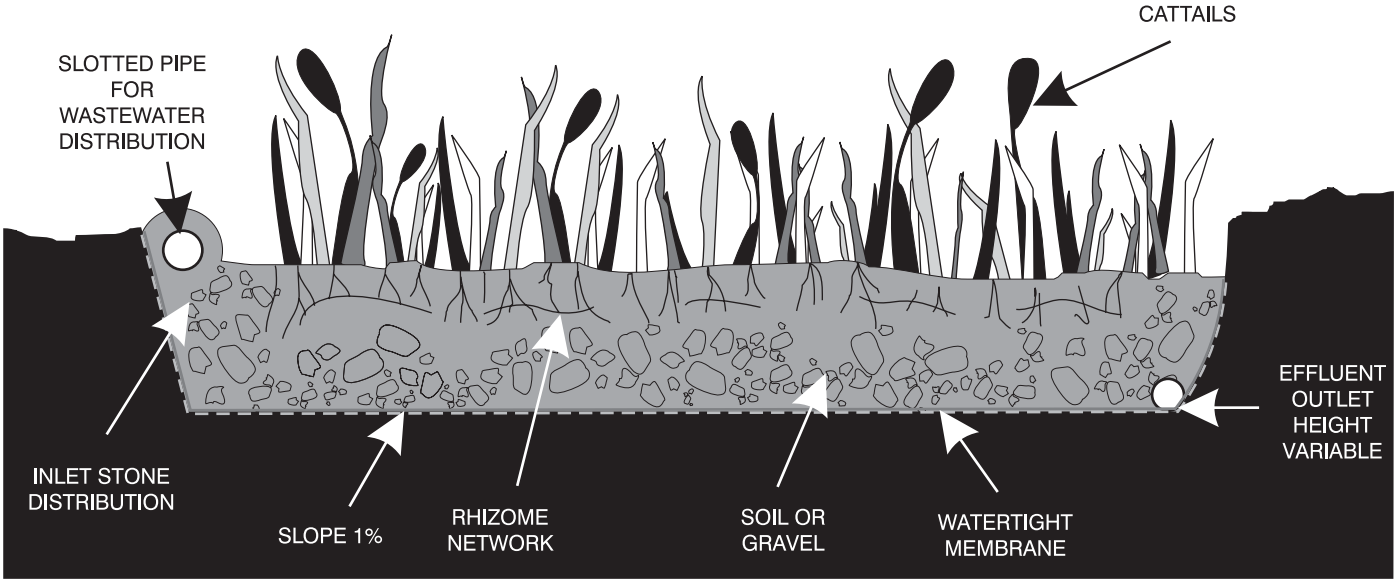


VSBs, as shown in figure 2, usually follow a septic tank and remove most of the suspended and larger colloidal particles, BOD, organic forms of nitrogen, and other particles. Although they are frequently identified as subsurface constructed wetlands, they do not fit the strict definition of a constructed wetland.

Three types of AUFs can be used as pretreatment devices for high-strength wastewater and some onsite pretreatment applications in the United States. They are in shown in figures 3, 4, and 5. Figure 3, with a rock medium, is the most typical U.S. application.

Figure 2. Elements of a vegetated submerged bed (VSB) system





Source: Toms Creek Project, VA.

Figure 3. Schematic of the upflow anaerobic filter process

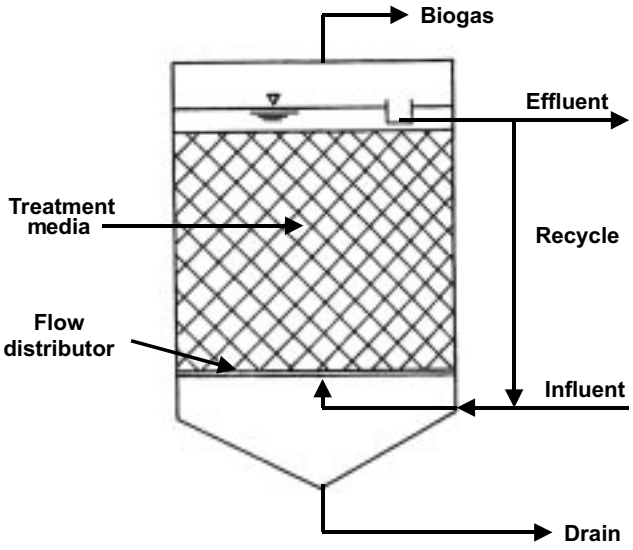


Figure 4. Schematic of the upflow anaerobic sludge blanket process

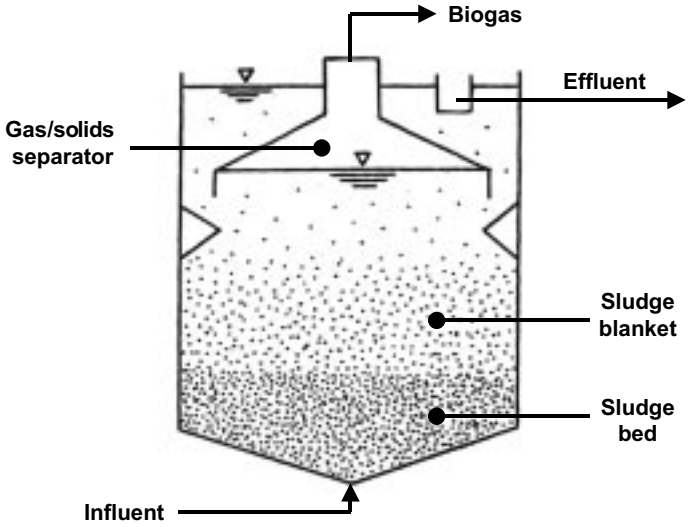
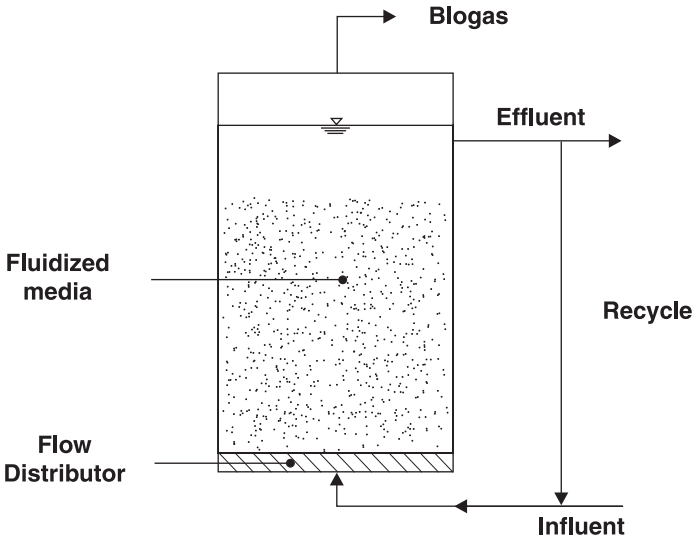


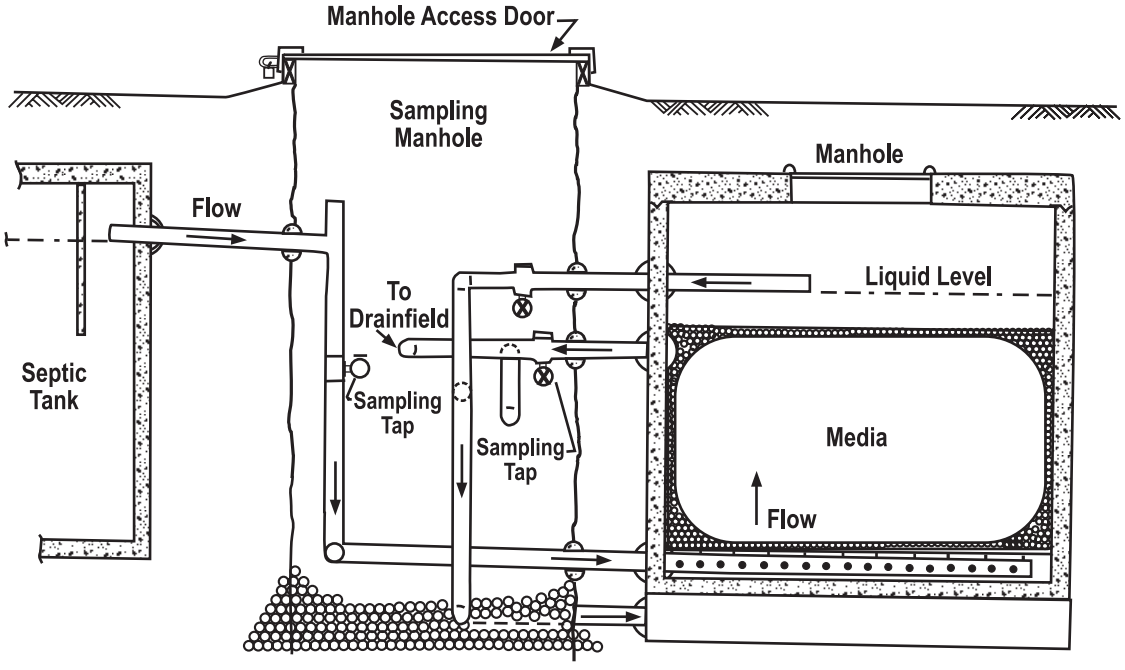
Figure 5. Schematic of the anaerobic fluidized bed process



Typical applications

AUFs are widely used in hot climates where domestic wastewaters are several times higher in strength than U.S. wastewaters. These systems can reduce high BOD and TSS to levels that can be readily treated by typical aerobic processes such as suspended and fixed growth aerobic units or recirculating/intermittent media filters. International literature contains numerous references to the three types of AUFs and their valuable contributions to water pollution abatement. Anaerobic rock upflow filters (figure 6) are also used to lower septic tank effluent BOD and TSS concentrations prior to discharge to the subsurface wastewater infiltration system (SWIS).

Figure 6. Anaerobic upflow filter



VSBs are extremely popular in the United States because of their aesthetic features and their ability to meet basic (secondary) effluent standards when treating septic tank effluent. Until recently they were purported to be capable of nitrification and nutrient removal at economically competitive HRTs. Since they are largely anaerobic, this would be biochemically impossible. However, they are fully capable of meeting secondary BOD and TSS standards. They are also sometimes used before a SWIS and can meet the same effluent TSS and BOD standards as aerobic units (Technology Fact Sheets 1, 2, and 3). VSBs can be considered as pretreatment units regarding SWIS design requirements. They do not, however, remove more than 2 logs of fecal coliform and would likely require disinfection for direct surface discharge. They also require some form of aeration to meet effluent standards for dissolved oxygen (DO). These VSBs will capture rainfall and snowmelt, effluent standards for requiring adjustment to designs of SWIS following these units.

Both VSBs and AUFs are being used in rural areas in combination with aerobic processes to remove significant amounts of nitrogen through denitrification. These processes are included in the nutrient removal fact sheets.

Design assumptions

VSB design guidance for small communities is provided in table 1. In the first few months of operation, excellent phosphorus removal will occur until the rock medium becomes saturated with phosphorus and breakthrough occurs. (Note: USEPA guidance on design of VSBs can be found in *Manual: Constructed Wetlands Treatment of Municipal Wastewater*, posted at **http://www.epa.gov/ordntrnt/ord/nrmrl/pubs/2001/wetlands/625r99010.pdf**)

Except for the anaerobic upflow rock filter, AUFs are rarely employed for U.S. onsite applications. Since the primary purpose of these systems is to improve the BOD and TSS of septic tank effluent, they are essentially physical processes. Therefore, they must be designed to maximize their flocculation and sedimentation functions. Limited field studies

Table 1. Summary of VSB design guidance

Pretreatment [a]	Objective
Surface area BOD TSS TKN TP	Based on desired effluent quality and areal loading rates as follows: 6 g/m^2-d (53.5 lb/ac-d) to attain 30 mg/L effluent 1.6 g/m^2-d (14.3 lb/ac-d) to attain 20 mg/L effluent 20 g/m^2-d (178 lb/ac-d) to attain 30 mg/L effluent Use another treatment process in conjunction with VSB VSBs not recommended for phosphorus removal
Depth Media (typical) Water (typical)	 0.5–0.6 m (20–24 in) 0.4–0.5 m (16–20 in)
Length	Minimum of 15 m (49 ft.)
Width	As calculated
Bottom slope	0–1%
Top slope	Level or nearly level
Hydraulic conductivity First 30% of length Last 70% of length	 1% of clean K 10% of clean K
Media Inlet zone (1st 2 m [6.5 ft]) Treatment zone Outlet zone (last 1 m [3.3 ft]) Planting media (top 10 cm [4 in])	All media should be washed clean of fines and debris; more uniform rounded media will generally have more void spaces; media should be resistant to crushing or breakage. 40–80 mm (1.5–3.0 in) 20–30 mm (3/4–1 in) use clean K = 100,000, if actual K not known 40–80 mm (1.5–3.0 in) 5–20 mm (1/4–3/4 in)
Miscellaneous	Use adjustable outlet control device with capability to flood and drain system and sizing of VSB and SWIS (if used) must include a water balance analysis

[a] *Use after primary sedimentation (e.g., septic tank, Imhoff tank, primary clarifier); not recommended for use after ponds because of problems with algae.*

indicate that successful removal of particulate BOD and TSS could be obtained with an average HRT between 16 and 24 hours, rounded media size of 1 to 2 inches or greater, and a means of periodically draining excess accumulated solids from the bottom of the unit. At higher temperatures, some partial digestion of accumulated organic solids occurs. This liquefaction may by accompanied by gas production. The amount and makeup of that gas depend on pH, wastewater constituents (e.g., protein, lipids, carbohydrates), sulfate, alkalinity, and other constituents.

Performance

VSB systems can treat septic tank effluent to a BOD of 20 to 30 mg/L, depending on the organic loading rate chosen. The VSB effluent TSS is almost always less than 30 mg/L. Some removal of all constituents (e.g., heavy metals, organic nitrogen and organic phosphorus, pesticides, and other toxic organics) can also be expected. Over and above these removals, there will be some small percentage of dissolved organic removal owing to anaerobic biological activity.

Rock AUFs after septic tanks have not been widely studied, but they appear to remove TSS by as much as 55 percent from septic tank effluent, while removing a similar percent of the BOD. Actual removals will depend on the specific fractions of particulate, colloidal, and soluble matter in the septic tank effluent. Little soluble or fine particulate removal is likely. Both systems will remove pathogens, with VSBs capable of removing from 1 to 3 logs (design average = 2 logs), while AUF removal is estimated to be closer to 1 log because of shorter HRTs.

Management needs

All of these anaerobic systems are passive in nature and require minimal O/M activity. AUF units may be constructed aboveground, but they usually are below the ground surface to provide insulation and protect against severe climatic conditions. The solid medium can be a coarse gravel or one of many commercially available synthetic media that will not easily clog with biomass. Access to inlet and outlet systems should be provided for purposes of cleaning and servicing. An easily accessible means to drain the unit and an effective alarm system should be provided.

VSB units are generally aesthetically pleasing additions to the landscape if sufficient area is available for their application. It is estimated that fewer than 4 hours per year will be required for O/M tasks, which will involve inspecting the system and making any adjustments required. Therefore, until more information becomes available, a site visit schedule of three to four times a year is suggested.

Residuals generate in VSB systems at a slow rate. Although the system inlet where most solids accumulate can be excavated or piped for high-pressure removal, it is more likely that a replacement system would be built after the service life of the original system ends.

AUF units will require periodic flushing of accumulated solids and inspection of inlet and outlet systems. If solids are allowed to accumulate, the filter may clog or release high solids “events” to the SWIS. This will clog the infiltrative surface or the distribution system. Therefore, a site visit schedule of three to four times per year is suggested until more information becomes available. This would entail from 6 to 8 hours per year of labor. Disposal and transport of excess solids will require similar management to septage.

Risk management issues

VSB systems can usually handle the flow variations likely to occur from residential sources, as well as toxic shock loads and power outages. Reed and colleagues (1995) proposed some models to support the view that insulation provided by dead vegetation (litter) on the surface should aid these systems during typical winters in northern climates. The potential for odor is low for properly sized systems.

AUF systems should also accommodate typical flow variations, toxic shocks, and power outages. They should be insulated from cold weather. AUFs are inherently odor and corrosion generators, so corrosion-resistant materials should be employed. Odor (hydrogen sulfide) production may require the use of an odor-control system (e.g., soil filters) to deodorize off-gases.

Costs

VSB systems for onsite application will cost about $20 per square foot (USEPA, 1999). Almost half of that cost is for the media, while excavation, liner, plants, control structures, and piping make up the rest. Operation and maintenance costs would run less than $100 per year if these services are professionally provided.

AUF systems are likely to cost about $1,000 to $1,500 per house, primarily related to the cost of the tank and related containment features. O/M costs would run around $200 per year, including solids transport as required.

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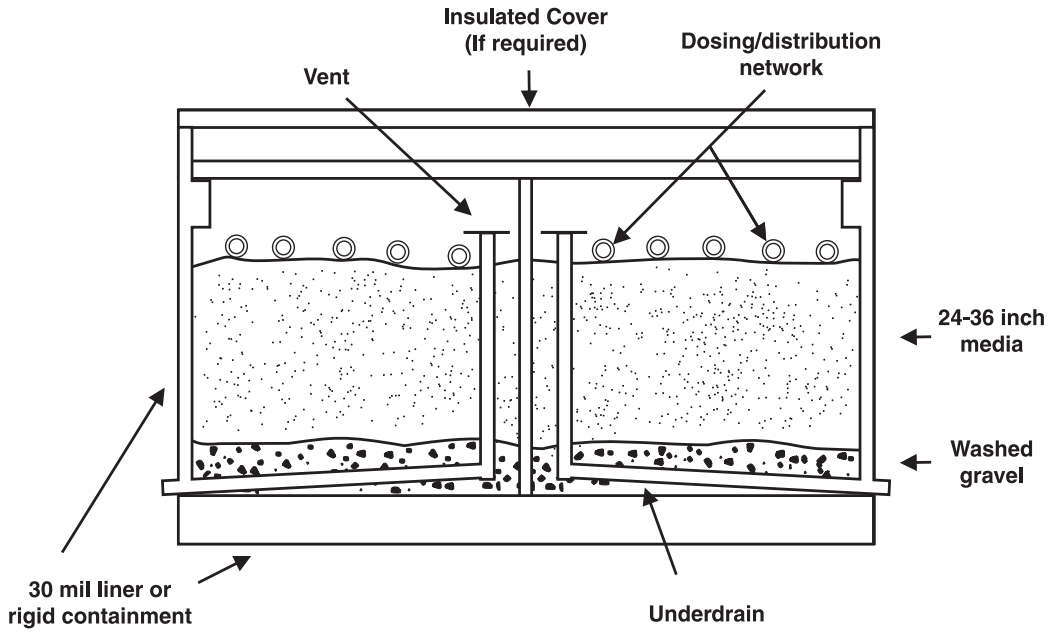
Onsite Wastewater Treatment Systems Technology Fact Sheet 10

Intermittent Sand/Media Filters

Description

The term *intermittent sand filter* (ISF) is used to describe a variety of packed-bed filters of sand or other granular materials available on the market. Sand filters provide advanced secondary treatment of settled wastewater or septic tank effluent. They consist of a lined (e.g., impervious PVC liner on sand bedding) excavation or structure filled with uniform washed sand that is placed over an underdrain system (see figure 1). The wastewater is dosed onto the surface of the sand through a distribution network and allowed to percolate through the sand to the underdrain system. The underdrain system collects the filter effluent for further processing or discharge.

Figure 1. Generic, open intermittent sand filter



Sand filters are aerobic, fixed-film bioreactors. Other treatment mechanisms that occur in sand filters include physical processes, such as straining and sedimentation, that remove suspended solids within the pores of the media. Also, chemical adsorption of pollutants onto media surfaces plays a finite role in the removal of some chemical constituents (e.g., phosphorus). Bioslimes from the growth of microorganisms develop as films on the sand particle surfaces. The microorganisms in the slimes absorb soluble and colloidal waste materials in the wastewater as it percolates over the sand surfaces. The adsorbed materials are incorporated into a new cell mass or degraded under aerobic conditions to carbon dioxide and water.

Most biochemical treatment occurs within approximately 6 inches of the filter surface. As the wastewater percolates through this layer, suspended solids and carbonaceous biochemical oxygen demand (BOD) are removed. Most suspended

solids are strained out at the filter surface. The BOD is nearly completely removed if the wastewater retention time in the sand media is sufficiently long for the microorganisms to absorb wastewater constituents. With depleting carbonaceous BOD in the percolating wastewater, nitrifying microorganisms are able to thrive deeper in the surface layer where nitrification will readily occur.

Chemical adsorption can occur throughout the media bed. Adsorption sites in the media are usually limited, however. The capacity of the media to retain ions depends on the target constituent, the pH, and the mineralogy of the media. Phosphorous is one element of concern in wastewater that can be removed in this manner, but the number of available adsorption sites is limited by the characteristics of the media.

The basic components of intermittent sand filters include a dosing tank, pump and controls (or siphon), distribution network, and the filter bed with an underdrain system (see figure 1). The wastewater is intermittently dosed from the dosing tank onto the filter through the distribution network. From there, it percolates through the sand media to the underdrain and is discharged. On-demand dosing is usually used, but timed dosing is becoming common.

There are a large number of variations in ISF designs. For example, there are different means of distribution, underdrain designs, housing schemes and, most notably, media choices. Many types of media are used in single-pass filters. Washed, graded sand is the most common. Other granular media used include gravel, crushed glass, and bottom ash from coal-fired power plants. Foam chips (polystyrene), peat, and coarse-fiber synthetic textile materials have also been used. These media are generally restricted to proprietary units. System manufacturers should be contacted for application and design using these materials.

There are also related single-pass designs, which are not covered in this fact sheet. These include lateral flow designs and upflow-wicking concepts, both of which use physical removal concepts closer to the concepts described in the fact sheet on anaerobic upflow filters and vegetated submerged beds. These processes are not discussed herein but may exhibit some pollutant removal mechanisms that are described here. Simple gravity-fed, buried sand filters are not discussed because their performance history is unsatisfactory.

Applications

Sand filters can be used for a broad range of applications, including single-family residences, large commercial establishments, and small communities. Sand filters are frequently used to pretreat septic tank effluent prior to subsurface infiltration onsite where the soil has insufficient unsaturated depth above ground water or bedrock to achieve adequate treatment. They are also used to meet water quality requirements (with the possible exception of fecal coliform removal) before direct discharge to a surface water. Sand filters are used primarily to treat domestic wastewater, but they have been used successfully in treatment trains to treat wastewaters high in organic materials such as those from restaurants and supermarkets. Single-pass ISF filters are most frequently used for smaller applications and sites where nitrogen removal is not required. However, they can be combined with anaerobic processes to reduce nitrogen significantly. Many studies have shown that ISF-treated onsite wastewaters can reduce clogging of the infiltrative surface by many times when compared with septic-tank effluents. However, be careful to evaluate the overall loading of pollutants and pathogens to the underlying aquifer and nearby surface waters before considering significant SWIS sizing reductions.

Design

ISF filter design starts with the selected media. The media characteristics determine the necessary filter area, dose volumes, and dosing frequency. Availability of media for a specific application should be determined before completing the detailed design. Typical specifications, mass loadings, and media depths are presented in table 1. The sand or gravel selected should be durable with rounded grains. Only washed material should be used. Fine particles passing the U.S. No. 200 sieve (less than 0.074 mm) should be limited to less than 3 percent by weight. Other granular media that have been used are bottom ash, expanded clay, expanded shale, and crushed glass. These media should remove BOD and TSS similar to sand and gravel for similar effective sizes, uniformity, and grain shape. Newer commercial media such as textile materials have had limited testing, but based on early testing should be expected to perform as well as the above types.

Traditionally, sand filters have been designed based on hydraulic loadings. However, since these filters are primarily aerobic biological treatment units, it is more appropriate that they be designed based on organic loadings. Unfortunately, insufficient data exist to establish well-defined organic loading rates. Experience presently suggests that BOD_5 loadings on sand media should not exceed about 5 lb/1,000 ft^3 per day (0.024 kg/m^2 per day) where the effective size is near 1.0 mm and the dosing rate is at least 12 times per day.

Higher hydraulic and organic loadings have been described in several studies, but the long-term viability of the systems loaded at those higher organic loads has not yet been fully verified. The values in the table are thus considered conservative and may be subject to increases as more quality-assured data become available.

Table 1. Specifications, mass loadings, and depth for single-pass intermittent sand filters

Design parameter	Typical design value
Material	Durable, washed sand/gravel with rounded grains
Specifications	
Effective size	
Sand	0.25–1.00 mm
Gravel	N/A
Uniformity coefficient	< 4
Percent fines (passing 200 sieve or < 0.074 mm)	≤ 3
Depth	2 to 3 ft
Mass loadings	
Hydraulic loading [a]	
Sand	1–2 gpd/ft^2
Gravel	N/A
Organic loading [b]	
Sand	5 lb $BOD_5/1{,}000 ft^2$-d
Gravel	N/A
Underdrains	
Slope	0–0.1%
Size	3–4 in. dia.
Dosing	
Frequency	12–24 times per day
Dosing tank	
Volume	0.5–1.5 times design daily flow

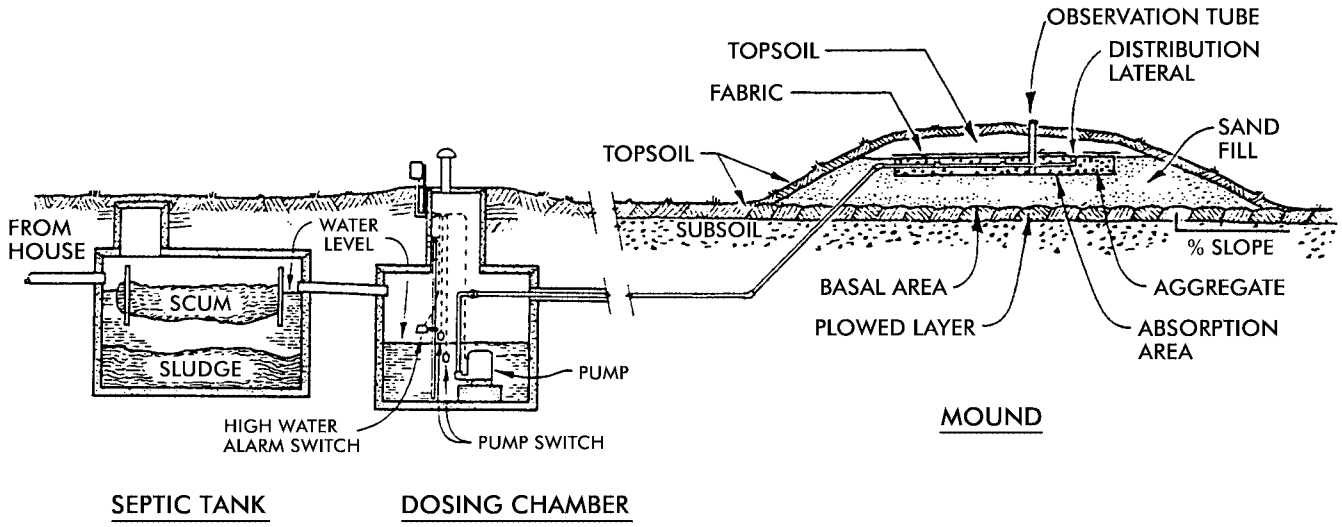
[a] 1 gpd/ft^2 = 4 cm/day = 0.04 m^3/m^2 per day
[b] 1 lb BOD/1000 ft^2 per day = 0.00455 kg/m^2 per day

Dosing volume and frequency have been shown to be the critical design variables. Small dose volumes are preferred because the flow through the porous media will occur under unsaturated conditions with higher moisture tensions. Better wastewater media contact and longer residence times occur under these conditions. Smaller dose volumes are achieved by increasing the number of doses per day. It has been suggested that each dose should be ≤0.5 cm (based on media surface perpendicular to infiltration direction) to fully nitrify the effluent in an ISF. This would limit maximum daily hydraulic loading to 12 cm/d, or 3 gpd/ft^2, if the maximum frequency of daily dosing is accepted as 24 (or hourly) as supported by the literature. Media characteristics can limit the number of doses possible. Reaeration of the media must occur between doses. As the effective size of the media decreases, the time for drainage and reaeration of the media increases.

Distribution network characteristics will also limit the number of doses possible. The primary characteristics are the volume, pressure, orifice sizes, and spacing. To achieve uniform distribution over the filter surface, minimum dose volumes are necessary and can vary with the distribution method selected. Therefore, if the dose volume dictated by the distribution network design is too high, the network should be redesigned. Since the dose volume is a critical operating parameter, the method of distribution and design of the distribution system should be considered carefully.

Distribution methods used include rigid pipe pressure networks with orifices or spray nozzles, drip distribution, and surface flooding, which is no longer recommended for small ISFs (see chapter 4). Rigid pipe pressure networks are the most commonly used method. Both orifices and spray nozzles are used. The use of spray nozzles is usually limited to recirculating filters because nozzle fouling from suspended solids is less likely than with undiluted septic tank effluent. Since the minimum dose volume required to achieve uniform distribution is five times the rigid pipe volume, the filter can be divided into multiple cells that are loaded individually so the distribution networks can be smaller to reduce the dose volume needed for uniform distribution. Optimum designs minimize the dose each time the system is dosed. Drip distribution is being used increasingly because the minimum dose volumes are much less than the volumes of rigid pipe networks.

Figure 2. ISF constructed in a mound with direct subsurface infiltration



Source: Converse and Tyler, 1998.

The underdrain system is placed on the floor of the tank or lined excavation. Ends of the underdrains should be brought to the surface of the filter and fitted with cleanouts that can be used to clean the biofilms underdrain, if necessary. The underdrain outlet is cut in the basin wall such that the drain invert is at the floor elevation and the filter can be completely drained. The underdrain outlet invert elevation must be sufficiently above the recirculation tank inlet to accommodate a minimum of 0.1 percent slope on the return line and any elevation losses through the flow splitting device. The underdrain (usually 1.25- to 2.0-inch PVC, class 200 [minimum]) is covered with washed, durable gravel to provide a porous medium through which the filtrate can flow to the underdrain system. The gravel should be sized to prevent the filter medium from mixing into the gravel, or a layer of 1/4- to 3/8-inch-diameter washed pea gravel should be placed over the washed underdrain gravel before the filter medium is added.

The filter basin can be a lined excavation or fabricated tank. For single-home systems, prefabricated concrete tanks are commonly used. Many single-home filters and most large filters are constructed within lined excavations. Typical liner materials are polyvinyl chloride and polypropylene. A liner thickness of 30 mil can withstand reasonable construction activities yet be relatively easy to work with. A sand layer should be placed below the liner to protect it from being punctured if the floor and walls of the excavation are stony. The walls of the excavation should be brought above the final grade to prevent entry of surface water.

Filters can be covered or buried. It is often necessary to provide a cover for the filter surface because the surface of a fine medium (e.g., sand) exposed to sunlight can be fouled with algae. Also, there may be concerns about odors, cold weather impacts, precipitation, leaf and debris accumulation, and snowmelt. In addition, the cover must provide ample fresh air venting. Reaeration of the filter medium primarily occurs from the filter surface. The lower 20 percent of the medium's depth maintains a high moisture content. At the bottom, the medium is near or at saturation, which is a barrier to air flow and venting from the underdrain system. The gravel surrounding the distribution piping must be vented to the surface to provide a fresh air flow. ISF filters open to the surface are built with roofs or removable covers or are merely shaded. Roofs provide cold weather protection and shed precipitation, debris, and snowmelt that would otherwise enter the system.

Performance

Treatment field performance of single-pass intermittent sand filters is presented in table 2. Typical effluent concentrations for these single-family wastewater treatment systems are less than 5 mg/L and less than 10 mg/L for BOD and TSS, respectively. Effluent is nearly completely nitrified but some variability can be expected in nitrogen removal capability. Controlled studies generally find typical nitrogen removals of 18 to 33 percent with an ISF. Fecal coliform removal ranges

from 2 to 4 logs (99 to 99.99 percent). ISF fecal coliform removal is a function of hydraulic loading, with reduced removals as the loading rate increases above 1 gpm/ft^2 (Emerick et al., 1997). Effluent suspended solids from sand filters are typically low. The media retains the solids. Most organic solids are digested by the media over time.

Table 2. Single-pass intermittent sand filter performance

Reference	BOD(mg/L) Influ.	BOD(mg/L) Efflu. (% Removal)	BOD(mg/L) Influ.	BOD(mg/L) Efflu. (% Removal)	BOD(mg/L) Influ.	BOD(mg/L) Efflu. (% Removal)	BOD(mg/L) Influ.	BOD(mg/L) Efflu. (% Removal)	BOD(mg/L) Influ.	BOD(mg/L) Efflu. (% Removal)
Cagle and Johnson, 1994 [a] (California)	160	2 (98.75%)	73	16 (78.08%)	61.8	5.9 (90.45%)	61.8	37.4 (39.48%)	1.14E+05	1.11E+02 (99.90%)
Effert et al., 1985[b] (Ohio)	127	4 (96.85%)	53	17 (67.92%)	-	- -	41.5	37.5 (9.64%)	2.19E+05	1.60E+03 (99.27%)
Ronayne et al., 1982[c] (Oregon)	217	3 (98.62%)	146	10 (93.15%)	57.1	1.7 (97.02%)	57.5	30.3 (47.30%)	2.60E+05	4.07E+02 (99.84%)
Sievers, 1998[d] (California)	297	3 (98.99%)	44	3 (93.18%)	37	0.5 (98.65%)	37.1	27.5 (25.88%)	4.56E+05	7.30E+01 (99.98%)

[a] Sand media: es = 0.25-0.65 mm; uc = 3-4. Design hydraulic loadings = 1.2 gpd/ft^2 based on 150 gpd/bedroom. Actual flows not measured.
[b] Sand media: es = 0.4 mm; uc = 2.5. Average loadings = 0.4 gpd/ft^2 / 0.42 lb BOD/1,000 ft^2. Doses per day = 3.3.
[c] Sand media: es = 0.14-0.30 mm; uc = 1.5-4.0. Average loadings = 0.33 gpd/ft^2 / 0.6-1.27 lb BOD/1000 ft^2 per day.
[d] Sand media: not reported; uc = 3-4. Design hydraulic loadings = 1. gpd/ft^2. Daily flows not reported.

Management needs

Construction of ISF units usually involves excavation, forming/framing, liner placement with supporting sand layers, and plumbing. ISF units should never be placed in surface depressions without thoroughly sealing against prolonged inundation and drainage configurations that prevent stormwater entry. In all cases, units must be watertight with sealed entries and exits for piping. Filter fabric should not be used at any location through which the filtrate would flow. Media delivered to the site should be tested against design-sizing specifications. Excess (3 percent or greater) fines are one of the greatest concerns of the construction inspector.

The operation and maintenance requirements of packed bed filters are few and simple. As with all treatment systems, flow monitoring should be conducted to identify excessive flows and check dose volumes and dosing rates. If the flows are excessive, the source of the flows should be identified and corrective measures taken. Reduced dose volumes or dosing rates suggest that the distribution network is plugged or the pump is not performing properly. The distribution network should be flushed annually (or more often, as necessary) using the manual flushing device. Also, the dosing pump should be recalibrated at least annually.

The filter surface should not pond if the filter is designed properly and the wastewater characteristics do not change significantly. If standby cells are not available for regular resting and the surface is not covered with pea gravel, the surface can be raked to break up any material clogging the filter surface. Reducing the dose volume and increasing the dosing frequency may help to increase the reaeration potential and reduce clogging of the media. If the ponding problem persists, however, removal of the top layer or complete replacement of the media may be necessary. Before replacing the media, monitor wastewater flows and concentrations to determine if they are the cause of the problem. Problem sources should be identified and addressed before repairs are effected. Premature clogging is often traceable to excess TSS and BOD loading or to fines in the media. Where the problem develops naturally over time and standby cells are available, resting may be used to supplement the raking and/or surface skimming steps.

Free-access ISFs should be checked regularly (at least every 3 to 4 months), to prevent surface problems. Periodic raking and resting is recommended to maintain percolation and prevent ponding. Scraping off the top layer (e.g., 1 inch) of sand helps to prevent clogging. Intervals between scraping vary from a minimum of 3 months up to greater than 1 year. Removed surface layers need not be replaced until the total filter depth falls below 18 inches. If new filter material is not

readily available, it may be cost-effective to clean and reuse the old filter material. Resting is considered the best rehabilitation approach due to possible clogging contributions from raking/scraping.

ISFs have low energy requirements compared with other systems offering comparable effluent quality. Free-access ISFs using pumped dosing would require approximately 0.3 to 0.4 kWh/day.

Risk management issues

ISF filters are simple in design and relatively passive to operate because the fixed-film process is very stable and few mechanical components are used. High flow variations after equalization in a septic tank are not a problem because the residual peaks and valleys are absorbed in the pressurization tank or in the last compartment of the preceding septic tank. Although ISFs have biological properties, the impact of toxic loading shocks are not well documented.

Free-access ISFs are often installed with removable covers to regulate temperatures in cold climates and to reduce odors. Space of 12 to 24 inches (30 to 61 cm) should be allotted between the sand surface and the installed cover (EPA, 1980). Odors from free-access filters treating septic tank effluent may warrant installation away from dwellings, especially if spray nozzles are used in distribution.

Power outages will impact ISF systems if these systems are uniformly dosed with pumps. During the power outage, all wastewater generated will accumulate in that dosing facility and septic tank, increasing the potential for odors.

Costs

Filter media is the most expensive component in ISF construction. Typically, filter media can be installed for $10 to $15 per square foot, depending primarily on the type of media and the contractor's experience with ISF construction. Operation/maintenance costs include electricity for pumping/dosing, and 3 to 6 hours of semiskilled management visits per year cost about $150 to $200. The electricity is about $10 to $20 of that total.

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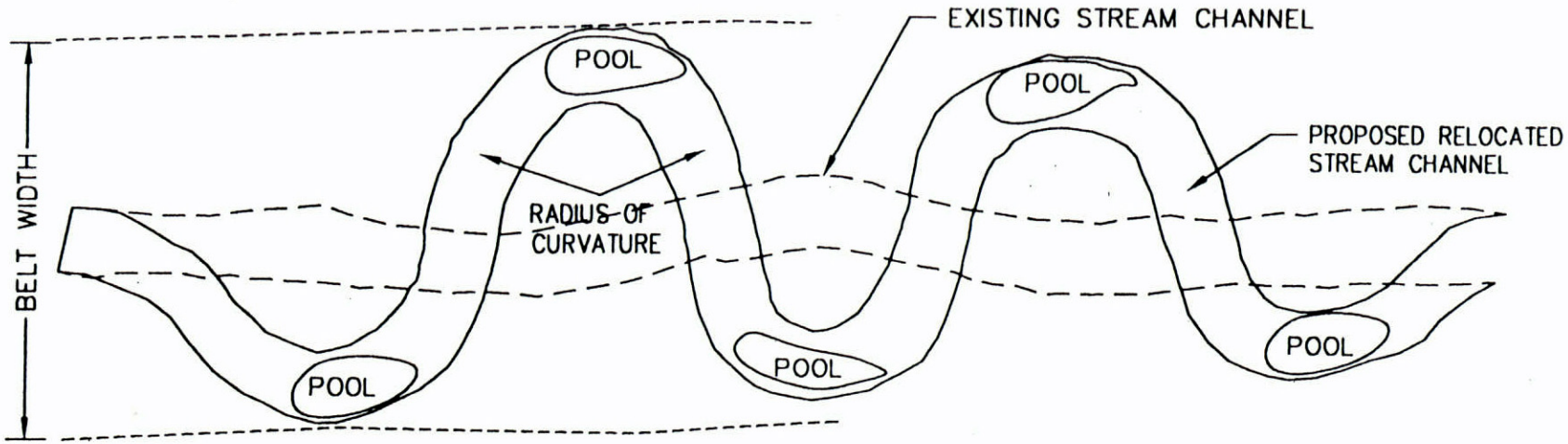
Appendix G

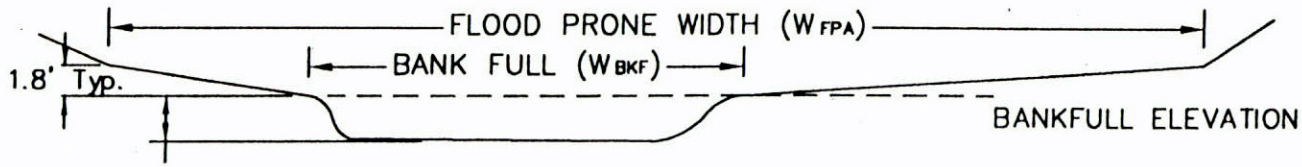
Examples of Streambank Stabilization Technical Drawings



$$\text{SINUOSITY} = \frac{\text{STREAM LENGTH}}{\text{VALLEY LENGTH}}$$

TYPICAL PLAN

(NO SCALE)

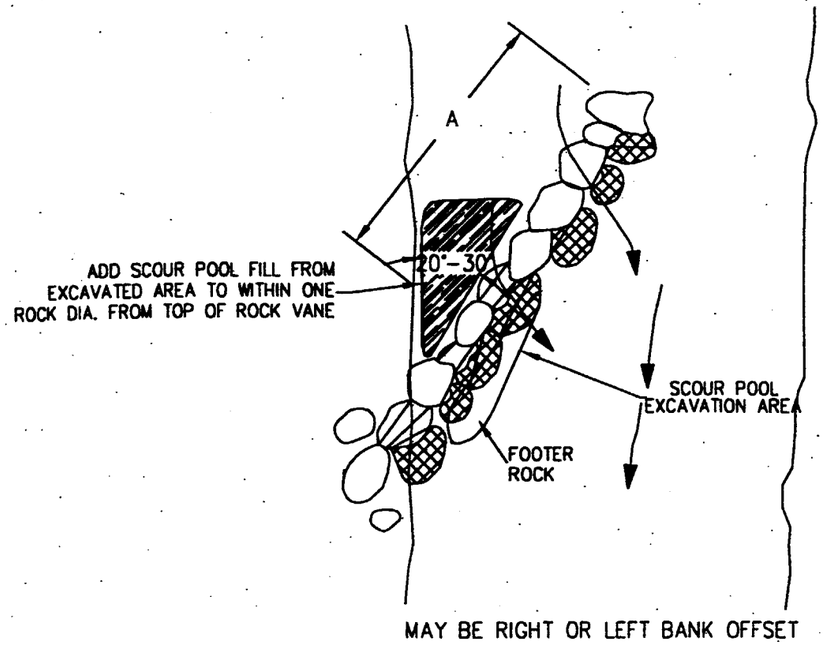


TYPICAL CROSS SECTION

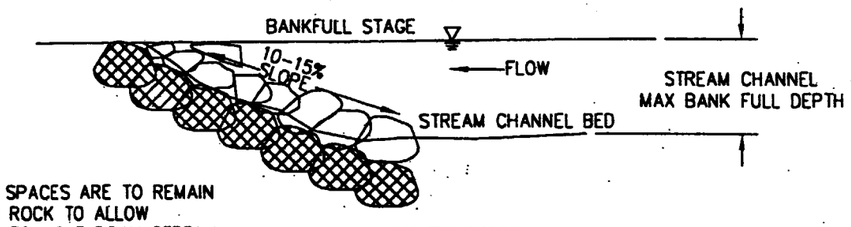
(NO SCALE)

BMP #1 NEW CHANNEL RECONSTRUCTION OR RELOCATION

SCALE: NO SCALE	SKELLY AND LOY	DRAWN BY: S. SOM
DATE: JUNE, 2000	CONSULTANTS IN	CHECKED BY: A.W.D.
NO. 1599269	ENVIRONMENT – ENERGY ENGINEERING – PLANNING	DWG. NO. BMP#1

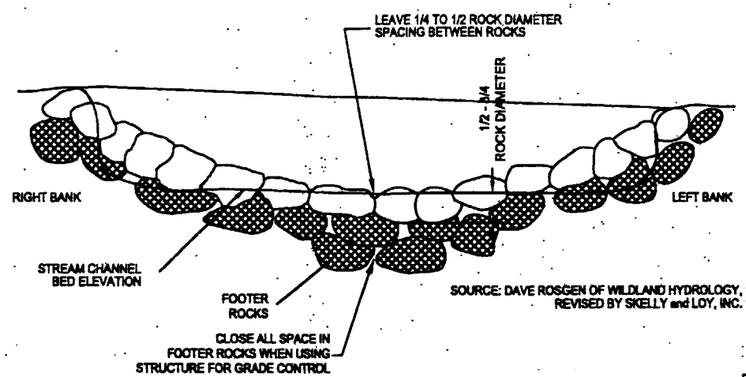


PLAN VIEW
NOT TO SCALE

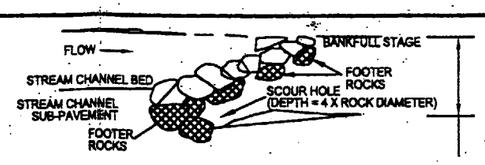


PROFILE VIEW
NOT TO SCALE

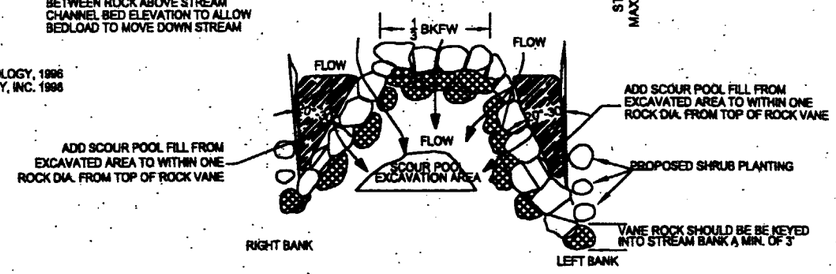
A) ROCK VANE



CROSS-SECTION VIEW
NOT TO SCALE

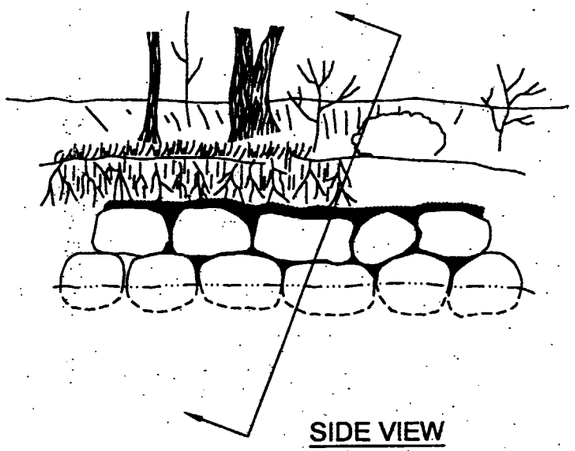


PROFILE VIEW
NOT TO SCALE



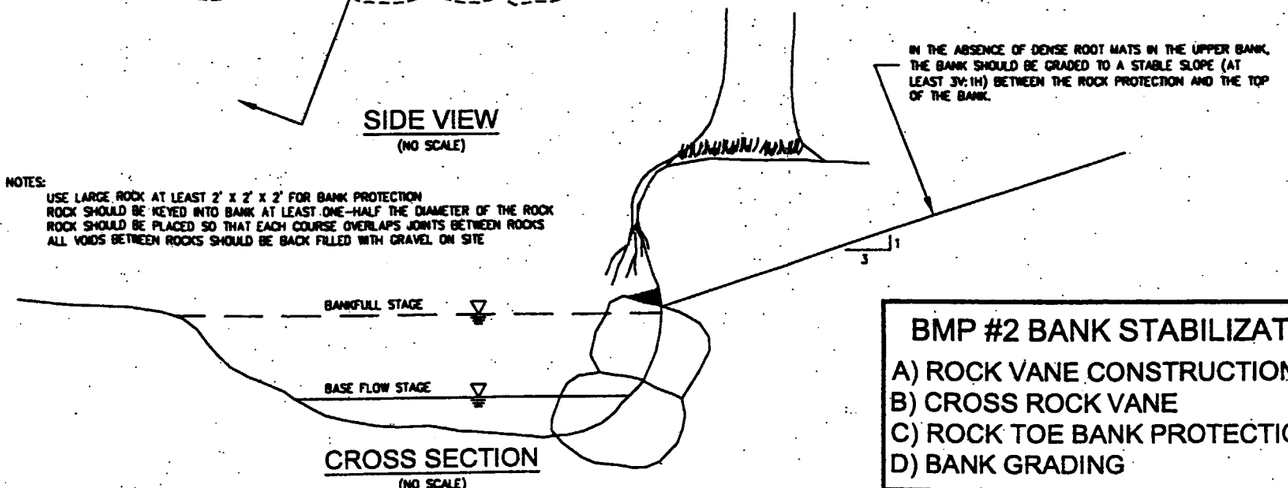
PLAN VIEW
NOT TO SCALE

B) CROSS ROCK VANE



SIDE VIEW
(NO SCALE)

NOTES:
USE LARGE ROCK AT LEAST 2' X 2' X 2' FOR BANK PROTECTION
ROCK SHOULD BE KEYED INTO BANK AT LEAST ONE-HALF THE DIAMETER OF THE ROCK
ROCK SHOULD BE PLACED SO THAT EACH COURSE OVERLAPS JOINTS BETWEEN ROCKS
ALL VOIDS BETWEEN ROCKS SHOULD BE BACK FILLED WITH GRAVEL OR SITE



CROSS SECTION
(NO SCALE)

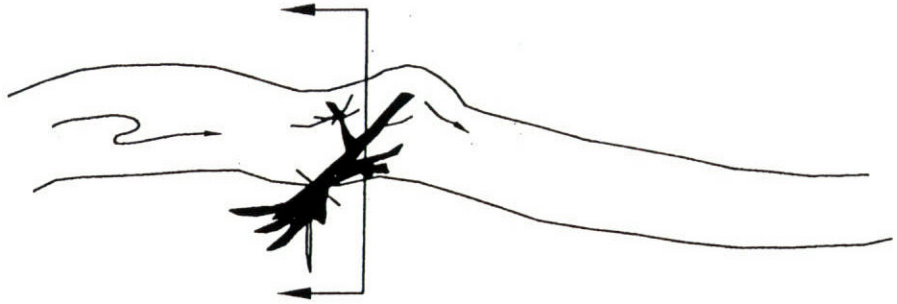
C, D) ROCK TOE BANK PROTECTION AND BANK GRADING

BMP #2 BANK STABILIZATION

A) ROCK VANE CONSTRUCTION
B) CROSS ROCK VANE
C) ROCK TOE BANK PROTECTION
D) BANK GRADING

SCALE: NO SCALE	SKELLY AND LOY CONSULTANTS IN ENVIRONMENT – ENERGY ENGINEERING – PLANNING	DRAWN BY: S. SOM
DATE: JUNE, 2000		CHECKED BY: A.W.D.
NO. 1599269		DWG. NO. BMP2

CROSS SECTION

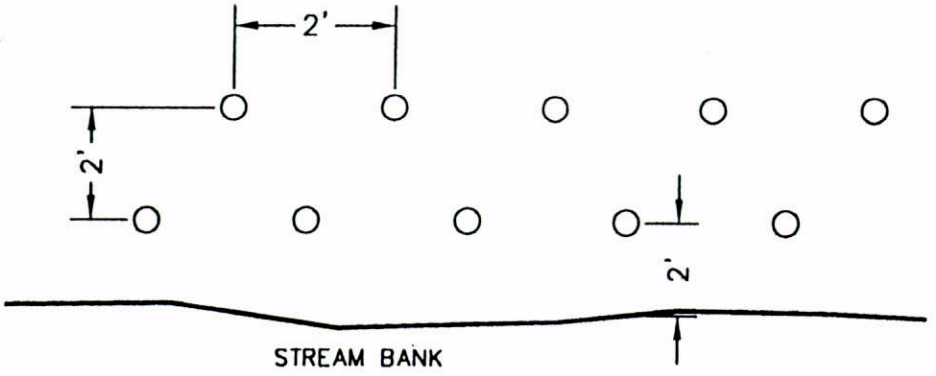


PLAN VIEW

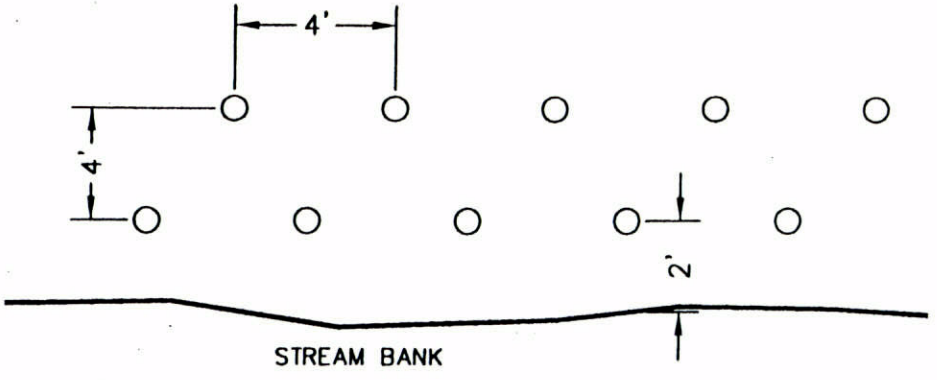
NOTES:
REMOVE CHANNEL DEBRIS ABOVE BASE FLOW WATER LEVEL AND DISPOSE OF OUTSIDE THE FLOODPLAIN AREA LARGE WOODY DEBRIS WHICH IS BURIED IN SUBSTRATED SERVES AS A CHANNEL GRADE CONTROL AND SHOULD REMAIN IN PLACE ALL ROOT MATERIAL IN STREAM BANK SHOULD REMAIN IN PLACE

BMP #3
DEBRIS JAM REMOVAL

SCALE: NO SCALE	SKELLY AND LOY CONSULTANTS IN ENVIRONMENT – ENERGY ENGINEERING – PLANNING	DRAWN BY: S. SOM
DATE: JUNE, 2000		CHECKED BY: A.W.D.
NO. 1599269		DWG. NO. BMP3



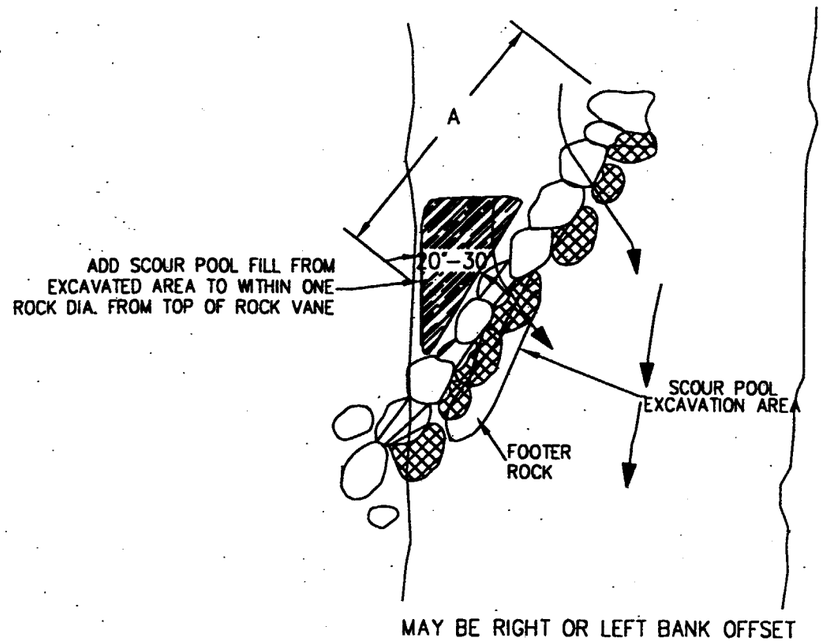
LIVE STAKES AND SHRUB PLANTING DETAIL



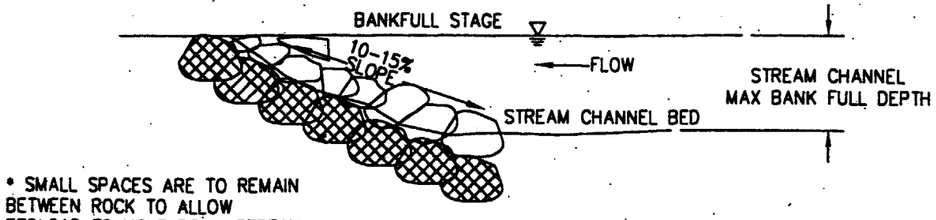
TREE PLANTING DETAIL

BMP #4 RIPARIAN/PLANTING DETAIL

SCALE: NO SCALE	SKELLY AND LOY CONSULTANTS IN ENVIRONMENT – ENERGY ENGINEERING – PLANNING	DRAWN BY: S. SOM
DATE: JUNE, 2000		CHECKED BY: A.W.D.
NO. 1599269		DWG. NO. BMP4

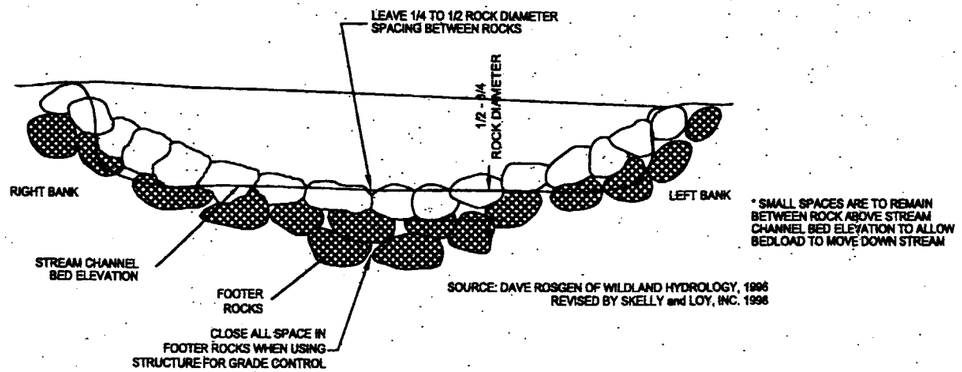


PLAN VIEW
NOT TO SCALE

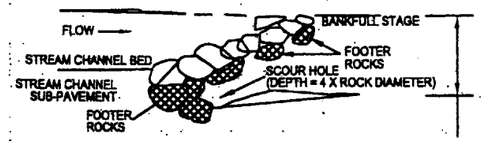


PROFILE VIEW
NOT TO SCALE

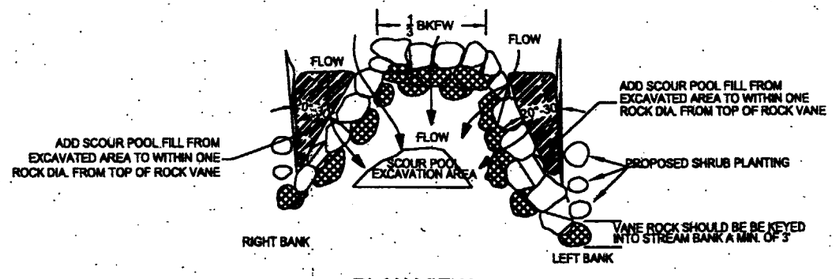
A) ROCK VANE



CROSS-SECTION VIEW
NOT TO SCALE



PROFILE VIEW
NOT TO SCALE



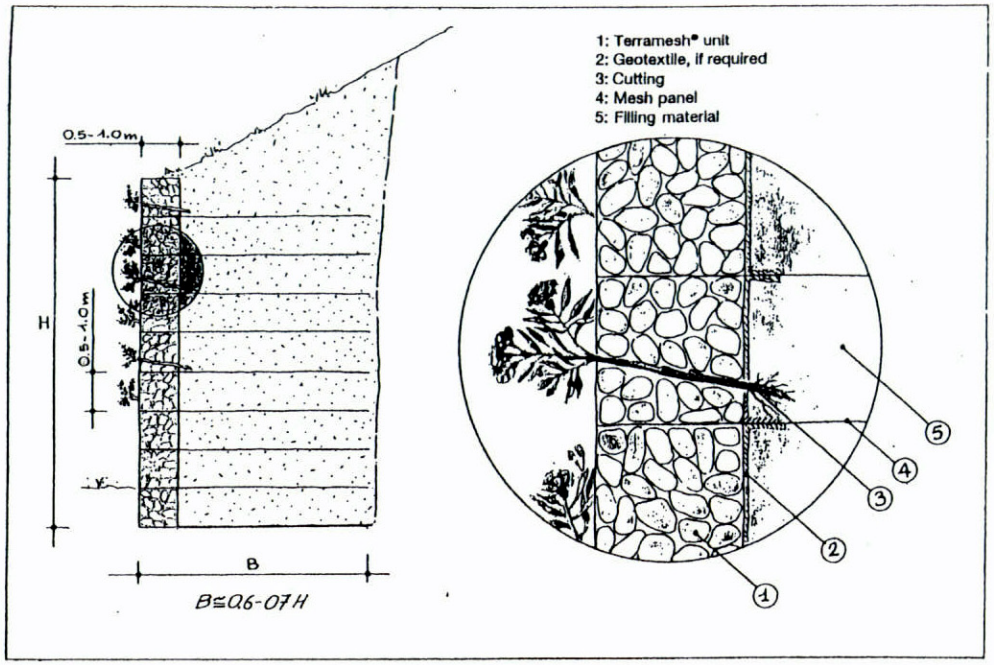
PLAN VIEW
NOT TO SCALE

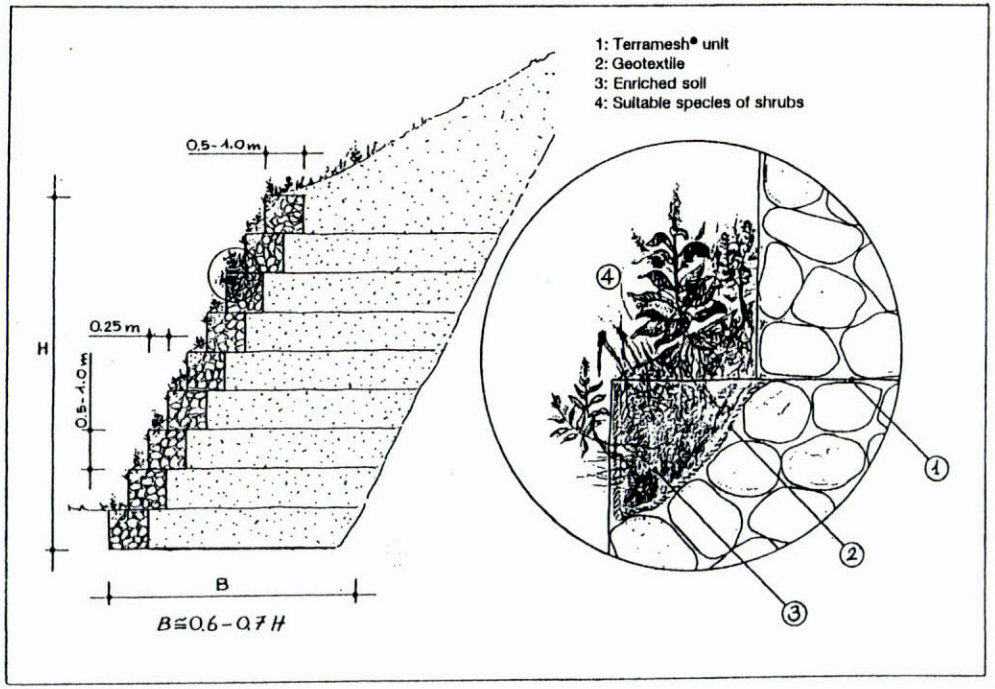
B) CROSS ROCK VANE

BMP #5 SEDIMENT TRANSPORT

A) ROCK VANE
B) CROSS ROCK VANE

SCALE: NO SCALE	SKELLY AND LOY CONSULTANTS IN ENVIRONMENT – ENERGY ENGINEERING – PLANNING	DRAWN BY: S. SOM
DATE: JUNE, 2000		CHECKED BY: A.W.D.
NO. 1599289		DWG. NO. BMP5





BMP #6

Environmentally Enhanced Traditional Engineer Stabilization (Typical)

SCALE: NO SCALE	SKELLY AND LOY CONSULTANTS IN ENVIRONMENT-ENERGY ENGINEERING-PLANNING	DRAWN BY: DKB
DATE: JUNE 2000		CHECKED BY: AWD
JOB NO. 1599269		DWG NO. BM#6

Source: Maccaferri Terramesh® System

Appendix H

Model Stream Protection Ordinances

Erosion and Sediment Control/ Grading Model Ordinance

Section I. Introduction/ Purpose

During the construction process, soil is the most vulnerable to erosion by wind and water. This eroded soil endangers water resources by reducing water quality, and causing the siltation of aquatic habitat for fish and other desirable species. Eroded soil also necessitates repair of sewers and ditches, and the dredging of lakes. In addition, clearing grading during construction causes the loss of native vegetation necessary for terrestrial and aquatic habitat, and to provide a healthy living environment for citizens of _____ (*Municipality)*.

As a result, the purpose of this local regulation is to safeguard persons, protect property, prevent damage to the environment and promote the public welfare by guiding, regulating, and controlling the design, construction, use, and maintenance of any development or other activity which disturbs or breaks the topsoil or results in the movement of earth on land in _____ (*Municipality*).

Section II. Definitions

Certified Contractor	An individual who has received training and is licensed by _____ (*State or Local Environmental Agency*) to inspect and maintain erosion and sediment control practices.
Clearing	Any activity which removes the vegetative surface cover.
Drainage Way	Any channel that conveys surface runoff throughout the site.
Erosion Control	Measures that prevent erosion.
Erosion and Sediment Control Plan	A set of plans prepared by or under the direction of a licensed professional engineer indicating the specific measures and sequencing to be used controlling sediment and erosion on a development site both before, during and after construction.
Grading	Excavation or fill of material, including the resulting conditions thereof.
Perimeter Control	A barrier that prevents sediment from leaving a site either by filtering sediment-laden runoff, or diverting it to a sediment trap or basin.
Phasing	Clearing a parcel of land in distinct phases, with the stabilization of each phase before the clearing of the next.
Sediment Control	Measures that prevent eroded sediment from leaving the site.
Site	A parcel of land, or a contiguous combination thereof, where grading work is performed as a single unified operation.
Site Development Permit	A permit issued by the municipality for which the construction or alteration of ground improvements and structures for the control of erosion, runoff and grading.

Stabilization The use of practices that prevent exposed soil from eroding.

Start of Construction The first land-disturbing activity associated with a development, including land preparation such as clearing, grading and filling; installation of streets and walkways; excavation for basements, footings, piers or foundations; erection of temporary forms; and installation of accessory buildings such as garages.

Watercourse Any body of water, including, but not limited to lakes, ponds, rivers, streams, and bodies of water which delineated by_____ (*Municipality*).

Waterway A channel that directs surface runoff to a watercourse, or to the public storm drain.

1. Permits
   1. No person shall be granted a site development permit for land-disturbing activity which would require the uncovering of *10,000 or more square feet* without the approval of an Erosion and Sediment Control Plan by _____ (*Erosion and Sediment Control Agency*).

L *The size of the site regulated under the erosion and sediment control ordinance varies widely. The proposed Phase II NPDES rules regulate disturbances greater than one acre, but communities regulate sites as small as 2,000 square feet.*

   2. No site development permit is required for the following activities:
      1. Any emergency activity which is immediately necessary for the protection of life, property or natural resources.
      2. Existing nursery and agricultural operations conducted as a permitted main or accessory use.

L *Communities may choose to exempt other activities, such as mining, from an erosion and sediment control permit, or in some cases include the exempted uses cited above..*

   3. Each application shall bear the name(s) and address(es) of the owner or developer of the site, and of any consulting firm retained by the applicant together with the name of the applicant=s principal contact at such firm, and shall be accompanied by a filing fee.

   4. Each application shall include a statement that any land clearing, construction, or development involving the movement of earth shall be in accordance with the Erosion and Sediment Control Plan, and that a Certified Contractor shall be on site on all days where construction or grading activity takes place.

L *Some states have "Certified Contractor" programs, in which contractors successfully completing a training course in basic erosion and sediment control. This individual would be responsible for ensuring the regular maintenance and proper installation of erosion and sediment control measures.*

   5. The applicant will be required to file with _____ (*Municipality*) a faithful performance bond or bonds, letter of credit, or other improvement security in an amount deemed sufficient by _____ (*Erosion and Sediment Control Agency*) to

cover all costs of improvements, landscaping, and maintenance of improvements for such period as specified by _____ (*Municipality*) and engineering and inspection costs to cover the cost of failure or repair of improvements installed on the site.

6. Review and approval
   1. _____ (*Erosion and Sediment Control Agency*) will review each application for a site development permit to determine its conformance with the provisions of this local regulation. Within thirty (30) days after receiving an application, __ (*Erosion and Sediment Control Agency*) shall, in writing:
      1. approve the permit application;
      2. approve the permit application subject to such reasonable conditions as may be necessary to secure substantially the objectives of this regulation, and issue the permit subject to these conditions; or
      3. disapprove the permit application, indicating the deficiencies and the procedure for submitting a revised application and/or submission.
   2. Failure of the _____ (*Erosion and Sediment Control Agency*) to act on original or revised applications within thirty (30) days of receipt shall authorize the applicant to proceed in accordance with the plans as filed unless such time is extended by agreement between the applicant and _____ (*Erosion and Sediment Control Agency*). Pending preparation and approval of a revised plan, development activities shall be allowed to proceed in accordance with conditions established by _____ (*Erosion and Sediment Control Agency*).

2. Erosion and Sediment Control Plan
   1. The Erosion and Sediment Control Plan shall include:
      1. A natural resources map identifying soils, forest cover, and resources protected under other chapters of this code.

L *This map should be at a scale no smaller than 1"=100'. For a more detailed discussion, see the buffer ordinance.*

      2. A sequence of construction of the development site, including stripping and clearing, rough grading, construction of utilities, infrastructure, and buildings, and final grading and landscaping. Sequencing shall identify the expected date on which clearing will begin, the estimated duration of exposure of cleared areas, and the sequence of clearing, installation of temporary erosion and sediment measures, and establishment of permanent vegetation.
      3. All erosion and sediment control measures necessary to meet the objectives of this local regulation throughout all phases of construction and permanently, after completion of development of the site. Depending upon the complexity of the project, the drafting of intermediate plans may be required at the close of each season.
      4. Seeding mixtures and rates, types of sod, method of seedbed preparation, expected seeding dates, type and rate of lime and fertilizer application, and kind and quantity of mulching for both temporary and permanent vegetative control measures.

5. Provisions for maintenance of control facilities, including easements and estimates of the cost of maintenance.

2. Modifications to the plan
   1. Major amendments of the erosion and sediment control plan shall be submitted to _____ (*Erosion and Sediment Control Agency*) and shall be processed and approved, or disapproved, in the same manner as the original plans.
   2. Field modifications of a minor nature may be authorized by (*Erosion and Sediment Control Agency*) by written authorization to the permitee.

3. Design Requirements

Grading, erosion control practices, sediment control practices, and waterway crossings shall meet the design criteria set forth in the most recent version of _____ (*Erosion and Sediment Control Manual)*, and shall be adequate to prevent transportation of sediment from the site to the satisfaction of _____ (*Erosion and Sediment Control Agency*).

1. Clearing and Grading
   1. Clearing and grading of natural resources, such as forests and wetlands, shall not be permitted, except when in compliance all other chapters of this Code.

L *For example, the stream buffer codes as well as the forest conservation code in the "Miscellaneous" section would also restrict clearing.*

2. Clearing techniques that retain natural vegetation and retain natural drainage patterns, as described in _____ (*Erosion and Sediment Control Manual)*, shall be used to the satisfaction of _____ (*Erosion and Sediment Control Agency*).
3. Phasing shall be required on all sites disturbing greater than *thirty* acres, with the size of each phase to be established at plan review and as approved by (*Erosion and Sediment Control Agency*).

L *While many communities encourage phasing, few actually require it. Phasing construction can reduce erosion significantly when well-designed. (See Claytor, 1997*).

4. Clearing, except that necessary to establish sediment control devices, shall not begin until all sediment control devices have been installed and have been stabilized.
5. Cut and fill slopes shall be *no greater than 2:1*, except as approved by (*Erosion and Sediment Control Agency*) to meet other community or environmental objectives.

2. Erosion Control
   1. Soil must be stabilized within *five days* of clearing or inactivity in construction.
   2. If vegetative erosion control methods, such as seeding, have not become established within *two weeks*, _____(*Erosion and Sediment Control Agency)* may require that the site be reseeded, or that a non-vegetative option be employed.

L *Numerical standards regarding the time to stabilization will vary. In particular, the time to establish*

seeding will depend on the climate.

3. On steep slopes or in drainage ways, special techniques that meet the design criteria outlined in _____ (*Erosion and Sediment Control Manual)* shall be used to ensure stabilization.
4. Soil stockpiles must be stabilized or covered at the end of each work day.
5. At the close of the construction season, the entire site must be stabilized, using a heavy mulch layer, or another method that does not require germination to control erosion.
6. Techniques shall be employed to prevent the blowing of dust or sediment from the site.

L *Dust control is most important in arid regions of the country*

7. Techniques that divert upland runoff past disturbed slopes shall be employed.

3. Sediment Controls
   1. Sediment controls shall be provided in the form of settling basins or sediment traps or tanks, and perimeter controls.
   2. Where possible, settling basins shall be designed in a manner that allows adaptation to provide long term stormwater management.
   3. Adjacent properties shall be protected by the use of a vegetated buffer strip, in combination with perimeter controls.

4. Waterways and Watercourses
   1. When a wet watercourse must be crossed regularly during construction, a temporary stream crossing shall be provided, and an approval obtained from __ (*Approving Agency, e.g., Waterways Division, ESC Agency*).
   2. When in-channel work is conducted, the channel shall be stabilized before, during and after work.
   3. All on-site stormwater conveyance channels shall be designed according to the criteria outlined in _____(*Erosion and Sediment Control Manual)*.
   4. Stabilization adequate to prevent erosion must be provided at the outlets of all pipes and paved channels.

5. Construction Site Access
   1. A temporary access road shall be provided at all sites.
   2. Other measures may be required at the discretion of _____(*Erosion and Sediment Control Agency)* in order to ensure that sediment is not tracked onto public streets by construction vehicles, or washed into storm drains.

4. Inspection
   1. _____ (*Erosion and Sediment Control Agency*) or designated agent shall make inspections as hereinafter required and shall either approve that portion of the work completed or shall notify the permitee wherein the work fails to comply with the erosion and sediment control plan as approved. Plans for grading, stripping, excavating, and filling work

bearing the stamp of approval of the _____ (*Erosion and Sediment Control Agency*) shall be maintained at the site during the progress of the work. In order to obtain inspections, the permitee shall notify _____ (*Erosion and Sediment Control Agency*) at least two (2) working days before the following:

1. Start of Construction
2. Erosion and sediment control measures are in place and stabilized.
3. Site Clearing has been completed
4. Rough Grading has been completed
5. Final Grading has been completed
6. Close of the Construction Season
7. Final Landscaping

L *The "Certified Inspector Program" in Delaware allows developers to hire an inspector who has passed a state licensing program. This individual would inspect the site at regular intervals, and file reports to the erosion and sediment control agency. The agency would then be responsible for spot checks on these reports.*

2. The permitee or his/her agent shall make regular inspections of all control measures in accordance with the inspection schedule outlined on the approved erosion and sediment control plan(s). The purpose of such inspections will be to determine the overall effectiveness of the control plan, and the need for additional control measures. All inspections shall be documented in written form and submitted to (*Erosion and Sediment Control Agency*) at the time interval specified in the approved permit.

3. _____ (*Erosion and Sediment Control Agency*) or its designated agent shall enter the property of the applicant as deemed necessary to make regular inspections to ensure the validity of the reports filed under Section B.

5. Enforcement

1. Stop-Work Order; Revocation of Permit
   In the event that any person holding a site development permit pursuant to this ordinance violates the terms of the permit, or implements site development in such a manner as to materially adversely affect the health, welfare, or safety or persons residing or working in the neighborhood or development site so as to be materially detrimental to the public welfare or injurious to property or improvements in the neighborhood, ____ (*Erosion and Sediment Control Agency*) may suspend or revoke the site development permit.

2. Violation and Penalties
   No person shall construct, enlarge, alter, repair, or maintain any grading, excavation, or fill, or cause the same to be done, contrary to or in violation of any terms of this ordinance. Any person violating any of the provisions of this ordinance shall be deemed guilty of a misdemeanor, and each day during which any violation of any of the provisions of this ordinance is committed, continued or permitted, shall constitute a separate offense. Upon conviction of any such violation, such person, partnership, or corporation shall be punished by a fine of not more than $_____for each offense. In

addition to any other penalty authorized by this section, any person, partnership, or corporation convicted of violating any of the provisions of this ordinance shall be required to bear the expense of such restoration.

L *Specific penalties will vary between communities, and should reflect realistically enforceable penalties given the political realities of a jurisdiction.*

6. Separability
The provisions and sections of this ordinance shall be deemed to be separable, and the invalidity of any portion of this ordinance shall not affect the validity of the remainder.

References

Caraco, D. 1997. Delaware Program Improves Construction Site Inspection. *Watershed Protection Techniques, 2(3): 440-442.*

Claytor, R. 1997. Practical Tips for Construction Site Phasing. *Watershed Protection Techniques, 2(3): 413-417.*

Buffer Model Ordinance

Section I. Background

Whereas, buffers adjacent to stream systems and coastal areas provide numerous environmental protection and resource management benefits which can include the following:

a) restoring and maintaining the chemical, physical and biological integrity of the water resources

b) removing pollutants delivered in urban stormwater

c) reducing erosion and controlling sedimentation

d) stabilizing stream banks

e) providing infiltration of stormwater runoff

f) maintaining base flow of streams

g) contributing the organic matter that is a source of food and energy for the aquatic ecosystem

h) providing tree canopy to shade streams and promote desirable aquatic organisms

This benefit applies primarily to forested buffer systems. In some communities, such as in prairie settings, the native vegetation may not be forest. See the example ordinance from Napa, California for an example.

i) providing riparian wildlife habitat

j) furnishing scenic value and recreational opportunity

It is the desire of the (Natural Resources or Planning Agency) to protect and maintain the native vegetation in riparian and wetland areas by implementing specifications for the establishment, protection and maintenance of vegetated along all stream systems and/or coastal zones within our jurisdictional authority.

Section II. Intent

The purpose of this ordinance is to establish minimal acceptable requirements for the design of buffers to protect the streams, wetlands and floodplains of (Jurisdiction); to protect the water quality of watercourses, reservoirs, lakes, and other significant water resources within (Jurisdiction); to protect (Jurisdiction's) riparian and aquatic ecosystems; and to provide for the environmentally sound use of (Jurisdiction's) land resources.

Section III. Definitions

Active Channel: The area of the stream channel that is subject to frequent flows (approximately once per one and a half years), and that includes the portion of the channel below where the floodplain flattens.

Best Management Practices (BMPs): Conservation practices or management measures which control soil loss and reduce water quality degradation caused by nutrients, animal wastes, toxins, sediment, and runoff.

Buffer: A vegetated area, including trees, shrubs and herbaceous vegetation, which exists or is established to protect a stream system, lake, reservoir or coastal estuarine area. Alteration of this natural area is strictly limited.

Development: 1) The improvement of property for any purpose involving building; 2) Subdivision, or the division of a tract or parcel of land in to 2 or more parcels; 3) the combination of any two or more lots, tracts, or parcels of property for any purpose; 4) the preparation of land for any of the above purposes.

Non-Tidal Wetland: Those areas not influenced by tidal fluctuations that are inundated or saturated 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.

The definition of "non-tidal wetland" here is adapted from the definition of "wetland" used by the US EPA and the Army Corps of Engineers. Other definitions will also be acceptable. See the Croton-on-Hudson Wetlands and Watercourses ordinance for an example.

Non-point Source Pollution: Pollution which is generated by various land use activities rather than from an identifiable or discrete source, and is conveyed to waterways through natural processes, such as rainfall, storm runoff, or ground water seepage rather than direct discharge.

One Hundred Year Floodplain: The area of land adjacent to a stream that is subject to inundation during a storm event that has a recurrence interval of one hundred (100) years.

Pollution: Any contamination or alteration of the physical, chemical, or biological properties of any waters that will render the waters harmful or detrimental to: public health, safety or welfare; domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses; livestock, wild animals, or birds; fish or other aquatic life.

Stream Channel: Part of a water course either naturally or artificially created which contains an intermittent or perennial base flow of groundwater origin. Base flows of groundwater origin can be distinguished by any of the following physical indicators:

1) Hydrophytic vegetation, hydric soil or other hydrologic indicators in the area(s) where groundwater enters the stream channel, in the vicinity of the stream headwaters, channel bed or channel banks

2) Flowing water not directly related to a storm event

3) Historical records of a local high groundwater table, such as well and stream gauge records.

Stream Order: A classification system for streams based on stream hierarchy. The smaller the stream, the lower its numerical classification. For example, a first order stream does not have tributaries and normally originates from springs and/or seeps. At the confluence of two first order streams, a second order stream begins, and so on. (See Figure 1)

Stream System: A stream channel together with one or both of the following:

1) 100-year floodplain and/or

2) Hydrologically-related non-tidal wetlands

Streams: Perennial and intermittent watercourses identified through site inspection and USGS maps. Perennial streams are those which are depicted on a USGS map with a solid blue line. Intermittent streams are those which are depicted on a USGS map with a dotted blue line.

Defining the term "stream" is perhaps the most contentious issue in the definition of stream buffers. This term determines the origin, and the length of the stream buffer. While some jurisdictions restrict the buffer to perennial or "blue line" streams, others include both perennial and intermittent streams in the stream buffer program. Some communities do not rely on USGS maps, and instead prepare local maps of all stream systems that require a buffer.

Water Pollution Hazard: A land use or activity that causes a relatively high risk of potential water pollution.

Section IV. Applications

A) This ordinance shall apply to all proposed development except for that development which meets waiver or variance criteria as outlined in Section IX of this regulation.

B) This ordinance shall apply to all timber harvesting activities, except those timber harvesting operations which are implementing a forest management plan which has been deemed to be in compliance with the regulations of the buffer ordinance and has received approval from . (*state forestry agency*)

C) This ordinance shall apply to all surface mining operations except that the design standards shall not apply to active surface mining operations which are operating in compliance with an approved (*state or federal agency*) surface mining permit.

D) The ordinance shall not apply to agricultural operations that are covered by an approved NRCS conservation plan that includes the application of best management practices.

Communities should carefully consider whether or not to exempt agricultural operations from the buffer ordinance, because buffer regulations may take land out of production and impose a financial burden on family farms. Many communities exempt agricultural operations if they have an approved NRCS conservation plan. In some regions, agricultural buffers may be funded through the Conservation Reserve Program (CRP). Consult the Conservation Technology Information Center (CTIC) at www.ctic.perdue.edu.

Livestock operations near and around streams may be regulated by communities. Livestock can significantly degrade the stream system, and accelerate streambank erosion. The King County Livestock Management Ordinance is one example of a local livestock ordinance. For more information, contact the King County Department of Development and Environmental Services at (206) 296-6602.

E) Except as provided in Section IX, this ordinance shall apply to all parcels of land, structures and activities which are causing or contributing to:

1) Pollution, including non-point pollution, of the waters of the jurisdiction adopting this ordinance.

2) Erosion or sedimentation of stream channels

3) Degradation of aquatic or riparian habitat

Section V. Plan Requirements

A) In accordance with section IV of this ordinance, a plan approved by the appropriate agency is required for all development, forest harvesting operations, surface mining operations, and agricultural operations.

B) The plan shall set forth an informative, conceptual and schematic representation of the proposed activity by means of maps, graphs, charts, or other written or drawn documents so as to enable the agency an opportunity to make a reasonably informed decision regarding the proposed activity.

C) The plan shall contain the following information:

The ordinance can identify the scale of maps to be included with the analyses in items 2) through 7). A 1"=50' to 1"=100' scale will generally provide sufficient detail.

1) a location or vicinity map

2) field delineated and surveyed streams, springs, seeps, bodies of water, and wetlands (include a minimum of two hundred (200) feet into adjacent properties).

3) Field delineated and surveyed forest buffers

4) Limits of the ultimate one hundred year floodplain

The limits of the ultimate floodplain (i.e., the floodplain under "built-out" conditions) may not be available in all locations.

5) hydric soils mapped in accordance with the NRCS soil survey of the site area

6) steep slopes greater than fifteen (15) percent for areas adjacent to and within two hundred (200) feet of streams, wetlands, or other waterbodies.

The ordinance may also explicitly define how slopes are measured. For example, the buffer may be divided into sections of a specific width (e.g., twenty five feet) and the slope for each segment reported. Alternatively, slopes can be reported in segments divided by breaks in slope.

7) a narrative of the species and distribution of existing vegetation within the buffer

D) The buffer plan shall be submitted in conjunction with the required grading plan for any development, and the forest buffer should be clearly delineated on the final grading plan.

E) Permanent boundary markers, in the form of signage approved by (*Natural Resources or Planning Agency*), shall be installed prior to final approval of the required clearing and grading plan. Signs shall be placed at the edge of the Middle Zone (See Section VI.E).

Section VI Design Standards for Forest Buffers

A) A forest buffer for a stream system shall consist of a forested strip of land extending along both sides of a stream and its adjacent wetlands, floodplains or slopes. The forest buffer width shall be adjusted to include contiguous sensitive areas, such as steep slopes or erodible soils, where development or disturbance may adversely affect water quality, streams, wetlands, or other waterbodies.

B) The forest buffer shall begin at the edge of the stream bank of the active channel.

C) The required width for all forest buffers (i.e., the base width) shall be a minimum of one hundred feet, with the requirement to expand the buffer depending on:1)stream order; 2)percent slope; 3)100-year floodplain; 4) wetlands or critical areas.

The width of the stream buffer varies from twenty feet to up to 200 feet in ordinances throughout the United States (Heraty, 1993). The width chosen by a jurisdiction will depend on the sensitivity and characteristics of the resource being protected and political realities in the community.

1) In third order and higher streams, add twenty five feet to the base width.

2) Forest Buffer width shall be modified if there are steep slopes which are within a close proximity to the stream and drain into the stream system. In those cases, the forest buffer width can be adjusted.

Several methods may be used to adjust buffer width for steep slopes. Two examples include:

Method A:

Percent Slope	Width of Buffer
15%-17%	add 10 feet
18%-20%	add 30 feet
21%-23%	add 50 feet
24%-25%	add 60 feet

Method B:

Percent Slope	Type of Stream Use	
	Water Contact Recreational Use	Sensitive Stream Habitat
0 to 14%	no change	add 50 feet
15 to 25%	add 25 feet	add 75 feet
Greater than 25%	add 50 feet	add 100 feet

3) Forest buffers shall be extended to encompass the entire 100 year floodplain and a zone with minimum width of 25 feet beyond the edge of the floodplain.

4) When wetland or critical areas extend beyond the edge of the required buffer width, the buffer shall be adjusted so that the buffer consists of the extent of the wetland plus a 25 foot zone extending beyond the wetland edge.

D) Water Pollution Hazards

The following land uses and/or activities are designated as potential water pollution hazards, and must be set back from any stream or waterbody by the distance indicated below:

1) storage of hazardous substances (150 feet)

2) above or below ground petroleum storage facilities (150 feet)

3) drainfields from on-site sewage disposal and treatment system (i.e., septic systems--100 feet)

4) raised septic systems (250 feet)

5) solid waste landfills or junkyards (300 feet)

6) confined animal feedlot operations (250 feet)

7) subsurface discharges from a wastewater treatment plant (100 feet)

8) land application of biosolids (100 feet)

For surface water supplies, the setbacks should be doubled.

A community should carefully consider which activities or land uses should be designated as potential water pollution hazards. The list of potential hazards shown above is not exhaustive, and others may need to be added depending on the major pollutants of concern and the uses of water.

E. The forest buffer shall be composed of three distinct zones, with each zone having its own set of allowable uses and vegetative targets as specified in this ordinance. (See Figure 2).

Although a three-zone buffer system is highly recommended, the widths and specific uses allowed in each zone may vary between jurisdictions.

1) Zone 1 Streamside Zone

a) The function of the streamside zone is to protect the physical and ecological integrity of the stream ecosystem.

b) The streamside zone will begin at the edge of the stream bank of the active channel and extend a minimum of 25 feet from the top of the bank.

c) Allowable uses within this zone are highly restricted to:

i) flood control structures

ii) utility rights of way

iii) footpaths

iv) road crossings, where permitted.

d) The vegetative target for the streamside zone is undisturbed native vegetation.

This ordinance assumes that the native vegetation in the stream corridor is forest. In some regions of the United States, other vegetation such as prairie may be native. See the Napa, California buffer ordinance for an example of a stream buffer ordinance that protects non-forested systems.

2) Zone 2 Middle Zone

a) The function of the middle zone is to protect key components of the stream and to provide distance between upland development and the streamside zone.

b) The middle zone will begin at the outer edge of the streamside zone and extend a minimum of 50 plus any additional buffer width as specified in Section VI C.

c) Allowable uses within the middle zone are restricted to:

i) Biking or hiking paths

ii) Stormwater management facilities, with the approval of (*Local agency responsible for stormwater).*

iii) Recreational uses as approved by *(Planning Agency).*

iv) Limited tree clearing with approval from (*Forestry agency or Planning Agency*).

d) The vegetative target for the middle zone is mature native vegetation adapted to the region.

3) Zone 3 Outer Zone

a) The function of the outer zone is to prevent encroachment into the forest buffer and to filter runoff from residential and commercial development.

b) The outer zone will begin at the outward edge of the middle zone and provide a minimum width of 25 feet between Zone 2 and the nearest permanent structure.

c) There shall be no septic systems, permanent structures or impervious cover, with the exception of paths, within the outer zone.

c) The vegetative target for the outer zone may vary, although the planting of native vegetation should be encouraged to increase the total width of the buffer.

Section VII. Buffer Management and Maintenance

A) The forest buffer, including wetlands and floodplains, shall be managed to enhance and maximize the unique value of these resources. Management includes specific limitations on alteration of the natural conditions of these resources. The following practices and activities are restricted within Zones 1 and 2 of the forest buffer, except with approval by (*Forestry, Planning or Natural Resources Agency)*:

1) Clearing of existing vegetation.

2) Soil disturbance by grading, stripping, or other practices.

3) Filling or dumping.

4) Drainage by ditching, underdrains, or other systems

5) Use, storage, or application of pesticides, except for the spot spraying of noxious weeds or non-native species consistent with recommendations of .(*Forestry Agency*)

6) Housing, grazing, or other maintenance of livestock.

7) Storage or operation of motorized vehicles, except for maintenance and emergency use approved by .(*Forestry, Planning or Natural Resources Agency)*

B) The following structures, practices, and activities are permitted in the forest buffer, with specific design or maintenance features, subject to the review of (*Forestry, Planning or Natural Resources Agency)*:

1) Roads, bridges, paths, and utilities:

a) An analysis needs to be conducted to ensure that no economically feasible alternative is available.

b) The right of way should be the minimum width needed to allow for maintenance access and installation.

c) The angle of the crossing shall be perpendicular to the stream or buffer in order to minimize clearing requirements

d) The minimum number of road crossings should be used within each subdivision, and no more than one fairway crossing is allowed for every 1,000 feet of buffer.

2) Stormwater management:

e) An analysis needs to be conducted to ensure that no economically feasible alternative is available, and that the project is either necessary for flood control, or significantly improves the water quality or habitat in the stream.

f) In new developments, on-site and non-structural alternatives will be preferred over larger facilities within the stream buffer.

g) When constructing stormwater management facilities (i.e., BMPs), the area cleared will be limited to the area required for construction, and adequate maintenance access, as outlined in the most recent edition of (*Refer to Stormwater Manual)*.

Rather than place specific stormwater BMP design criteria in an ordinance, it is often preferable to reference a manual. Therefore, specific design information can change over time without going through the formal process needed to change ordinance language.

The Maryland Stormwater Design Manual, is one example of an up-to-date stormwater design manual. For more information, go to www.mde.state.md.us. Under topics, choose "Stormwater Design Manual".

h) Material dredged or otherwise removed from a BMP shall be stored outside the buffer.

3) Stream restoration projects, facilities and activities approved by (*Forestry, Planning or Natural Resources Agency)* are permitted within the forest buffer.

4) Water quality monitoring and stream gauging are permitted within the forest buffer, as approved by (*Forestry, Planning or Natural Resources Agency)*:.

5) Individual trees within the forest buffer may be removed which are in danger of falling, causing damage to dwellings or other structures, or causing blockage of the stream.

6) Other timber cutting techniques approved by the agency may be undertaken within the forest buffer under the advice and guidance of (*State or Federal Forestry Agency*), if necessary to preserve the forest from extensive pest infestation, disease infestation, or threat from fire.

C) All plats prepared for recording and all right-of-way plats shall clearly:

1) Show the extent of any forest buffer on the subject property by metes and bounds

2) Label the forest buffer

3) Provide a note to reference any forest buffer stating: "There shall be no clearing, grading, construction or disturbance of vegetation except as permitted by the agency."

4) Provide a note to reference any protective covenants governing all forest buffers areas stating: "Any forest buffer shown hereon is subject to protective covenants which may be found in the land records and which restrict disturbance and use of these areas."

D) All forest buffer areas shall be maintained through a declaration of protective covenant, which is required to be submitted for approval by (*Planning Board or Agency*). The covenant shall be recorded in the land records and shall run with the land and continue in perpetuity.

This protective covenant can be kept either by the local government agency responsible for management of environmental resources, or by an approved non-profit organization. An example conservation easement is included later in this section.

E) All lease agreements must contain a notation regarding the presence and location of protective covenants for forest buffer areas, and which shall contain information on the management and maintenance requirements for the forest buffer for the new property owner.

F) An offer of dedication of a forest buffer area to the agency shall not be interpreted to mean that this automatically conveys to the general public the right of access to this area.

G) (*Responsible Individual or Group)* shall inspect the buffer annually and immediately following severe storms for evidence of sediment deposition, erosion, or concentrated flow channels and corrective actions taken to ensure the integrity and functions of the forest buffer.

A local ordinance will need to designate the individual or group responsible for buffer maintenance. Often, the responsible party will be

identified in any protective covenants associated with the property.

H) Forest buffer areas may be allowed to grow into their vegetative target state naturally, but methods to enhance the successional process such as active reforestation may be used when deemed necessary by (*Natural Resources or Forestry Agency)* to ensure the preservation and propagation of the buffer area. Forest buffer areas may also be enhanced through reforestation or other growth techniques as a form of mitigation for achieving buffer preservation requirements.

Explicit forestry management criteria are often included in a forestry or natural resources conservation ordinance. An example forest conservation ordinance from Frederick County, Maryland is included in the Miscellaneous portion of this site.

Section VIII Enforcement Procedures

A) (Director of *Responsible Agency)* is authorized and empowered to enforce the requirements of this ordinance in accordance with the procedures of this section.

B) If, upon inspection or investigation, the director or his/her designee is of the opinion that any person has violated any provision of this ordinance, he/she shall with reasonable promptness issue a correction notice to the person. Each such notice shall be in writing and shall describe the nature of the violation, including a reference to the provision within this ordinance which has been violated. In addition, the notice shall set a reasonable time for the abatement and correction of the violation.

C) If it is determined that the violation or violations continue after the time fixed for abatement and correction has expired, the director shall issue a citation by certified mail to the person who is in violation. Each such notice shall be in writing and shall describe the nature of the violation, including a reference to the provision within this ordinance which has been violated, and what penalty, if any, is proposed to be assessed. The person charged has thirty (30) days within which to contest the citation or proposed assessment of penalty and to file a request for a hearing with the director or his designee. At the conclusion of this hearing, the director or his designee will issue a final order, subject to appeal to the appropriate authority. If, within thirty (30) days from the receipt of the citation issued by the director, the person fails to contest the citation or proposed assessment of penalty, the citation or proposed assessment of penalty shall be deemed the final order of the director.

D) Any person who violates any provision of this ordinance may be liable for any cost or expenses incurred as a result thereof by the agency.

E) Penalties which may be assessed for those deemed to be in violation may include:

1) A civil penalty not to exceed one thousand dollars ($1,000.00) for each violation with each days continuance considered a separate violation.

2) A criminal penalty in the form of a fine of not more than one thousand dollars ($1,000.00) for each violation or imprisonment for not more than ninety (90) days, or both. Every day that such violations shall continue will be considered a separate offense.

3) Anyone who knowingly makes any false statements in any application, record, plat , or plan required by this ordinance shall upon conviction be punished by a fine of not more than one thousand dollars ($1,000.00) for each violation or imprisonment for not more than thirty (30) days, or both

Specific penalties will vary between communities, and should reflect realistically enforceable penalties given the political realities of a jurisdiction.

E) In addition to any other sanctions listed in this ordinance, a person who fails to comply with the provisions of this buffer ordinance shall be liable to the agency in a civil action for damages in an amount equal to twice the cost of restoring the buffer. Damages that are recovered in accordance with this action shall be used for the restoration of buffer systems or for the administration of programs for the protection and restoration of water quality, streams, wetlands, and floodplains.

Section IX Waivers/Variances

A) This ordinance shall apply to all proposed development except for that development which prior to the effective date of this ordinance:

1) Is covered by a valid, unexpired plat in accordance with development regulations

2) Is covered by a current, executed public works agreement

3) Is covered by a valid, unexpired building permit

4) Has been accepted to apply for a building permit

5) Has been granted a waiver in accordance with current development regulations.

B) The director of the agency may grant a variance for the following:

1) Those projects or activities where it can be demonstrated that strict compliance with the ordinance would result in practical difficulty or financial hardship

2) Those projects or activities serving a public need where no feasible alternative is available.

3) The repair and maintenance of public improvements where avoidance and minimization of adverse impacts to nontidal wetlands and associated aquatic ecosystems have been addressed

4) For those developments which have had buffers applied in conformance with previously issued requirements.

C) Waivers for development may also be granted in two additional forms, if deemed appropriate by the director:

1) The buffer width made be relaxed and the buffer permitted to become narrower at some points as long as the average width of the buffer meets the minimum requirement. This averaging of the buffer may be used to allow for the presence of an existing structure or to recover a lost lot, as long as the streamside zone (Zone I) is not disturbed by the narrowing, and no new structures are built within the one hundred (100) year floodplain.

2) (*Planning Agency*) may offer credit for additional density elsewhere on the site in compensation for the loss of developable land due to the requirements of this ordinance. This compensation may increase the total number of dwelling units on the site up to the amount permitted under the base zoning.

D) The applicant shall submit a written request for a variance to the director of the agency. The application shall include specific reasons justifying the variance and any other information necessary to evaluate the proposed variance request. The agency may require an alternatives analysis that clearly demonstrates that no other feasible alternatives exist and that minimal impact will occur as a result of the project or development.

F) In granting a request for a variance, the director of the agency may require site design, landscape planting, fencing, the placement of signs, and the establishment

of water quality best management practices in order to reduce adverse impacts on water quality, streams, wetlands, and floodplains.

Section X. Conflict With Other Regulations

Where the standards and management requirements of this buffer ordinance are in conflict with other laws, regulations, and policies regarding streams, steep slopes, erodible soils, wetlands, floodplains, timber harvesting, land disturbance activities or other environmental protective measures, the more restrictive shall apply.

References

Heraty, M. 1993. Riparian buffer programs: a guide to developing and implementing a riparian buffer program as an urban best management practice. Metropolitan Washington Council of Governments. US EPA Office of Wetlands, Oceans and Watersheds. Washington, DC.

Schueler, T. 1995. Site planning for urban stream protection. Metropolitan Washington Council of Governments. US EPA Office of Wetlands, Oceans and Watersheds. Washington, DC.

Welsch, D. 1991. Riparian forest buffers. US Department of Agriculture, Forest Service. Forest Resources Management. FS Pub. No. NA-PR-07-91. Radnor, PA.

TRANSFER OF DEVELOPMENT RIGHTS ORDINANCE

Sarasota County, FL

Department of Planning

(941) 951 - 5593

TRANSFER OF DEVELOPMENT RIGHTS

SARASOTA, FLA.

ORDINANCE NO. 82-61

An ordinance of the county of Sarasota, Florida, amending Sarasota County Ordinance No. 75-38, relating to transfer of development rights; providing findings; providing for establishment of sending and receiving zones; providing circumstances under which development rights may be issued and transferred; providing for issuance of transferable development rights; providing for disqualifying land; providing for change of zoning upon transfer of development rights; providing for imposition of a development limitation on property transferring development rights; providing the procedures for approval of transfer of development rights; providing for initiation of the issuance of transferable development rights by the county; providing for the issuance of a transfer permit; providing for the exercise of rights granted by transfer permits; providing definitions; providing for the RSZ, residential sending zone and the RRZ, residential receiving zone; providing for permitted uses and special exceptions; providing for maximum residential density and other requirements; providing for severability; providing an effective date.

Be it ordained by the Board of County Commissioners of Sarasota County, Florida:

Section 1: *Findings*. The Board of County Commissioners hereby makes the following findings:

7. Zoning as applied to land permits certain right to develop the land for residential and other purposes.
8. Such development rights are identifiable, valuable, and severable from the parcel where initially permitted.
9. It is desirable planning practice to permit the transfer of development rights from certain locations in the County to other locations which can accommodate growth without increasing the overall amount of permitted development in the County.
10. Issuance of development rights for a particular parcel of land and permitting their transfer to other more suitable land can serve to prevent an unconstitutional taking of property rights without just compensation.
11. In the process of permitting the transfer of development rights from one parcel to another, the public health, safety, and general welfare may be furthered by providing for the prevention of urban sprawl, and the preservation of open space, important agricultural lands, and environmentally sensitive areas, and other purposes which serve to implement the Comprehensive Plan.

Section 2. *Amendment of Ordinance 75-38.* Sarasota County Ordinance No. 75-38 is hereby amended as follows:

In Subsection 6.5, after ARTR, Residential, Tourist Resort@ add the following:

RSZ Residential Sending Zone
RRZ Residential Receiving Zone

In Subsection 6.6.a, after ARTR, Residential, Tourist, Resort@ add the following:

RSZ Residential Sending Zone
RRZ Residential Receiving Zone

In Section 7, add Subsection 27 to read as follows:

27. Transfer of Development Rights. Transfer of development rights is intended as one method of implementing the Sarasota County Comprehensive Plan, permitting the transfer of development rights from one location to another where the associated development can be more appropriately accommodated. The transferring, or sending, location is designated as an RSZ Residential Sending Zone. The receiving location is designated as an RRZ Residential Receiving Zone. At the same time that the development rights are transferred from property, a Development Limitation is placed on the transferring property to control the nature and extent of its subsequent use and development, and the transferring property will normally be rezoned to reflect the absence of the rights transferred.

1. *Establishment of Sending Zones.* The RSZ district is herewith concurrently established as an overlay sending zone for the transfer of development rights. The RSZ district when applied designates land from which development rights may be transferred upon issuance of a Transfer Permit as provided below; provided, however, the RSZ district shall not be applied unless such zoning is consistent with and serves to implement the Comprehensive Plan and the land involved constitutes:

    1. A platted subdivision which due to the size of the lots, the lack of paved streets or drainage, or other deficiencies fails substantially to conform to the requirements of the Sarasota County Land Development Regulations, Ordinance No. 81-12, in force at the time such zoning is to be applied;
    2. An environmentally sensitive area; or
    3. An area which should be retained in agricultural open space, or other conservation uses.

2. *Establishment of Receiving Zones*. The RRZ district is herewith concurrently established as an overlay receiving zone for the transfer of development rights. Where the RRZ district is applied, land may be used as permitted by the underlying

zoning and in addition may be used for single family, two family, townhouse, cluster housing, or multiple family dwellings at a density which combines that permitted by the underlying zoning and that allowed by any development rights transferable to the land in the RRZ district. The RRZ district shall not be applied where such zoning would be inconsistent with the Comprehensive Plan. Further, it is not intended that by designating land in the RRZ district that rezoning to higher density is appropriate for the land generally or its immediate environs.

3. *Circumstances Under Which Transfer of Development Rights May Be Allowed.* After land has been designated under the RSZ district, the Board of County Commissioners may issue transferable development rights for such land and authorize their transfer in accordance with this section where the Board finds that issuance and transfer of the development rights will serve to implement the Comprehensive Plan. Any development rights issued pursuant to this section shall not be used on the property from which they derive, but may be used on any land designated under the RRZ district consistent with the Comprehensive Plan.

1. *Issuance of Transferable Development Rights*. Transferable development rights shall be issued in dwelling units based upon the amount of dwelling units permitted under the current zoning on the property, taking into consideration any pre-existing plats. A suitable numbering system shall be followed by the County to identify particular development rights issued pursuant to this section.
2. *Disqualifying Land*. In the computation of any transferable development rights under this section, no transferable development rights shall be computed for any land in a right-of-way or easement which precludes its occupation by dwellings or where, by operation of private restrictions or state or federal law, development of the land is prohibited.

3. *Change of Zoning.* Upon issuance of development rights in accordance with this section, the zoning on the land from which they derive shall be changed to reflect the absence of the rights to be transferred unless the zoning has already been so changed.

4. *Development Limitation*. Prior to exercise of the transferable development rights issued pursuant to this section, the property owner shall grant a conservation easement to Sarasota County pursuant to Section 704.06, Florida Statutes. Such easement shall limit use of the transferring property to agricultural or open space uses and shall prohibit, except as reasonably incidental to agricultural use, the activities and uses cited in paragraphs (a)-(g) of section 704.06(1), Florida Statutes. The easement may provide, however, upon Board of County Commissioners approval, for existing uses to continue and for limited development of new uses based upon any residual development rights remaining

after the primary development rights have been transferred evidence of title satisfactory to the County Attorney shall also be provided. Upon the establishment of conservation easements pursuant to this section, the County shall not authorize their release.

4. *Initiation by Property Owner - Approval Procedure.*

1. *Application.* A property owner desiring to obtain permission to transfer development rights from particular property which has been zoned RSZ shall apply for issuance of a Transfer Permit. Such application shall be filed with the Planning Director on a form requesting information as the Director may reasonably require and approved by the Board of County Commissioners, which shall include the following:

Name, address and telephone number of applicant and the applicant=s agent, if any.

Legal description of the property.

Map drawn to scale of not less than 1 inch equals 400 feet showing existing land use on the property and any existing streets, structures, water courses and easements within or adjacent to the property. This map shall include a North directional arrow and shall also show the gross acreage of the property.

Statement identifying the existing zoning on the property.

The proposed grant of easement to Sarasota County creating the Development Limitation for the property, and evidence of title.

Such fee as the Board of County Commissioners may by resolution establish.

Agency Review. The Planning Director shall circulate any application for review by appropriate County agencies, and upon completion of such review shall forward the application to the Planning Commission for review.

Planning Commission Review. The Planning Commission shall review the application, the comments of County agencies, and, after notice and hearings required by Section 20.2 and 20.3 for special Exceptions, shall make findings of fact and recommend the application to the Board of County Commissioners for approval, approval with modifications or conditions, or denial.

Board of County Commissioners Action. The Board of County Commissioners shall review the application and the findings and recommendation of the Planning Commission, and after notice and hearing as required by Section 20.2 and 20.3, shall approve,

approve with modifications or conditions, or deny the application for a Transfer Permit. Such approval shall be conditioned upon delivery to the County of an executed grant of easement creating a Development Limitation pursuant to paragraph c(4) above, as approved in the application or as specified by the Board, and recording copies of same together with a copy of the Transfer Permit in the deed records for Sarasota County, and may include other reasonable conditions including, but not limited to, rezoning related to the transfer and vacation or change to existing plats.

Initiation by the County. In addition to the foregoing procedures for initiation of a transfer of development rights by a property owner, the Board of County Commissioners on its own motion may issue transferable development rights to a given parcel of property zoned RSZ. Such rights shall only be issued where the Board finds, after review by the Planning Commission in accordance with Paragraph d(3) above and notice and hearing as required by Sections 20.2 and 20.3, that issuance and transfer of the development rights will serve to implement the Comprehensive Plan.

Exercise of Rights Granted by Transfer Permit.

(1) *Who May Exercise Such Rights.* Upon issuance of a Transfer Permit by the Board of County Commissioners, the Clerk to the Board shall register the identifying numbers of such rights together with the name and address of the person to whom they are issued. Such rights may be subsequently exercised by the registrant or they may be assigned. In the event of assignment, the name and address of the assignee must be registered with the clerk to the Board identifying the rights assigned prior to their exercise by assignee. All assignments shall also be recorded in the deed records for the property for which the Transfer Permit was issued.

(2) *Application for Building Permits.* Upon application for a building permit in an RRZ district where the applicant seeks to utilize development rights authorized by a Transfer Permit, the applicant shall also submit a copy of the Transfer Permit, evidence of compliance with the conditions of the Permit=s issuance, a copy of any assignment of development rights being relied upon in the application, and a certification by the Clerk to the Board that the applicant is the current registrant for such rights as shown by the Clerk=s records. Upon such submission, the applicant shall be authorized to utilize the development rights transferred in addition to rights allowed under existing zoning on the receiving parcel, subject to the requirements of the RRZ district and the underlying zoning.

(3) *Extinguishment of Rights.* Utilization of particular development rights transferred shall extinguish such rights.

(4) In Section 28, add Subsections 135A and 135B as follows:

135A. *Transfer of Development Rights*. Transfer of development rights is a means of transferring residential density authorized pursuant to this ordinance form one parcel in an RSZ Residential Sending Zone district to another parcel in the RRZ Residential Receiving Zone district. (See also Section 7.27, Transfer of Development Rights.)

135B. *Transfer Permit.* Transfer Permit means a permit issued by the Board of County Commissioners authorizing the transfer of rights to develop a specified number of units from one parcel in an RSZ Residential Sending Zone district to another parcel in the RRZ Residential Receiving Zone district.

(5) In the Official Schedule of District Regulations make the following amendments:

1. Amend sheet S-i adding in the three columns on the line after A›RTR=, Residential, Tourist Resort@ the following:

ARSZ@	Residential Sending Zone	S-60-f
ARRZ@	Residential Receiving Zone	S-60-g

2. Add new pages beginning with S-60-f as follows:

ARSZ@ B RESIDENTIAL SENDING ZONE
(See also Section 7.27, Transfer of Development Rights.)

INTENT:

The RSZ Residential Sending Zone is established to designate areas for the transfer of development rights to other locations in the county. It is further the intent of these regulations that the RSZ district is to operate as an overlay zone in conjunction with the underlying zoning on the land where the RSZ district is applied. It is intended to utilize this district to implement the Comprehensive Plan within locations which meet the requirements of subsection 7.27.a of the regulations for the application of this district.

ii. PERMITTED USES, SPECIAL EXCEPTIONS, AND OTHER REQUIREMENTS:
Uses permitted by right and by special exception and other requirements in this district shall be as provided by the underlying zoning where the RSZ district is applied.

12. Add new pages beginning with S-60-g as follows:

ARRZ@ B RESIDENTIAL RECEIVING ZONE
(See also Section 7.27, Transfer of Development Rights.)

INTENT:

The RRZ Residential Receiving Zone is established to provide areas for the receipt of development rights transferred from other locations in the county. It is further the intent of these regulations that the RRZ district is to operate as an overlay zone in conjunction with the underlying zoning on the land where the RRZ district is applied. It is generally intended to utilize this district to implement the Comprehensive Plan within locations which can reasonable accommodate the increased density associated with this district.

ii. PERMITTED USES AND EXCEPTIONS

In addition to the permitted uses and special exceptions allowed by the underlying zoning where the RRZ district is applied the following are allowed as permitted uses with the utilization of development rights transferred in accordance with Section 7.27, Transfer of Development Rights.

Single family dwellings.
Two family dwellings.
Multiple family dwellings.
Townhouses (see Section 7.27 and Section 28.131) or cluster housing (see Section 7.26 and Section 28.25).

The foregoing uses in addition to being permitted in the RRZ district shall also be deemed to be permitted uses in the underlying district where the RRZ district is applied provided that development rights are utilized as provided above.

For multiple family dwellings, townhouses, and cluster housing developments, site plan approval is required (See Section 15.5).

iii. MAXIMUM RESIDENTIAL DENSITY

The residential density of permitted uses shall not exceed one hundred and twenty-five percent (125%) of the maximum residential density of the underlying zoning nor shall it exceed under any circumstances the applicable density limitations set forth in the Comprehensive Plan. A special exception shall be required to exceed the limit of
one hundred and twenty-five percent (125%) provided that in no case shall the residential density exceed eighteen (18) units per acre.

Section 3. *Severability*. If any provision of this ordinance is for any reason finally held invalid or unconstitutional by any court of competent jurisdiction, such provision shall be deemed a separate, distinct, and independent provision and such holding shall not affect the validity of the remaining provisions.

Section 4. *Effective Date*. This ordinance shall take effect immediately upon receipt of official acknowledgment from the office of the Secretary of State of Florida that his ordinance has been filed with said office

Appendix I

Correspondence

BUREAU OF FISHERIES

Delano R. Graff, Director
(814) 359-5154
FAX: (814) 359-5153

DIVISION OF FISHERIES MANAGEMENT

Richard A. Snyder, Chief
(814) 359-5110
FAX: (814) 359-5153

IN REPLY REFER TO
SIR# 6542

COMMONWEALTH OF PENNSYLVANIA
PENNSYLVANIA FISH & BOAT COMMISSION
450 Robinson Lane
Bellefonte, PA 16823-9620

May 14, 2001

SKELLY AND LOY, INC.
Matthew Sipe
240 Scott Avenue, Suite 1
Morgantown, PA 26508

Dear Mr. Sipe:

RE: Species Impact Review (SIR) - Rare, Candidate, Threatened and Endangered Species
Cross Creek Watershed Assessment, Restoration and Protection Plan
Washington County, Pennsylvania

I have examined the map accompanying your recent correspondence which shows the location of the proposed above referenced project.

Presently, none of the fishes, amphibians or reptiles we list as endangered or threatened are known to occur at or in the immediate vicinity of this study area.

To allow faster processing of Species Impact Reviews (SIRs) in the future, we are requesting that the attached form be completed and returned to this office together with other relevant project information. Please make copies of the attached form and use with all future project reviews. If you have received, and in fact are using the new form, disregard the above request. Please note that the PFBC conducts Species Impact Reviews **only for reptiles, amphibians, fishes, and aquatic invertebrates**. Reviews concerning other natural resources must be submitted to other appropriate agencies. In any future correspondence with us regarding this specific project, please refer to the SIR number above. Thank you in advance for your cooperation.

Sincerely,

for Andrew L. Shiels, Leader
Nongame and Endangered Species Unit

kjg

Encl. (1)

Pennsylvania Natural Diversity Inventory

Scientific information and expertise for the conservation of Pennsylvania's native biological diversity

June 5, 2001

fax 717-772-0271
717-772-0258

RECEIVED
JUN 11 2001
BY: MS

Bureau of Forestry

Matthew Sipe
Skelly & Loy, Inc.
240 Scott Avenue, Suite 1
Morgantown, WV 26508

Re: Pennsylvania Natural Diversity Inventory Review of Cross Creek Watershed Assessment Project, in Multiple Twps., Washington County, PA. **PER NO:11384**

Dear Mr. Sipe:

In response to your request on May 2,2001, to review the above mentioned project, we have reviewed the area using the Pennsylvania Natural Diversity Inventory (PNDI) information system. PNDI records indicate no occurrences of species of special concern are known to exist within the project area, therefore we do not anticipate any impact on endangered, threatened, or rare species at this location. PNDI attempts to be a complete information resource on species of special concern within the Commonwealth. However, it may not contain all location information for species within the jurisdiction of other agencies. Please contact the Fish and Boat Commission, Game Commission, and US Fish and Wildlife Service for information on species within their purview.

PNDI is a site specific information system that describes significant natural resources of Pennsylvania. This system includes data descriptive of plant and animal species of special concern, exemplary natural communities and unique geological features. PNDI is a cooperative project of the Department of Conservation and Natural Resources, The Nature Conservancy and the Western Pennsylvania Conservancy. This response represents the most up-to-date summary of the PNDI data files and is good for one year. An absence of recorded information does not necessarily imply actual conditions on-site. A field survey of any site may reveal previously unreported populations.

Feel free to phone our office if you have questions concerning this response or the PNDI system, and please refer to the P.E.R. Reference Number at the top of the letter in future correspondence concerning this project.

Sincerely,

Jeanne Harris (DH)

Jeanne Harris
Environmental Review Specialist

Western Pennsylvania Conservancy
209 Fourth Ave.
Pittsburgh, PA 15222
(412)288-2777
www.paconserve.org

Pennsylvania Dept. of Conservation and Natural Resources
Bureau of Forestry
P. O. Box 8552
Harrisburg, PA 17105-8552
(717)787-3444
www.dcnr.state.pa.us

The Nature Conservancy
208 Airport Drive
Middletown, PA 17057
(717)948-3962
www.tnc.org

COMMONWEALTH OF PENNSYLVANIA
PENNSYLVANIA GAME COMMISSION
2001 ELMERTON AVENUE, HARRISBURG, PA 17110-9797

August 10, 2001

Mr. Matthew Sipe
Skelly and Loy, Inc.
240 Scott Avenue
Suite 1
Morgantown, WV 26508

In re: Cross Creek Watershed
Assessment, Restoration and
Protection Plan Project
Washington County, PA

Dear Mr. Sipe:

This is in response to your letter requesting information concerning endangered and threatened species of birds and mammals as related to the above project.

We have completed an office review of the proposed project and determined that except for occasional transient individuals, this project should not affect any endangered or threatened species of birds and mammals recognized by the Pennsylvania Game Commission.

This response is related only to endangered species, it does not address other concerns of the Game Commission. If, in the normal review process, it is determined that the project may impact critical or unique habitats such as wetlands, wintering areas, or nesting cover, etc., you may be requested to conduct additional studies.

If you have any questions, please contact me directly at (717) 783-1728.

Very truly yours,

Gary R. Camus

Gary R. Camus
Game Land Officer Manager
Section Oil/Gas and Mineral Development
Bureau of Land Management

cc: File
GRC

Cross Creek Watershed
35 Perry Rd.
Burgettstown, PA. 15021
724-356-2232

April 9, 2003

Dear Rick,

In reviewing the section of Management Unit 1 on page5-51, the last paragraph, needs to drop the reference to agriculture fertilizers as a possible source of manganese. I don't know where this above threshold level comes from except possibly the soil because I called Agway Crop Services and they have not sold any fertilizer with manganese in many years. Prior to 1994 Agway had an additive 50 lb. bag with micronutrients the could be added to custom blended fertilizers. It contained 6% manganese and the bag would be added to 1-2 tons of fertilizer. In the 3-4 years they stocked the product, prior to 1994 , the sales were so low that they discontinued stocking it. Agway is the largest provider of pre mixed both bagged and bulk, and custom mixed fertilizer for the farm community.

It may make sense to state this manganese possibility comes from rocks and soil period and it may be leached out.

Kindest regards,

Dick Lehman

Appendix J

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