DEC

PUBLICATION

Division of Water
Bureau of Water Quality

Stream Corridor Management

A Basic Reference Manual

New York State Department of Environmental Conservation
Albany, New York 12233

Our State is blessed with thousands of miles of rivers and streams which provide important benefits to every New Yorker. Streams provide much of the water we drink. They enhance our commerce and provide other economic benefits. Aesthetically pleasing streams add to the quality of human experience. Streams may be pleasant to look upon, to walk or rest beside, to contemplate. They may enhance the visual scene wherever they occur—whether in cities or in wilderness. Streams provide a variety of recreational benefits and they may enhance the value of adjoining properties, public or private. A well maintained stream may provide a focal point of pride for a community.

In spite of these values, streams are not always accorded treatment which allows them to function properly. Many have been needlessly polluted, unwisely dammed, or insensitively channelized, thereby reducing their capability to satisfy diverse human needs.

This manual identifies the various approaches, opportunities and techniques which can be employed to restore, protect and enhance streams which flow throughout communities. The manual should be of particular interest to local planning agencies, environmental groups, planning and engineering consultants, sportsmen's organizations, county environmental management councils and local conservation advisory commissions.

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STREAM CORRIDOR MANAGEMENT:

A BASIC REFERENCE MANUAL

New York State
Department of Environmental Conservation
Division of Water
Bureau of Water Quality
Albany, New York

January 1986
(second printing)

Henry G. Williams, Commissioner

PREFACE

Note to Local Officials:

Properly managed streams and lakes, and the corridors through which they flow, can bring a variety of economic, social, and cultural benefits to a community. These waterways may satisfy public water supply needs, provide opportunities for fishing, or be developed in ways which mark the character of a community and result in a favorable and lasting impression on residents and visitors alike. A well-planned greenbelt walkway, a park, or a creatively planned housing, commercial or industrial development properly located along a waterway, are features which help distinguish one community from another.

Unfortunately, opportunities such as these are sometimes not fully recognized. Frequently, a water body and its natural features are neglected. Despite great strides made in the past decade in the control of municipal and industrial wastewater discharges, flood plain management and other water resource programs, there remain many examples in New York State where man's use of the land and various cultural activities result in runoff of pollutants or otherwise infringe upon the natural assets of a stream. Livestock graze on the edge of many streams, destroying fish habitat. Urban runoff fouls waters with pesticides, oil, heavy metals, and organic chemicals. Nutrients from cropland stimulate algal blooms, causing odors in water supplies and reducing the aesthetic quality of recreational waters.

This manual discusses these and other land-use related stream problems and their causes, and it emphasizes ways in which these problems can be prevented or remediated, and identifies opportunities (once the stream is restored) to enhance the use of a stream to meet new community needs.

It will become apparent to the reader of this manual that no single action, no single development or project is usually the cause of the stream problems discussed above. Such problems are the accumulation of off-site impacts from incompatible land use activities which have occurred at many locations in the stream corridor over an extended period of time. It follows then, that no single action is likely to bring about an immediate solution.

Measures can be taken, however, which will eventually bring results. They can best be initiated at the local level by groups of individuals concerned about their community and its environment. The first step is taken when a community recognizes and agrees on the importance and value of a particular stream and has a commitment to do something about stream rehabilitation. This awareness leads eventually to the implementation of one or more of the actions discussed at length in this report including:

- community education programs,
- incentive programs to encourage landowners to implement conservation practices for water quality improvement, (called "best management practices" or "BMPs"),
- protective laws, zoning and land use standards
- mobilization of existing grants-in-aid programs,
- stream easements and acquisitions.

The end result can be a water body that has been restored and perhaps developed. In a rural area this may mean the return of a scenic and productive trout stream; in a village — a park, river walk or commercial shop and a riverside cafe. In an urban area, it can mean waterfront revitalization.

DEC has prepared this manual to encourage the protection, restoration and enhancement of streams and to provide local groups and officials with tools to accomplish this end. We are interested in learning about your stream conservation program initiatives, successes, and shortfalls. By keeping an open line of communication, we will be able to learn more about your program and serve as a conduit for sharing information and experiences for communities throughout the state. Please contact us where we can be of help. Your nearest DEC regional office is listed on the inside of the back cover of this report, or you may contact the New York State Department of Environmental Conservation, Division of Water, Bureau of Water Quality, Room 201, 50 Wolf Road, Albany, New York, 12233.

NEW YORK STATE

ENVIRONMENTAL CONSERVATION DIRECTORY

Throughout this manual, frequent reference is made to agencies which may lend stream corridor management assistance. Addresses and telephone numbers for the agencies, as well as for other organizations which may also assist, can be found in the New York State Conservation Directory. This directory is available upon request from the Bureau of Preserve, Protection and Management, Room 412, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233.

ACKNOWLEDGEMENTS

More than ever, this manual is a synthesis of the work of others. Adequate acknowledgement cannot be made to the many authors and researchers from whose work much of this manual is drawn. Aside from these, there are a number of people who must be singled out individually. I am deeply indebted to Paul Sausville who, after suffering through early drafts, was able to provide me with an overall sense of organization together with important suggestions and unfaltering encouragement, and yes, occasional but necessary prodding to complete the manual in a timely manner. To Daniel Barolo and Daniel Halton, who provided critical comments, and perhaps as important, who afforded me with uninterrupted time in which to prepare the manual, I remain indebted. Also, I would be remiss in not expressing my gratitude to Charles Morrison, Philip Hulbert, Russel Fieldhouse, Thomas Male, Bruce Zeisel, Shari Chrimes, William Clark, Timothy Cooke, Thomas Wahl, Carl Inglestrom, Michael Barylski, Betty Hawkins, Mark Brown, Scott Quinn and James Madigan of the Department of Environmental Conservation; Richard Boos and James Coon of the Department of State; Robert Myers and Patricia Paul of the USDA Soil Conservation Service; Donald Martin and the Monroe County Planning Department, George Schanzenbacher and the Erie County Department of Environment and Planning; Philip Street and the Temporary Commission on Tug Hill; and Paul Robillard of Cornell University who offered valuable suggestions and comments. For any errors or deficiencies that remain, none of the foregoing are responsible for my interpretation or treatment of their many suggestions.

I wish also to thank George Furman who prepared a majority of the figures in the manual and Edward Kenney who prepared the cover. I am also grateful to David Lis and James Fullam who assisted in preparing figures.

I am deeply indebted to Vera Koble for typing the original manuscript. To Susan Reilly who graciously volunteered to transfer the entire manuscript onto the word processor, and who patiently assisted in a major way with subsequent revisions, I am most indebted. A special note of appreciation is extended to Barbara Crier who assisted with revisions and to Jill Hoag who also assisted.

Finally, I wish to thank Robert deVilleneuve and Jake Warnken who assisted with the layout of the manual.

William B. Morton
Department of Environmental Conservation
January 1986

CONTENTS

	Page
CHAPTER 1: INTRODUCTION	1
Need for Manual	1
The Public Benefits of Stream Conservation	1
The Stream Corridor and Beyond	4
Stream Management is Part of Lake Management Too	5
CHAPTER 2: STREAM PROBLEMS	7
Problems Created By Land Use Activities	7
Impaired Fisheries Habitat	7
Impaired Water Supplies	17
Impacts to Recreation	18
Flood Damage	19
Causes of Problems	19
Construction/Development	19
Urbanization	20
Transportation	26
Mining	26
Agriculture	27
Forestry	30
CHAPTER 3: TECHNIQUES FOR ASSESSING LAND USE IMPACTS ON WATER QUANTITY AND QUALITY	31
Estimating Runoff from Urban Areas	31
Methods for Predicting Water Quality Responses to Changes in Land Use	31
Radz Methodology for Predicting Stream Temperature Change in Response to Alternations in Riparian Vegetation	31
The Universal Soil Loss Equation	32
Sediment Yield	32
Vollenweider Analysis	33
CHAPTER 4: STEPS FOR SOLVING THE PROBLEM (A PLANNING AND PROBLEM-SOLVING FRAMEWORK)	36
Step 1: Identify the Planning Area	36
Step 2: Inventory and Analysis of Land Use and Environmental Resources	36
Existing Land Use and Development Trends	36
Natural and Cultural Resource Inventory and Assessment	39
Environmental Constraints Analysis	39
Step 3: Problem and Need Assessment	41
Step 4: Establish the Stream Corridor Management Boundary	43
Step 5: Establish Goals and Objectives	44
Step 6: Analyze Plans, Land Use Controls, and Their Consistency with Goals and Objectives	44
Step 7: Examine Management Options	47
Step 8: Prepare Stream Corridor Management Plan	47
Step 9: Implementation and Feedback	47

Page

CHAPTER 5: STREAM CONSERVATION OPTIONS AND CHOICES FOR LOCAL GOVERNMENT . . . 48
Policy Development . . . 48
Highway Construction and Maintenance . . . 48
Building Inspection and Zoning Enforcement . . . 48
Mobilize Service Organization . . . 49
Implement the State Environmental Quality Review Act (SEQRA) . . . 49
Information and Education . . . 50
Land Acquisition . . . 50
Land Use Controls . . . 52
Zoning . . . 53
Subdivision Regulations . . . 55
Other Regulatory Techniques . . . 56
Floodplain Regulations . . . 59
Single Purpose Ordinances . . . 60
Tax Incentives . . . 60
Governmental Aid Programs . . . 61
Special Improvement Districts . . . 63
Watershed Rules and Regulations . . . 63
New York State's Wild, Scenic, and Recreational Rivers Program . . . 63

CHAPTER 6: BEST MANAGEMENT PRACTICES . . . 65
BMPs for Minimizing Disturbance to Streams . . . 65
Stream Crossing BMPs . . . 68
BMPs for Culvert and Bridge Installation . . . 68
Stream Channelization BMPs . . . 69
BMPs for Dredging and Gravel Removal . . . 71
BMPs for 'Snagging' and Channel Clearing . . . 71
BMPs for Protecting Streambanks and Fish Habitat . . . 74
BMPs for Controlling Stormwater Runoff . . . 78
Diversion Terraces . . . 83
Grassed Waterways . . . 83
Stormwater Detention Basins (Ponds) . . . 83
Parking Lot Storage . . . 84
Rooftop Detention . . . 84
Rooftop Runoff Disposal . . . 85
Cistern Storage . . . 85
Infiltration Pits and Trenches . . . 85
Concrete Grid and Modular Pavement . . . 85
Porous Asphalt . . . 85
Stormwater Conveyance System Storage . . . 85
Fluidic Flow Regulators . . . 85
Treatment of Stormwater . . . 86
BMPs for Pollution and Source Control . . . 86
Fertilizer and Pesticide Application Practices . . . 86
Practices for Pasture Management and the Application of Animal Wastes to Land . . . 87
Chemical Storage and Handling Practices . . . 88
BMPs for Soil Erosion Control . . . 89
Field Tillage Practices (Agriculture) . . . 89
Cropping Practices (Agriculture) . . . 91
Vegetation Practices (Construction) . . . 92
Timber Harvest BMPs . . . 92

Page

CHAPTER 7: IMPLEMENTING A PROGRAM IN YOUR COMMUNITY 94
Organizing to Solve the Problem 94
Local Leadership 94
County Level Participation 94
State Level Involvement 95
Watershed Associations 95
Program Alternatives 96
The "No-Action" Alternative 96
The Single Purpose Alternative 96
Comprehensive Stream Conservation Program 96
Experiences In Stream Conservation 97
The Little Hoosic Greenbelt Project 97
The City of Troy Initiates A Stream Corridor
Management Program on the Wynants Kill 99
The Inspiring San Antonio (Texas) Riverwalk 100
The Tragedy of the Commons 104

Bibliography 105

Glossary 109

Appendix 111

LIST OF FIGURES

		Page
Figure 1	Stream Corridor Management Categories	6
Figure 2.	Pool-to-Riffle Ratio	8
Figure 3	Relationships Between Suspended Sediment Concentrations, Apparent Integrated Water Velocity and Mortality Rates of Rainbow Trout Eggs	15
Figure 4	Effects of Channelization in the Physical Environment and Biota of Streams	16
Figure 5.	Volume of Sediment from Lands of Different Uses	19
Figure 6	Hydrologic Changes Resulting from Urbanization	23
Figure 7	Conceptualized Flow Chart of Adverse Effects of Stream Habitat Damage by Livestock on Trout Populations	28
Figure 8	Sediment Delivery Ratio vs. Size of Drainage Acres	33
Figure 9	Total Phosphorus Loading vs. Mean Depth Relationship Showing Degrees of Eutrophy	34
Figure 10	Base Map	37
Figure 11	Land Use	38
Figure 12	Natural Resource Data	40
Figure 13	Natural Resources Inventory and Environmental Constraints Assessment	42
Figure 14	Floating Stream Corridor Boundary	43
Figure 15	Traditional Zoning Map	53
Figure 16	Overlay Zoning Map	54
Figure 17	Subdivision Configuration	55
Figure 18	Cluster Zoning	57
Figure 19	Transfer of Development Rights	58
Figure 20	Floodplain Management	60
Figure 21	Concentrating Flows in Mid Stream	70
Figure 22	Concentrating Flows on Curved Alignments	70
Figure 23	Conceptualized Cross-sectional Characteristics of a Stream in Degraded, Recovering, and Recovered Phases	78
Figure 24.	Stormwater Management: No Yes	82
Figure 25	Participants in Riverwalk Development	103

LIST OF TABLES

		Page
Table 1.	Public Benefits of Stream Corridor Conservation	2
Table 2.	Temperature Preferences of Trout and Salmon	8
Table 3.	Water Quality Impacts of Nonpoint Pollutants from Different Land Use Activities	9
Table 4.	Effects of Urbanization on Streams	21
Table 5.	Relationship Between Increasing Urbanization and Increases in Mean Annual Flooding	21
Table 6.	Comparison of Pollutional Loads from Hypothetical City: Street Runoff vs. Raw Sanitary Sewage	24
Table 7.	Sources of Urban Runoff	25
Table 8.	Sources and Effects of Agricultural Nonpoint Sources on Water Quality	28
Table 9.	Typical Values of Nutrient Runoff Coefficients	35
Table 10.	Guidelines for Establishing A Floating Stream Corridor Boundary	44
Table 11.	Goals and Objectives	45
Table 12.	Criteria for Determining Environmental Significance	50
Table 13.	Land Acquisition Techniques	52
Table 14.	Agencies and Assistance Offered	61
Table 15.	Best Management Practices and Their Relative Effectiveness for Controlling Nonpoint Sources	66
Table 16.	Guide for Determining Culvert Size for Permanent Stream Crossings	69
Table 17.	Functions of a Buffer Strip	74
Table 18.	Recommended Buffer Widths for Protecting Streams from Timber Harvest Activities	75
Table 19.	Recommended Buffer Widths for Protecting Streams from Construction and Developmental Activities	76
Table 20.	Objectives of Controlling Stormwater Runoff	79
Table 21.	Allowable Watershed Development Rates	80
Table 22.	Stormwater Management Guidelines	81
Table 23.	Storage of Hazardous Substances: Design Considerations and Practices	89
Table 24.	Manuals in New York State's Bulk Storage Program	90
Table 25.	Function of a Watershed Association	95

CHAPTER 1: INTRODUCTION

NEED FOR MANUAL

It is often assumed that water management issues and needs are solely the responsibility of federal and state agencies. This is not always the case. Federal and state stream protection programs, technical assistance, and cost/share incentive programs offer an important, but nevertheless, fragmented approach to the stream management task. Local government, on the other hand, traditionally has had an important role to play in land use planning and decision-making. Local land use decisions, for example, obviously influence patterns of stormwater runoff and the impacts of runoff on the natural and man-made environment. Ultimately, all local land use decisions influence water quality.

If government at all levels is to share the responsibility of conserving and enhancing the quality of streams and related shoreland resources, public administrators must have appropriate guidance as to the availability and use of planning, technical, regulatory, and other tools. The purpose of this manual is to provide public officials and administrators who, either because of past or present urbanization pressures or current land use trends, wish to address stream conservation and management issues and related problems. Developers, planning and engineering consultants, environmental groups, sportsmen's organizations, county environmental management councils, local conservation commissions, landowners, and citizens in general should find this manual useful.

THE PUBLIC BENEFITS OF STREAM CONSERVATION

Streams provide a variety of benefits including: drinking water, process and cooling water for industry, water for agriculture, a means for a community to assimilate its wastes, as well as habitat for fish and wildlife. Streams also offer potential for hydroelectric power generation, and they provide a community "open space" amenity and recreational benefits. As an indication of recreational value, anglers spend nearly 90 million dollars annually on goods and services to fish the streams and rivers of New York State. Undoubtedly, expenditures of this magnitude provide significant economic benefits to many communities in the state (see Table 1).

Aesthetically pleasing waters add to the quality of human experience. Water can be pleasant to look upon, to walk or rest beside, to contemplate. It may enhance the visual scene wherever it appears, in cities and in wilderness. It may provide a variety of active recreational experiences. Because of this, it also may enhance values of adjoining properties, public and private, or it may provide a focal point of interest in which a community can take pride.

> RECREATIONAL DEVELOPMENT OF A STREAM CORRIDOR CAN PROVIDE IMPORTANT BENEFITS TO A COMMUNITY. ONCE USED FOR RECREATION, A STREAM WILL PRODUCE MORE CONSERVATION ATTENTION. NO RECREATION EQUALS LITTLE INTEREST IN STREAM PRESERVATION.

TABLE 1. PUBLIC BENEFITS OF STREAM CORRIDOR CONSERVATION

Recreation

- Fishery
- Parks
- Playgrounds
- Urban walkways
- Picnic groves
- Bikeways
- Nature trails
- Canoeing
- Scenic and aesthetic amenities
- Wildlife habitat

Water Supply

- Domestic supplies
- Industrial supplies
- Groundwater recharge
- Irrigation and other agricultural uses

Waste Removal

- Disposal of treated waste effluent through assimilative capacity

Other Stream Corridor Conservation Benefits

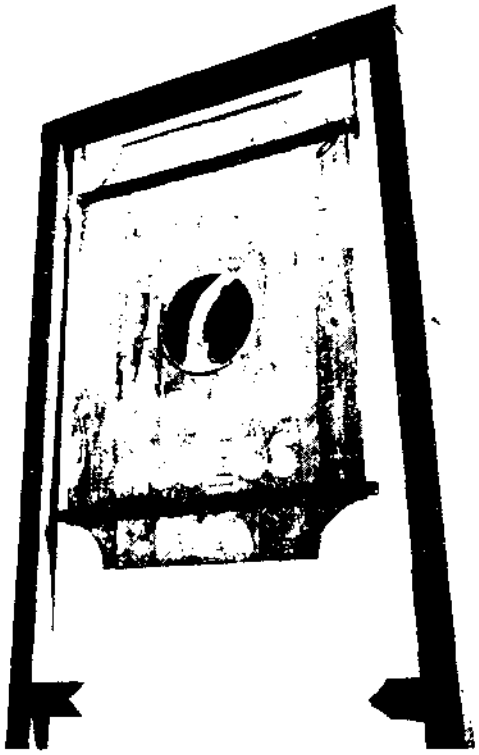
- Flood storage and retention
- Navigation
- Hydropower
- Historic preservation

In spite of these values, streams are not always accorded treatment which allows them to function properly. Many have been needlessly polluted, unwisely dammed, or insensitively channelized, thereby reducing their capability to satisfy diverse human needs. All too frequently development has been permitted to occur too close to streams and rivers only to incur costly flood damage later. In 1978, for example, flood damage in New York State was assessed at 100 million dollars. In June 1972, a major storm killed twenty people and caused over one billion dollars in damages in the Chemung, Allegheny, and Oswego Basins. The areas affected by Hurricane Agnes are among the least populated in the State. Had the storm centered on any other area, these damages undoubtedly would have been much greater.

Clearly, a community can reap economic and social benefits if its streams are properly managed. Conversely, a stream can become an economic and social liability if a community neglects a stream or permits adjacent lands to be improperly used. When incorporated by local officials within a land use planning and regulatory framework, the tools described in this manual will contribute to the provision of the following water resource and environmental benefits:

- protection of the natural environment including water quality, soil conservation, aquatic ecology (fisheries) and terrestrial ecology (wildlife);
- protection of health and safety from flooding and storm damage;
- improved cultural and economic environment through the protection of aesthetic conditions along streams.

Streams can be pleasant to look upon . . . to contemplate. (Photo Courtesy of the Water Pollution Control Federation)



Streams afford a community with recreational and economic benefits. .

With foresight and vision, streams can enhance our urban areas. . .

THE STREAM CORRIDOR AND BEYOND:

> THE STREAM CORRIDOR (STREAM AND ITS IMMEDIATE SHORELAND ENVIRONMENT) IS AN AREA OF CRITICAL ENVIRONMENTAL SIGNIFICANCE WHICH, BECAUSE IT IS AN AREA WHICH INCLUDES THE STREAM AND THE NATURAL AND CULTURAL RESOURCES THAT ARE CLOSELY RELATED TO IT, IS THE MOST IMPORTANT ZONE FOR CONCENTRATING WATERWAY CONSERVATION AND MANAGEMENT EFFORTS.

Stream corridor management places primary emphasis on water quality protection and enhancement through the control of nonpoint sources of pollution, such as erosion and sedimentation, and on protection of natural and cultural resources in the stream corridor. Flood plain management, which places emphasis on the protection of people and structures from flood hazards, also is a part of stream corridor management. With proper management, a stream corridor can serve as a buffer zone to filter the sediment and pollution produced by urbanization and other land use activities such as agriculture or timber harvesting. It can also provide a margin of safety from flood and erosion hazards to adjacent populations.

Flooding is a natural occurrence, but can be costly to society
(Photo courtesy Elmira Star-Gazette, Inc.)

. . . and to individuals when development of floodplains is uncontrolled.
(Photo courtesy Elmira Star-Gazette, Inc.)

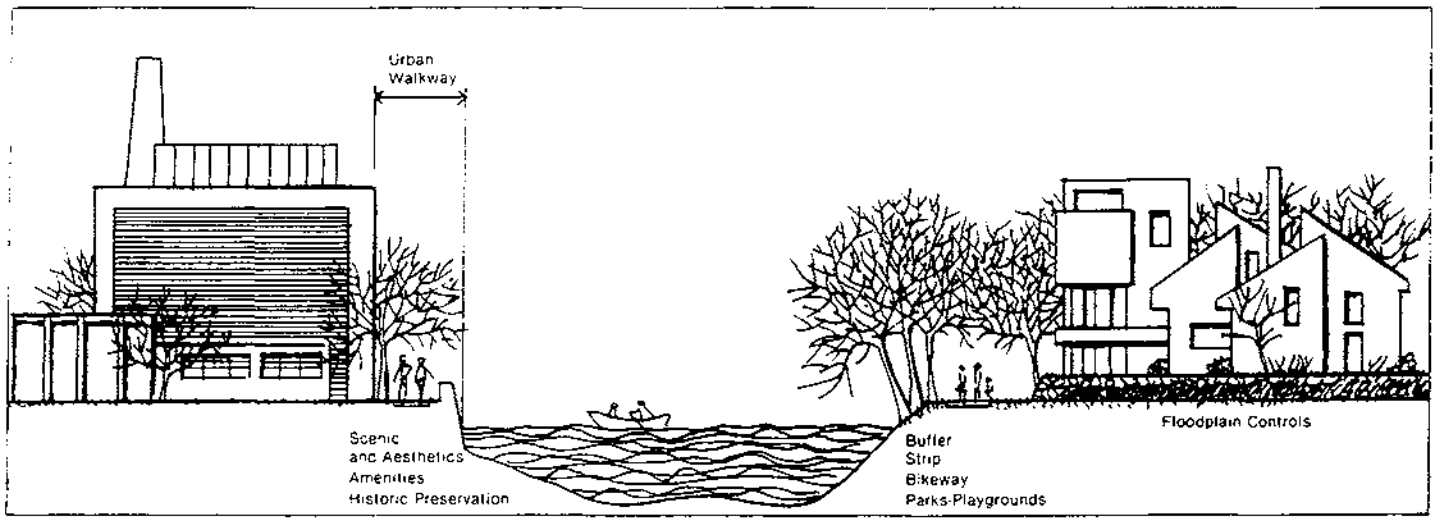
For conservation and management purposes, a stream corridor may be classified according to its relationship to land use as reflected in either of the following three categories.

- **The Urban Stream Corridor** — Stream, river, or waterfront areas characterized by hard surface paving, complex storm drainage system, and land uses related to commerce and industry. The overriding concern of urban stream corridor management is to take advantage of the opportunities that the stream corridor may provide in terms of enhancing the 'livability' of the urban environment. Urban stream corridor management normally would express itself through greenway or park development; or the stream corridor may provide the focal point from which to target urban redevelopment or restoration and historic preservation efforts. As the case examples in Chapter 7 illustrate, creative and imaginative use of the stream corridor can provide significant economic and recreational benefits to the community.
- **The Suburban Stream Corridor** — Areas characterized by a combination of soft ground cover and hard surface paving, storm drainage, and natural drainage, and a wide range of land uses including residential, commercial, and industrial uses. A suburban stream corridor management strategy should capitalize on the opportunities afforded by the establishment of a greenway to serve as a filtering and buffering mechanism for protecting and enhancing water quality. Passive recreation, such as sightseeing, nature photography, and observing wildlife and active recreation, such as hiking and fishing, are some of the benefits that can be provided by the suburban stream corridor. Consideration also should be given to preserving historical sites and cultural values along the suburban stream corridor.
- **The Natural Stream Corridor** — Cultivated land and natural vegetation with little hard paving typify this category. Farming and recreation are the prevalent uses with the exception of resource-oriented industries such as mining or logging. The primary emphasis for management of the natural stream corridor should be for the preservation of open space values and protection of water quality from agricultural runoff. The buffering or filtering capacity of the natural stream corridor also should be maintained to protect water quality from mining and logging activities (See Figure 1).

While the primary focus of this manual is on the stream corridor as the planning area for stream and waterway conservation and management, communities intent on protecting and enhancing their water resources may have to look beyond the stream corridor and consider the entire watershed from which the stream originates. Even though a properly managed stream corridor can afford a protective buffer zone for negating watershed-wide land use activities, frequently such land use activities can exceed the capability of the stream corridor to offer protection to the stream and adjacent land resources. The tools and techniques presented in this manual are applicable beyond the stream corridor.

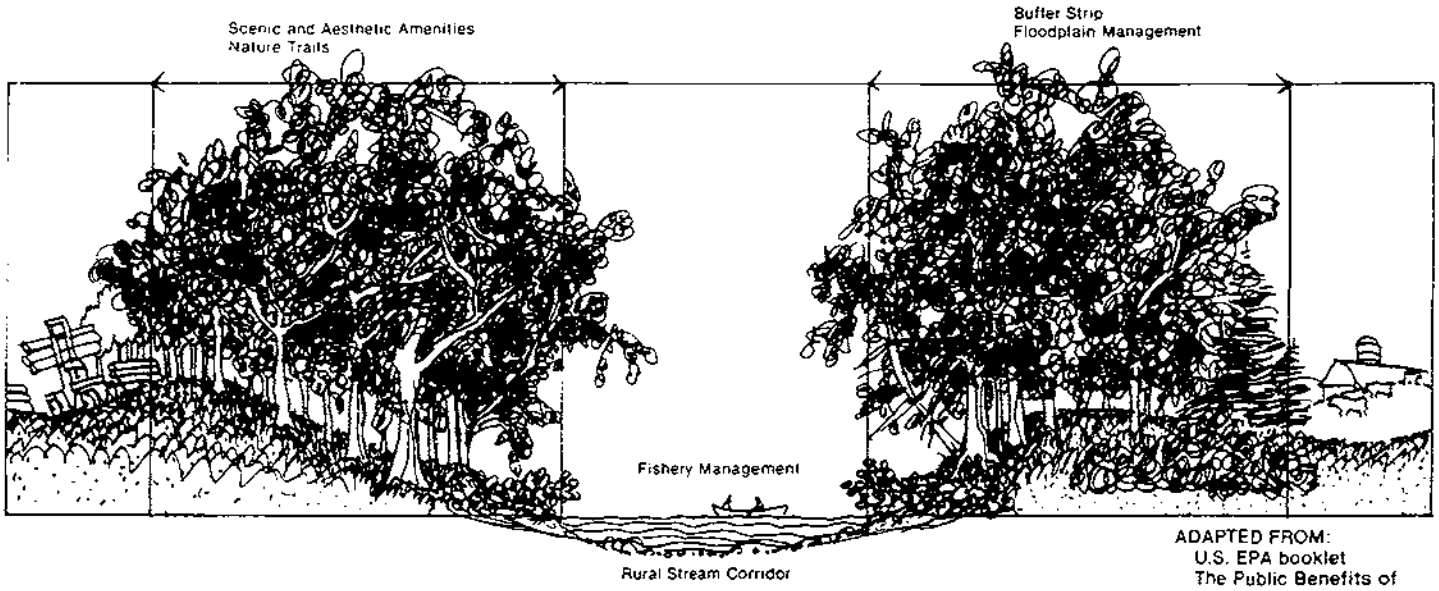
STREAM MANAGEMENT IS PART OF LAKE MANAGEMENT TOO:

The quality of water in a lake is, in large part, a reflection of the health of the watershed that surrounds it. Thus, protection of water quality in streams is absolutely essential to lake management. Control of sediment and nutrients associated with stormwater runoff in a watershed is of critical importance for protecting the water quality of a lake. The land management tools and practices contained in this manual should be of particular interest to communities seeking guidance for protecting the health of a lake.



Urban Stream Corridor

Suburban Stream Corridor



Rural Stream Corridor

ADAPTED FROM:
U.S. EPA booklet
The Public Benefits of
Cleaned Water: Emerging
Greenway Opportunities

CHAPTER 2. STREAM PROBLEMS

> A STREAM CANNOT BE MANAGED AS A RESOURCE ISOLATED FROM THE LAND AND THE USES OF LAND THROUGH WHICH IT FLOWS.

Before a local agency can take positive steps to manage and enhance a stream and the corridor through which it flows, there first must be a general recognition and understanding of the nature of the stream management problem. The purpose of this chapter is to identify stream problems and to discuss the underlying causes of these problems.

PROBLEMS CREATED BY LAND USE ACTIVITIES

The principal stream management problems found in many communities throughout New York State include impaired fisheries habitat, loss of recreational opportunity, impaired water supplies, and damage to property and natural resources brought about by flooding. Following is a discussion of each problem area.

Impaired Fisheries Habitat

Habitat Requirements

Fish species such as trout and salmon have a number of habitat requirements which include food, shelter, and spawning and nursery habitat, in addition to chemical water quality requirements of dissolved oxygen, pH, and total alkalinity. Stream temperatures, particularly during warm periods in summer, also are of critical importance to fish populations. Under natural conditions, streams normally provide the required habitat, in part, through the proper combination of "pools" and "riffles". Pools, or the deeper slack water segments of a stream, are critical to fish as they provide the cover or shelter and resting places required of fish. Not all pools, however, are equally attractive to fish. A pool in narrow, deep gorges is one scoured out during heavy rains. It generally has a bottom of smooth bedrock or hardpan and the forage is scant. A good fish pool generally is deeper and wider than the average width and depth of the stream, the current within it is appreciably slower than that upstream or downstream from it, and hiding places for the fish are more extensive in it than adjacent parts of the stream. An open pool devoid of undercut banks, sunken logs or log jams, boulders, water plants, or whatever form of protection for fish is afforded in the pools, is not attractive to fish even though the water may be fairly deep.

The segment of a stream containing riffles (or rapids) is the food-producing and spawning area of the stream. Riffle areas normally consist of rocks and "rubble" separated by spaces which are "flushed out" or otherwise kept free of silt, sediment, and other debris by the scouring action of flowing water. It is in these spaces, between and underneath stones and rubble, that habitat for aquatic organisms is secured. Insect larvae, for example stonefly and mayfly larvae upon which trout are dependent, steadfastly cling to the under surfaces of the rocks. Through intricately constructed webs, many insects obtain their nourishment by filtering plankton from the stream as it flows between the spaces.

Trout and salmon also utilize the riffle area of a stream as spawning and nursery habitat. Eggs are deposited and fertilized in the spaces between the gravel in spawning "redds" where they incubate and eventually hatch. The young fish, referred to as "fry", gradually emerge from the gravel as their yolk sac, which nourishes them during their first few weeks, becomes absorbed and as they begin to feed on their own. Small "pockets" of slack water in the stream's riff serve as nursery habitat for the emerging fish, often referred to as "fingerlings", or in the case of salmon, "par".

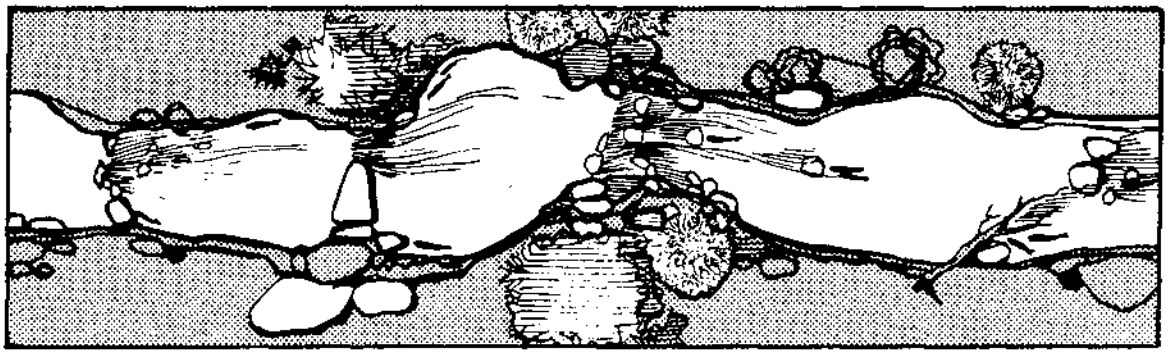


Figure 2. Pool-to- Riffle Ratio. In general, a rather close succession of pools and riffles, for example a 50 percent-to-50 percent ratio, provides ideal fisheries habitat.

In addition to the above habitat features, stream temperature, particularly during warm periods in summer, is of critical importance to fish populations. In general, for a trout fishery to be successful, stream temperatures should not exceed the mid-60's during summer periods. Table 2 shows the temperature preferences of several species of trout and salmon found in New York State.

TABLE 2

TEMPERATURE PREFERENCES OF TROUT AND SALMON (IN DEGREES FAHRENHEIT)

Species	Preferred Comfort Range	Preferred Breeding Temperature
Landlocked Salmon	52 - 65	58 - 61
Rainbow Trout	55 - 67	59 - 62
Brown Trout	54 - 68	59 - 63
Brook Trout	50 - 65	58 - 61

Impacts to Habitat

ELIMINATION OF NATURAL FEATURES WITHIN A STREAM SYSTEM CAN DECREASE ITS DIVERSITY AND VALUE. IT CAN RESULT IN THE LOSS OF IMPORTANT SPAWNING AND NURSERY AREAS, INTERFERE WITH NATURAL FOOD SUPPLIES, AND, ULTIMATELY, REDUCE PLANT, FISH, AND OTHER ANIMAL LIFE IN A STREAM AND CAUSE PROPERTY DAMAGE DOWNSTREAM.

Table 3 identifies a variety of impacts to fisheries habitat from selected nonpoint source contaminants and from physical disturbances to streams brought about by in-stream and watershed (off-stream) hydrologic modifications. Impacts of greatest concern, owing to their frequency of occurrence, include loss of cover (pools), loss of food producing substrate and spawning habitat (riffles), and elevated stream temperatures during summer months which has a significant influence on the species composition of a fishery.

TABLE 3

WATER QUALITY IMPACTS OF NONPOINT SOURCE POLLUTANTS FROM DIFFERENT LAND USE ACTIVITIES

Pollutant	*Nonpoint Source(s)*	*Water Quality and Associated Impacts*
		Fisheries Impacts
Sediment	Construction, Urban Runoff, Mining, Agriculture, Logging Operations, Stream Channelization	• Decrease in transmission of light through water. — Decrease in primary productivity (aquatic plants and phytoplankton) upon which other species feed, causing decrease in food supply. — Obscures sources of food, habitat,hiding places, nesting sites; also interferes with mating activities that rely on sight and delays reproductive timing. • Direct effects on respiration and digestion of aquatic species (e.g., gill abrasion). • Decrease in vitality of aquatic life, decrease in survival rates of fish eggs and therefore in size of fish population, affects species composition. • Increase in temperature of surface layer of water — increases stratification and reduced oxygen-mixing with lower layers, therefore decreasing oxygen supply for supporting aquatic life. • Decrease spawning habitat and cover (e.g., filling of pools and riffles). • Increase stress on aquatic organisms making them more susceptible to disease, reduce growth rates of fish.
		Water Supply Impacts
		• Impede water treatment plant operation; increase damage to pumps and other equipment.

TABLE 3

WATER QUALITY IMPACTS OF NONPOINT SOURCE POLLUTANTS FROM DIFFERENT LAND USE ACTIVITIES (Continued)

Pollutant	*Nonpoint Source(s)*	*Water Quality and Associated Impacts*
		Water Supply Impacts (Con't.)
Sediment		• Increase treatment costs.
		• Reduce volume of storage reservoirs.
		• Transport toxic substances (including pesticides, herbicides, metals through chemical absorption to soil surface.
		• Provide a medium for supporting growth of bacteria and other disease organisms.
		• Transport nutrients which stimulate nuisance algae.
		Recreational Impacts
		• Decrease in value for recreational and commercial activities:
		— Reduced water clarity.
		— Reduced aesthetic value.
		— Reduced sport and commercial fish populations.
		— Decreased boating and swimming activities.
		— Interference with navigation.
		— Loss of tourism.
		Flooding
		• Elevate streambed and reduce the drainage capacity of streams thereby increasing flooding risks.
		• Deposition results in property damage.

TABLE 3

WATER QUALITY IMPACTS OF NONPOINT SOURCE POLLUTANTS FROM DIFFERENT LAND USE ACTIVITIES (Continued)

Pollutant	*Nonpoint Source(s)*	*Water Quality and Associated Impacts*
		Fisheries Impacts
Thermal Energy	Construction, Urban Development, Mining, Agriculture, Logging Operations, Stream Channelization	• Reduce vigor and growth of fish; reduce resistance to disease. • Reduce dissolved oxygen concentration as stream temperature increases. • Change a cold water sport fishery to a less desirable nonsport fishery. • Increase stress to a fishery thereby reducing resistance to disease. • Increase in temperature in combination with proper nutrients enhances production of oxygen depleting algae and other nuisance aquatic vegetation.
		Water Supply Impacts
		• Increase in water temperature. — Accelerates corrosive action in pumps and equipment. — Promotes biological activities which produces odors and objectionable taste. — Creates more favorable conditions for pathogenic organisms including bacteria, viruses and parasites.
		Recreational and Economic Impacts
		• In combination with proper nutrients, stimulates nuisance algal blooms and other aquatic vegetation which: — Reduces water clarity. — Reduces aesthetic value. — Reduces sport and commercial fish populations.

TABLE 3

WATER QUALITY IMPACTS OF NONPOINT SOURCE POLLUTANTS FROM DIFFERENT LAND USE ACTIVITIES (Continued)

Pollutant	*Nonpoint Source(s)*	*Water Quality and Associated Impacts*
		Recreational and Economic Impacts (Con't.)
Thermal Energy		— Decreases boating and swimming activities. — Reduces tourism.
		Other Impacts
		• Increased temperature reduces waste assimilative capacity of a stream.
		Fisheries Impacts
Nutrients (Phosphorus & Nitrogen)	Construction, Urban Development, Mining, Agriculture, Logging Operations, Stream Channelization (On-site Disposal/ Septic Tanks)	• Promotes algal blooms which — Create turbid conditions that eliminate submerged aquatic vegetation and destroy habitat and food supplies of fish and waterfowl — Favors survival of less desirable species of fish over commercially/ recreationally more desirable/sensitive species. — Can deplete oxygen supplies sufficient to result in changes in fish species composition in favor of less desirable species, or sufficient to result in fish mortality.
		Water Supply Impacts
		• Algal blooms impart noxious odors and objectionable tastes to water supplies which adds substantially to the cost of treatment.
		Recreational and Economic Impacts
		• Promotes premature aging of lakes — eutrophication. • Blooms of toxic algae can affect health of swimmers and aesthetic qualities of waterbodies (odor and murkiness).

TABLE 3

WATER QUALITY IMPACTS OF NONPOINT SOURCE POLLUTANTS FROM DIFFERENT LAND USE ACTIVITIES (Continued)

Pollutant	*Nonpoint Source(s)*	*Water Quality and Associated Impacts*
		Recreational and Economic Impacts (Con't.)
Nutrients		• Eutrophication and associated algal blooms interfere with boating and sport/commercial fishery activities. • Reduces tourism and waterfront property values.
		Fisheries Impacts
Toxic and Hazardous Substances (Metals, Pesticides, Herbicides and other Organic Materials)	Construction, Urban Development, Mining, Agriculture, Silviculture	• Accumulates in bottom sediments, posing risks to bottom-feeding organisms and their predators. • Hinders photosynthesis in aquatic plants. • Sublethal effects lower organisms resistance and increase susceptibility to other environmental stresses. • Can affect reproduction, respiration, growth and development to aquatic species as well as reduce food supply and destroy habitat for aquatic species. • By definition, pesticides and herbicides are poisons; if released to the aquatic environment before degradation, can kill non-target fish and other aquatic species. • Some pesticides/herbicides can bioaccumulate in tissues of fish and other species.
		Water Supply Impacts
		• Can produce odors in water supplies. • Some pesticides/herbicides are carcinogenic and mutagenic and/or teratogenic.

TABLE 3

WATER QUALITY IMPACTS OF NONPOINT SOURCE POLLUTANTS FROM DIFFERENT LAND USE ACTIVITIES (Continued)

Pollutant	*Nonpoint Source(s)*	*Water Quality and Associated Impacts*
		Water Supply Impacts (Con't.)
Toxic and Hazardous Substances		• Reduces commercial/sport fishing and other recreational values.
		• Health hazard from human consumption of contaminated fish/water.
		Recreational and Economic Losses
		• Can reduce waterfront property values.
		• Can affect recreational and commercial fishing or otherwise adversely affect opportunities for tourism.
		Impact on Water Supplies
Pathogens (Bacteria, Viruses)	Urban Development Agriculture, On-site Disposal/ Septic Tanks	• Introduction of disease-bearing organisms to surface waters.
		— Increases hazard to human health.
		— Increases treatment costs for drinking water.
		Recreation and Economic Losses
		• Reduced recreational usage.

Sediment Impacts — Sediment from eroding soil can place considerable stress on a stream fishery. The accumulation of silt on the bottom of a trout stream having a rock/rubble substrate may change it permanently to a warm water stream suitable for minnows and other non-game species and unsuitable for trout. The suspended solids concentration and, in particular, the accumulation of silt in the riffle area, interferes with the successful hatching of eggs and eliminates trout spawning habitat. Sediment settles into spaces between gravel in which trout eggs are incubated. As a result, intergravel flow is impeded and developing embryos do not receive adequate quantities of oxygen, which has an adverse impact on their development and survival. Metabolic wastes of the embryos are not flushed, which also contributes to higher mortality (see Figure 3). One factor which indirectly affects the fish population of a stream is the silting in of crevices between rock and rubble where invertebrate food organisms live. The accumulation of silt on the stream bottom eventually eliminates certain food organisms.

Thermal Impacts — The thermal effect on streams of cutting or removing riparian vegetation is an extremely important factor that influences summer water temperatures, which in turn can impact a fishery. The protective canopy associated with stream bank vegetation keeps the water cool by scattering direct sunlight and shading the water below. The air temperature under a continuous tree or shrub canopy may be ten degrees or more cooler than unshaded air temperatures on a hot day. Removal of riparian vegetation results in elevated stream temperatures, which

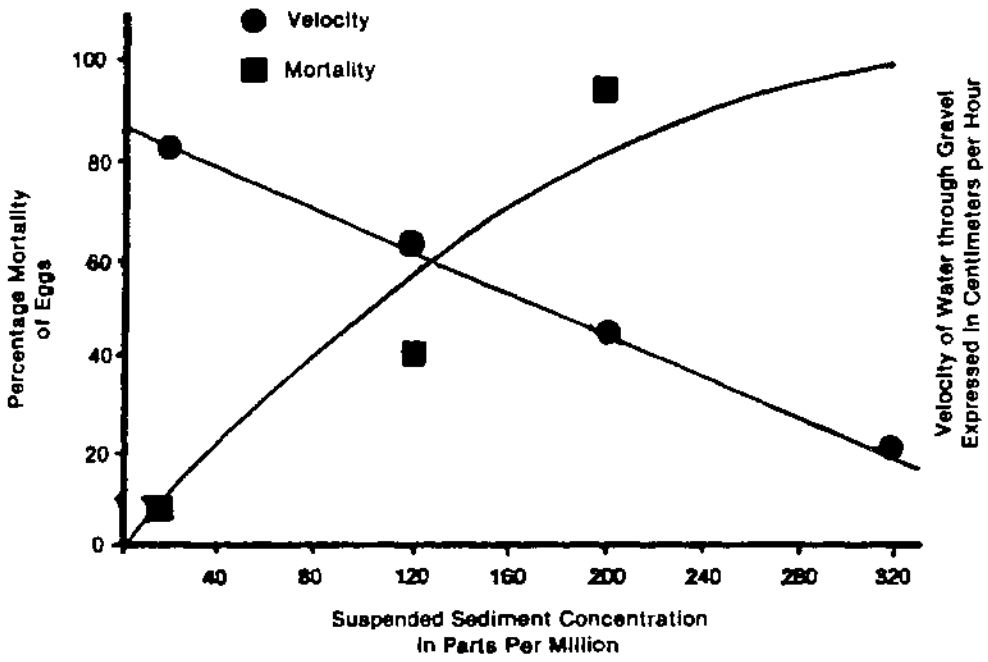


Figure 3. Relationships Between Suspended Sediment Concentrations, Apparent Intergravel Water Velocity, and Mortality Rates of Rainbow Trout Eggs in Bluewater Creek, Montana. For the velocity plot, measurements were taken within the gravel. As suspended sediment concentrations increase, velocity decreases, indicating sediment deposition and clogging of spaces between gravel. Data plotted from Peters (1962).

The influence of groundwater combined with the canopy afforded by stream bank vegetation is of critical importance in maintaining suitable stream temperatures for a trout population. Temperatures of streams in watersheds where stream-side vegetation has been removed can rise by as much as 5° to 10°F. or more during summer, either destroying fisheries habitat or, at best, making it marginal. Streambank vegetation serves another important function — that of stabilizing the stream bank. (USDA Soil Conservation Service Photo)

can exceed the tolerance limits of a fishery. This may reduce the growth rate of fish and lower their resistance to disease. Furthermore, a coldwater fishery may be entirely eliminated or, at best, habitat may become marginally supportive of the fishery when stream temperatures exceed the tolerance limits of a particular species. When this occurs, the coldwater species trout, for example, may be replaced by more tolerant warm water species or minnows.

Physical and Hydrologic Impacts on Fisheries — Fisheries habitat may be impaired or destroyed through physical disturbances to the bed or banks of a stream and as a result of hydrologic modifications in a watershed. In-stream physical disturbances generally involve, for example, stream channelization projects or construction of dams and reservoirs. The effects of stream channelization on the physical environment and biota of streams are illustrated in Figure 4.

Under natural conditions, a stream channel normally is quite stable, and changes to stream morphology (shape and configuration) often are imperceptible. Land use activities, particularly those that result in changes to the stream bank, such as channelization to eliminate bends or meanders or removal of stream bank vegetation (which reduces stream bank stability), may change the equilibrium of a stream channel for long distances.

Meanders or bends are important to a stream's stability. Streams do not normally flow in a straight line for greater than 7 to 10 channel widths. Meanders add to a stream's length and create a more gradual angle of descent as gravity pulls water downstream to sea level; thus meanders slow down the flow of water.

Straightening and channelization projects speed up streamflow and increase the velocity of water. The erosive or more destructive forces of increased velocity can trigger a chain of adjustments to the stream channel downstream which often are detrimental to other landowners and to the public good. For example, if a meander or bend is removed from a stream through channelization, the change in stream flow direction combined with increased stream velocity may adversely alter pool-to-riffle relationships to the detriment of a fishery. Furthermore, disruption of natural streamflow patterns can be of particular concern to riparian landowners downstream whose property may be eroded or damaged.

If the stream corridor is left in an undeveloped state, the stream will have more room in which to meander. This improves the chances for maintaining a greater level of equilibrium and stability between the stream, its gradient, its aquatic resources and adjacent shorelands.

Significant hydrologic changes in a watershed, for example the creation of extensive impervious land areas brought about by urbanization, contribute to increased flooding and diminished groundwater supplies, which reduces the base flow of a stream. Both flooding and reduced base flows can impair fisheries habitat.

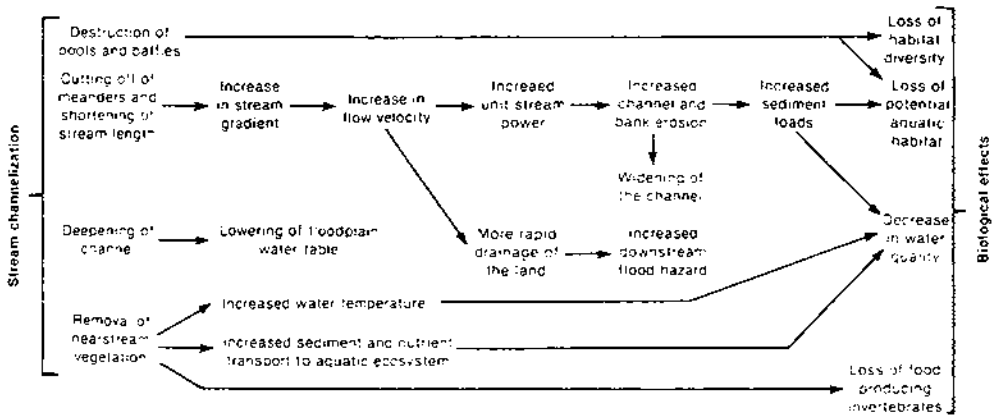


Figure 4. Effects of Channelization on the Physical Environment and Biota of Streams (J.R. Karr and I.J. Schlosser, 1978).

The suitability of a stream for fish declines as base flow diminishes. The adverse effects attributed to reduced base flow include loss of cover, reduced velocities, alteration of temperature regimen, impairment of the ease with which riffles can be negotiated by fish, and loss of spawning habitat. It has been concluded that "fair to degrading" conditions for a fishery are maintained when April to September base flows drop to 30 percent of the average and that "severe degradation" occurs when 30 to 70 percent of the watershed is covered by impervious surfaces. Stream quality impairment is initially evidenced when watershed imperviousness due to urbanization reaches 15 percent (Klein, 1979).

Flooding also may seriously affect a stream fishery. For example, Hoopes (1975), in his study of the effects of Hurricane Agnes, found that flooding reduced the young-of-the-year trout population by 96 percent. In another study, Elwood and Waters (1969) found that several age classes of brook trout *(Salvelinus fontinalis)* were nearly eliminated by four severe floods which occurred over a two-year period. Under natural conditions, such catastrophic events usually are spread out over a long period of time and therefore have a minimal effect upon the overall health of the stream. Some flooding is, in fact, essential to the health of streams through the scouring and cleansing effect it has on a stream. But as floods become more frequent, the outgrowth of urbanization, the resiliency of the stream's biotic community is strained, making it difficult to rebuild stable invertebrate populations and fish populations.

Impacts of Nutrients — The enrichment of a water body by nutrients, particularly phosphorus and occasionally nitrogen, is a process commonly referred to as eutrophication. Eutrophication can result in an excessive growth of algae and other aquatic vegetation in a stream or lake. Plants respire during daylight hours to produce oxygen while taking up carbon dioxide. The reverse occurs during darkness. Carbon dioxide is given off and oxygen is taken up by plants. Under eutrophic conditions, excessive growth of aquatic vegetation may, through respiration and decay of plant materials, deplete oxygen in a water body below the level necessary to support a viable fishery.

Impacts of Toxic Substances — Toxic substances, including certain pesticides, heavy metals, and other materials, are of particular concern once they become introduced into the environment through dumpage, misuse, leaks, or spills. While toxic or hazardous materials can kill fish directly or destroy their habitat, the principal problem is that many toxic substances can be taken up by lower organisms in the food chain. Once in the food chain, toxic substances are magnified greatly in dosage as they become concentrated more intensely in organisms such as fish higher in the food chain. Concentrations in fish may become sufficient so as to render them unfit for human consumption. This problem is limited to several major rivers and lakes in New York State and is attributed to point source discharges, although urban runoff and improper handling procedures for toxic substances also contribute to the problem. Improper use of pesticides within a watershed contributes to the problem. Toxic substances have contaminated shellfish in several coastal areas of Long Island.

Impaired Water Supplies

The development of adequate supplies of high quality water to satisfy domestic, industrial, and institutional needs is of continuing concern to numerous communities throughout New York State. Because of higher than average precipitation and runoff, it appears that the quantity of water will be sufficient in the state for at least the remainder of this century if supplies are properly developed and managed.

The protection and enhancement of water quality will be of critical importance in the years ahead in order to ensure the adequacy of supplies. While treatment of water to remove bacteria, color, and turbidity will continue to be of necessity, water quality protection will be complicated because of the difficulties encountered in treating the increasing array of contaminants reaching surface and groundwater (see Table 3).

Impact of Erosion and Sedimentation — Contaminants, such as pesticides or heavy metals, may become attached to sediment through ionic adsorption. Pollutant concentrations generally are higher in sediment than the open water of the receiving

water body. It should be recognized that the consequences of pollutant adsorption by clays may affect drinking water quality. Clay-pollutant complexes may be mobilized by erosion from the landscape, or when eroded clay enters a stream containing a pollutant. If the pollutant/clay complex survives water treatment and enters the drinking water system, it becomes available for ingestion by humans. In the adsorbed state on the clay surface, the pollutant is probably not toxic, but the possibility exists that the pollutant might be released from the clay in the environment of the alimentary tract and thus exert toxic effects. In addition to the above, sediment or suspended solids in a water source, a stream or river for example, may gain access to and accumulate in a water supply system and provide protective habitat for the general bacterial population.

Impact of Increasing Water Temperatures — For water supply purposes, the lowest water temperature possible is a characteristic of "good water quality". The temperature of treated water generally is the same as that of the source from which it is withdrawn. Elimination of shade through the removal of riparian vegetation along a stream that serves as a water supply leads to increased water temperatures. High water temperatures affect water supply facilities and usage in the following ways:

- corrosive action is accelerated which results in damage to equipment in treatment plants and distribution systems;
- biological activity in the water supply source is accelerated, which in turn produces odors and objectionable tastes that must be removed through higher treatment costs to the consumer;
- warm water provides a more suitable medium for supporting pathogenic organisms and parasites which must be removed through treatment at higher costs to the consumer.

Impact of Toxic Substances — A variety of toxic and hazardous substances are commonly used in agriculture, in industrial processes, and in the production of a variety of consumer products and provision of consumer services. Many of these toxic substances are conveyed to streams and other water bodies from urban and agricultural land areas in stormwater runoff and from point source discharges. The major concern centers around the reuse of water receiving toxic substances and the implications of this on public health. In the future, the seriousness of this problem will grow as the reuse factor increases. Greater reuse will be a necessity to meet long-range water supply demands. Considerable research on the public health effects of toxic substances in water supplies is under way, which is certain to influence water treatment practices and costs.

Impact of Nutrients — Nutrients impact water supplies by stimulating algae production. Algae, particularly blue green algae, imparts a foul or noxious odor to water and leaves it with an objectionable taste which adds to treatment costs.

Impacts to Recreation

Table 3 shows the impact of various pollutants on recreation. Suspended solids increase turbidity in a stream or lake which reduces the transparency or clarity of water. This not only diminishes the aesthetic appeal of a water body, it also increases hazards to navigation.

Eutrophication is a process in which a clear stream, river, or lake having low fertility and high transparency is transformed into a highly productive water body characterized as having excessive weed growth, nuisance algae blooms, low transparency, reduced oxygen, and eventually a deteriorated fishery.

Recreational use and aesthetic attributes become increasingly impaired as the water body changes to a more eutrophic condition. As a natural aging process which normally occurs over several thousands of years, eutrophication is being accelerated in numerous water bodies in New York State such that dramatic shifts toward more eutrophic conditions, particularly in lakes, are becoming discernible in as few as 10 to 30 years.

Phosphorus is the nutrient most often responsible for accelerating the eutrophication in New York's streams, rivers, and lakes. Phosphorus can enter a water body

either as an ion in solution, for example in stormwater runoff, or attached through adsorption to soil and other particulate matter such as dust in urban areas. Thus land use activities which result in erosion and sedimentation, or which contaminate stormwater runoff with this pollutant, are prime causes of accelerated eutrophication.

Flood Damage

Flooding is a natural occurrence. Problems arise when commercial, institutional, residential, and other types of development are improperly situated in a flood plain. Flooding and the potential for damage on improperly developed flood plains can be exacerbated by hydrologic changes in a watershed, for example, through the creation of extensive paved and impervious land areas. Large impervious surfaces and decreased infiltration, an outgrowth of urbanization, increases the level of flooding by altering the character of a watershed so that too much water runs off at one time.

Erosion and sedimentation also contribute to flooding. Sediment deposited in a stream elevates the streambed so that the banks of the stream are more likely to be overtopped during a storm event.

CAUSES OF PROBLEMS

Water quality is a function of land use activity including construction, urban development, transportation, mining, agriculture, and forestry (see Table 3). The relationship between the above land use activities and the aforementioned water management problems will be discussed briefly as follows:

Construction/Development

Each year nearly 50,000 acres of land in New York State come under development through public and private construction activities. Although this represents a very small portion of the state's land area, sedimentation, stemming from erosion at construction sites, can cause locally severe water quality problems. Construction activities often are accompanied by removal of riparian vegetation and by stream channelization or realignment.

Most of the land where construction occurs is situated at the fringes of large metropolitan areas. In contrast to more highly urbanized fringe areas, sediment delivered to streams and lakes from construction is generally low in rural areas of the state due to the relatively few acres disturbed. Nevertheless, small acreages inadequately treated with erosion control practices during and following construction can add significant quantities of sediment to streams and lakes, resulting in locally severe water quality problems, even in rural watersheds (see Figure 5).

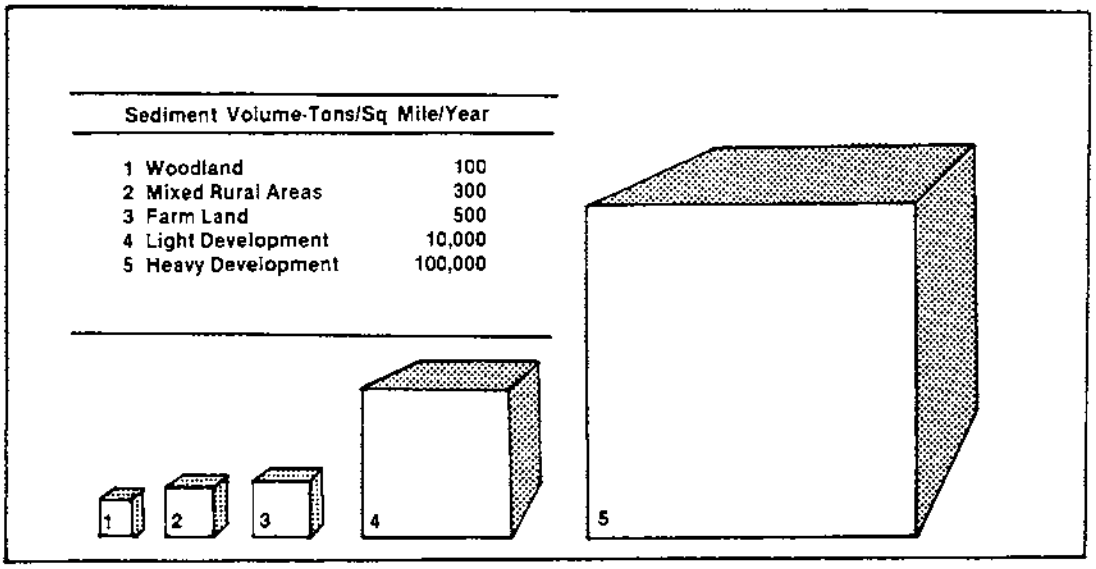


Figure 5. Erosion from construction activities is high on a volume comparison with other land uses. The amount of sediment reaching a water body from a particular site is highly variable and is dependent upon a number of factors such as acres of disturbed area, proximity to waterways, soil type and slope (L.B. Leopold, 1968).

Floods are a natural occurrence. Problems arise when homes, roads, and other developments are placed in their path. Most flood problems exist because of improper floodplain development during the sometimes long periods between floods. These problems increase as forests and pastures along rivers are converted to cropland or intensive urban uses. (Photo courtesy of Elmira Star-Gazette, Inc.)

A variety of construction activities are sponsored by the public sector. Examples of major construction activities include highway and bridge construction, sewage treatment facilities, public housing, and institutional facilities. The private sector sponsors a variety of construction projects, including industrial, commercial, and residential development. Both public and private sector sponsored projects can impair stream usage if proper precautions are not taken during and following construction. Chapter 6 discusses practices which will minimize off-site damage to streams from construction activities.

Urbanization

Nearly 5 percent of the land in New York State is urban. Urbanization is a natural outgrowth of construction and developmental activities. The physical and chemical characteristics, and the biological structure of urban streams, are generally quite different from those streams draining a rural or natural watershed. Specifically, the typical urban stream exhibits a paucity of life with the inhabiting organisms being those normally associated with stressed environments related to hydrologic changes and point and nonpoint source pollution. The factors which affect urban streams where point source discharges and sewerline overflows are absent are presented in Table 4.

Significant hydrologic changes which affect peak and base stream flow normally occur in urbanizing areas. A direct relationship exists between the number of bankfull flows that occur and the extent of urbanization. Studies by Leopold (1968) provide the following rule of thumb: When the watershed is in a rural or natural condition, bankfull flows usually recur once or twice annually. When watershed imperviousness reaches 40 percent, bankfull flows occur three times annually.

When the drainage area is completely developed, the stream fills from bed to banktop with runoff on an average of 5-6 times each year. Table 5 shows the relationship between the intensity of development and the frequency of annual flooding. Streams draining urban or developed watersheds average twice the channel width of rural streams due to increased runoff and subsequent stream bank erosion. It is estimated that 15 years are required for the enlargement period to end.

TABLE 4

EFFECTS OF URBANIZATION ON STREAMS

- Increased stormwater runoff, which in turn causes an increase in the frequency and severity of flooding, accelerated channel erosion, and alteration of the streambed composition.
- Alteration of the natural stream temperature regimen.
- Alteration of the character and volume of energy inputs to the stream.
- Increased entry of toxic substances such as heavy metals, pesticides, oil, road salt, synthetic organic chemicals, detergents, etc.
- Elevated nutrient inputs to streams.
- Increased entry of sediments to streams.
- Elevated inputs of organic matter to streams.
- Litter, dumpage of rubbish and debris along stream banks.

TABLE 5

RELATIONSHIP BETWEEN INCREASING URBANIZATION AND INCREASES IN MEAN ANNUAL FLOODING[a]

	Annual Runoff Generation (Increase in Mean Annual Flood)					
Impervious	*Percent of Area Served by Storm Sewers*					
Cover	*0*	*20*	*40*	*60*	*80*	*100*
0-2½	1.0	1.1	1.1	1.1	1.1	1.1
2½-5	1.1	1.2	1.2	1.2	1.2	1.2
5-10	1.2	1.3	1.4	1.4	1.4	1.4
10-20	1.3	1.4	1.7	2.0	2.1	2.1
20-33	1.4	1.8	2.0	2.4	2.5	2.5
33-50	1.5	2.2	2.4	2.7	2.8	3.0
50-75	1.8	2.5	3.0	3.8	4.0	4.2
75-100	2.5	3.0	4.2	5.0	5.4	6.0

(a) Source: Tourbier, J. and R. Westmacott. A HANDBOOK OF MEASURES TO PROTECT WATER RESOURCES IN LAND DEVELOPMENT: The Urban Land Institute, Washington, D.C.; 1981.

In addition to increasing peak flows, urbanization reduces infiltration and therefore base flows. This occurs because the imperviousness associated with urbanization results in a larger percentage of direct runoff leaving a smaller amount of water available for soil moisture replenishment and for groundwater storage. Figure 6 shows the typical hydrographic changes due to increasing the area of impermeable paved surface — roofs, etc. — in an urbanizing or developing area.

In addition to the influence of urbanization on the peak and base flows of streams, urban stormwater runoff transports pollutants from the land surface to rivers, streams, and lakes. The problem is particularly severe in urban and urbanizing areas where paved surfaces collect pollutants which are rapidly washed into drains and surface waters during rainstorms. Paved surfaces allow stormwater to run unchecked into surface waters.

The degraded character of urban streams does not result from any single factor, but rather from the interaction of a variety of detrimental effects related to stormwater runoff. . . .

. . . and stream channelization.

Litter and various types of debris are symbolic of man's disrespect for urban waterways. New York's bottle bill will help reduce litter. (Photo Courtesy of John Georg — DEC.)

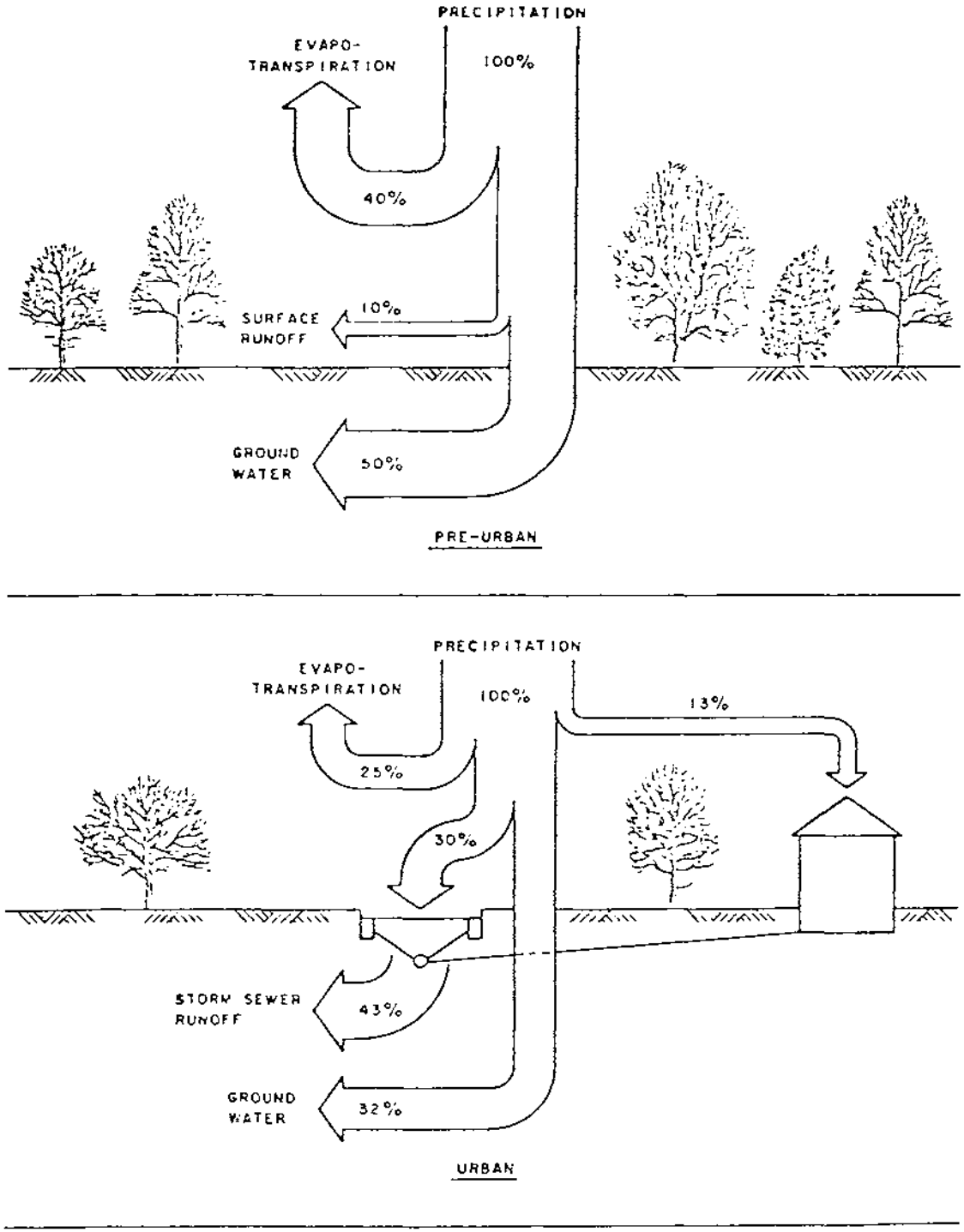


Figure 6. Hydrologic Changes Resulting from Urbanization (Based on Values from L.B. Leopold, USGS Circular 554, 1968). Source: Environment Canada: Modern Concepts in Urban Drainage, Conference Proceedings No. 5; Canada-Ontario Agreement on Great Lakes Water Quality: Toronto, Ontario, March 1977.

While the need to manage stormwater runoff for flood prevention purposes has long been acknowledged, the full magnitude of the pollution problems from urban stormwater has only recently been recognized. Calculations based on a hypothetical but typical U.S. city indicate that the runoff from the first hour of a moderate-to-heavy storm (brief peaks to at least ½ inch an hour) would contribute considerably more pollutional load than would the same city's sanitary sewage during the same period of time, as shown in Table 6.

TABLE 6

COMPARISON OF POLLUTIONAL LOADS FROM HYPOTHETICAL CITY[a] STREET RUNOFF VS. RAW SANITARY SEWAGE

	Contaminant Loads on Receiving Waters Street Surface Runoff (lb/hr)	*Raw Sanitary Sewage (mg/l)*	*Raw Sanitary Sewage (lb/hr)[b]*	*Ratio Street Sewage[c]*	*Secondary Plant Effluent (lb/hr)*
Settleable & Suspended Solids	560,000	300	1,300	430	130
BOD_5	5,600	250	1,100	5.1	110
COD	13,000	270	1,200	11	120
Total Coliform Bacteria	40×40^{12} Organisms/hr	250×10^6 Organisms/liter	4.6×10^{14} Organisms/hr	0.0087	4.6×10^{10}
Kjeldahl Nitrogen	880	50	210	4.2	20
Phosphates	440	12	50	8.8	2.5
Zinc	260	0.20	0.84	310	—
Copper	80	0.04	0.17	470	—
Lead	230	0.03	0.13	1,800	—
Nickel	20	0.01	0.042	480	—
Mercury	29	0.07	0.27	110	—
Chromium	44	0.04	0.17	260	—

(a) U.S. Environmental Protection Agency. Water Pollution Aspects of Street Surface Contaminants, EPA-R2-72-081, Office of Research and Monitoring, Washington, D.C., November 1972.

(b) Loadings discharged to receiving waters (average hourly rate).

(c) Ratio of loadings: street runoff/sanitary discharge.

It should be noted that the calculations in the table are for a situation in which streets are cleaned intentionally or by rainfall on the average of about once every five days. Thus, the above discharge of contaminated runoff could conceivably occur many times a year. On the basis of this information, there is little question that street surface contaminants warrant serious consideration as a source of receiving water pollution, particularly in cases when such discharges of contaminants coincide with times of low streamflow or poor dispersion.

Typical nonpoint sources of pollution found in the urban environment are identified in Table 7.

TABLE 7

SOURCES OF URBAN RUNOFF

Street pavement. The components of road surface breakup, including degradation of asphalt, tar, and other oil based-substances, become a part of the urban runoff loading. The amount of pollutant depends on the age and type of surface, the quantity and type of traffic, and the weather.

Motor vehicles. Fuels and lubricants spill or leak, particles are worn off from tires or brake linings, exhaust emissions collect on the road surface, and corrosion products or broken parts fall from vehicles. While the quantity of material deposited from individual motor vehicles may be small, the combined impact from numerous vehicles is significant. Vehicles are the principal nonpoint source of asbestos and some heavy metals including lead.

Atmospheric fallout. Air pollutants include dust, contaminants, and particles from stacks and vents, from automobiles and planes, and from exposed land. The airborne matter will settle on the land surface and wash off as contaminated runoff.

Vegetation. Leaves, grass clippings, and other plant materials that fall or are deposited on urban land may become part of the runoff problem. Quantities depend on the geographic location, season, landscaping practices, and disposal methods.

Spills. Producers and manufactures must store and use large quantities of hazardous substances to supply the goods we demand. Sometimes — through mismanagement, neglect, or unforeseen accidents — leaks or spills of these substances introduces them into the air, land, and water. Consumer products such as paint thinner, lacquers, wax resins, detergents, etc., also find their way into storm drainage systems.

Land surface. The type of ground cover found in a drainage basin and the amount of vehicular and pedestrian traffic is a function of land use and will affect the quality of runoff.

Litter. This consists of various kinds of discarded refuse items, packaging materials, and animal droppings. Although the quantities may be small, the pollutant sources can be significant and may be the most visible form of urban runoff.

Anti-skid compounds and chemicals. In the northeast, urban areas employ large amounts of substances designed to melt ice in the winter. Salts, sand, and ash are the commonly used agents. A variety of other chemicals may be used as fertilizers, pesticides, and herbicides. Many of these substances will become part of the urban runoff.

Construction sites. Soil erosion from land disturbed by construction is a highly visible source of solids in urban runoff. Important sites include large-scale projects such as highway construction and urban renewal. Construction methods and control measures will influence quantity and quality.

Storm sewers. These tend to accumulate deposits of materials that will eventually be dislodged and transported by storm flows.

Combined sewage overflow. Wet-weather loading from combined storm/sewage overflows may be many times larger than loads discharged from treatment plants during storms, and equal or exceed total annual discharges from treatment plants.

Transportation

Stormwater runoff from the vast network of highways, roads, and streets in the state has a potential for impacting streams. Roadbank erosion, for example, contributes substantially to stream and lake sedimentation in many communities in the state. The problem is aggravated by a lack of vegetative cover along roadbanks and in roadside ditches. In addition, as a part of routine maintenance, highway departments often remove debris and soil from roadside ditches with heavy equipment. This often results in the disturbance of vegetation, which accelerates erosion and sedimentation. Frequently, no effort is made to reestablish and maintain roadside ditch vegetation once it is removed.

A similar problem relates to highway runoff following winter sanding operations. Deicing agents and sand are used extensively throughout New York State during winter by state, county, town, city, and village highway departments. Some have advocated substituting sand for deicing agents where chemical contamination of groundwater poses a threat. However, unless proper practices are employed, sand spread on highways often is transported to roadside ditches and stormwater drainage systems where as much as 20 percent may reach a stream according to the New York State Department of Transportation.

Mining

There are nearly 1,800 known mines occupying about 100,000 acres in New York's communities. Sand and gravel operations account for nearly 85 percent of the mining activity occurring in New York. Of these, about 76 percent or 1,000 are classed as surface mines and 16 percent are subsurface mines. The balance, or 8 percent, are underwater mines.

Almost all water quality degradation in streams associated with surface and subsurface mining can be attributed to erosion and sedimentation stemming from improper placement and maintenance of mining access roads, transportation of sediment from exposed soil surfaces in open pit mining during periods of high runoff, and improper placement of mine tailings, spoil banks, and stockpiles. Proper mining and mine-land reclamation practices can minimize these problems.

Soil loss from unstable roadbanks in New York State averages 29 tons/bank mile. In 1975, about 4,505,800 tons of soil were lost from 154,000 bank miles of unstable roadbank. Much of this soil is transported directly to streams (USDA Soil Conservation Service Erosion and Sediment Inventory, 1975).

Unless proper containment practices are installed at highway maintenance facilities, stockpiles of sand used in winter as a highway abrasive may be transported by stormwater runoff to a stream where it is deposited as sediment.

Until remedial land treatment measures were applied, this abandoned gravel mine contributed more than 25 tons of soil per year to a small trout stream receiving stormwater runoff from the mine (E. Blackmere, 1981).

Agriculture

Agriculture and agribusiness are leading industries in New York State and a critical sector of the State's economy. Nearly 31 percent of the land area of the State, comprising about 9.4 million acres, is devoted to agriculture.

Agriculture can be compatible with and can even complement stream conservation needs. However, if proper management practices are either ignored or disregarded, agricultural activities may come into direct conflict with stream conservation requirements. Table 8 identifies potential sources and effects of agricultural nonpoint source contaminants on water quality.

The removal of stream bank vegetation to create additional cropland, and the overgrazing and trampling of livestock along streams, are among the most important activities in New York State that have led in the past to locally severe stream conservation and water quality management problems which persist at the present time (see Figure 7). These activities not only contribute to erosion and sedimentation, but through the removal of the vegetative canopy along a stream, water temperatures increase significantly during warm periods in summer to the detriment of a cold water fishery.

TABLE 8

SOURCES AND EFFECTS OF AGRICULTURAL NONPOINT SOURCES ON WATER QUALITY

Water Quality Problem	*Possible Non-Point Sources*
Nutrient Loading (nitrogen, phosphorus)	— fertilizer application — soil erosion leading to sedimentation — animal wastes including barnyard runoff and improper storage and application of manure
Sedimentation	— improper tillage and crop culture practices followed by cropland runoff — overgrazing by livestock leading to erosion
Oxygen demanding organics	— animal wastes including barnyard runoff and improper storage and application of manure
Infectious agents	— animal wastes including barnyard runoff and improper storage and application of manure
Pesticides	— transported in solution in cropland runoff — absorbed to detached soil particles — aerial drift

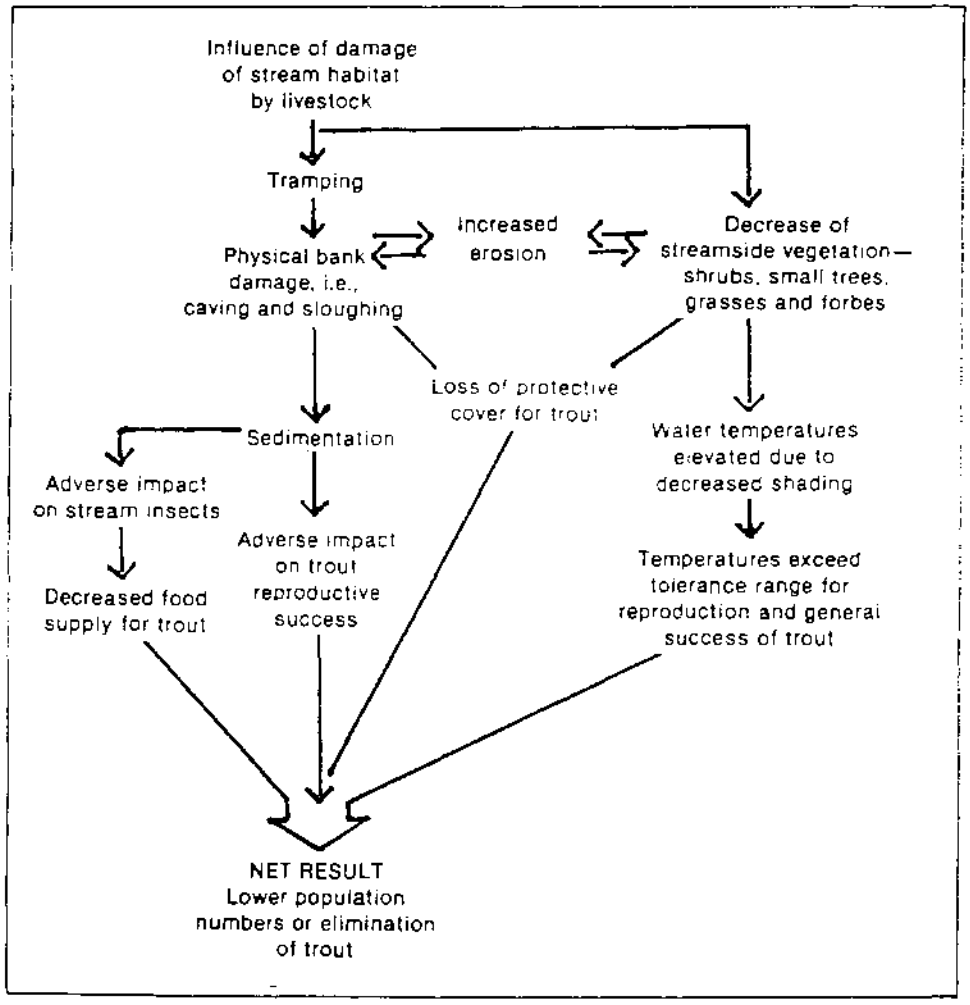


Figure 7. Conceptualized Flow Chart of Adverse Effects of Stream Habitat Damage by Livestock on Trout Populations. (C.L.Armour; Bureau of Land Management; 1978).

Note the lack of stream bank vegetation along this tributary to Oneida Lake. The USDA Soil Conservation Service has established soil loss tolerance guidelines for various soil groups. The tolerable soil loss for most of New York's cropland is three tons/acre/year. This is a rate at which soil productivity will not be reduced over time. For much cropland, the soil loss ranges between six and twelve tons per acre and is over twenty tons per acre in some locations. Some of this soil reaches streams where it is deposited as sediment (USDA, Soil Conservation Erosion and Sediment Inventory, March 1975). Photograph courtesy of J. Goerg-DEC.

Removal of natural vegetation can destabilize a stream bank and result in substantial soil erosion which represents a loss of future productivity to the landowner and which also impairs the biotic potential of a stream (West Branch of the Delaware River). Photograph courtesy of USDA Soil Conservation Service.

A significant number of stream segments in New York's rural communities show signs of extensive abuse as a result of overgrazing by livestock. Fisheries specialists recognize that unlimited access of livestock to streams has been responsible for causing damage to trout streams in dairy regions of the state. Grazing livestock destroy the vegetative cover and cave in overhanging stream banks, thereby eliminating the most important trout habitat as this tributary to the Black River illustrates. Symptoms for a stream in an impaired condition include bank caving, channel straightening and widening, decreased average water depth, a high percentage of bottom area with superimposed silt and sand, and limited stream shading.

Nutrient enrichment is another aspect of agriculture that is of particular significance not only to streams, but to lakes and reservoirs into which the streams flow. Nutrients associated with the transport of soils from cropland, barnyard runoff, manure "mismanagement," and unlimited access of livestock to a stream can accelerate the eutrophication process of both streams and lakes, thus impairing their use as a water supply or for recreation. Stormwater runoff can also transport pesticide residues and organic substances to streams from croplands if precautionary measures are not applied.

Forestry

Nearly 57 percent, or 17 million acres, of the land in New York State is forested. Over 14 million acres are considered as commercial forests that can be harvested. Foresters, soil scientists, and water resource managers generally agree that almost all water quality degradation associated with forestry activities in the state can be attributed to erosion and sedimentation related to the design, location, construction, use, maintenance, and abandonment of logging roads, skid trails, and log landings. The prospect of water pollution by sediment is frequently present because of the use of heavy equipment on roads that are built for a transitory use which tends to preclude substantial investments in sophisticated erosion control or prevention devices.

> EROSION FROM LOGGING ROADS AND SKID TRAILS LOCATED TOO CLOSE TO STREAMS CONTRIBUTES TO SEDIMENTATION. THE DEPOSITION OF WASTE MATERIALS SUCH AS LIMBS AND BRANCHES IN A STREAM CAN CAUSE A SHIFTING OF THE STREAM CHANNEL AND INCREASED SEDIMENT LOADING.

Another category of concern is the thermal effects on water from the cutting of stream bank vegetation. The extension of clear cuts and even the removal of only a part of the forest canopy close to a stream can result in a larger variation of stream water temperature. The thermal balance of the waterbody can be significantly altered due to the increased penetration of direct sunlight. This has been shown to be especially critical for small streams, particularly during periods of low flow.

Barnyard runoff, as well as physical disturbances to a stream caused by unlimited access of livestock, impairs water quality and fisheries habitat.

CHAPTER 3: TECHNIQUES FOR ASSESSING LAND USE IMPACTS ON WATER QUANTITY AND QUALITY

Numerous techniques have been developed to assess water quantity and quality impacts stemming from different land use activities. The purpose of this chapter is to identify several methods for estimating runoff from urban areas, and for predicting water quality responses to changes in land use. It is not the intent of this chapter to train the manual user to directly apply the techniques discussed herein. Rather, the manual seeks to raise the level of awareness by presenting concepts and to steer the user to others who are versed in the application of the techniques.

ESTIMATING RUNOFF FROM URBAN AREAS

As population density and land values increase, the effects of uncontrolled runoff may become an economic burden and a serious threat to the health and well-being of a community and its citizens. There is a need for thorough understanding of stormwater runoff problems associated with rapid conversion of undeveloped land to urban use and for adequate technical procedures for assessing the effects of land use changes on streamflow. Estimating the magnitude and frequency of future flood events is an essential first step in the systematic planning and installation of structural and nonstructural measures to reduce hazards to acceptable levels.

The USDA Soil Conservation Service has prepared a technical manual, entitled "Urban Hydrology For Small Watersheds", Technical Release Number 55, for estimating runoff from urban areas. A methodology for estimating increases in runoff due to urbanization, including runoff volume and peak rates of discharge, including time of concentration, travel time, and lag time is presented in the manual. The volume of runoff is determined primarily by measuring the amount of precipitation and by evaluating infiltration characteristics related to soil type, antecedent rainfall, type of vegetative cover, impervious surfaces, and surface retention. Travel time, the time it takes water to travel from one point to another, is determined primarily by slope, flow length, depth of flow, and roughness of flow surfaces. Peak rates of discharge (the flood peaks) are based on the relationship of the above parameters as well as the total drainage area of the watershed, the location of the development in relation to the total drainage area, and the effect of any flood control works or other man-made storage. Technical assistance for making these determinations so that runoff from urbanizing areas can be estimated is available from County Soil and Water Conservation Districts.

METHODS FOR PREDICTING WATER QUALITY RESPONSES TO CHANGES IN LAND USE

A number of techniques have been developed to assess the impacts to water quality from nonpoint sources of pollution associated with various land use activities. Many of the techniques that have been developed are highly sophisticated and clearly beyond the scope of this manual. This manual will present several relatively simple techniques which local planning agencies and environmental conservation commissions might wish to employ to make cursory assessments of the impacts of land use on water quality.

Radz Methodology for Predicting Stream Temperature Change in Response to Alterations in Riparian Vegetation.

As discussed in Chapter 2 (Stream Problems), trout cannot survive for more than a few days in waters which exceed 75°F. Any land use activity, such as agriculture, log-

ging, or urbanization, which eliminates stream shading through the removal of riparian vegetation has the potential for elevating stream temperatures above the tolerance limits of a cold water (trout) fishery.

Predicting stream temperature variations in response to changes in land use is an essential element of the stream management task. To this end, a simple model has been developed which will facilitate estimation of the effect of removal or re-establishment of riparian vegetation on downstream temperatures. The basis of the analysis is that stream temperature is influenced largely by absorbed solar radiation. Since other variables, including air temperature, evaporation, and conduction, have an insignificant influence on stream temperature, they are omitted from the model. The model provides a step-by-step methodology which, with a set of nomographs, enables the user to predict changes in stream temperature response to alterations in riparian vegetation. The model is available upon request from the Bureau of Water Resources, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233.

The Universal Soil Loss Equation

Sediment is characterized as the largest single nonpoint source water pollutant. Consequently, a major effort has been made to develop methods to estimate erosion and sedimentation from different land use activities. The Agricultural Research Service of the U.S. Department of Agriculture developed the 'Universal Soil Loss Equation' (USLE) for predicting the soil loss on cultivated lands to ascertain whether or not soil and water conservation practices should be implemented. In more recent years, factors in the USLE have been modified to enable predictions to be made of soil loss in forested watersheds or urbanizing areas.

The USLE takes into account the influence of total rainfall energy for a specific area and is expressed as follows:

$$A = RKLSCP$$

where A is the computed average annual soil loss per unit area; R is rainfall factor; K is the soil erodibility factor; L is the slope length factor; S is the slope gradient factor; C is the cropping factor; and P is the erosion control practice factor. The limitation of the USLE is that, while it is used to predict soil loss from a unit area, it does not predict how much soil actually reaches a stream or lake. Nevertheless, this tool may be used to estimate "gross erosion" which, as described below, is a necessary parameter to have in estimating sediment yield to streams. Communities may wish to avail themselves of the technical assistance provided by County Soil and Water Conservation Districts in applying the USLE to soil erosion problems.

Sediment Yield

The term "sediment yield" may be defined as the amount of eroded material that is transported and deposited in a stream either as suspended sediment or as settled bed material, or both.

Sediment yield is dependent on **gross erosion** in the watershed and on the ability of runoff to transport and deposit material into streams and lakes. The yield from a given area varies with changing patterns of precipitation, cover, and land use.

There are several ways to calculate the sediment yield of a watershed, depending on the data available. Average annual sediment yields may be obtained from: (1) measured sediment accumulations; (2) sediment-rating curves, flow-duration techniques; (3) predictive equations; and (4) gross erosion and sediment delivery ratios. Of these

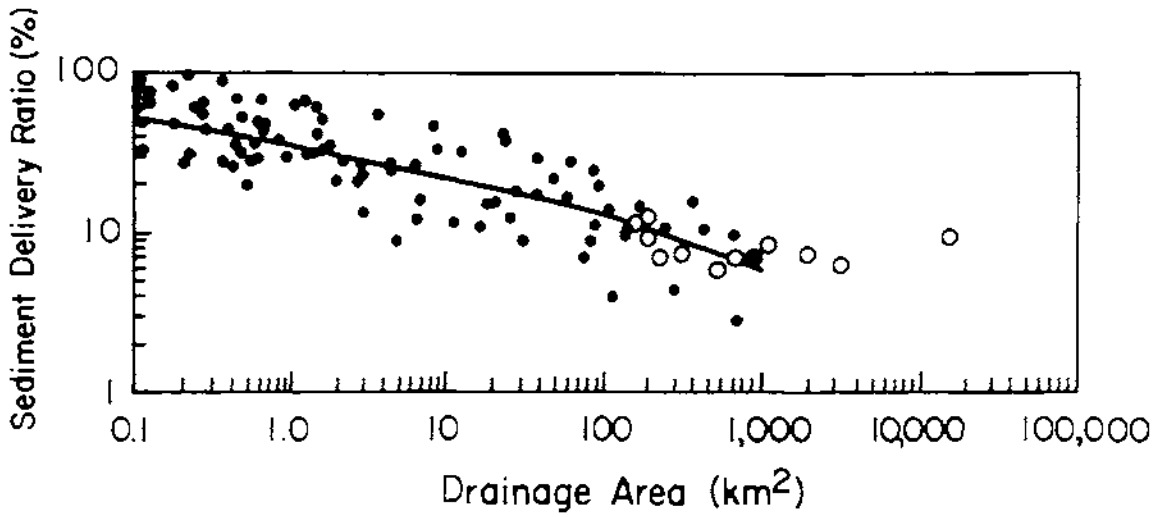


Figure 8. Relationship Between Delivery Ratio and Watershed Size from Roel (1962) with Ratio from Watersheds in Northwestern Ohio from Baker (1982)

techniques, only the latter — gross erosion and sediment delivery ratios — will be discussed. There are other techniques that are beyond the scope of this manual.[1]

Gross erosion in a drainage area includes sheet and rill erosion, and channel-type erosion (gullies, valley trenches, streambank erosion, etc.). Gross erosion can be estimated by using the Universal Soil Loss Equation discussed above. The sediment delivery ratio is that fraction of the soil removed by gross erosion which is delivered to a stream as follows:

$$Y = E(D)$$

where Y is the sediment yield, E is the gross erosion, and D is the sediment ratio.

Several factors affect sediment delivery ratios: type of sediment sources, size and texture of erodible materials, climate, transport systems, land use, proximity of sediment sources, source size, watershed characteristics, and the nature of depositional areas.

There are no generalized sediment delivery relationships that can be applied to every watershed situation. However, trend data from widely scattered areas show that sediment delivery ratios throughout the country vary inversely as the 0.2 power of the drainage area.[2] This relationship is illustrated by Figure 8.

Rough estimates of sediment delivery ratios can be made through the use of Figure 8, but such estimates should be blended with judgement of other influencing factors such as soil texture, type of erosion, and areas of deposition within the drainage area.

Vollenweider Analysis

The trophic condition of a lake is influenced in part by the concentration of nutrients transported to it by streams in the drainage system. Phosphorus, in particular, has been singled out for attention, partly because it is the nutrient which causes eutrophication in freshwater lakes and streams, and partly because its introduction is, for most streams and lakes, easier to control than other nutrients such as nitrogen.

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[1] Techniques for estimating sediment yield are more fully discussed in "Methods for Identifying and Evaluating the Nature and Extent of Non-Point Sources of Pollutants", U.S. Environmental Protection Agency, EPA-430/9-73-014, October 1973. See also "Loading Functions for Assessment of Water Pollution Nonpoint Sources", U.S. Environmental Protection Agency, Washington, D.C., Environmental Protection Series, EPA-600/2-76-151, May 1973.

[2] U.S. Department of Agriculture, **National Engineering Handbook**, Section 3, "Sedimentation", USDA – SCS (1973).

The Vollenweider Analysis provides a relatively simple method for estimating the trophic condition of a lake. It is based on the relationship between total phosphorus loading and mean depth as illustrated in Figure 9. The trophic status of a lake may be predicted by plotting the mean lake depth and total phosphorus loading on the Vollenweider curves shown in Figure 9. The plotting of this information will provide an indication as to whether or not total phosphorus loading is sufficient to alter the trophic state of a lake. Initial phosphorus loading estimates from nonpoint sources can be made by applying the loading coefficients for various land use activities found in Table 9 to unit areas of land use in a watershed. The conversion factor for changing kg/ha in Table 9 to g/m^2 for application to the Vollenweider curves (See Figure 9) is expressed as kg/ha .1 = g/m^2 or simply multiply kg/ha x .1. Mean depth data for many lakes can be found in the **New York State Lake Classification and Inventory — 1982 Annual Report** available from the Bureau of Water Research, Room 317, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233.

Refined modelling techniques for determining phosphorus loading and trophic state have been developed which are beyond the scope of this manual. Planners and others who have an interest in learning more about or actually implementing these refined assessment techniques are encouraged to contact the Bureau of Water Research.

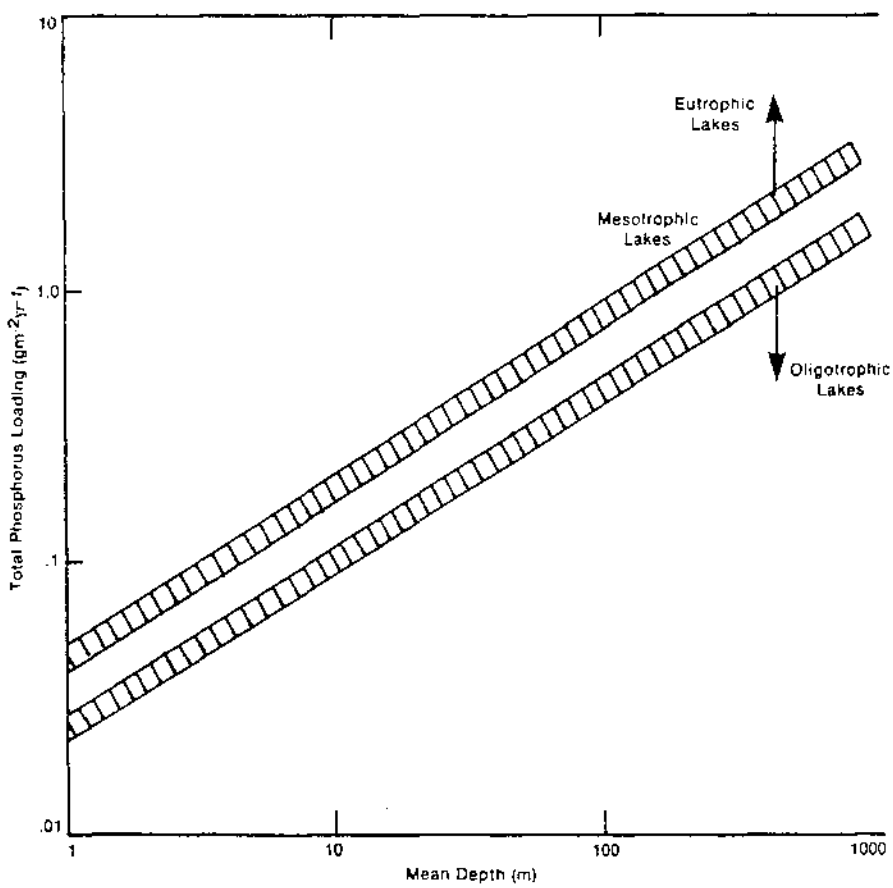


Figure 9. Total Phosphorus Loading vs. Mean Depth Relationship Showing Degrees of Eutrophy. Note that "eutrophic" refers to a nutrient rich lake having high productivity characterized by algal blooms and/or substantial rooted aquatic vegetation. Water in a eutrophic lake is normally turbid and may appear as "pea soup" at certain times of the year. An "oligotrophic" lake is low in fertility and is highly transparent. A "mesotrophic" lake is one which is becoming eutrophic. (Taken from Vollenweider, 1968.)

TABLE 9

TYPICAL VALUES OF NUTRIENT RUNOFF COEFFICIENTS[1]

	NO_3-N + NH_4-N kg/ha/yr			Total-N kg/ha/yr		
Land Use	*High*	*Low*	*Ave*	*High*	*Low*	*Ave*
Urban	5.0	1.0	2.0	10.0	2.5	5.0
Forests	3.0	0.5	1.6	5.0	1.0	2.5
Agricultural	10.0	1.0	5.0	10.0	2.0	5.0

	Diss inorg-P kg/ha/yr			Total-P kg/ha/yr		
	High	*Low*	*Ave*	*High*	*Low*	*Ave*
Urban	2.0	0.5	1.0	5.0	1.0	1.5
Forests	0.1	0.01	0.05	0.8	0.05	0.2
Agricultural	0.5	0.05	0.1	1.0	0.1	0.3

	Nitrogen loss, kg/N/ha/yr		Phosphorus loss, kg/P/ha/yr	
	NO_3+ NH_4	Total-N	Diss Inorg	Total-P
Agricultural				
Row crops	1.6	37.0	0.21	1.62
Close-grown crops	1.7	15.0	0.13	0.47
Pasture & meadow	2.3	2.5	0.22	0.24
Idle (fallow) land	3.9	67.0	0.05	1.23

1 USEPA, Office of Research and Development, "Estimating Nutrient Loadings of Lakes from Non-Point Sources", EPA-660/3-74-020, Ecological Research Series, August 1974.

CHAPTER 4: STEPS FOR SOLVING THE PROBLEM

(A PLANNING AND PROBLEM-SOLVING FRAMEWORK)

The purpose of this chapter is to present a planning and problem-solving framework for addressing critical stream corridor management issues, problems, and needs. Without such a planning framework, problems and issues may be addressed in piecemeal fashion, decision-making will be disjointed, and actions taken will tend to be fragmented and unrelated. Most important, actions taken without a planning overview or focus provide little or no assurance that critical natural and cultural resources within the stream corridor are being protected or enhanced. The planning and problem-solving framework in this chapter is presented in a step-by-step format as follows:

STEP 1: IDENTIFY THE PLANNING AREA

The first step is to identify the planning area. This may be accomplished by obtaining a base map of the principal drainages and subdrainage basins within the community. Planning area boundary lines then should be superimposed on the base map (see Figure 10). The planning area should include all that land area from which stream corridor management problems are perceived to arise. The planning area could include an entire watershed; it is suggested that it not be less than several hundred feet landward from both banks of a stream. Under no circumstances should it be less than the 100-year flood plain. At this stage, the planning area boundary should remain flexible. There will be ample opportunity to fine tune the planning area boundary and to establish stream corridor management boundaries as information is assembled and analyzed in subsequent steps.

STEP 2: INVENTORY AND ANALYSIS OF LAND USE AND ENVIRONMENTAL RESOURCES

In Step 2, existing land use and natural and cultural resources in the planning area should be mapped. The maps used for this work should be at the same scale as that used in establishing planning area boundaries. This will facilitate comparison of data in analyzing developmental trends and environmental constraints (See Figure 11).

Existing Land Use and Developmental Trends

Evaluate existing land use and county and local economic development trends in the planning area or that impact the planning area. Include in the evaluation such growth-inducing factors as current and anticipated major public and private capital investments; for example:

— industrial expansion
— major commercial development
— suburban residential development
— development of natural resources (e.g., forestry, mining, recreation, etc.)
— other social and economic factors

The evaluation should include (a) development that has occurred over the past few years, (b) developmental activities which are currently influencing the patterns and magnitude of growth in the planning area, and (c) development now in the early stages of programming which may impact the stream corridor ten or twenty years hence. This evaluation should show patterns and intensity of land use in the planning area, including urban and non-urban uses in undeveloped areas. The relative density and classification of development, i.e., industrial, commercial, residential, etc., should be mapped.

Figure 10. Base Map

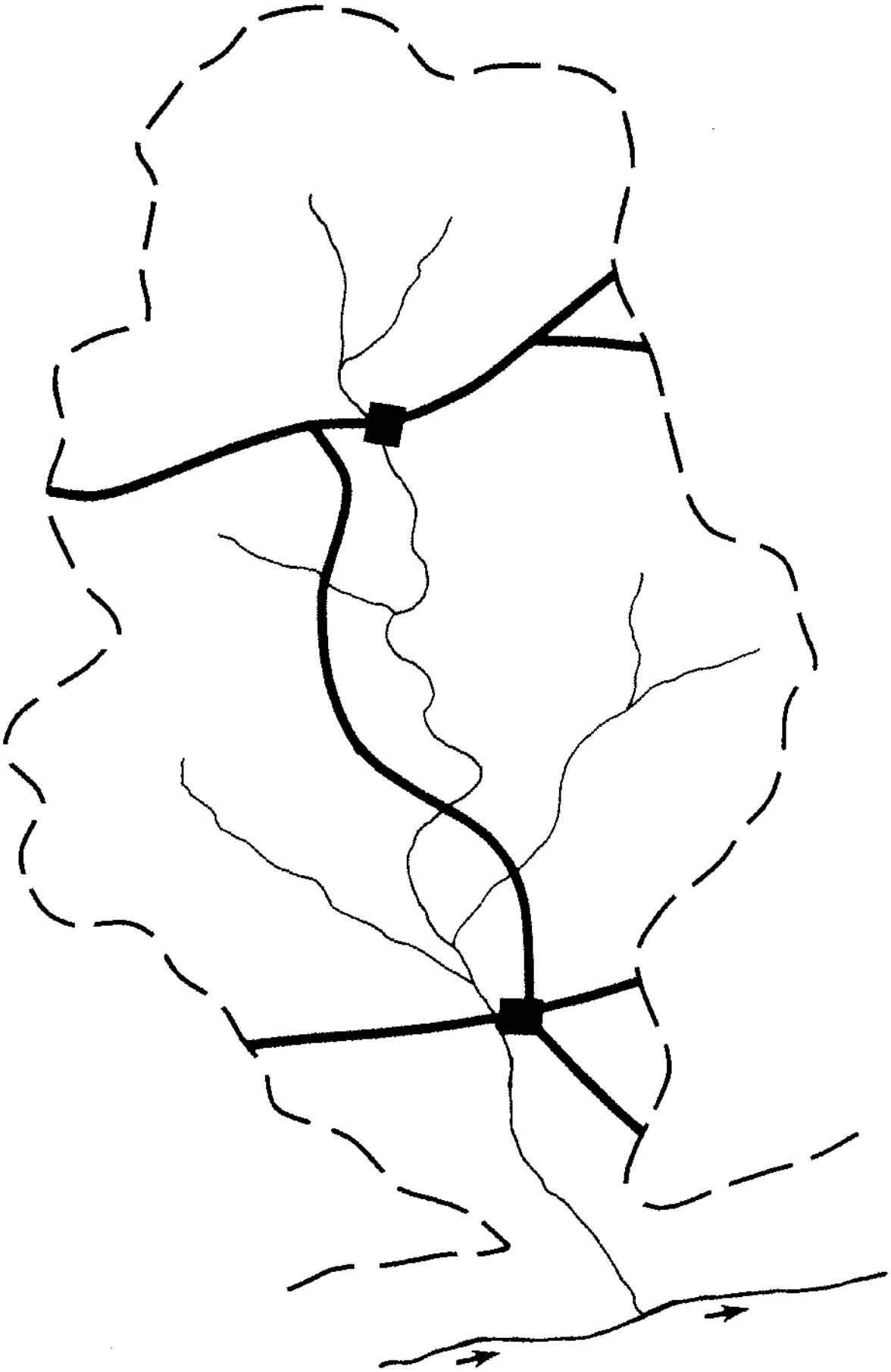
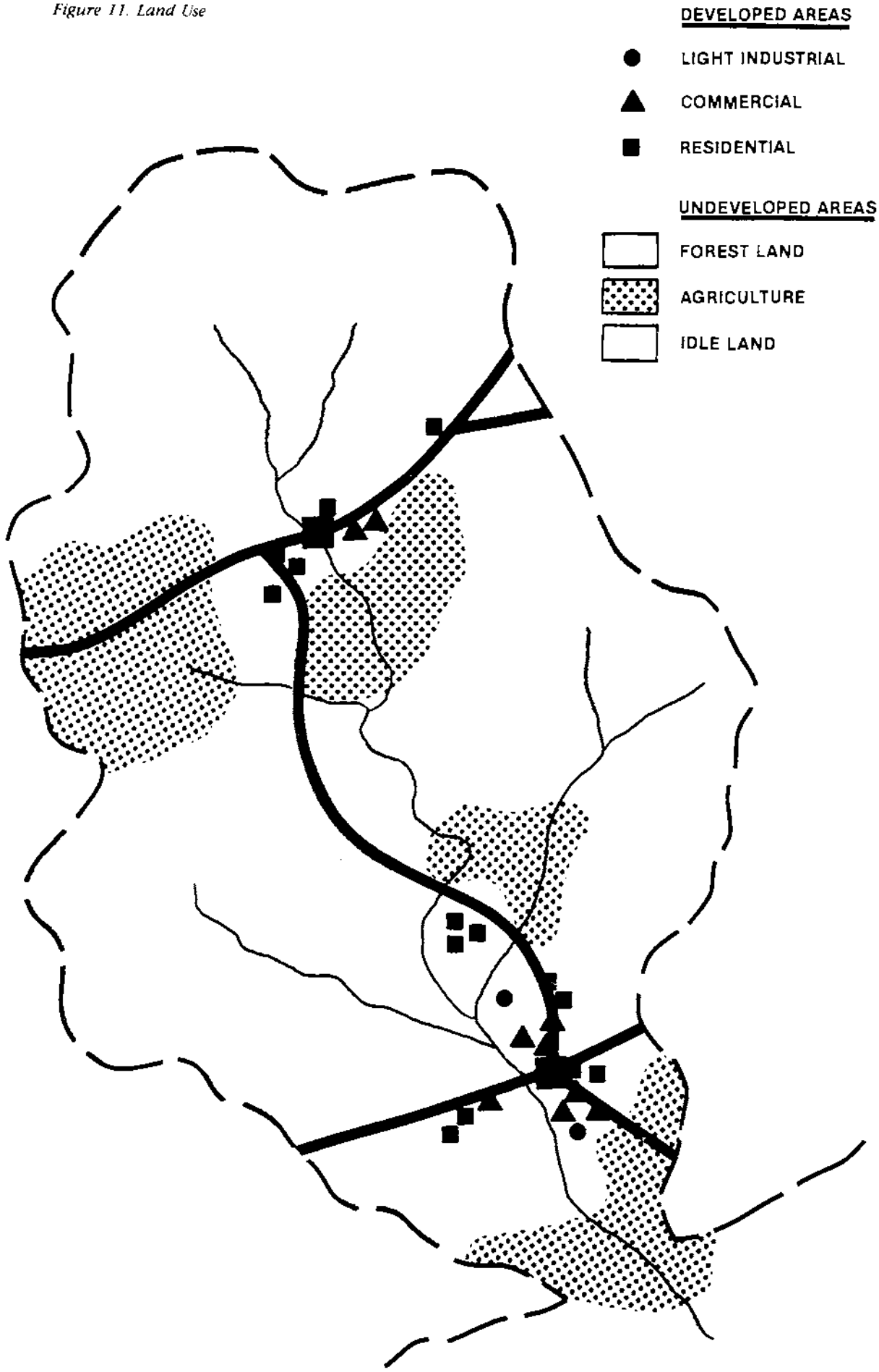


Figure 11. Land Use



Natural and Cultural Resource Inventory and Assessment

An inventory of natural and cultural resources in the planning area should be prepared. This inventory will involve acquiring, field checking (where appropriate) and mapping data, on overlays on the base map, the following kinds of information:[1]

- Surficial and bedrock geology.
- Soils and related information on development constraints and potentials, including soil depth, soil erodibility, soil structure, soil wetness, soil percolation, and slope.
- Major vegetative types.
- Surface and groundwater hydrology. (Include water quality classifications, known aquifers and aquifer recharge areas, and lakes).
- Historical and archeological sites and districts.
- Wetlands.
- Flood plains and areas of tidal inundation (including flood plains not identified on HUD maps).
- Agricultural lands.
- Fish and wildlife habitats by species.
- Rare or endangered plant and animal species in study area.
- Areas of outstanding scenic quality, e.g., waterfalls, scenic vistas, etc.

The preceding items are illustrative of factors that should be considered in the natural and cultural resources inventory. This list is not meant to be all-inclusive. Additional relevant factors, as may relate to the local situation, also should be identified in the inventory. Areas subject to special protective measures, such as park lands or rivers that have been designated in the State's Wild and Scenic River Program, and streams for which fishing easements have been acquired, should be identified and mapped (see Figure 12).

The resources inventory must be based on reliable and acceptable sources of information such as that which is available from county soil and water conservation districts, United States Geological Survey's research papers, and from federal and state flood plain maps. The Department of Environmental Conservation publication "Natural Resources Inventory: A Guide to the Process" may be helpful for identifying potential sources of information. Information also might be obtained from regional and local planning agencies, county environmental management councils, local conservation advisory councils, and conservation advisory boards. Many of these agencies have prepared natural resources inventories, open space indexes, and natural resource plans.

An assessment of the existing benefits that the natural and cultural resources in the planning area provide to the community should be made. The assessment should also examine the potential for restoring or rehabilitating a resource, a fishery, for example. This can be a descriptive statement which recognizes the importance of the resources to the community, i.e., whether the resource serves (or could serve) active recreational interests such as fishing, or passive recreational interests such as sightseeing, or water supply needs, etc. The assessment should be based on the natural and cultural resource inventory.

Environmental Constraints Analysis

Information from the resources inventory should be used to evaluate constraints to growth and development in the planning area such as flood plains, critical wildlife habitats, high soil erosion potential, historical landmarks, scenic vista, high groundwater table, wetlands, etc.

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[1] Map information may be obtained from the Map Information Unit, New York State Department of Transportation, Building 4, Room 105, State Campus, Albany, New York 12232, 518-457-4755.

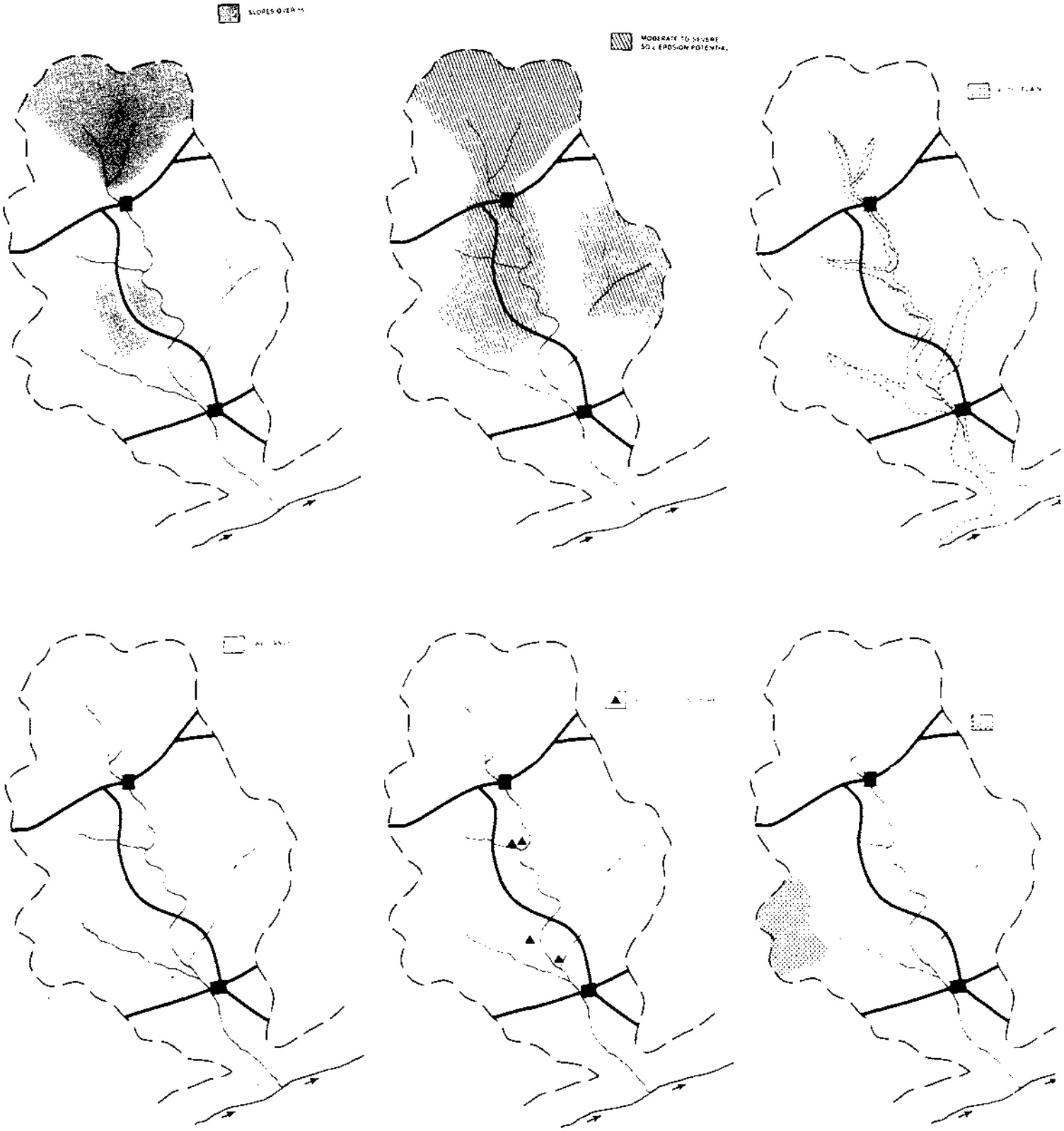


Figure 12. Natural Resources Data

For some situations, a three-element scale for rating constraints to development as "slight," "moderate," or "severe" might be useful. Transparent overlay maps of the various resource features can be superimposed upon one another and from this a summary map can be produced that can be used for making informed land use decisions in the planning area (see Figure 13).

In undertaking the constraints analysis, it will be useful to consult with other planning agencies, environmental management councils and conservation commissions and also, professional resource managers, to assist in the classification and interpretation of information in the natural resource inventory. The sources of data and methods used in the analysis should be included as part of the narrative in the report.

STEP 3: PROBLEM AND NEED ASSESSMENT

Identifying the water problems, needs, and opportunities for use or environmental enhancement is one of the most important steps of the evaluation process. Problems and needs should be separated into three categories: in-stream problems, stream corridor problems, and watershed problems as discussed below:

In-Stream Problems and Needs— Under this category problems directly related to the bed and banks of the stream, as well as to the stream proper, should be discussed. Problems, such as those described in Chapter 2 — for example, destruction of fisheries habitat through stream channelization, removal of streambank vegetation, sedimentation, and problems related to littering of streambed with trash or rubbish, including bottles, cans, or other debris — should be briefly discussed. The location of these problems and sources should be mapped on a base map overlay. As a corollary to the problems, management needs such as fisheries management, water quality management, flood plain management, recreational development, restoration or rehabilitation of scenic resources, etc., should be discussed.

Stream Corridor Management Problems and Needs — Aside from the direct impacts of various activities to the bed and banks of a stream, the stream corridor is the land unit that normally has the greatest influence on the quality and character of a stream. A stream is most vulnerable to sediment stemming from erosion and runoff which originates in the stream corridor, or to heat gain through removal of a stream corridor's vegetative canopy. Also, portions of a stream corridor may be flood prone. Thus, flood prone areas, and land use activities in the stream corridor which adversely affect a stream, whether they are related to agriculture, forestry, construction/urban encroachment, or mining activities, should be identified and mapped. A description also should be made of these activities and how they are impacting the stream, i.e., whether it is a quantity or quality relationship, or alteration of the biological structure of the stream. Professional resource managers from Regional Offices of the Department of Environmental Conservation, County Soil and Water Conservation Districts, and county and local planning agencies and environmental management councils should be consulted during this assessment to the extent necessary.

Watershed Management Problems and Needs — If local communities are to protect and conserve the resources of streams and creeks, they may have to look beyond the water course and stream corridor and consider the watershed in its entirety. Because of the cause/effect relationships of various processes inherent in land use to streams and creeks, water courses serve as an index of health of the entire watershed. Accordingly, stream management problems related to various land use activities that extend beyond the stream corridor, which are more of a watershed-wide concern, should be described and mapped. Here again the assistance of professional resource managers may be necessary.

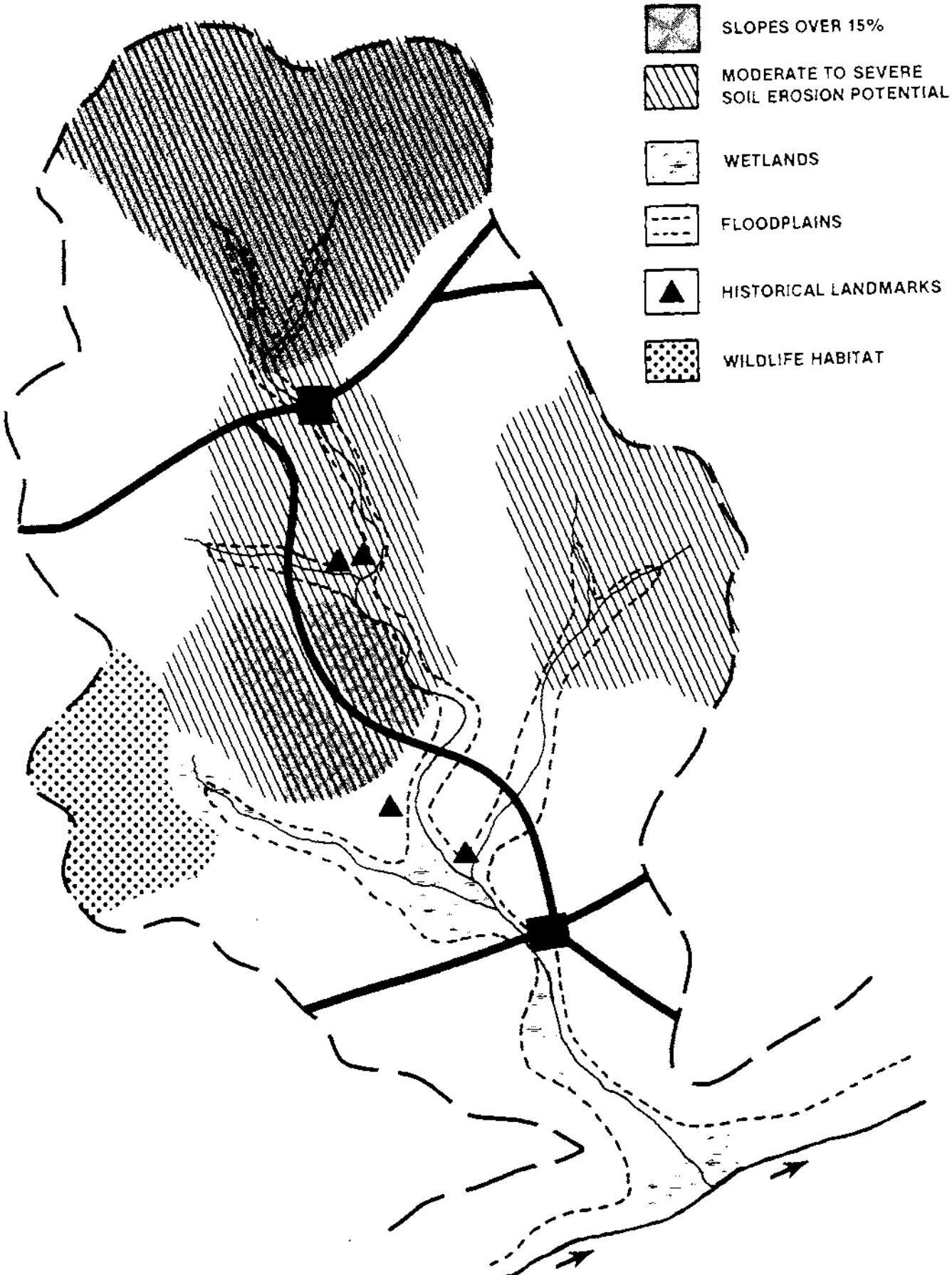


Figure 13. Natural Resources Inventory and Environmental Constraints Assessment

STEP 4: ESTABLISH THE STREAM CORRIDOR MANAGEMENT BOUNDARY

While there is no precise scientific formula for determining the optimum boundary location for any single stream corridor management unit, completion of the preceding steps should facilitate this process. The stream corridor management unit should have a "floating" boundary.

A floating stream conservation and management corridor varies in width according to the location of important natural resource features and environmental constraints which exert a strong influence on the character and quality of the stream and its surroundings. Wooded areas, wetlands, floodplains, scenic vistas, and areas having land use constraints, such as steep hillsides or soils having high erosion potential, should be included in the floating corridor (see Figure 14). Guidelines for establishing a stream corridor boundary are presented in Table 10.

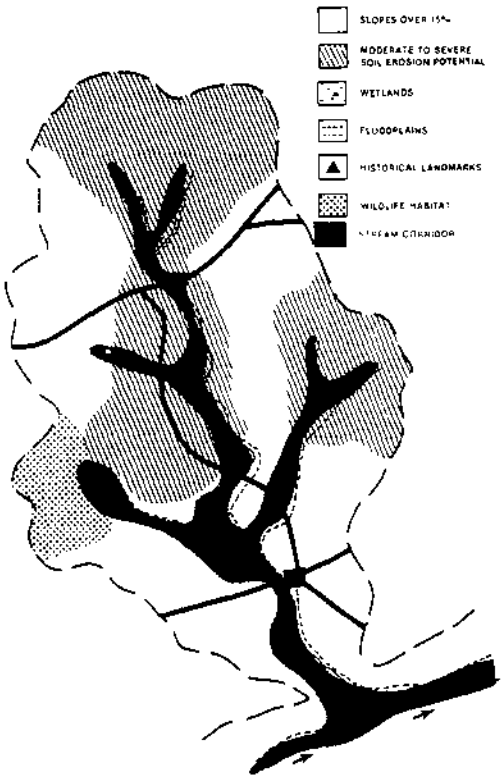


Figure 14. Floating Stream Corridor Boundary

Table 10

GUIDELINES FOR ESTABLISHING A FLOATING STREAM CORRIDOR BOUNDARY

1. A floating stream corridor management boundary should be delineated so as to include within the management area those natural, cultural, and historic features whose protection and preservation are important with respect to community stream conservation goals and objectives.
2. Such features may include, for example, scenic areas, natural, or historic landmarks, floodplains and wetlands, significant wildlife habitat, watershed and aquifer areas, ecologically important areas, and stream or waterway related outdoor recreational facilities. Such features should be identified on a list and briefly described in a narrative and, in addition, each feature should be referenced on an official map.
3. In establishing a floating stream corridor management boundary, consideration should be given to protecting natural and cultural features, such as the above, by establishing the boundary a reasonable distance landward, for example 100 feet for a wetland, to provide an adequate protective buffer area.
4. In defining the stream corridor management boundary, consideration should be given to the applicability of property boundaries, or regulatory boundaries, such as those on a zoning map, and to features such as roads or railroads which may parallel the stream and make the stream relatively easy to delineate and identify on a map.
5. By law (Environmental Conservation Law, Article 15, Title 27), the boundary width for a river (or stream) designated by the state as "Wild", "Scenic", or "Recreational" can be no farther landward than one-half mile from the mean high water mark in the river.

STEP 5: ESTABLISH GOALS AND OBJECTIVES

Goals and objectives must be established for the planning area. A goal is a general statement of policy focused on long-term accomplishments for the common good of the community; for example, to protect and enhance fisheries habitat, to protect soil resources, to protect drinking water supplies, to provide for increased recreational opportunity, or to protect the scenic and visual communities in the planning area. An objective is a specific, task-oriented statement which needs to be carried out in order to achieve a goal; for example, to establish a vegetative canopy in the stream corridor, or to ensure that development of the planning area is consistent with environmental constraints. Each goal is usually accompanied by two or more objectives which identify a variety of tasks that must be achieved in order to achieve the goal. Table 11 identifies several goals and a number of objectives which can either be adopted directly or modified to meet local stream corridor management needs.

STEP 6: ANALYZE PLANS, LAND USE CONTROLS, AND THEIR CONSISTENCY WITH GOALS AND OBJECTIVES

Land use and land-related plans, if implemented, can have a significant influence on the intensity and patterns of development in the stream corridor. Therefore, as factors of growth, each plan which has been adopted, or is expected to be adopted, should be evaluated to determine its potential for shaping growth patterns. Similarly, plan implementation mechanisms, both existing and proposed, should be evaluated.

Plan Review. Examine relevant state, regional, county, and local land use and land use-related plans and briefly describe their geographical area of coverage, and indicate the purpose of the plans through a summarization of their goals and objectives.

TABLE 11. GOALS AND OBJECTIVES

Goals and objectives reflect the vision and aspirations that a community has for the future. The following goals and objectives represent not only a vision, but also the state's aspirations for its streams and associated water resources. Communities across the State are encouraged to reflect upon these goals and objectives, tailor them to local problems and needs, and incorporate them into ongoing local planning efforts. Above all, local agencies are encouraged to serve as the driving force to ensure that programs to achieve adopted goals and objectives are effectively implemented.

Goal

- To restore, protect, and enhance water quality and associated aquatic resources and water supplies.

Objectives

- To minimize erosion and prevent sedimentation of waterways.
- To prevent the accelerated enrichment of streams and contamination of waterways from runoff containing nutrients, pathogenic organisms, organic substances, and heavy metals and toxic substances.
- To maintain or restore a natural vegetative canopy along streams where required to ensure that mid-summer stream temperatures do not exceed tolerance limits of desirable aquatic organisms.
- To maintain the stream or waterway free from litter, trash, and other debris.
- To minimize the disturbance of streambed and prevent streambank erosion and, where practical, to restore eroding streambanks to a natural or stable condition.
- To restore, rehabilitate, or enhance water quality and associated resources through the implementation of appropriate Best Management Practices on the land.

Goal

- To minimize the threat to life and the destruction of property and natural resources from flooding, and preserve (or reestablish) natural flood plain hydrologic functions.

Objectives

- To ensure that runoff from developing and urbanizing areas is controlled such that it does not unnecessarily increase the frequency and intensity of flooding at the risk of threatening life and property.
- To adopt appropriate land use controls and performance standards for controlling development of flood plains.

Goal

- To restore, protect, develop, and enhance the historic, cultural, recreational, and visual amenities of rural and urban stream corridors.

Objectives

- To ensure that environmental resource constraints are fully considered in establishing land use patterns in stream corridors.
- To retain and preserve open space and visual amenities in urban and rural areas by establishing and maintaining greenbelts along stream corridors.
- To ensure that development in the stream corridor is consistent with the historical and cultural character of the surroundings and fully reflects the need to protect visual amenities.

Table 11. (Continued)

- To ensure that the recreational and fisheries potential of a stream corridor are developed to the fullest extent practicable.
- To maximize the use of creative and imaginative resources to rehabilitate and transform urban stream corridors, which through neglect may represent a source of urban decay and blight, into attractive community assets consistent with historical or other cultural amenities.

Plan Implementation Effects on the magnitude, quality, direction, and timing of growth. Analyze, evaluate, and describe, in narrative and graphic form, how the proposals in the plans are expected to influence land use and growth in the stream corridor planning area, and describe how the proposed stream corridor management unit relates to various plans. For example, show, on a map overlay scaled to the stream corridor planning area base maps, how various land use planning activities and implementation strategies, such as zoning and other land use controls and infrastructure investment (e.g., water supply, transportation, sewers) will influence and direct growth, including timing, density, and magnitude. Questions to be answered include:

— Are emerging and potential growth and land use patterns in accord with stream corridor management goals and objectives?

— Do land use plans and implementation mechanisms, including zoning and other controls, provide adequate protection of environmentally critical areas within a stream corridor planning area such as: flood plains, wetlands, significant wildlife habitats, scenic and historical features, riparian vegetation, and agricultural areas? If not, explain the reasons therefore.

— Are the plans responsive to the physical conditions of the planning area, such as shallow or clay soils, topography, high water table, and poor drainage?

Plan Consistency. To avoid land use conflicts, it is important to ensure that stream corridor management plans are consistent with state, regional, and local plans and their implementation strategies. If they are not, adjustments or modifications to various plans may have to be made. Some existing county and local plans may be out-of-date or inadequate in other ways. Some may not be sensitive to physical or environmental resource conditions.

Land use and related plans that are inconsistent with the goals and objectives of the established stream corridor management planning area, may be updated, revised, or refined by the local agency or other agencies responsible for plan preparation, so as to ensure consistency.

CONSISTENCY WITH DEC STREAM
AND RIVER CONSERVATION PLANS AND PROGRAMS

In order to ensure greater planning consistency, local agencies and organizations are encouraged to contact DEC regional offices (listed on inside of back cover) to discuss stream corridor management goals and objectives, and implementation strategies. Such discussion should be helpful not only for learning about technical assistance which DEC may also be able to provide, but also to avoid potential planning conflicts and to ascertain whether or not permits may be required to implement any segment of the stream corridor management plan (See Chapter 6).

Plan Effectiveness. Indicate whether or not policies and plans and implementation strategies, including state and local land use controls and infrastructure investment, educational programs, incentive programs, etc., are likely to be effective in terms of meeting stream corridor management goals and objectives. Indicate whether or not the performance standards in zoning, subdivision, or site plan review regulations are adequate.

STEP 7: EXAMINE MANAGEMENT OPTIONS

Once the goals and objectives have been formulated, management options for achieving them should be arrayed and examined. The options will range from remedial and preventative land management measures and practices, for addressing existing problems and for preventing new ones from occurring, to opportunities for developing stream corridor resources to their fullest potential. The remaining chapters in this manual are devoted largely to a discussion of stream corridor management opportunities.

STEP 8: PREPARE STREAM CORRIDOR MANAGEMENT PLAN

A stream corridor management plan should be prepared in consultation with interested local, county, and regional agencies and affected property owners and private interest groups. The plan, which should be based on the analysis of information generated under the preceding steps, should:

- Contain a clear description and delineation in narrative and graphic form (maps and photographs) of the significant natural, cultural, and aesthetic resources and features of the stream corridor; existing land and water uses; land ownership; and existing land and water controls and management activities and programs.
- Set forth a detailed plan to address existing or potential issues, problems, and needs which impact, or may impact, resources and features in the stream corridor which are important to protect and preserve. The protection and enhancement of natural resources and cultural features may include the restoration of resources negatively impacted by previous or existing land use and development.
- Set forth land and water management goals and objectives, and specific policies, standards, and management guidelines to implement a definitive, long-range program of protection, enhancement, and compatible public uses.
- Set forth specific regulations, including standards and restrictions, that will govern the use of land and water resources. Standards and restrictions should include, as necessary and appropriate, provisions for forest management; provisions for construction of roads, trails, and bridges; motorized access; and subdivision, principal buildings, and other structures; water quality; refuse disposal; stream improvement; and signs and utilities, etc.
- Provide for the continuing involvement of the affected and interested public in the development, implementation, and administration of the plan.
- Contain a fiscal element which identifies funding sources and schedule for plan implementation.

STEP 9: IMPLEMENTATION AND FEEDBACK

It is during this step that stream management plans are implemented. As a function of this phase, implementation activities should be evaluated on an ongoing basis to identify program success and shortfalls. As program deficiencies become apparent, new strategies can be developed to achieve goals and objectives.

CHAPTER 5: STREAM CONSERVATION OPTIONS AND CHOICES FOR LOCAL GOVERNMENT

The purpose of this chapter is to discuss the opportunities available to local government through policy development, education, land acquisition, land use controls, floodplain regulations, tax incentives, governmental aid programs, and other options for protecting, conserving, and enhancing their streams and stream corridor resources.

STREAM CORRIDOR MANAGEMENT OPTIONS

- Policy Development
- Information and Education
- Land Acquisition
- Land Use Controls
- Tax Incentives
- Governmental Aid Programs
- Special Improvement Districts
- Watershed Rules and Regulations
- Wild, Scenic, and Recreational Rivers Program

POLICY DEVELOPMENT:

Counties, towns, cities, and villages can have a positive influence on streams and stream corridors within their political jurisdiction through the adoption of policies to guide the activities and actions of local program administrators. Stream conservation policy directives adopted by a local legislative body can be of particular significance in the following program areas:

Highway Construction and Maintenance

Local policies can be adopted which direct highway supervisors to adhere to and implement various stream conservation practices during highway planning, construction, and maintenance operations. Contractual arrangements for highway construction also can include requirements for taking proper safeguards and implementing proper "best management practices" (BMPs) during and following construction activities.

Stream conservation practices and measures (BMPs) are contained in Chapter 6 of this manual. These range from providing guidance to properly locating stream crossings and proper culvert installation techniques to locating areas for properly disposing of spoil material from a stream channel clearing operation.

Additional site-specific guidance on the selection and design of appropriate management practices, for example seeding mixtures for road bank stabilization, may be obtained from County Soil and Water Conservation Districts. County highway department engineers also can provide substantial guidance on site-specific measures for protecting streams from highway construction and maintenance activities.

Building Inspection and Zoning Enforcement

Building inspectors and zoning enforcement officials have significant influence over the manner in which development proceeds in a community, particularly in terms of guiding the behavior of developers. Through development of policies, local legislators can direct inspectors and zoning officials to assist community efforts to achieve stream corridor conservation goals and objectives. Policy development in this regard can occur essentially in the following three areas:

- Designated Priority Area — Building inspectors can be advised through a policy memorandum that the legislative body considers streams and stream corridors to be of special significance to the community and, as such, building inspectors and zoning officers are to give priority attention to projects within a stream corridor. They can direct inspectors to ensure that developers are in close compliance with local zoning laws designed to protect stream corridors and they can insist that such laws be rigorously enforced. Local boards also can direct inspectors and zoning officers to work closely with developers to ensure that appropriate BMPs (many of which are contained in Chapter 6) are implemented as needed.
- Training — A local legislative body may adopt a policy which seeks to ensure that building inspectors and zoning officers receive the proper training to perform their tasks. A block of time in a training program could be devoted to stream corridor management. Regional and county planning agencies have the potential to structure such a training program for communities within their jurisdiction.
- Increased Staffing — A local legislative board may find it necessary and desirable, particularly in rapidly expanding communities, to expand the staff of building inspectors to assist in the administration of a variety of regulatory activities including those related to stream corridor management.

Mobilize Service Organizations

Local officials can mobilize the resources of community service organizations by encouraging their participation in stream corridor conservation projects, such as litter removal and tree planting along stream banks. For example, boy and girl scouts, youth groups, and other organizations have been extremely effective in tree planting projects and removing litter from streams. Inmates from many state and county correctional facilities often are available for community projects such as streambank fencing and tree planting.

Implementing the State Environmental Quality Review Act (SEQRA)

On November 1, 1978, local governments became responsible for implementing SEQR (Article 8 of the New York State Environmental Conservation Law). Local officials can adopt policies and procedures to ensure full implementation of SEQR as mandated.

SEQR applies to the following local (and state) actions:

- **projects** affecting the environment that:
  - — are directly undertaken by an agency
  - — are funded by an agency, or
  - — require one or more permits or approvals from an agency
- **planning activities** that affect future choices
- the making of **rules, regulations, procedures, or policies**
- any combination of the above.

Under the Act, local agencies include: any local board, agency, authority, district, commission, or governing body, including any city, county, or other political subdivision of the state.

SEQR is of particular significance to stream corridor management as it creates a process by which decision-makers can identify, measure, and interpret the potential impacts of a proposed action at the earliest possible time in the planning of a project, communicate this information to others, and utilize this information in making their decisions. The law emphasizes the importance of protecting the natural environment and requires environmental factors to be considered along with social and economic considerations when decisions are being made. Table 12 provides criteria for determining whether or not a proposed project within a stream corridor is of environmental significance. Additional guidance on implementing SEQR may be obtained from Regional Offices of the Department of Environmental Conservation listed inside the back cover.

TABLE 12

CRITERIA FOR DETERMINING ENVIRONMENTAL SIGNIFICANCE

This list is designed to aid lead agencies in determining whether impacts which may be expected to result from a proposed action will have a significant effect on the environment. It should be consulted for Type I and Unlisted Actions. The list is not exhaustive, but these criteria are definite indications of significant environmental effects:

- A substantial adverse change in existing air quality, water quality, or noise levels; a substantial increase in solid waste production; a substantial increase in potential for erosion, flooding, or drainage problems.
- The removal or destruction of large quantities of vegetation or fauna; the substantial interference with the movement of any resident or migratory fish or wildlife species; impacts on a significant habitat area; or substantial adverse effects on a threatened or endangered species of animal or plant or the habitat of such a species.
- The encouraging or attracting of a large number of people to a place or places for more than a few days compared to the number of people who would come to such place absent the action.
- The creation of a material conflict with a community's existing plans or goals as officially approved or adopted.
- The impairment of the character or quality of important historical, archeological, or aesthetic resources or of existing community or neighborhood character.
- A major change in the use of either the quantity or type of energy.
- The creation of a hazard to human health or safety.
- A substantial change in the use or intensity of use of land or other natural resources or in their capacity to support existing uses.
- The creation of a material demand for other actions which would result in one of the above consequences.
- Changes in two or more elements of the environment, no one of which has a significant effect on the environment, but which when taken together result in a substantial adverse impact on the environment.
- Two or more related actions undertaken, funded, or approved by an agency, no one of which has or would have a significant effect on the environment, but which cumulatively meet one or more of the criteria in this section.

Source: Johnson, T.H., **et.al.**, 1979

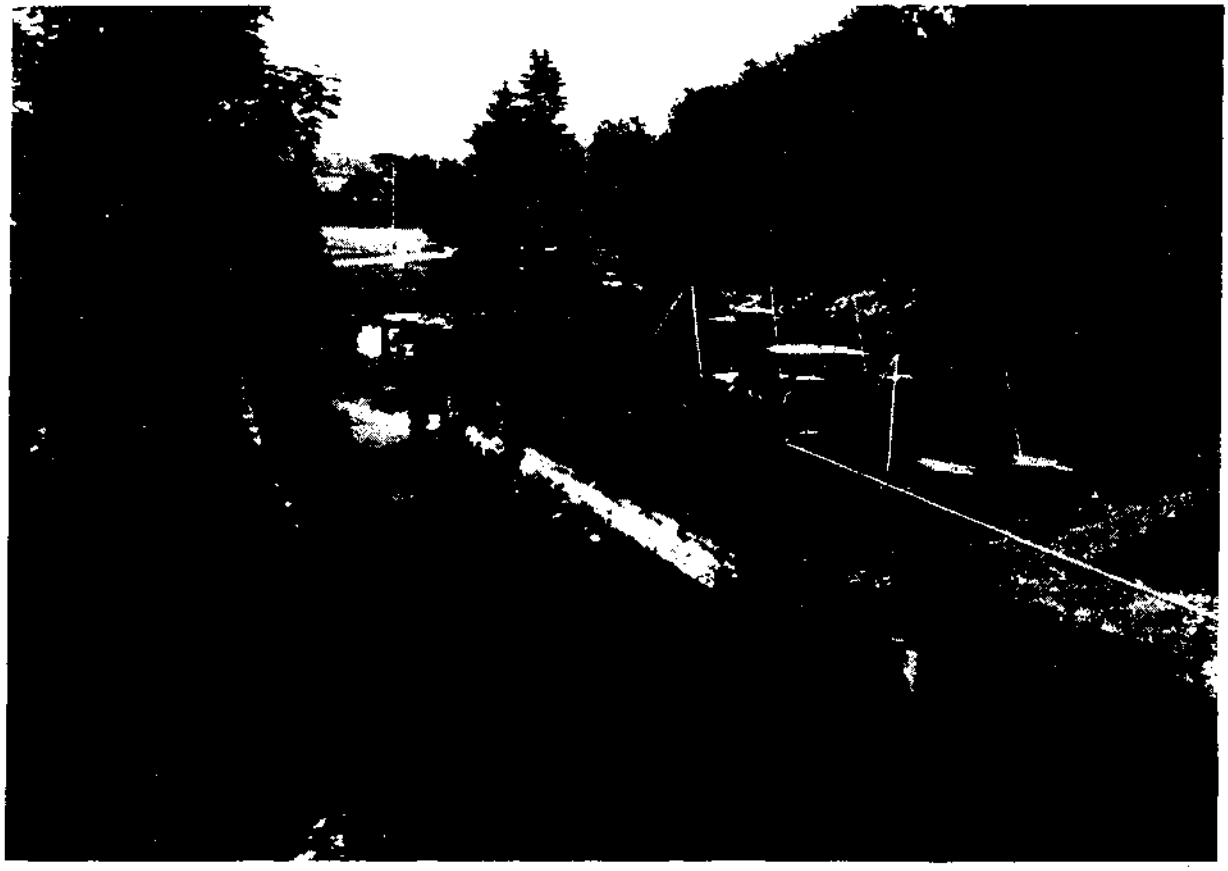
INFORMATION AND EDUCATION

Information and education is an essential element of a stream corridor management program. If such a program is to be successfully implemented, the public will have to be fully informed about such factors as the problems and issues, goals and objectives, and implementation strategies. The information base which is developed in a series of steps for solving the problem (see Chapter 4) will be invaluable for purposes of educating the public about the stream corridor management program.

LAND ACQUISITION

Land acquisition is an important stream corridor management tool which is available to communities for protecting critical environmental areas or for acquiring recreational lands or public access thereto. A variety of land acquisition techniques, including their advantages and limitations, are presented in Table 13. Potential sources of funding for land acquisition, including the Land and Water Conservation Fund and "Return a Gift to Wildlife Fund", are identified in Section F (Governmental Aid Programs) of this chapter.Additionally, Section 247 of the General Municipal Law allows a municipality to acquire land for conservation of natural or scenic resources. The municipality can acquire outright title to the land or some lesser interest, such as an easement or a restrictive covenant.

These boy scouts are pulling debris from Halfway Brook, a stream in the Glens Falls region. (Courtesy: Glens Falls Post Star)



The character of West Winfield, New York, is enhanced by this stream which meanders through its park. Acquisition of stream corridor lands having great potential for recreational development is a major consideration in stream corridor planning and management.

TABLE 13
LAND ACQUISITION TECHNIQUES[1]

METHOD	EXPLANATION	ADVANTAGES	LIMITATIONS	AGENCY OR GROUP LIKELY TO BE INVOLVED
Fee Acquisition				
1. Purchase	Outright acquisition of entire interest to property (may be subject to existing easement(s))	Total ownership of property; management and public use facilitated; best protection afforded	High cost; possibly politically undesirable; possible cultural and community disruption	Local, State, and Federal governments; private trusts
2. Purchase and sellback with restrictions	Fee acquisition with subsequent sale of fee, with restrictions or retention of partial interest	Value of underlying fee established by market; possibly the best method of delineating the specific retained interests desired	Possibly politically undesirable as it may force removal of original landowner; public agency has burden of management until underlying fee resold	Same as above
3. Purchase and leaseback	Fee acquisition with subsequent lease of the property	Productive use and management of the property; income; more control over misuse of property than if only an interest was retained	Public use probably precluded; possibly politically disruptive	Same as above
Purchase and granting of life/term estate or other reservation of use	Fee acquisition but public use of property delayed until termination of a "lease" for specified term or until death of present owner	Smoother, phased transition from private ownership; politically more acceptable	Public use postponed; management of retained interest required	State and Federal governments; private trusts
5. Donation/bargain sales	Acquisition of full or partial interest in property at less than fair market value	Use of public funds maximized; some tax benefits to donor	Limited Federal tax benefits to donor (e.g., maximum tax reduced from 70% to 50%, making charitable contributions less attractive in 1982)	Local, State, and Federal governments; private trusts
6. Right of first refusal	Requirement of present owner to offer property to the government for purchase prior to sale to another private owner; right can either be purchased, legislated, or condemned; right may or may not be exercised	One method of selectively controlling rate of growth; fair market value established by market	Currently unclear how this method may or may not violate public acquisition laws; mechanics for governmental use not fully delineated	State and Federal governments
Partial Interest				
1. Easement	Ownership of portion of the rights included in fee-simple ownership of property such as development, access, and timber rights	Private owner retains fee title and is responsible for management of property; less costly in most cases than fee acquisition; flexible	Cost may nearly equal fair market value of fee-simple in some cases; potentially very limited or no public use of property; possible management problems; limitations on charitable contributions of easements	Local, State, and Federal governments; private trusts
2 Leases	"Rental" of all or portion of property for contractual period	Continued private use and ownership of property; often involves shorter time period to achieve desired use; does not commit public entity to site in perpetuity	Lack of public ownership can limit public expenditures and restricts long-term site planning; annual lease fees	Local, State, and Federal governments
3. Combination of Both Full Fee Purchase and Partial Interest	For example, purchase of full fee on one portion of a site and an easement purchase on the remainder	Allows for creative land uses and a great deal of flexibility in negotiation with landowner	Can involve complex rights and uses; can also be timeconsuming to package land protection scheme	Same as above

1 Source: U.S. Department of Interior, *Draft Environmental Impact Statement for the River Management Plan: Upper Delaware*, (National Scenic and Recreational River/New York–Pennsylvania) National Park Service, Denver. October 1982.

LAND USE CONTROLS

SAMPLE LAND USE CONTROL PROVISIONS
AND PERFORMANCE STANDARDS
APPLICABLE TO STREAM
CORRIDOR MANAGEMENT

Sample land use control provisions and performance standards which can be used in a stream corridor management context are available from the Bureau of Water Resources, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233. The Appendix provides a list of sample provisions available.

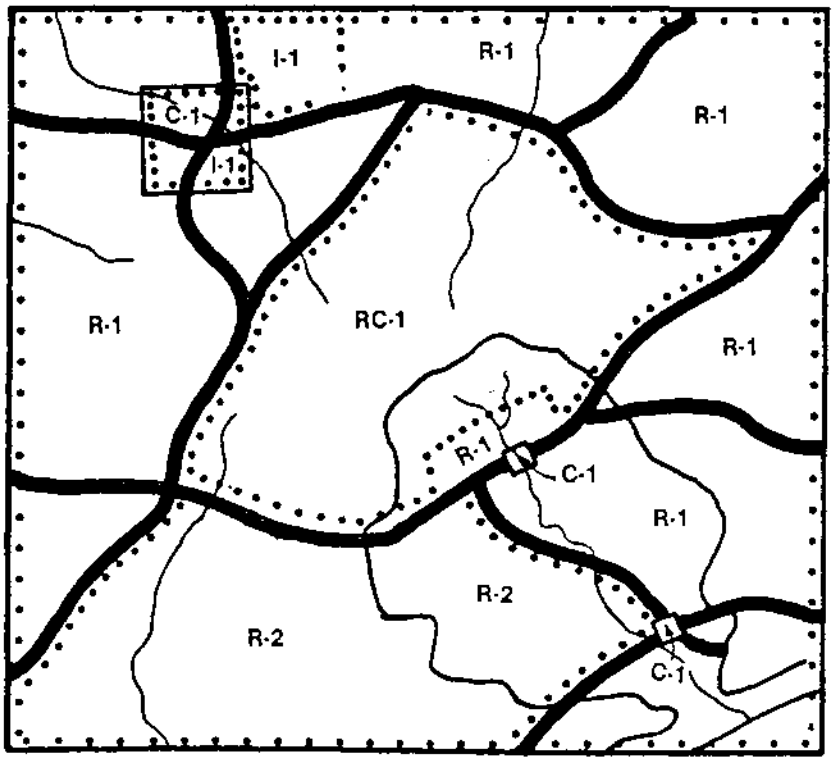
Local government can draw upon a variety of regulatory techniques to control land use activities for the purpose of protecting and enhancing streams and stream corridor resources. The approaches which should find most widespread application are briefly described as follows:

Zoning

Zoning is the most widely used tool for controlling land use and managing community growth which local governments have at their disposal. Basically, zoning entails the division of a community into sections or districts and prescribes what uses can be made of the land therein. Zoning also prescribes the density of development in a community through provisions which establish minimum setback distances, percentage of lot that may be occupied, and minimum lot size which applies to entire districts. Figure 15 is illustrative of a traditional zoning map.

Without the inclusion of provisions which specifically respond to stream conservation needs, zoning as described above may be inadequate to respond to the stream corridor management task for the following reason. Regulatory standards for each land class or zoning district are uniformly applied; therefore, landscape features within a stream corridor are treated the same as land for the entire zoning district. As a result of this uniformity, zoning may not take into consideration such development constraints as steep hillsides, scenic vistas, erosive sites, natural drainage, and many other environmental features. In recognition of this limitation, several variations of zoning have evolved which have specific application to stream corridor planning and management. These include zoning provisions for establishing *stream conservation districts* and *incentive zoning*.

Figure 15. **TRADITIONAL ZONING MAP**

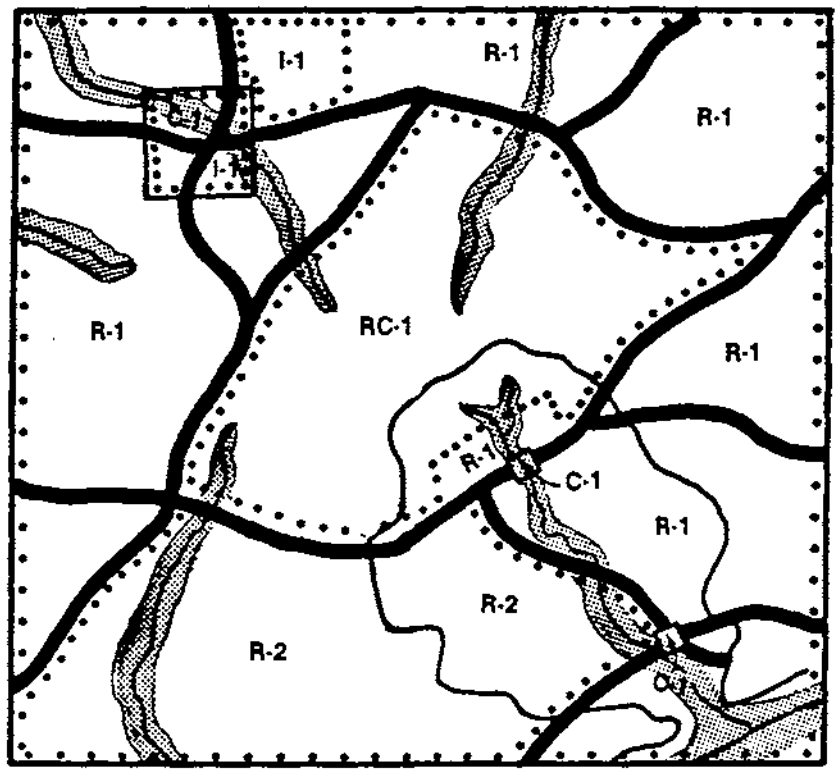


R-1 RESIDENTIAL
R-2 RESIDENTIAL
C-1 COMMERCIAL
I-1 INDUSTRIAL
RC-1 RESOURCE CONSERVATION

ROADS
ZONING DISTRICTS
VILLAGES

Figure 16.

STREAM CONSERVATION OVERLAY DISTRICTS



R-1 RESIDENTIAL
R-2 RESIDENTIAL
C-1 COMMERCIAL
I-1 INDUSTRIAL
RC-1 RESOURCE CONSERVATION

Stream Conservation Districts — Communities can elect to establish stream conservation districts to protect and enhance streams and stream corridors. This can be accomplished through overlay zoning where zoning already exists or through the creation of a special stream conservation district in communities which have not enacted zoning ordinances. Performance standards excerpted from the state Wild, Scenic, and Recreational River (draft) regulations are available from the Department of Environmental Conservation upon request (see Appendix R). These standards may be used directly or tailored for application to a stream conservation district.

Overlay Zoning — Overlay zoning is the basic approach that a community can take to control land use activities within the stream corridor. As applied to stream corridors, overlay zoning delineates a stream conservation district through mapping and superimposes a set of regulations or standards and requirements on existing zoning (see Figure 16). Overlay zoning is particularly suited to stream corridor management where there is a special public interest such as the need for floodplain management, conserving erosive soils on steep hillsides, and protecting historic sites, scenic vistas, or other natural resource features in a geographic area (i.e., the stream corridor) that does not coincide with the underlying zoning boundary (see Appendixes C and R).

No Community-wide Zoning — A community which has not adopted a community-wide zoning ordinance may wish to protect its stream corridor through the adoption and enforcement, by local law, of a special stream conservation district regulation. Such a district would be applicable only to those parts of the community within established stream corridor district boundaries. This approach would re-

quire the local governing body to designate an enforcement officer, for example, the town clerk. Stream conservation district regulations would be required, and an appeals procedure would have to be established. The site plan review process described below could serve as the project review mechanism.

Incentive Zoning — Incentive zoning, or bonus zoning, as it is often referred to, provides another approach to stream corridor management. Essentially, incentive zoning provides for a trading arrangement between the community and the property owner. In exchange for the developer providing something that the community feels is in its interest, for example, the protection of a stream corridor, more open space, and the use of cluster development designs rather than conventional lot-by-lot development, the developer is given a bonus. The bonus usually is permission to build at greater density, for example more floor area or more dwelling units. A common use of incentive zoning is found in Planned Unit Development Regulations described in a later section of this chapter (see Appendix F).

Subdivision Regulations

Subdivision regulations are a tool to fashion development in defined ways and by prescribed methods so as to regulate the use of private land in the public interest. Within recent years, the exercise of subdivision regulation has become increasingly broadened by incursions into the area of timing of development, wetlands and floodplain protection, reservation of land for recreational use and other purposes and mandatory dedications of open space, and for protection against environmental degradation.

Viewed in this context, the relationship between stream corridor management and subdivision regulation should be obvious. A prime example is the ability and necessity to control development in areas where the replacement of the natural vegetation and undisturbed soil — which would normally absorb stormwater runoff — by artificial concrete, asphalt, and steel construction would lead to increased problems of flooding (see Figure 17).

The state's planning laws permit cities, villages, and towns (and in certain cases, counties and regional planning boards, if authorized by the counties) to review subdivisions to ensure that good subdivision design is obtained through compliance with established standards of performance. Communities with or without zoning may enact subdivision regulations.

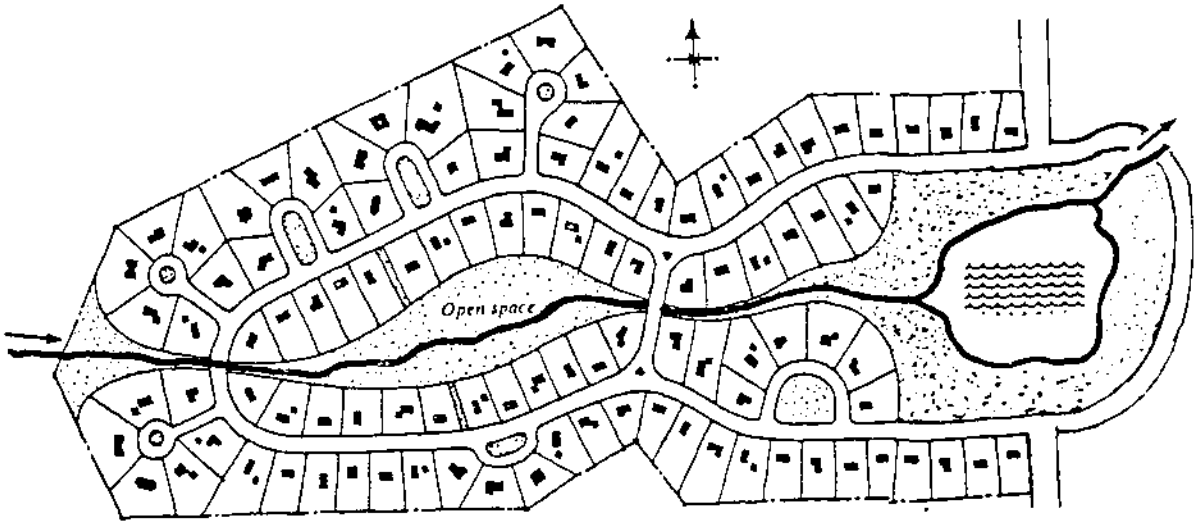


Figure 17. Subdivision Configuration. A well maintained stream can serve as a focal point to a subdivision. (Adopted from "Control of Land Subdivision", 1974)

Other Regulatory Techniques

Several other regulatory techniques, which have evolved out of zoning and the regulation of subdivisions, are applicable to stream corridor management. These include: cluster zoning, planned unit development (PUD), transfer of development rights (TDR), and site plan review.

Cluster Zoning — Cluster zoning is a means to permit the transfer of density, in conjunction with the approval of a subdivision plat, from a preset standard by grouping or concentrating the building units on a reduced area of land. For example, if a given tract of land of 100 acres is zoned in such a way that 100 dwellings could be built on individual lots of one acre apiece, cluster development would permit these 100 dwellings to be grouped on, say, twenty acres, while the 80 acres remaining could be devoted to open space preservation.

The clustering concept provides community officials with an opportunity for negotiating with the developer over the location and density of clustering on developable portions of the tract so as to leave natural areas, the stream corridor, for example, and areas more difficult to develop virtually unobstructed.

It is important to note, however, that unless provisions are contained in the zoning ordinance for incentive zoning or planned unit development (PUD), state enabling legislation for cluster development does not permit a violation of the overall density ceiling otherwise applicable for the particular tract under the zoning ordinance.* Thus if the land could be used for 100 homes on one-acre plots, the clustered development on the same tract could not exceed 100 homes (see cluster zoning example in Figure 18).

Planned Unit Development (PUD) — A PUD is a diversified development project which does not fit the standard zoning regulations of a municipality and which is built as a "planned unit". This feature permits variation in many of the traditional controls related to density, land use, setbacks, open space, and other design elements. It differs from the cluster development concept in that it is easily amenable to any mixture of uses and is not subject to any of the underlying zoning for the land involved. For example, a single PUD permits: flexibility in site design that allows buildings to be clustered; mixtures of housing types such as detached houses, townhouses, or garden apartments; combining housing with such other ancillary uses as neighborhood shopping centers; better design and arrangement of open space — including the protection and preservation of streams and the stream corridor; and retention of such natural features as flood plains, steep slopes, or wetlands (Meshenberg, J., 1976).

PUD regulations typically are included within the district regulations of the zoning ordinance, i.e., the use requirements, development standards, and procedures are spelled out in the ordinance text (see Appendix E).

Transfer of Development Rights (TDR) — The "transfer of development rights" permits all or part of the density potential (established in the zoning ordinance) of one tract of land to be transferred to a noncontiguous parcel or even to land owned by someone else. The development rights become a separate article of property, which can be sold to a landowner whose property is better suited to greater densities of development. After selling the development rights, a landowner still retains title and all other rights to the land. These other rights permit farming, forestry, some recreational uses, and other nonintensive uses such as stream corridor conservation, open space preservation, and preservation of buildings or neighborhoods of historical or architectural significance (see Appendix H).

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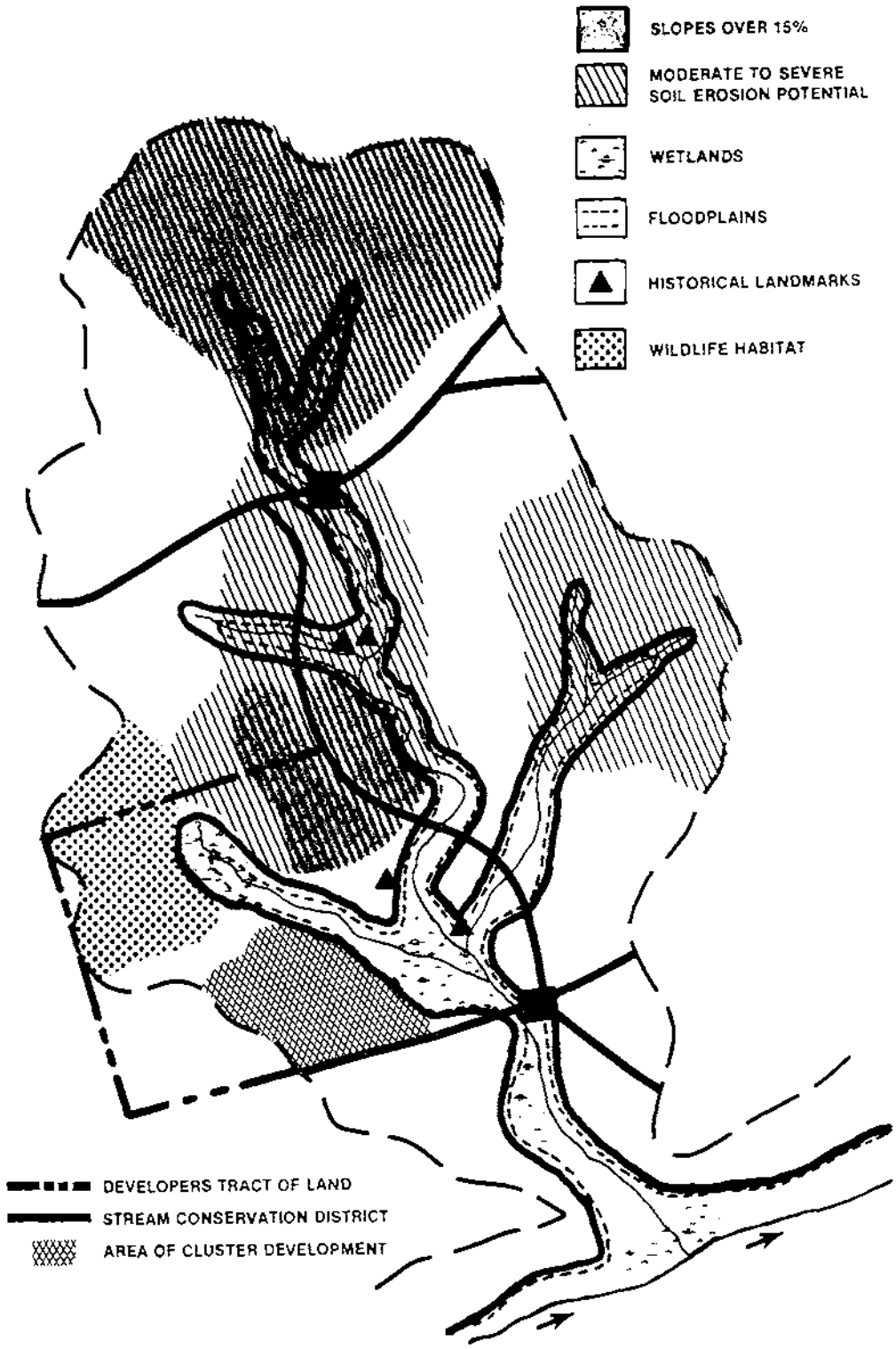
* The enabling statutes permitting clustering are in General City Law §37, Village Law §7-738, and Town Law §251.



EXAMPLE: Cluster zoning concept on a 100 acre tract of land

Assume—tract contains 24 acres in stream conservation district zoned at 1 unit per 4 acres for a total of 6 allowable units

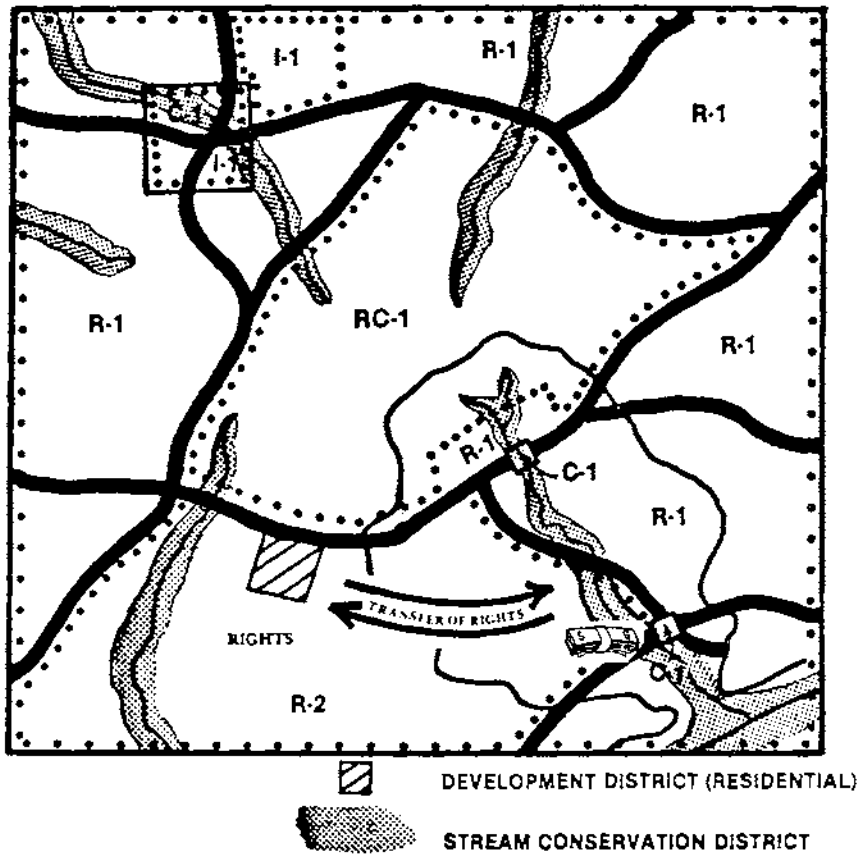
—the remainder of the tract-76 acres-consists of open space, forest and agricultural land having a zoning density of 1 unit per acre (76 acre parcel-76 units)

Cluster Development—cluster zoning provisions seek to encourage efficient development in areas having few environmental constraints to development. In this example, the total number of units permitted through clustering is 6 + 76 = 82.

Figure 18 Cluster Zoning

There are several significant benefits of TDR: it permits preservation of lands where further development is undesirable for a variety of reasons; it compensates the owner of preserved land financially by allowing him to sell his unused development rights; it reduces the impact that the exercise of the community's police power can have on property owners; it provides a reasonable economic return to landowners selling development rights; it involves minimal loss of revenue to the community in that the total economic base does not change and tax revenues remain at the same level — on the one hand the owner who sells his unused development rights also reduces the assessed value of his land and so lowers his taxes; on the other hand, the landowner who purchases the development rights increases the assessed use value of the land and so pays higher taxes. Finally, there is no loss of new development to the community. Figure 19 illustrates how TDR works (NYS Zoning Technical Series, 1981).

Figure 19. **TRANSFER OF DEVELOPMENT RIGHTS**



R-1 RESIDENTIAL
R-2 RESIDENTIAL
C-1 COMMERCIAL
I-1 INDUSTRIAL
RC-1 RESOURCE CONSERVATION

EXAMPLE: Transfer development rights from 100 acres of land in stream conservation district

Assume—zoning density of stream conservation district is 1 unit per 4 acres (100 acre parcel-25 units)

—zoning density of development district is 1 unit per acre (100 acre parcel-100 units)

Transfer of rights—stream conservation district after transfer of development rights at fair market value is 0 units

—the right to develop an additional 25 units transferred to development district for a total of 125 units

Site Plan Review — Site plan review is a process that can be used by decision-makers in communities with or without zoning to evaluate the potential impact that a land development proposal has on a community. Such a review focuses attention on a site development plan. Site development plans have two functions:

(1) they illustrate the intended design, arrangement, and uses of the land to be developed

(2) they describe the proposal's physical, social, and economic effects on the community

Site plan reviews can include both small and large scale proposals ranging from gas stations, drive-in facilities, and offices to complex ones such as multifamily housing, shopping centers, and planned unit developments. Within the sites, the prime concerns might include, among other factors, minimizing ecological disturbances, management of stormwater runoff, and preservation of open space and historic and cultural features in the stream corridor.

The site plan review process may be conducted over the following three phases:

(1) Presubmission Phase — which provides an opportunity for the community to learn of the developer's intent and for the developer to learn of the community's requirements and standards for development

(2) Preliminary Site Development Plan Phase — which includes the submission of an application for preliminary site development plan approval for a developer. The application should be accompanied by information about the proposal including legal data, impact on the environment, natural features, existing development and infrastructure, and site development proposal. Because it is a preliminary action and not final, board action on the proposal should be given as tentative approval with modifications or disapproval.

(3) Final Site Development Plan Phase — If approval or approval with modification is tentatively given in the preliminary site development phase, the next step will be submission of a final application, including the necessary documentation for final approval. In this case, the requested modification should be satisfied in the final application (NYS Zoning Technical Series, 1979)

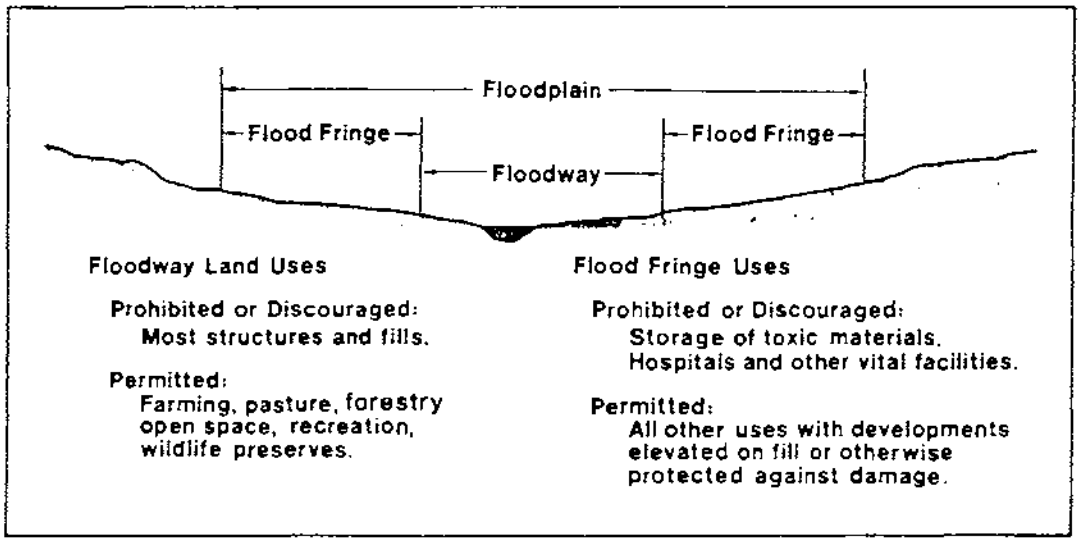
Floodplain Regulations

Floodplain regulation is a form of overlay zoning which designates flood-prone areas and limits their uses to those compatible with the degree of risk. It serves several purposes including:

- preventing new development in flood-prone areas that could result in loss of life and excessive damage to property, or reducing the potential for such losses and damages
- protecting unwary buyers from purchasing land or homes in flood-prone areas
- preventing encroachments that decrease the flood-carrying capacity of flood plains, increase flood heights, or otherwise aggravate flood problems
- reducing need for future expenditures for construction, operation, and maintenance of reservoirs, levees, and other flood control measures
- preserving natural floodplain values, including water quality (U.S. Water Resources Council, 1981).

Figure 20 contains a cross-sectional diagram of a floodplain and shows how floodplain regulations can be employed to limit uses in an area to those which are consistent with the flood hazard.

Local governmental jurisdictions, including towns, cities, and villages, must adopt floodplain regulations to enable landowners to obtain flood insurance. Model floodplain regulations which satisfy the eligibility requirements of the federally sponsored flood insurance program are available upon request from the Bureau of Flood Protection, Room 422, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233. Over 95 percent of all communities in New York State have adopted floodplain regulations. Flood plain development permits are



Source: U. S. Water Resources Council, 1981

Figure 20. Land Use Considerations in Floodway and Flood Fringe Areas

managed by the Department of Environmental Conservation in those areas where local government is not administering the program. Permit applicants should contact the appropriate regional office listed on the inside back cover of this manual for DEC administered flood plains.

Single Purpose Ordinances

Towns, cities, and villages having no zoning may adopt single purpose ordinances to control off-site damages to streams from construction and related development activities. For example, communities may adopt an erosion and sediment control ordinance or a stormwater management ordinance (or a combination thereof) to protect streams and lakes from sedimentation, nutrient loading, and other nonpoint source contaminants, and from stormwater runoff in urbanizing areas. Model local erosion and sediment control ordinances and sample laws for controlling stormwater runoff may be obtained from the Bureau of Water Resources, Room 328, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233 (see Appendix). Communities in which zoning already exists need only extract the relevant provisions, from the model local laws referred to above, and incorporate them into the appropriate sections of their zoning ordinance.

TAX INCENTIVES

Tax incentives may be offered by local government to riparian landowners to protect and enhance stream corridors. A locally administered tax incentive program may appear in the form of:

1. Tax Exemptions. Tax exemptions can be offered to landowners who retain land for public benefit such as a scenic vista in a stream corridor, historic places, public access areas, or other similar public uses in a stream corridor.
2. Preferential Assessment. Under this approach, land may be assessed at current open space values so as to remove tax pressure on owners to sell at a speculative price for profit.
3. New York's Agricultural Districts Law and Forest Tax Law can provide tax incentives to motivate landowners to retain farmland and forest land in an undeveloped condition.

The above approaches to providing tax incentives normally have the following feature in common: often a lower artificial assessment is levied on the property to achieve a jurisdictions long-term land use goal for a given area until the land is subjected to an undesired use, at which time a tax pay-back penalty clause is invoked. The major advantage of a tax incentive approach is that it assists those landowners who desire to retain the present land use but cannot because of increasing tax burdens. On the other hand, long-term protection goals may not be met unless the land is retained in the desired use in perpetuity.

GOVERNMENTAL AID PROGRAM

Planning, technical, and funding assistance to implement an effective stream conservation program is potentially available to local government from various federal, state, and county agencies. For example, many projects which have benefitted streams have been partially funded through Land and Water Conservation Grants, and various Soil Conservation Service Programs. The Agricultural Conservation Program of the Agricultural Stabilization and Conservation Service provides funding assistance to private landowners to implement various agricultural practices.

Some key agencies and the type of assistance they provide are identified in Table 14. There are numerous federal, state, and local laws, programs, and activities which are directly applicable to the protection and management of resources and land use

TABLE 14
AGENCIES AND ASSISTANCE OFFERED

Agency	Program	Type of Assistance	Address of Assisting Agency
Federal			
1. Department of Housing and Urban Development	— Community Planning and Development (cities having a population over 50,000)	— Funding (Construction Grants)	— U.S. Department of Housing and Urban Development, Community Planning and Development Division, 107 Delaware Avenue, Buffalo, New York 14202
	— Urban Development Action Grant	— Funding (Construction Grants	
2. Department of Interior	— State and Local River Conservation Program	— Technical Assistance	— National Park Service — Office of Recreational Programs
	— Land and Water Conservation Grant	— Funding (Land Acquisition)	— National Park Service — Office of Recreational Programs
	— Historic Preservation Grants-In-Aid	— Funding (Property Acquisition and Building Rehabilitation)	— Office of Cultural Programs Mid-Atlantic Region, 143 S. 3rd St., Philadelphia, PA 19106
3. Soil Conservation Service	— Soil and Water Conservation Program	— Conservation Planning and Technical Assistance	— Contact County Soil and Water Conservation Districts
	— Resource Conservation and Development	— Funding and Technical Assistance (Construction Cost Sharing)	
	— PL 566 (Flood and Erosion Control)	— Funding (Construction Cost Sharing)	
4. Agricultural Stabilization and Conservation Service (ASCS)	— Agricultural Conservation Program	— Funding assistance to private landowners for erosion control and other land treatment measures	— Consult County Soil and Water Conservation District or Local Telephone Directory
State			
5. Office of Parks, Recreation, and Historic Preservation	— Environmental Quality Bond Act of 1972	— Funding (Land Acquisition)	— New York State Office of Parks, Recreation, and Historic Preservation: Nelson A. Rockefeller Empire State Plaza; Agency Bldg. #1; Albany, NY 12238
6. Department of State	— Small Cities Program	— Funding (Construction Grants)	— New York State Department of State, 162 Washington Avenue, Albany, NY 12231

TABLE 14
AGENCIES AND ASSISTANCE OFFERED

Agency	Program	Type of Assistance	Address of Assisting Agency
7. Department of Environmental Conservation	— Stream Conservation/Non-point Source Planning — Local Community Assistance Program	— Funding (Planning Grants)	— Office of Community Affairs/Division of Water, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, NY 12233
Regional/County			
8. Regional Planning Board	— Local Planning Assistance and Regional Coordination	— Planning and Technical	— Refer to NYS Environmental Conservation Directory
9. County Planning Department	— Local Planning Assistance and County-wide Coordination	— Planning and Technical	— Refer to NYS Environmental Conservation Directory or Local Telephone Directory
10. County Soil and Water Conservation Districts	— Technical Assistance Program	— Planning and Technical	— Refer to NYS Environmental Conservation Directory or Local Telephone Directory

within the stream corridor. It is important for those who have initiated a stream corridor management planning process to become well-informed about all such laws and programs so as to take full advantage of the legal authority and financial or technical assistance that is available for the task at hand. A full partnership should be developed with those agencies and organizations, at all levels of government and in the private sector, that have an ongoing or potential role to play.

Funding assistance usually is the most difficult type of assistance to obtain. Often there is considerable competition among communities for such assistance. Because of competition, funding agencies generally establish priorities as a basis for funding. Therefore, as a general rule, communities seeking funding assistance for a stream conservation program should design projects to produce a multiplicity of benefits as a way of promoting the proposal. Two sources of information, the Funding Resources Center and a "Guide to Resources", are available for identifying sources of funding which might potentially be used for stream corridor management purposes.

FUNDING RESOURCE CENTER

The Economic Development Unit within the Division of Community Affairs, NYS Department of State, 162 Washington Avenue, Albany, New York 12231 has computer capability to assist local agencies in identifying potential sources of funding that can be used for stream conservation and management purposes. This is a very important service which local government should take every opportunity to utilize, not only for stream conservation projects, but for other community development projects as well.

also:
A STEP-BY-STEP
GUIDE TO RESOURCES
FOR ECONOMIC DEVELOPMENT
2ND EDITION
STATE OF NEW YORK
DEPARTMENT OF STATE
DIVISION OF COMMUNITY AFFAIRS
162 WASHINGTON AVENUE
ALBANY, NEW YORK 12231

SPECIAL IMPROVEMENT DISTRICTS

A special improvement district, for example a park district which has a stream corridor as its focal point, may be established. Under a special improvement district, taxes can be levied to finance park operation and maintenance requirements. Currently, there are over 100 park districts in the state.

WATERSHED RULES AND REGULATIONS

Many communities protect their water supplies with watershed rules and regulations. These regulations, which are enacted through the New York State Department of Health, usually contain setbacks and other standards for salt storage, pesticide use, sewage discharges, solid waste disposal, and the storage and handling of toxic chemicals. Watershed regulations carry the weight of State regulations, and they may extend across municipal boundaries if necessary.

Any community with a municipal water supply may prepare these regulations. Model regulations are available from the Health Department and technical assistance is usually available from state health engineers or from county officials where county health departments exist. Once a municipality completes a draft of the regulations, it is submitted to the Health Department for approval and promulgation. Legal notices are subsequently published in local newspapers and public hearings are held when necessary. When approved by the Health Department, the regulations are filed with the Secretary of State and become enforceable standards for protecting the community's water supply.

The municipality must then appoint an official who is responsible for watershed inspections, serving notice to violators and reporting noncompliance to the Health Department. The Health Department in turn, investigates reports and may direct the local board of health to enforce compliance or take direct enforcement action.

> Today most surface water supplies serving over 5,000 people and all supplies serving over 10,000 people are protected by Watershed Rules and Regulations.

Watershed rules and regulations can be used effectively to protect water supplies from chemicals which may be spilled or leaked from bulk storage facilities. Unfortunately, most existing rules and regulations were passed prior to our knowledge of trace concentrations of chemicals in water supplies and do not adequately protect waters from contamination caused by poor bulk storage practices. A recent review of such regulations found that most of the rules and regulations now in use are archaic. They are concerned solely with human and animal waste disposal practices and use language of decades past. Only the rules and regulations enacted or revised since 1970 address current environmental concerns. The greatest threats to water supply today besides sewage disposal are synthetic or organic chemicals, radioactive materials, heavy metals, chlorides, nutrients, sediment and petroleum products.

Watershed regulations provide municipalities in New York State with an excellent means of protecting water supplies. However, the regulations must contain provisions which address the storage of petroleum and other hazardous chemicals. Those communities with watershed rules and regulations should be sure that they include controls over bulk storage facilities. Communities without rules and regulations should consider the benefits of using them. Guidance for establishing watershed rules and regulations may be obtained from State or County Health Department offices.

NEW YORK STATE'S WILD, SCENIC, AND RECREATIONAL RIVERS PROGRAM

One of the most important State programs to protect and enhance rivers and streams and their corridors, was established in 1972 through the enactment of the State Wild, Scenic, and Recreational River Systems Act (Environmental Conservation

Law S15-2701). This law encourages maximum local initiative in the development, implementation, and administration of river conservation studies and plans. It also provides fundamental regulatory protection for rivers that are designated in the system.

Communities may find the state's Wild, Scenic, and Recreational Rivers Program to be an attractive option for protecting and enhancing a stream or river corridor. The Wild, Scenic, and Recreational River Systems Act is designed to protect, preserve, and enhance significant rivers (and streams) throughout the state, including the important natural and cultural resources that are associated with shoreland environs of such rivers. Rivers are designated into the Wild, Scenic, and Recreational River System by act of the legislature, after an eligibility study has been completed.

In order to give detailed attention to the natural and cultural resources and land use conditions that are unique to the corridor of each designated river (or stream), a management plan should be prepared after designation. This plan may be prepared locally, in cooperation with the Department of Environmental Conservation (or the Adirondack Park Agency for rivers and streams on private land within the Park). The resources and land use management recommendations that are set forth in the plan then provide the basis for future local and state decisions and actions. The plan, therefore, must be adopted by DEC (or APA) as well as by affected local governments.

At the local level, the river corridor plan usually will be incorporated as a detailed element in the local comprehensive plan, to be implemented, in part, through local subdivision and zoning ordinances. When this is done, state protective responsibilities for designated rivers may be delegated to local government, specifically in the area of land use regulation.

The cooperative intergovernmental approach that is embodied in the state Wild, Scenic, and Recreational River System Act ensures that a reasonable negotiation process is set in motion whereby firm and lasting agreements can be reached by all interested parties on the means for achieving conservation and development objectives.

If a river is designated in the system, the law requires that actions of all State agencies must be consistent with its river conservation objectives. This is a major benefit of designation. For example, State-sponsored projects may be precluded from being located within a designated river corridor. Designation also means that the river will be maintained in its present natural free-flowing condition. No new dams may be constructed and no new diversions of water will be allowed. Water quality must be maintained or improved. The present natural, scenic, historic qualities of the landscape will be protected and land uses that are compatible with the purpose of the Act will be continued and encouraged.

Framework provisions of the act together with the regulations and standards of performance for rivers (or streams) designated either "wild", "scenic", or "recreational" are available upon request (see Appendix P).

CHAPTER 6: BEST MANAGEMENT PRACTICES

A GOAL OF STREAM CORRIDOR MANAGEMENT IS TO REHABILITATE DAMAGED STREAM SYSTEMS AND AQUATIC RESOURCES THROUGH THE APPLICATION OF REMEDIAL PRACTICES AND MEASURES. PREVENTIVE MEASURES SHOULD BE USED CONCURRENTLY WITH THE APPLICATION OF REMEDIAL PRACTICES TO ENSURE THAT REOCCURRENCE OF THE PROBLEM CAN BE AVOIDED.

Many preventive and remedial land conservation practices, commonly referred to as "best management practices" (BMPs), can be used to protect and conserve streams and other water bodies through the control of nonpoint sources of pollution. The purpose of this chapter is to identify and briefly describe BMPs commonly employed to control nonpoint source contaminants normally associated with construction, urbanization, mining, timber harvest operations and agriculture. The BMPs described are arranged and organized according to various nonpoint source controls which can be implemented to correct existing problems or prevent stream and associated water resource problems from occurring through improper land use. Table 15 identifies the range of BMPs which will be discussed, and it provides an indication of their relative effectiveness for controlling nonpoint source contaminants.

BMPS FOR MINIMIZING DISTURBANCES TO STREAMS[1]

THE SINGLE MOST IMPORTANT MEASURE THAT CAN BE TAKEN TO PROTECT A STREAM IS TO AVOID DISTURBING IT.

The above statement notwithstanding, it is recognized that various public and private land use activities necessarily require the construction of bridges, installation of culverts, realignment of stream channels, and other modifications to streams. Unless proper precautions are taken, each of these activities can result in physical damage to the stream and to the biotic community therein. For example, if a culvert is installed improperly, it may serve as a barrier to fish migration through increased stream velocity, shallow water, or lack of an effective "jump pool." Improper installation of a culvert also may contribute to streambank erosion through improper placement in the stream channel, and, if undersized, a culvert may contribute to upstream flooding. Whether the modifications are derived from agricultural, forestry, mining, or construction activities, there are six categories of best management practices that can be adopted to minimize stream disturbances or to enhance streams. These include BMPs for crossing streams, culvert and bridge installation, stream channelization, dredging and gravel removal, protecting fisheries cover and shelter, and protecting streambanks.

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[1] Source: NYS Conservation Department, "Suggested Measures for Minimizing Damage to Fishing Streams from Highway Projects", 1964; NYS Department of Environmental Conservation, "Timber Harvest Guidelines", 1981; and "Guides for Controlling Soil Erosion and Water Pollution on Logging Jobs in Vermont" (undated).

PERMITS FOR PROTECTING
NEW YORK STATE'S WATERS

All parties are alerted to the legal requirements affecting *protected streams*. Individuals wishing to undertake work that could disturb a protected stream are required to obtain a Protection of Waters Permit (Article 15) from their Regional Office of the Department of Environmental Conservation (see inside back cover of this manual for address and telephone number). The Regional Office can tell you if the stream segment to be affected is on the protected list. The Regional Office also can advise you whether or not other permits may be required, for example, Article 24 — Freshwater Wetlands permits; Article 25 — Tidal Wetlands permits; Article 36 — Floodplain permits (whether administered by local government or DEC); as well as possible requirements for work proposed along a stream or river protected under the Wild, Scenic and Recreational Rivers Act. The Regional DEC Office will advise you of Section 404 and Section 10 federal permits which might be required. By becoming a "party-in-interest", the public has the opportunity to review and comment, and thus to influence the issuance of permits under the above programs.

TABLE 15

BEST MANAGEMENT PRACTICES AND THEIR RELATIVE EFFECTIVENESS FOR CONTROLLING NONPOINT SOURCE POLLUTANTS

	NonPoint Source Pollutants					
Best Management Practices	Sediment	Thermal[1] Energy	Nutrients[2]	Toxic and Hazardous Substances[3]	Pathogens	Hydrologic Modifications[4]
BMPs for Minimizing Disturbances to Streams						
Stream Crossing BMPs	●		•			●
Proper crossing location						
Approaches to crossing						
Crossing only at right angles						
BMPs for Culvert and Bridge Installation	●		•	•		●
Utilize natural streambed						
Concentrate streamflows						
Culvert and bridge size						
Installing multibarrel culverts						
Stabilizing disturbed streambanks						
Stream Channelization BMPs	●		•			●
Concentrating stream flow						
Bank stabilization						
Mitigating damage to fisheries habitat						
BMPs for Dredging and Gravel Removal		●				•

1 Direct solar penetration through removal of riparian venegation
2 Includes nitrate and nitrite nitrogen and available soluable phosphate
3 Includes metals, pesticides, herbicides, PCBs, greases, and oil substances
4 Although not a nonpoint source pollutant in itself, the modification of the hydrology of a watershed may increase the rates of stormwater runoff and lead to flooding, and erosion and sedimentation. The BMPs in this table are intended to offset or otherwise minimize hydrologic modifications.

LEGEND: ● = More Effective • = Less Effective

TABLE 15 (Cont'd)

BEST MANAGEMENT PRACTICES AND THEIR RELATIVE EFFECTIVENESS FOR CONTROLLING NONPOINT SOURCE

	NonPoint Source Pollutants					
Best Management Practices	Sediment	Thermal[1] Energy	Nutrients[2]	Toxic and Hazardous Substances[3]	Pathogens	Hydrologic Modifications[4]
BMPs for "snagging" and Channel Clearing	●	●				●
Practices for Snagging						
Log jam removal						
Removal of other logs						
Protecting riparian vegetation						
Equipment for snagging and log removal						
Log disposal Practices						
Practices for Channel Clearing						
Small debris accumulation						
Removal of sediments and soil						
Disposal of spoil material						
BMPs for Protecting Stream Banks and Enhancing Fisheries Habit	●	●	•			•
Buffer strips or greenbelts						
Streambank fencing						
BMPs for Control of Stormwater Runoff	●		●	•	•	●
Diversion Terraces						
Grassed waterways or outlet channels						
Stormwater detention basins (ponds)						
Parking lot storage						
Rooftop detention						
Rooftop runoff disposal						
Cistern storage						
Infiltration pits and trenches						
Concrete grid and modular pavement						
Porous asphalt pavement						
Stormwater conveyance system storage						
Fluidic flow regulators						
Treatment of stormwater						
BMPs for Pollution Source Control			●	●	●	
Fertilizer and pesticide application practices						
Practices for pasture management and the application of animal wastes to land						
Chemical storage and handling practices						
BMPs for Soil Erosion Control	●	•	●	•		•
Field tillage practices (agriculture)						
Cropping practices (agriculture)						
Vegetative practices (construction mining, etc.)						
Timber Harvesting BMPs	●	●	•	•		•

STREAM CONSERVATION NOTE TO CONTRACTOR

A special note in connection with contractors work should be inserted in all plans for projects affecting fishing streams or waterways which are a source of water supply. This may be referred to in recommendations simply by title, "Special Note — Stream Conservation" with wording as follows:

"During the course of stream-related construction or work activity, the Contractor shall conduct his operations in such a manner to prevent or reduce to a minimum any damage to any stream from pollution by debris, sediment, or other foreign material, or from the manipulation of equipment and/or materials in or near such streams. He shall not return directly to a stream or to a ditch immediately flowing into a stream, any water which has been used for wash purposes or other similar operations which cause the water to become polluted with sand, silt, cement, oil, or other impurities. If he uses water from a stream, he shall construct any intake or temporary coffer dam required to protect and maintain water quality and to sustain fish life downstream."

Stream Crossing BMPs

a. Proper crossing location: Crossings should be located where the stream channel is straight with an unobstructed flow of water. Find crossing sites that have low, stable banks and a firm stream bottom. Cross at a few carefully chosen places, rather than any place that seems convenient. Avoid crossing at bends and through pools.

b. Approaches to crossing: The roadway approaching the stream should be reasonably level for a distance of 50 feet to each side of the crossing, definitely no more than a gentle slope. Dips or turnups should be used on the road or trail before crossing a stream. This will ensure that water is drained off the side of the road rather than into the stream.

c. Cross at right angles: Cross streams by the most direct route. Crossings should be made at right angles to the stream.

BMPs for Culvert and Bridge Installation

Stream crossings can be accomplished by ford, culvert, or bridge. Where water resource values are high, as in the case of domestic use or for protecting a fishery, water courses always should be bridged. This will not only reduce erosion and stream sedimentation, but also reduce the amount of gasoline, oil, and grease which is often washed from the wheels and undercarriage of vehicles when crossing streams.

a. Utilize natural streambed: Culverts and bridges which utilize the natural streambed as the floor are preferred to culverts which have a floor.

b. Concentrate stream flows: Culverts or bridges which have a floor, rather than the natural streambed, should be designed to provide a V or dish-shaped channel so as to concentrate stream flow during low water periods. For floors up to 50 feet wide, the center line elevation should be 8 inches below the edges of the floor. For floors over 50 feet wide, the center line elevation should be 12 inches below the edges. Floor elevations should conform as closely as possible to existing streambed elevation at the point of proposed installation. The culvert outfall should not be suspended above the stream channel or cascade on to rocks; rather, the outfall should gently merge with the "tailwater" pool, thereby facilitating the upstream migration of fish.

c. Culvert and bridge size: Permanent bridges or culverts must be designed to handle the largest potential stream flows. The minimum recommended culvert diameter for a stream crossing is 15". Table 16 contains the appropriate culvert size based on drainage area. The municipal engineer, county highway department engineer, or the County Soil and Water Conservation District can assist in determining proper culvert size (diameter).

TABLE 16

GUIDE FOR DETERMINING CULVERT SIZE FOR PERMANENT STREAM CROSSINGS

Drainage Area (acres)		
Well Drained Soils	Shallow Soils with Frequent Rock Outcrops	Recommended Pipe Diameter (inches)
16	4	15
25	7	18
40	12	21
55	16	24
84	27	30
130	47	36
190	64	42
260	90	48
335	120	54
400	166	60
550	205	66
650	250	72

Source: Guides for Controlling Soil Erosion and Water Pollution on Logging Jobs in Vermont. Vermont Agency of Environmental Conservation, et. al., Montpelier, Vt.

d. Installing multibarrel culverts: Where twin or multibarrel culverts are used, one culvert should be installed slightly lower in the streambed than the other(s) so as to concentrate stream flow in one culvert for passage of fish during periods of low water.

e. Stabilizing disturbed streambanks: Channel realignment in connection with approaches and exits to bridges and culverts should be kept to an absolute minimum. All new channel bank slopes should be treated with loose, truck-dumped or placed rock rip-rap in a manner acceptable to good construction practices. All exposed soil should be seeded and mulched within two weeks of culvert or bridge installation to establish protective ground cover as quickly as possible.

Stream Channelization BMPs

Stream channel work should be kept to a minimum. In those instances where stream channel work is planned, it is advisable to inspect stream conditions prior to construction to determine existing pools and their frequency, percentage of shade provided as compared to a new channel, amount of fisheries habitat available in the form of pools, or tree and brush shelter. It will then be possible to approach the determination of minimum habitat requirements for the new channel with these facts in mind.

a. Concentrating stream flow: Where stream channelization work is involved, the streambed should be sloped down from the edges towards the center (except on curves) as follows:

— For a stream bed up to fifty (50) feet wide, the center line elevation should be eight (8) inches below the edges of the bed (See Figure 21).

— For a stream bed over fifty (50) feet wide, the center elevation should be twelve (12) inches below the edges of the bed.

— On curved alignments, the above specified slope should be towards the outside of the curve instead of the center line. Loose, truck-dumped rip-rap or stone fill should be placed on new channel slopes in areas where erosion is

likely to occur, particularly on curves and near new structures. This should be done as quickly as possible to help reduce bank erosion and sedimentation (See Figure 22).

b. Bank stabilization: New channel streambanks should be sloped 3 on 1, seeded, and mulched within two weeks of completion of grading. All roadside and cross-drain ditching should be paved, lined with stone or rip-rap, or seeded and mulched within two weeks of completion of grading.

FIGURE 21

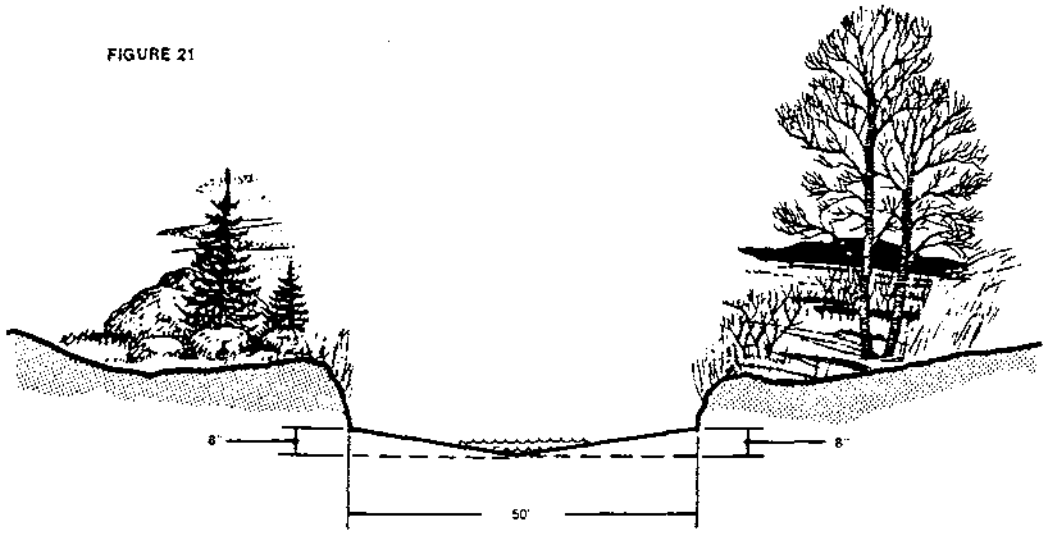


Figure 21. Concentrating Flows in Mid-Stream. Center line elevation should be eight (8) inches below the edges of the streambank for streams up to 50 feet wide, or twelve (12) inches below the edges of the streambed for streams over 50 feet wide.

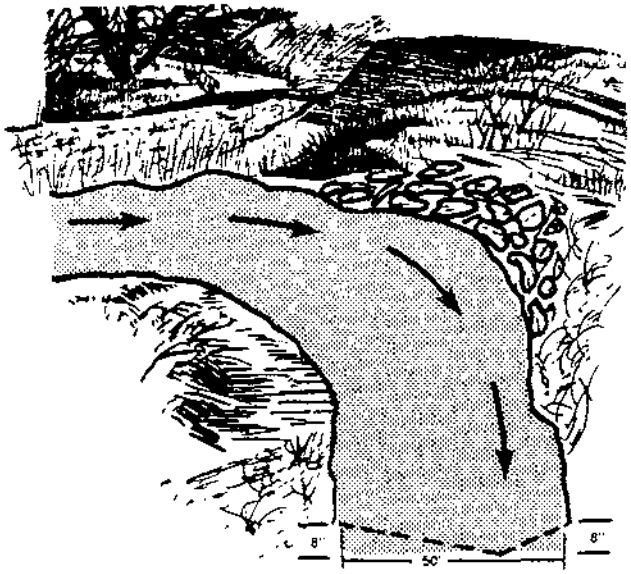


Figure 22. Concentrating Flows on Curved Alignments. On curved alignments, the specified slopes in Figure 21 should be shifted to the outside of the curve instead of the center line. Rip-rap and suitable vegetation should be established on outside curve to protect streambank and prevent erosion.

This roadside ditch has been stabilized with rock rip-rap. Establishment of a vegetative cover to stabilize a ditch can usually be accomplished at less cost; however, for especially critical areas involving steep gradients or highly erosive soils, rip-rap, concrete, or asphalt, storm drainage systems might be the only practical alternative.

On top of streambanks, plant species such as purple osier willow and silky dogwood should be planted, particularly where soils encountered are highly erosive. To provide shade, higher growing species such as black, weeping, or shining willow or other high-growing, deep-rooted trees conducive to good growth in the soils encountered may be used. County Soil and Water Conservation Districts can recommend alternative plant materials best suited to a particular site and they can identify sources of the plant stock.

c. Mitigating damage to fisheries habitat: In planning any section of new channel over 150 feet long, consideration should be given to mitigating damage by creating pools through proper placement of large boulder retards where no danger of scour or erosion is anticipated. If large stone for this purpose is not available, it may be possible to use Gabions (wire boxes containing small, loose stones) to take the place of large boulders. A group of retards should be placed at approximately 100-foot intervals.

BMPs for Dredging and Gravel Removal

Gravel removal should not be conducted on streams except in sections which have large, repeating alluvial deposits, the removal of which would benefit rather than harm fish life. If gravel is removed, the stream bed should be sloped and graded in accordance with the above Stream Channelization BMPs.

BMPs for "Snagging" and Channel Clearing[2]

Trees and brush which shade streams and stabilize the banks should not be disturbed. In new channel construction, existing trees and brush should be left in place along the tops of banks. No stream work, including bank clearing and excavation or removal of materials, "snags", or other channel obstructions, should be allowed except at specific locations where significant blockages in streams occur. Channel excavation and snag removal should be accomplished with the minimum streambank clearing needed to provide access to the stream and should not be undertaken unless it is absolutely necessary. The following BMPs prescribe the manner in which snag removal and stream channel clearing should be undertaken:

[2] The BMPs for snagging and channel clearing were developed as guidelines by several governmental agencies and private organizations for the Wolf River System in the State of Tennessee. They subsequently appeared in an article entitled "Stream Rennovation Alternatives, the Wolf River Story," by C.A. McConnell, et. al., in the *Journal of Soil and Water Conservation*, Vol. 35, No. 3, January-February 1980. The *JSWC* is copywrited by the Soil Conservation Society of America.

a. Practices for snagging

— Log jam removal: Only those log accumulations that are obstructing flows to a degree that results in flooding or significant ponding or sediment deposition should be removed.

— Removal of other logs:

- Affixed logs. Isolated or single logs should not be disturbed if they are embedded, jammed, rooted, or water-logged in the channel or the floodplain, if they are not subject to displacement by current, and if they are not presently blocking flows. Generally, embedded logs that are parallel to the channel are not considered to cause blockage problems and should not be removed. Affixed logs that are crossways to the flow of waters in the channel and are trapping debris to the extent that could result in significant flooding or sedimentation may be removed.
- Free logs. All logs that are not rooted, embedded, jammed, or sufficiently waterlogged to resist movement by stream currents may be removed from the channel.

— Protecting riparian vegetation. No rooted trees, whether alive or dead, should be cut unless:

- they are leaning over the channel at an angle greater than 30% of vertical and they are dead or severely undercut, or damaged root systems are relying upon adjacent vegetation for support and it appears they will fall into the channel within one year and create blockage to flows; or
- their removal from the floodplain is required to secure access for equipment to a point where a significant blockage has been selected for removal.

Trees selected for removal should be cut well above the base, leaving the stump and roots undisturbed. Procedures for removing the felled portion should be the same as for other logs as discussed below.

— Equipment for log removal. First consideration should be given to the use of hand-operated equipment to remove log accumulations. When the use of hand-operated equipment is infeasible, vehicular equipment should be used in accordance with the following guidelines:

- Water-based equipment, e.g. a crane or winch mounted on a small, shallow draft barge or other vessel, should be used for removing material from the stream. A small crawler tractor with winch or similar equipment may be used to remove debris from the channel to selected disposal points.
- When it can be demonstrated that stream conditions are inadequate for the use of water-based equipment, the smallest feasible equipment with tracking systems that minimize ground disturbance should be specified for use. Larger equipment may be employed from non-wooded areas where cables

Removal of riparian vegetation can result in sloughing of streambanks. Note that the streambank downstream is protected and stabilized where riparian vegetation is retained.

could be stretched down to the channel to drag out materials to be removed.

- Access routes for equipment should be selected to minimize disturbance to existing floodplain vegetation, particularly in the riparian zone. Equipment should be selected which will require little or no tree removal in forested areas.

— Log disposal practices. All logs or trees designated for removal from a stream or floodplain should be removed or secured in such a manner as to preclude their reentry into the channel by flood waters. Generally, they should be transported well away from the channel and floodway and positioned parallel to the stream channel so as to reduce flood flow impediment. When large numbers of logs are removed at one location (e.g. log jams), their use for firewood may be most appropriate. Burying of removed material should not be permitted.

b. Practices for stream channel clearing

— Small debris accumulation. Small debris accumulations should be left undisturbed unless they are collected around a log or blockage that should be removed. (It is felt that small debris accumulations will not constitute a significant blockage to flows. Upon removal of logs and other blockages under these BMPs and following completion of the project, the changed water velocities will remove and disperse these small debris accumulations so that no significant blockage of water flows will result.)

— Removal of sediments and soils. Major sediment plugs in the channel may be removed if they are presently blocking the channel to a degree that results in ponding and dispersed overland flow through poorly defined or nonexistent channels and, in the opinion of appropriate experts, will not be removed by natural stream or river forces after logs and other obstructions have been removed.

— Disposal of spoil material. Conventional excavating equipment may be required for sediment blockages. This equipment should be employed in a manner which will minimize environmental damages as follows:

- Access routes for equipment should be selected to minimize disturbance to existing floodplain vegetation, particularly in the riparian zone.
- Material disposal and necessary tree removal should be limited to one side of the original channel at any given location.
- To the maximum extent possible, excavating equipment should not be employed in the stream channel bed.
- Where feasible, excavated materials should be removed from the floodplain. If floodplain disposal is the only feasible alternative, the spoil material should be placed on the highest practical elevation and no material should be placed in any tributary or distributary channels which provide for ingress and egress of waters to and from the floodplain.
- No continuous spoil pile should be created. It is suggested that no pile exceed fifty (50) feet in length or width and a gap of equal or greater length should be left between adjacent spoil piles.
- Spoil piles should be constructed as high as sediment properties allow.
- The placement of spoil material around the bases of mature trees should be avoided where possible.

All disturbed areas should be reseeded or replanted with plant species which will stabilize soils and benefit fish and wildlife. Revegetation should be in accordance with County Soil and Water Conservation District recommendations.

BMPs for Protecting Streambanks and Enhancing Fish Habitat

Several techniques are available for repairing, protecting, or stabilizing eroding streambanks, or restoring fisheries habitat, including the use of rock deflectors, rip-rap, log cribbing, gabion baskets, the establishment of buffer strips or greenbelts, and streambank fencing.

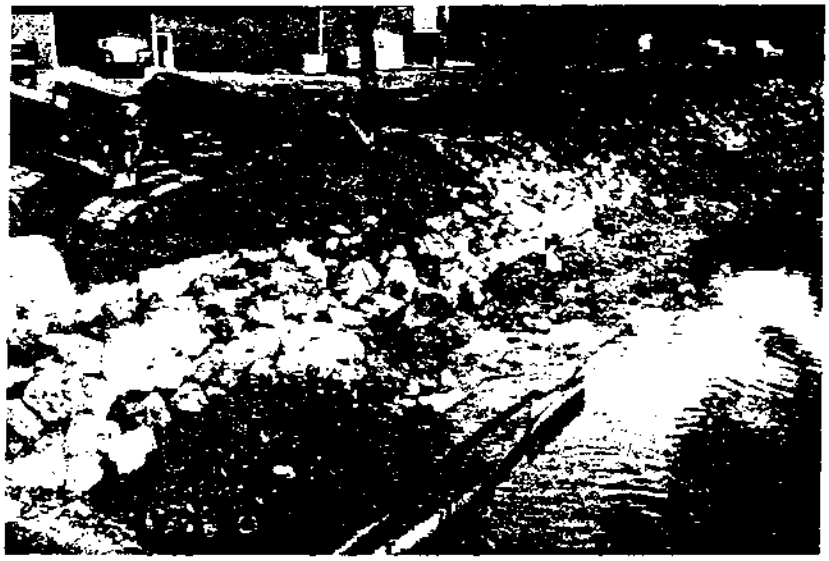
a. Buffer strips or greenbelts.

Buffer strips should be established to protect streams from land use activities adjacent to a stream. Buffer strips consist of grasses, shrubs, and trees along streambanks. Table 17 shows the functions of buffer strips.

TABLE 17. FUNCTIONS OF A BUFFER STRIP*

- filter sediment and other substances, e.g., nutrients, pesticides, and metals from land use activities in adjacent areas;
- maintain the stream integrity by retaining the natural vegetation corridor;
- enhance recreational use of the stream;
- preserve vegetation which shades the stream, helping to maintain lower water temperatures;
- inhibit stream bank erosion and meandering;
- restore degraded fish and wildlife habitat.

* Source: Arkansas Landowners' Guide to Streambank Management (updated).



Rock rip-rap can be used to protect a streambank. Although installation costs may be high, generally they are not as great as the costs of installing log cribbing — and the maintenance costs are not as great.

Notwithstanding installation and maintenance costs, log cribbing can be used effectively to protect and stabilize an eroding streambank. Also, spaces between the logs provide excellent fisheries habitat.

Gabion baskets have been employed to protect the bank of this Westchester County stream.

Tables 18 and 19 contain recommended buffer strip or greenbelt widths in watersheds where logging and construction and development-related activities will be undertaken.

TABLE 18. RECOMMENDED BUFFER WIDTHS FOR PROTECTING STREAMS FROM TIMBER HARVEST ACTIVITIES[1,2]

Slope of Land	Degree From Horizontal	Width of Buffer Strip for Logging Areas (ft.)
0	0	25
10	6	45
20	17	65
30	17	85
40	23	106
50	26	125
60	31	145
70	35	165
80	39	185
90	42	205
100	45	225

1 Source: Hartung, R.E., and Kress, S.M.: Woodlands of the Northeast, USDA, SCS, and Forest Service, Philadelphia, PA; 1977.

2 Except at properly located stream crossings (see Stream Crossing BMPs), logging roads or skid trails should not be allowed within the mean high water mark. The location of logging roads or skid trails should conform to the slope-distance relationship in the table.

TABLE 19. RECOMMENDED BUFFER WIDTHS FOR PROTECTING STREAMS FROM CONSTRUCTION AND DEVELOPMENTAL ACTIVITIES[1]

Slope of Land	Degree From Horizontal	Width of Buffer Strip in Municipal Watersheds & Critical Area (ft)
0	0	50
10	6	90
20	12	130
30	17	170
40	23	210
50	26	250
60	31	290
70	35	330
80	39	370
90	42	410
100	45	450

[1] Source: Hartung, R.E., and Kress, S.M.: Woodlands of the Northeast, USDA, SCS, and Forest Service, Philadelphia, PA; 1977.

In addition to adhering to the recommended buffer strip widths in the above tables, the following BMPs should be followed:[3]

— Avoid clear cut timber harvesting in the buffer strip. Retain greenbelts along streams consistent with recommended buffer widths in Table 18 and 19.

— Avoid major land clearing within the buffer strip for agricultural, construction and development, and other land use activities.

— Avoid extensive use of heavy machinery in a buffer strip area. It can cause erosion by breaking down fragile stream banks and by compacting the soil so that it can no longer absorb runoff. Soil compaction also prevents aeration of the soil, which in turn causes vegetation to die, and eventually leads to erosion.

— Reestablish vegetation in the buffer strip as soon as possible by using native grasses, shrubs, and trees, subsequent to any land clearing which does occur.

— Except at stream crossings, avoid building roads in the buffer zone.

— Avoid building near a streambank. During floods or heavy rains, banks can slump many feet in a short time.

b. Streambank fencing.

Grazing by livestock within a buffer strip should be avoided. Protect the buffer strip by fencing livestock away from the stream except at properly constructed stock watering areas. Temporary electric fencing (installed after the threat of spring flooding and removed after the grazing season) offers an alternative to permanent fencing.

Fencing along the banks of streams to prevent grazing and trampling of vegetated banks by unlimited access of livestock to streams is among the most effective steps that can be taken to rehabilitate and protect a stream. Where additional protection of stream banks by mechanical devices is not necessary, fencing will promote the growth of vegetation, including grasses, shrubs, and trees. Not only will this reduce erosion, but also beneficial shade will be derived from

[3] Source: Arkansas Landowners' Guide to Streambank Management (undated).

trees. In many streams, a reduction in water temperature by shade trees alone will mean the difference in terms of a stream's capability of supporting a viable fishery. County Soil and Water Conservation Districts can provide technical guidance in the actual layout of streambank fencing.

If the goal is to restore aquatic habitat or rehabilitate degraded streams through the use of buffer strips or greenbelts, the degree of recovery of a fishery would be related to (1) the degree and quality of habitat enhancement achieved; (2) the size of the stream; and (3) its original fish supporting capacity. The recovery time for a given stream would depend on the type of management implemented, composition and stability of existing streambanks and degree of degradation, soil moisture relationships, and water runoff patterns within a watershed (White and Brynildson, 1976).

ONCE A STREAM SYSTEM AND ITS AQUATIC RESOURCES HAVE BEEN DAMAGED, THE RECOVERY PHASE MAY REQUIRE CONSIDERABLE TIME — 15 YEARS OR LONGER WOULD NOT BE UNUSUAL.

Types of predictive changes for a stream transformed from a degraded to a recovered phase are shown in Figure 23. After recovery, improved conditions for fish success would be associated with (1) a deeper average water depth; (2) flushing of silt and sand to expose gravel, rubble, and rock bottoms; (3) stabilized banks due to vegetative cover; (4) bank undercutting to provide additional cover for fish; (5) overhanging vegetation to shade and keep water temperatures lower during hot periods of the year; and (6) a tendency for a more favorable combination of pools and riffles to develop.

This stream would benefit by the establishment of riparian vegetation at the top of the rip-rap and along both sides of the stream as a way of maintaining lower stream temperatures during the summer.

This fencing has been installed along the Little Hoosick by Trout Unlimited, in cooperation with the Rensselaer County Soil and Water Conservation District, to provide a buffer strip between pasture land and the stream. Willow, dogwood, and spruce seedlings and other plant species will be planted to form a greenbelt along this stream.

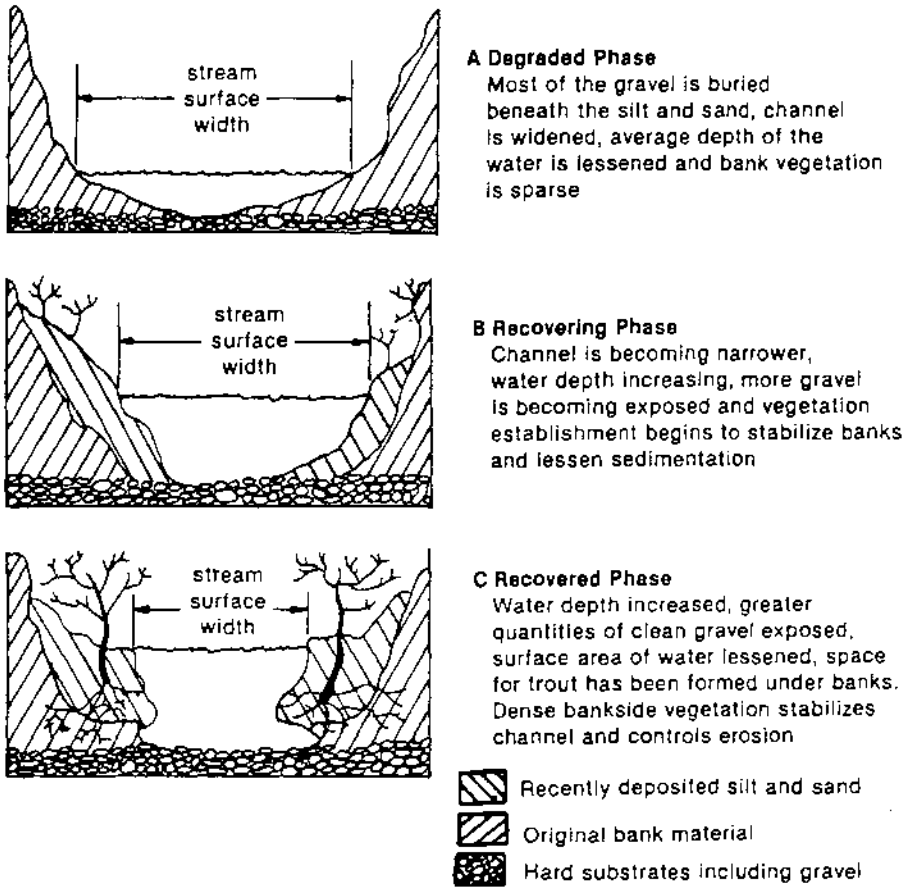


Figure 23. Conceptualized Cross-Sectional Characteristics of a Stream in Degraded, Recovering, and Recovered Habitat Phases. For the Phase A condition, pool and riffle relationships are disrupted. In effect, there is a tendency for channeling to occur which lessens the abundance and quality of pools. For Phase C, note undercut areas which eventually develop. If bank damage occurs, this important trout cover is usually the first to be destroyed and years can be required for natural restoration. Adapted from White and Brynildson (1967).

BMPs FOR CONTROLLING STORMWATER RUNOFF[4]

THE THEME OF STORMWATER MANAGEMENT IS SIMPLE. RUNOFF FROM ANY SPECIFIC DEVELOPMENT MUST NOT BE GREATER THAN WOULD BE THE CASE UNDER NATURAL CONDITIONS.

Inadequate management of accelerated runoff of stormwater resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of streams and storm sewers, greatly increases the cost of public facilities to carry and control stormwater, undermines floodplain management and flood control efforts in downstream communities, reduces ground water recharge and, in general, threatens public health and safety.

[4] BMPs for controlling stormwater runoff were excerpted from the following sources: "Identifying and Implementing Agricultural BMPs to Control Water Pollution in New York State" by the NYS Soil and Water Conservation Committee, 1981; BMP Handbook for Controlling Urban Stormwater Runoff by the Virginia Soil and Water Conservation Commission, *et.al.*, 1979; and USDA, Soil Conservation Service, *National Handbook of Conservation Practices*, 1977.

Managing stormwater is both fiscally and politically sound when approached as a preventative strategy. Retention of water where it falls is the primary source of replenishing groundwater. The longer rainfall stays on land, the greater the recharge; also, the more slowly surface water moves before entering a channel, the less scouring and sediment transfer takes place. This, in turn, helps produce better water quality. For instance, twenty minutes of ponding or filtering through vegetation removes most of the heavy metals carried from the streets and parking lots in stormwater runoff. Table 20 identifies additional objectives to be achieved from controlling stormwater runoff.

TABLE 20. OBJECTIVES OF CONTROLLING STORMWATER RUNOFF

- To prevent the degradation of property by enhancing the environmental character and quality of streams.
- To prevent damages to life and property from flooding resulting from excessive rates and velocities of runoff.
- To reduce public expenditures for replacement or repair of public facilities resulting from artificially induced flood peaks.
- To enhance the quality of non-point source runoff by water retention measures.
- To prevent degradation of stream quality due to impairment of the stream's biological system.
- To prevent degradation of the stream caused by excessive flushing and sedimentation.
- To maintain natural stream channels and prevent accelerated bank erosion by controlling the rate and velocity of runoff into streams.

Source: South Branch Watershed Association, *et.al.* (undated).

The concept of stormwater management provides for the:

— quantitative control of stormwater through a system of vegetative and structural measures which detain (delay) the increased volume and rate of stormwater runoff, caused by man-made changes to the land, so as to prevent increases in the magnitude and frequency of flooding.

— qualitative control of stormwater through a system of vegetative, structural, and other measures, which retain (store), minimize, or treat pollutants carried by surface runoff.

Stormwater retention and detention help to control flooding and reduce water pollution in several ways. First, the total volume of stormwater entering surface waters is reduced, since additional time is provided for water to infiltrate the soils. Second and most important, the rate of flow from the site is reduced. Slower rates of discharge allow pollutants to settle out and reduce the potential for non-point source pollution loading including nutrient enrichment and erosion and sedimentation.

THE RETAINMENT OF NUTRIENTS FROM STORMWATER IS ESPECIALLY IMPORTANT WHERE DEVELOPMENTAL ACTIVITIES ARE ACCELERATING EUTROPHICATION IN BOTH LAKES AND STREAMS.

The reduction of non-point source loading through stormwater management practices may be difficult to quantify; nevertheless, some generalizations can be made. Assuming the pollutants are available for retainment, generally, the more efficient the storm drainage system, the greater the pollution loading. The term "efficient" refers to how quickly stormwater can be concentrated and removed from where it is not wanted. The implication is that efficient systems are not necessarily the best choice, particularly where protection or enhancement of water quality is an objective.

> METHODS WHICH TEND TO REDUCE THE VOLUME OF RUNOFF ARE PREFERRED OVER METHODS WHICH TEND TO INCREASE THE VOLUME OF RUNOFF.

Generally, stream quality impairment can be prevented if watershed imperviousness does not exceed 15 percent. For the more sensitive stream ecosystems, such as those supporting self-sustaining trout populations, watershed imperviousness should not exceed 10 percent. Table 21 provides watershed development rates for different land use categories to achieve 10 percent and 15 percent levels of imperviousness.

When engineering a site for stormwater management, two overall concepts must be considered:[5]

- the permeability of the system should be maintained or enhanced.
- the rate of runoff should be slowed

TABLE 21.
ALLOWABLE WATERSHED DEVELOPMENT RATES 1

Land Use Category	Imperviousness	Maximum Amount of Watershed That Can Be Developed Based Upon An Imperviousness of 10%	15%
Individual Homes			
0.4. Hectare (1.00 acre) Lot	20%	50%	75%
0.20 Hectare (0.50 acre) Lot	25%	40%	60%
0.13 Hectare (0.33 acre) Lot	30%	33%	50%
0.10 Hectare (0.25 acre) Lot	38%	26%	29%
0.05 Hectare (0.12 acre) Lot	65%	15%	23%
Townhouse/Garden Apartments	44%	22%	33%
High-Rise Residential	56%	18%	27%
Industrial Districts	75%	13%	20%
Commercial Business Area	85%	12%	18%
Shopping Centers	95%	11%	16%

1 Klein, Richard D., "Urbanization and Stream Quality Impairment", in *Water Resources Bulletin*. American Water Resources Association, Volume 15, No. 4. August 1979.

5 "Maryland Interim Watershed Management Policy", 1977.

In employing these concepts, attention needs to be given to understanding and implementing "natural engineering" techniques which preserve and enhance existing features of a site and maximize economic and environmental benefits.[6] Natural engineering refers to the use of buffer strips, depressions, grassed areas, wetlands, and other open spaces for stormwater detention. These and other stormwater management guidelines are presented in Table 22. Through site grading, runoff can be directed to these natural areas which catch the stormwater, slow the flow, and allow infiltration into the soils and ground water. Detention and retention of stormwater on the site also can be achieved by the construction of basins or ponds to hold stormwater. These and other BMPs are described as follows:

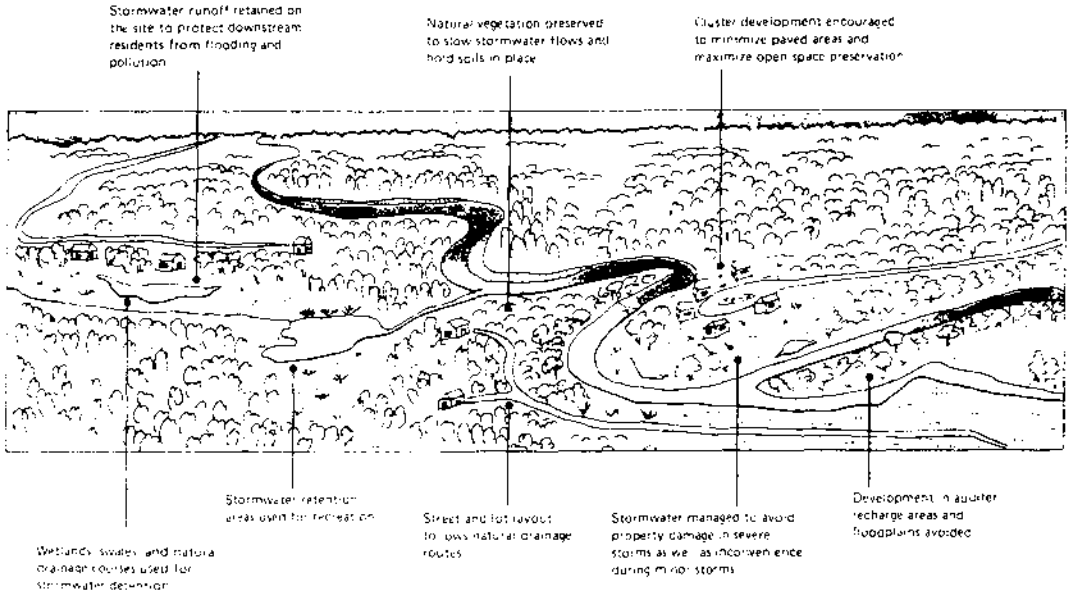
TABLE 22. STORMWATER MANAGEMENT GUIDELINES

- Use depressions, swales, wetlands, and other natural drainage areas to hold stormwater and provide for a slow release to ground waters (when soils permit). The use of natural drainage engineering concepts can save storm drain construction costs while adding to the recreational and open space amenities of the development.
- Minimize the amount of paved surfaces on the site. Cluster development helps reduce the amount of pavement and provides larger open space and retention areas.
- Coordinate erosion control measures with longer-term stormwater management measures. A sediment basin, for example, may sometimes be converted to a detention or retention basin for use after the completion of construction.
- Identify and assess stormwater runoff flows from drainage areas above the site, including the potential runoff effects downstream. A general assessment can be made during initial development plan reviews and detailed engineering calculations and considerations can be made at a later stage in the approval process.
- Manage stormwater so that the outflow from the site after development does not exceed the outflow from the site prior to the development.
- Coordinate stormwater management plans with open space plans for the site, encouraging the multiple use of drainage courses and stormwater management areas whenever possible.
- Delineate stormwater easements which will be used for maintenance purposes on the development plan. The relationship of stormwater easements to utility easements should be shown on the development plan.
- Identify stormwater routing and storage for the 100-year storm event as well as the 10-year storm event.
- Assign clear responsibilities for long-term maintenance of retention and detention basins, including periodic cleaning of filters, removal of debris and sediment, and weed cutting. Consider the use of a performance bond if facility maintenance is assigned to a homeowner's association. Restrictive deed covenants should be used to assure that maintenance responsibilities are legally binding.

Source: "Water Quality Guidelines for Development Plan Reviews", Southeast Michigan Council of Governments, 1980.

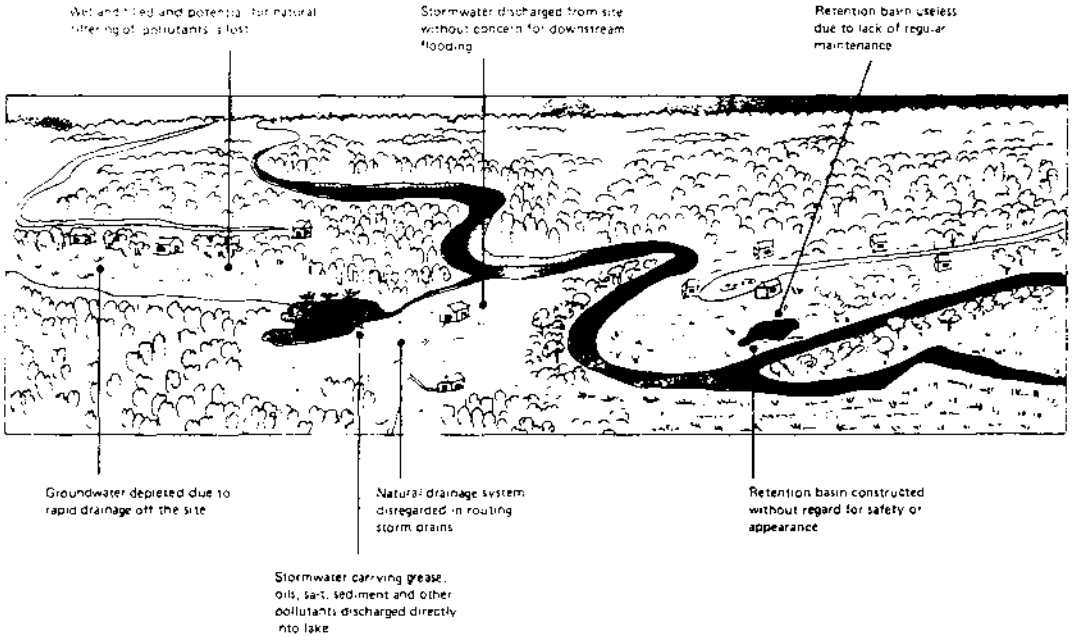
6 *Ibid.*

Figure 24. Stormwater Management: Yes



Adapted from "Water Quality Guidelines for Development Plan Reviews", Michigan, 1980

Stormwater Management: No



Diversion Terraces

Diversion terraces are generally installed above construction areas, cropland fields, gully headcuts, or other critical areas where stormwater runoff or erosion are serious problems. Diversion terraces break the length of the slope into a series of shorter segments and reduce runoff velocities, thereby reducing soil losses. They usually consist of a ridge, or a combination of ridges and channels, constructed to a predetermined grade across the slope. These ridges are placed high enough on the slope to collect the expected volumes of surface runoff from above. Some diversion terraces on more permeable soils are designed to stop runoff and hold the water until it is absorbed. Others on less permeable soils are designed to intercept and divert runoff in a controlled manner to a protected outlet, swale, depression, or wetland. If diversion terraces are improperly designed, or used with poor land or farm management practices, they may increase rather than reduce soil loss.

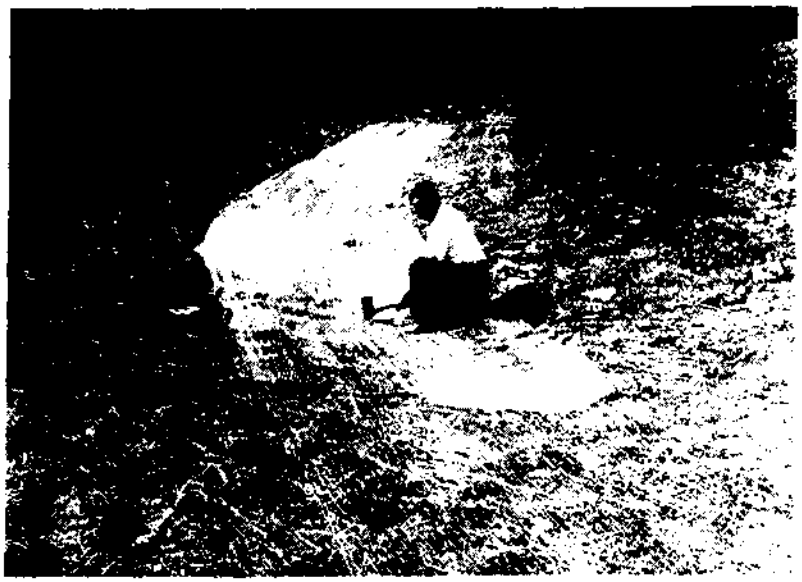
Diversion terracing may be used to reduce the length of slopes thereby breaking up the concentration of water on croplands, above construction sites, gully headcuts, and other areas where stormwater runoff causes problems. (USDA Soil Conservation Service Photo)

Grassed Waterways, Filter Strips, and Seepage Areas

This practice involves utilizing grassed surfaces to reduce runoff velocities, enhance infiltration, and remove runoff contaminants, thus improving runoff quality and reducing the potential for downstream channel degradation and sediment pollution from urban, agricultural, and other land use activities. Concepts covered include using grass-lined roadside swales instead of curb and gutter installations, using grass-lined open drainage channels instead of paved channels, using grass-covered surfaces to intercept runoff and filter out some of the contaminants, and using small shallow basins over permeable soils to capture and infiltrate runoff. Grass waterways are a basic conservation practice commonly used by farmers.

Stormwater Detention Basins (Ponds)

Detention ponds may be constructed to protect downstream areas from potential water quality degradation, flooding, and stream channel degradation due to urbanization or other upstream land use activities. The objective is to detain stormwater and release it at a controlled rate. Downstream water quality is improved through sediment removal, plant uptake of nutrients, chemical transformations, and other processes. This practice generally is limited to structures less than 25 feet in height which impound less than 100 acre-feet of water.



Jute netting or a commercial erosion control fabric can be used as a channel liner to prevent erosion until vegetation in a greased waterway becomes established. Liners may not be needed if run-off can be diverted from the channel during the establishment period. (USDA Soil Conservation Service Photo)

This detention basin in Westchester County retains stormwater runoff. Note the vegetation which acts as a biological filter to remove nutrients and other contaminants from the runoff.

Parking Lot Storage

This practice involves the use of impervious parking areas as temporary impoundments during rainstorms. Parking lot drainage systems can be designed to temporarily detain stormwater in special designated areas, to increase infiltration and ground water recharge, and release it at a controlled rate. The objective is to protect water quality and downstream areas from increased flooding, stream channel degradation, and/or combined sewer overflows caused by urban development. It is important that these facilities be designed to minimize potential safety hazards and inconvenience to motorists and pedestrians.

Rooftop Detention

This practice describes how stormwater falling directly onto flat roof surfaces can be temporarily ponded and gradually released by incorporating controlled flow roof drains into building designs. The purpose is to reduce adverse impacts of rooftop runoff on sewer systems and receiving streams. Rooftop detention can be incorporated into the design of most new buildings, and many existing structures also can be modified for this function.

Rooftop Runoff Disposal

This practice encourages the disposal of rooftop runoff by systems and techniques that avoid or replace direct connections of roof drainage systems to sewer systems. The objective is to reduce the frequency of sewer overflows. Proposed alternatives to sewer connection include surface drainage, subsurface infiltrations, and runoff collection and storage.

Cistern Storage

This practice involves the collection and storage of stormwater runoff in a storage tank or chamber above or below the ground. A cistern can serve solely as a stormwater detention device to protect downstream areas from flooding, stream channel degradation, and/or sewer overflows, or it can be used to collect polluted runoff for later treatment. Water collected in a cistern may also be put to use for lawn watering, fire protection, or other purposes.

Infiltration Pits and Trenches

This practice involves the excavation of pits or trenches which are backfilled with sand and/or graded aggregates. Stormwater runoff from impervious surfaces can be directed to these facilities for detention and infiltration. Permeable soils are a prerequisite. The potential for ground water pollution must also be carefully evaluated.

Concrete Grid and Modular Pavement

This practice involves the use of a special pervious paving material in low traffic areas. The pavement consists of concrete grids or other structural units alternated with pervious fillers such as sod, gravel, or sand. The resultant pavement provides an adequate bearing surface and yet allows a significant amount of infiltration, thereby reducing runoff volume and discharge rate and improving the water quality.

Porous Asphalt Pavement

This practice involves the use of a special asphaltic paving material which allows stormwater to infiltrate at a high rate. Infiltration water is stored below the pavement in a high-void aggregate base. This practice provides for stormwater detention and, in some cases, increases infiltration into the ground. Use of the practice can contribute to reduced sewer overflows, decreased flooding and stream channel degradation, and improved water quality. This type of pavement offers many other benefits not related to water quality, including enhanced visibility, increased safety, and reduced drainage system costs.

Stormwater Conveyance System Storage

This practice involves providing storage capability within stormwater conveyance systems for temporary detention and controlled release of urban stormwater during wet weather flows. Where combined sewers are utilized for stormwater conveyance, the purpose is to reduce the frequency and magnitude of sewer overflows and to increase the quantity of stormwater receiving treatment before entering receiving waters. Where separate conveyance systems exist, the purposes are to reduce downstream flow peaks and to provide some particulate removal through stormwater detention. Both in-line and off-line storage facilities can be employed.

Fluidic Flow Regulators

This practice involves the use of an innovative self-powered and controlled fluid flow regulator. Depending upon the design and application, these devices can be used to selectively divert the first flush of a storm into treatment facilities or temporary storage areas; to automatically proportion runoff flows between receiving streams and retention or detention facilities; or to provide increased operating efficiency of storm and combined sewers during wet weather flows. All of these functions serve to reduce the impacts on receiving waters.

Treatment of Stormwater

This practice involves the use of water treatment unit operations applied at such a scale that they are less involved and less costly than treatment plant technology and can be either used independently or in conjunction with other best management practices to remove contaminants from collected stormwater. Unit operations considered applicable are the physical processes of settling, filtration, and screening, and the chemical processes of flocculation and disinfection.

BMPs FOR POLLUTION SOURCE CONTROL[7]

The BMPs discussed below are intended to control nonpoint pollution at its source and thus to prevent water quality problems from occurring.

Fertilizer and Pesticide Application Practices

a. Reducing excessive application rate: Fertilizer inputs into crop production should not exceed that needed for plant nutrient determined through periodic soil testing and familiarity with plant requirements. Manufacturers' recommendations should be strictly adhered to in the application rate for pesticides.

b. Timing of application: The timing of fertilizer application affects the efficiency of plant utilization of nutrients. The timing of application is much more important for nitrogen fertilizers that are easily leached, particularly on sandy soils, than for phosphorus, which is more readily absorbed by soil particles.

   In general, phosphate and potash fertilizer must be applied at seeding time or earlier for satisfactory results. Nitrogen may be applied in the fall, or in the spring for fall-sown green crops. For row crops, a portion of the nitrogen may be applied at planting time. Additional amounts may be side-dressed. In areas of leaching or denitrification where losses may occur, spring application usually is best. Nitrogen fertilizer should never be broadcast on frozen land.

   Timing is critical in the application of pesticides. Unless timing is proper, pesticides application may fail to control the target organism, leaving unnecessary pesticide residues which are a potential pollutant in the environment.

c. Method of application: The method of application and placement of fertilizers in relation to root distribution and moisture is important in increasing the effectiveness of fertilizers. General methods for applying fertilizers include: broadcasting and disking, plowing before planting, and top dressing after the crop has been established.

   On soils of low or moderate fixing capacities, broadcasting the fertilizer on the surface and plowing it under is one of the most economical methods of application, but nutrients may be lost if the fertilizer is not plowed under. Fertilizers should be incorporated in the soil by such methods as disking and drilling.

   Slow-release fertilizers may be used to minimize possible nitrogen losses on soils subject to leaching. However, a "slow-release" nitrogen fertilizer is also a "long-release" fertilizer; therefore, this may not be the total answer to controlling nutrient pollution. The placement of phosphate fertilizer with respect to the plant root system is critical because of its limited movement.

   The amount of pesticides entering lakes and streams is influenced by the method of application and the solubility and volatility of pesticides. Pesticides incorporated into the soil, rather than left on the surface of soil or plants, are less subject to movement by runoff waters and to evaporation.

   Pesticides applied as dusts and sprays are subject to considerable drift. Drifting can be reduced by spraying and dusting when wind and other weather conditions are suitable.

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[7] Source: Identifying and Implementing Agricultural BMPs to Control Water Pollution in New York State, 1981; and the National Handbook of Conservation Practices, 1977.

Pesticides can enter the environment through careless or improper disposal of containers and unused materials. If these items are deposited or buried near waterways, the ground water may become polluted. If they are burned, pollution may result through wash or fallout.

In addition, proper cleansing of spray equipment following use is important. Washing should not occur where washwater may enter a waterway. It also is a good practice to spray targeted fields, croplands, etc. with washwater rather than to allow it to drain from spray rigs at a central wash location where it has a greater opportunity to concentrate and contaminate surface and ground waters.

d. Use of alternative pesticides: Using pesticides which are relatively less toxic and less persistent in the environment will minimize potential water contamination effects. Also, using different pesticides each year may result in more effective control and a decrease in the quantity needed.

e. Use of insect and disease resistant crop varieties: Use of plant varieties that are resistant to diseases, insects, and nematodes is one means of solving pest problems in an economical and relatively desirable manner. Indeed, many crops could not be profitably grown in numerous locations if it were not for the use of insect-resistant varieties. The use of resistant varieties has been the only practical method found to suppress a large number of disease and insect pests of wheat, corn, alfalfa, small grains, clover, and grasses. Many tolerant varieties of crops are available. Absolute resistance to pests is rare. However, even modest resistance can greatly reduce the need for pesticides.

f. Cultural practices: A number of cultural practices can partly substitute for pesticides to prevent or reduce crop damage from insects, nematodes, weeds, and diseases. These practices include changes in methods of cultivating and harvesting crops that make the environment less hospitable to pests. Cultural practices are most successful if applied at a vulnerable stage in the pest's life cycle. Examples are the removal of crop debris to eliminate host sites and adjustments in planting schedules to minimize pest influence on the crop.

g. Using mechanical weed control methods: Mechanical weed control is a generally accepted farm management practice. Such measures as row cultivation, proper seed bed preparation, and mowing of weeds on uncropped land can reduce the production of weed seeds. Herbicides can then be applied at lower levels than under reduced tillage methods.

h. Agricultural intensity: Reducing the intensity of cropping or fertilizer or pesticide application on fields with the highest potential for causing water quality problems, while using fields with low pollution potential more intensively, can reduce total pollutant loading from a farm unit.

Practices for Pasture Management and the Application of Animal Wastes to Land

a. Pasture management practices

Good management is the best insurance against pollution of water from pasture systems of livestock production. Although the relative importance of production practices differ by types of livestock, the following generally apply:

— Maintain an adequate land-to-livestock ratio. Avoid concentrations of animals that will create holding areas rather than grazing areas.

— Maintain a highly productive forage on the land to retard runoff, entrap animal wastes, and utilize nutrients.

— Plan a stocking density and rotation system of grazing to prevent overgrazing and eroding soil.

— Locate feeders and waterers a reasonable distance from streams and water courses. Move them to new locations often enough to avoid creating erodible paths through repeated trampling by livestock.

— Provide an adequate land absorption area downslope from feeding and watering sites, preferably with filter strip of lush forage growth between such sites and the streams.

— Provide fences to prevent animals from wading randomly in streams and at points where they may concentrate.

— Pump water from a stream, farm pond, or well to watering troughs or tanks where the number of animals or characteristics of land present critical pollution problems.

b. Land disposal of runoff from confinement areas

Most confined animal facilities must include a system for capturing and disposing of storm runoff. Retention ponds or basins may be used to store runoff prior to land disposal. Runoff effluent should be removed from the retention pond and applied on land as soon as possible after a runoff event, or additional storage should be provided for runoff from subsequent storms.

c. Application of animal wastes to land

Rates and methods for applying animal wastes on agricultural land are so diverse that specific recommendations cannot be given that will apply in all cases. However, some good management practices include the following:

— Estimate the plant nutrient value of the waste and apply it on land uniformly in accordance with crop requirements.

— Schedule the time and frequency of manure applications for maximum nutrient utilization by plants.

— Incorporate manure into the soil as quickly as feasible following application, or inject the liquid wastes into the soil.

— Ensure enough land is available at the appropriate time for disposal of manure.

— When large amounts of wastes are applied to the land, a highly productive crop should be planted to utilize the nutrients, reduce runoff, and reduce the amounts of nitrates and other pollutants that may reach the ground water.

— Wet land, steep land, frozen or snow-covered land, and grassed waterways generally should not be treated with wastes since the material will not be readily absorbed and may result in polluted runoff.

Chemical Storage and Handling Practices[8]

Producers and manufacturers must store and use large quantities of hazardous substances to supply goods and services demanded by society. Sometimes through mismanagement, neglect, or unforeseen accidents, leaks or spills of these substances occur resulting in their introduction to air, land, and water. Although it is important to reduce all spills of hazardous substances, it is essential to reduce spills to protect water quality. Once most substances reach a water body, it is almost impossible to recover them. Contaminants may remain emulsified or absorbed on soil particles for an indefinite amount of time even after cleanup efforts. Because water contamination often is irreversible, prevention is paramount.

Local government has the primary responsibility for land use planning and siting facilities for storage of hazardous substances. It is important that local officials have the most up-to-date information and technology for the storage of hazardous substances. Table 23 lists a number of design consideration and precautionary practices for the storage and handling of hazardous substances. Each of these design considerations and practices is thoroughly discussed in a series of bulk storage program manuals (see Table 24).

[8] Source: "Siting Manual for Storing Hazardous Substances", 1982.

Table 23

Storage of Hazardous Substances: Design Considerations and Practices

Product Storage

- .aboveground tanks
- .underground tanks
- .single wall tanks
- .double-wall tanks
- .tank linings and coatings
- .tank wrappings
- .design considerations
  - -corrosion resistances
  - -chemical/materials compatability
  - -structural strength
  - -factors of safety
- .materials selection
  - -carbon steel
  - -stainless steel
  - -fiberglass reinforced plastic (FRP)
  - -fiberlass/steel bonded

Product Transfer

Piping and Accessories

- .surface/subsurface piping
- .hoses
- .loading racks
- .design considerations
  - -corrosive resistance
  - -chemical/materials compatibility
  - -structural strength
  - -factors of safety
- .materials selection
  - -carbon steel
  - -stainless steel
  - -fiberglass reinforced plastic (FRP)
  - -polyvinyl chloride (PVC)
  - -polypropylene
- .emergency shutoff valves
- .check valves
- .coupling mates to prevent mixing of incompatible chemicals

Overfill Protection

- .high level alarms
- .redundant instrumentation
- .automatic overflow diversion devices
- .dry disconnection hose valves
- .check valves
- .catchment
- .level control and automatic shut-off devices
  - -floats
  - -displacers
  - -gas bubblers
  - -hydrostatic head devices
  - -capacitance devices
  - -thermal conductivity devices
  - -ultrasonic devices
  - -optical devices
  - -nucleonic devices
- .sound operating practices

Spill Containment

- .impervious perimeter dikes and cutoff walls
- .curbing, impervious slabs, troughs
- .liners
- .in situ abosorbing/neutralizing media for spill containment
- .double-walled tanks
- .spill/leachate collection systems
- .catchment (slop) tanks

Leak Detection

- .inventory control
- .visual inspection
- .interstitial monitoring of double wall tanks
- .soil/groundwater monitoring
- .tightness tests
- .structural tests

Source: "Siting Manual for Storing Hazardous Substances," 1982

BMPs FOR SOIL EROSION CONTROL[9]

The following BMPs may be implemented to prevent erosion or to alleviate erosion problems resulting from various land use activities including agriculture, construction and development, mining, or timber harvest activities.

Field Tillage Practices (Agriculture)

The following BMPs are intended to control erosion and sedimentation associated with agricultural activities.

a. Timing of field tillage operations: Tillage, in which the soil is inverted, generates the highest possible potential for erosion by water and wind. Optimum timing of tillage operations can greatly reduce sediment loss hazards. In general, from a water quality standpoint, it is preferable to delay field tillage operations until immediately prior to planting time.

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9 Source: Identifying and Implementing Agricultural BMPs to Control Water Pollution in New York State, 1981; and the National Handbook of Conservation Practices, 1977.

TABLE 24.

MANUALS IN NEW YORK STATE BULK STORAGE PROGRAM

The *Technology Assessment Manual* compiles much of the latest information on the equipment available for storing and handling hazardous liquids. Included are data on tanks, hoses, overfill prevention devices, piping, valves, and pumps. Important information is also provided on the field practices and equipment available for leak detection and spill cleanup.

The *Manual on Criteria and Guidance for Storing Hazardous Substances* provides information on the proper installation and storage methods for bulk storage facilities. The manual brings together recommended practices for preventing spills and leaks.

The *Model Local Ordinance for Storage of Hazardous Substances Manual* provides suggested wording and format for local ordinances to regulate the storage of hazardous materials. Alternatives to fit specific needs are presented.

This *Siting Manual* presents information and procedures to assist local officials prevent leaks and spills of hazardous substances in sensitive environments. Discussed are: types of hazards, causes of leaks and spills, site evaluation procedures, and practices for spill prevention and mitigation.

The manuals are available from:

Environmental Facilities Corporation
Room 538
50 Wolf Road
Albany, New York 12233
Telephone No.: (518) 457-4114

b. Reduced tillage systems: Tillage systems are often used in combination with other erosion control measures and, in many cases, may be the only control measures needed. The reduced tillage system that best fits a farm operation depends on the crops grown, soil characteristics, and climate of the area. Reduced tillage may be effective if used in conjunction with residue from the previous crop left on the soil surface to break raindrop impact and reduce the flow velocity of the runoff. A soil surface configuration prepared to retain water and increase infiltration may be used in conjunction with a reduced tillage system.

c. No tillage: This system uses a fluted colter or double-disk openers to cut through residues of the previous crop, ahead of the planter shoe. No seed bed preparations precede this operation and there is generally no cultivation during production. However, chemicals are normally used for weed control.

d. Contour farming: Performing tillage operations on the contour, in a direction perpendicular to the slope of the land, provides more protection from water erosion than tilling parallel to the slope. The contour rows collect and hold water during rainstorms and reduce runoff velocity, thereby increasing the time for infiltration and reducing erosion.

e. Stripcropping: Stripcropping is practiced as a means of reducing erosion on tilled soils. The intent is to break the length of the slope into segments by laying out strips across the natural slope of the land. Strips of close-growing crops or meadow grasses are planted between tilled row crop strips to serve as sediment filters or buffer strips in controlling erosion. The practice effectively reduces the velocity of water as it leaves the tilled area. Additionally, water runoff is absorbed and soil particles are retained in the buffer strip.

Contouring, practiced alone on gentle slopes, or in combination with strip cropping or terracing on moderate slopes, can effectively reduce erosion (USDA, Soil Conservation Service Photo).

The system of cropping where the strips are laid out nearly perpendicular to the direction of the slope is referred to as contour stripcropping. The buffer strips can vary in width across the field to make them compatible with modern farm equipment use.

Cropping Practices (Agriculture)

Cropping practices used either by themselves, or in combination with other BMPs, are usually implemented to control soil erosion or improve soil productivity. Following are several cropping practices that can have significant soil conservation and water quality benefits:

a. Crop rotations: In a crop rotation system, different crops are grown in a sequential pattern on the same field. Combinations of soil conserving and depleting crops provide opportunities for maintaining soil productivity and reducing soil erosion.

   Continuous row cropping can deplete the organic matter (the decaying plant and animal residues which are necessary for good soil tilth and fertility) in some soils and thereby increase soil erodibility. Sod-forming grasses and legume crops, used in rotation with row crops, are highly effective in maintaining the soil structure and tilth and in reducing soil and nutrient losses by erosion. Sod will stabilize the soil matrix, prevent soil detachment, increase infiltration, and, in some cases, reduce the requirement for pesticides and nitrogen fertilizer on the following row crop. In addition, the rotation of crops often provides for the planting of both shallow- and deep-rooted plants; this pattern improves the physical condition and the internal drainage of both the surface soil and the subsoil.

b. Winter cover crops: Grasses and other close-growing crops provide more soil protection than row crops such as corn and grain sorghum. Crops that leave large quantities of residue after harvest offer more soil protection than crops with small quantities of residue.

   Cover crops are grown when there would otherwise be no growing plants and/or residues to protect the soil from leaching and erosion. An example is winter rye seeded immediately after a corn crop is harvested for tillage. The growing rye protects the soil during the fall, winter, and early spring when the field would otherwise be bare and subject to erosion. Many cover crops are left on the soil to serve as a protective mulch, or are plowed under for soil improvement.

c. Improved soil fertility: Improved vegetative cover through increased soil fertility will reduce soil detachment and direct runoff. Soil fertility may be improved through the combined use of fertilizers, crop rotations, nitrogen fixing legumes, and incorporation of plant and animal organic residues to soil.

d. Permanent vegetative cover: Where slope and soils are particularly vulnerable to erosive runoff, a year-round grass cover or other plant material such as trees, shrubs, and vines may be required to provide permanent protection against runoff.

e. Field borders: Sod cover along the perimeters of tilled fields will increase sediment deposition and, in addition, soil absorption; and uptake of nutrients by plants will increase.

Vegetative Practices (Construction)

Vegetative measures for controlling erosion and sedimentation from construction sites include the use of cover crops, both temporary and permanent, and mulches. These practices also are particularly useful for controlling erosion that may occur from mining and logging operations.

a. Stabilizing moderate sites: Areas of moderate slopes and fertile soil can be easily stabilized by using plants and cultural methods common in the region. Establishing heavy plant cover on moderate slopes will usually protect the site from erosion. During land use changes, a temporary cover of annual vegetation is sufficient and, at the completion of the chaoge, more permanent cover crops should be used.

b. Stabilizing critical areas: Sites that have exposed subsoil, steep slopes, shallow depth to bedrock, drought conditions, or other limiting properties require additional treatment. Such sites demand special attention be given to seed bed preparation, adjusted fertility levels, supplemental irrigation, adapted seedlings or plantings, and site protection until the vegetative cover is established. More emphasis must be placed on the stabilization of critical areas because they erode severely and are the source of much sediment.

c. Mulching: Mulch can be used to protect constructed slopes and other areas brought to final grade at an unfavorable time for seeding. The areas can be seeded when the time is favorable without removing the mulch. Mulch is essential in protecting bare areas and in establishing good stands of grasses and legumes on steep cut-and-fill slopes and other areas where it is difficult to establish plants. By reducing runoff, mulch allows more water to infiltrate the soil. It also reduces the loss of soil moisture by evaporation; holds seed, lime, and fertilizer in place; and reduces seedling damage from heaving of the soil caused by freezing and thawing.

   The materials most widely used for mulching are small-grain straw, hay, and certain commercially processed materials.

Timber Harvesting BMPs[10]

Forest harvest studies have demonstrated that the greatest potential for water quality degradation from forestry activities is associated with timber harvesting. Poorly planned and carelessly performed logging operations may expose and disturb soils in ways that increase chances for erosioo, which in turn may lead to sedimentation of waters.

Fortunately, soil erosion from logging activity can be controlled by applying some simple BMPs. These practices are designed to prevent or minimize soil erosion and sedimentation of waters from improperly designed and constructed logging roads, skid trails, log landings, and stream crossings. Proper site-specific planning for the use of the BMPs before forestry operations are begun can prevent problems from occurring.

The BMPs listed below represent the range of practices generally applicable to New York. However, variation in environmental conditions across the state and differences in proximity to water make it impractical to require application of each one for all cases involving timber harvesting and road building. The following practices should be used as a check list when evaluating a logging site. Those BMPs best fitted to the local situation should then be implemented.

[10]Source: New York State Timber Harvest Guidelines, 1981.

a. Practices for crossing streams: Refer to page 68 of this chapter. Protection of water permits (Article 15 of the Environmental Conservation Law) should be obtained where necessary from the Regional Offices of the Department of Environmental Conservation (refer to inside back cover).

b. Harvesting of timber adjacent to streams

— Avoid cutting trees and destroying understory vegetation within 10 feet of the streambank;

— Keep skidders back at least 50 feet from the water and retrieve any logs closer than 50 feet to the streambank with a winch so as to prevent erosion. For slopes over 10 percent, maintain a buffer zone of at least 100 feet;

— Directionally fell trees so the tops land away from the stream;

— When clearcutting, leave a 50-foot wide, uncut buffer strip along both sides of flowing streams, ponds, and marshes to keep the water shaded and prevent its heating up by direct exposure.

Additional guidelines and performance standards that may be applied to timber harvesting in a stream corridor are contained in the Draft Rules and Regulations for Administration and Management of the Wild, Scenic and Recreational Rivers System in New York State which are available from the Department of Environmental Conservation (see Appendix P). Also see Table 18 on recommended buffer widths for protecting streams from timber harvest activities.

c. Felling and skidding on steep slopes adjacent to waterbodies:

— On steep slopes (over 30%), logging roads and skid trails should be no closer than 150 feet from streams, ponds, and marshes;

— Steep slopes should be logged only during summer when soils are dry; or alternatively when the ground is frozen and covered with snow;

— After logging, regrade roads and primary skid trails and install diversion devices and/or reseed as necessary.

d. Design, location, and use of roads and skid trails

— Keep roads and ski trails out of wet and poorly drained locations, and off tops and toes of streambanks;

— Provide ways to divert running water off roads and primary skid trails by using water bars, broad-based drainage dips, and proper sloping of roads and trails as needed;

— Carefully choose road and trail location to minimize steepness and to bypass potential erosion problem areas.

e. Location and use of log landings

— Keep landings out of low spots and poorly drained places;

— Put landings on gently sloping ground that will give good drainage;

— Landings should be established no closer than 200 feet from streams, ponds, lakes, and marshes to reduce chances of siltation from erosion.

CHAPTER 7: IMPLEMENTING A PROGRAM IN YOUR COMMUNITY

Previous chapters in this manual outline the tools and techniques for identifying stream problems, step-by-step processes for addressing the problems, and options which can lead to stream improvement. The purpose of this chapter is to tie the preceding chapters together. This will be accomplished by briefly examining how to organize to solve the problem. Also, several levels of program development ranging from "no-action" to a comprehensive program design will be discussed. Three case examples will be used to illustrate programming alternatives and organizational arrangements.

ORGANIZING TO SOLVE THE PROBLEM

> IT IS IMPORTANT TO MATCH STREAM MANAGEMENT PROBLEMS AND NEEDS WITH THE PROPER LEVEL OF GOVERNMENT.

When a community, or group therein, decides that it wants to initiate a stream corridor management program, a "lead" agency must be designated to provide the leadership to accomplish that task. A number of options are available. Following are some of the more obvious possibilities:

Local Leadership

Stream conservation activities may be initiated by towns, cities, or villages. A local governing body may designate its planning department or conservation advisory council (CAC) as the lead agency for developing and implementing a stream corridor management program. What makes the establishment and designation of a CAC particularly attractive is that:

a. These councils serve within the structure of local government as advisory, coordinating, planning and reviewing entities to assist in the protection, preservation, and enhancement of the quality of the environment.

b. State financial assistance for CACs is currently available for environmental conservation programs such as stream corridor management. This aid is available through the Local Assistance Program administered by the Department of Environmental Conservation (refer to Table 14).

County Level Participation

Stream corridor problems and management needs may transcend the jurisdictional limits of a municipality. Several communities having a common interest in protecting or enhancing a stream corridor for their collective benefit may find that the county is the most appropriate level of government to assist with the stream corridor planning and management task.

Within the county, a county planning department or environmental management council (EMC) may be designated as the lead agency for mobilizing resources, planning, and coordinating implementation efforts among communities. As in the case of local CACs, funding assistance is potentially available to county EMCs through the Local Assistance Program administered by the Department of Environmental Conservation. A county soil and water conservation district may be the best agency when assistance is required to design and install specific BMP's: for example, for the control of erosion and sedimentation, stormwater runoff, streambank stabilization (riprap, cribbing), development of buffer strips, snagging and channel clearing, and for installa-

tion of culverts which may be required as part of a stream corridor management program. Soil and water conservation districts also can be designated as the lead agency for planning, mobilizing resources and coordinating implementation efforts among communities.

State Involvement

State involvement should be reserved for rivers and streams and their shoreland environments which have been designated for inclusion in the state's Wild, Scenic, and Recreational Rivers system. A brief discussion of this program is presented in Chapter 5. The enabling legislation for the Wild, Scenic, and Recreational Rivers Act and regulatory standards for protecting stream and river corridors may be obtained from the Department of Environmental Conservation (see Appendix).

Watershed Associations

A watershed association may be formed by the local citizenry to provide leadership for solving quality problems in the stream corridor. Typically, a watershed association is organized as a private, non-profit corporation to preserve and enhance the natural qualities of a stream or river. This structure provides a formal framework for decision-making, makes the organization eligible for foundation grants, and encourages private donations (see Table 25).

TABLE 25
FUNCTIONS OF A WATERSHED ASSOCIATION

A watershed association serves three distinct functions:

1. Works to preserve and protect the river as a whole and is:

   — not limited by political boundaries

   — able to set stream corridor management priorities

2. Develops expertise and experience on stream or river corridor management issues:

   — develops knowledge of stream, land uses, water quality, etc.

   — develops knowledge of laws, regulations, and government processes

   — develops credibility with local and state officials

   — develops a professional staff

   — develops long-term projects, goals, and objectives.

3. Serves as a focus for public participation and private involvement in river protection activities by:

   — developing good relationships with the news media

   — interacting with local citizens groups, officials, businessmen, statewide environmental organization

   — public participation in programs of federal and state agencies

   — newsletters and other written materials

From: Draft — "River Conservation in the Northeast": A Citizen's Guide: National Park Service — 1984

PROGRAM ALTERNATIVES

There are essentially three program options available to a community which is considering whether or not to initiate a stream corridor management program. These include; "no-action", a single purpose alternative, and a comprehensive program design. Each alternative is briefly discussed as follows:

The "No-Action" Alternative

Under the no-action alternative, the impacts of improper land management practices on stream quality would not be recognized, and land use activities affecting the stream corridor would be unguided and left to chance. There would be no sense of direction and few programs to address stream corridor management needs. Nonpoint source contaminants, for example, sediment, nutrients, toxic substances, and pathogens would, over the long run, impair the usage of a stream as a water supply, or for fishing, swimming, and other recreational activities, particularly in urbanizing or rapidly developing areas. Similar stream problems could be anticipated in rural areas from a failure to implement BMPs to control nonpoint source pollutants from agriculture and timber harvesting. Furthermore, no consideration would be given to protecting scenic, aesthetic, or historic resources within a stream corridor, consequently, under the no-action alternative, the stream corridor would be indistinct from other areas in the community. Except for the success of the sewage and industrial wastewater treatment program in New York State, under the no-action alternative no remedial action would be taken to rehabilitate a stream for which usage has been impaired by nonpoint sources of pollution. The above scenario reflects the current situation in numerous communities throughout the state, and it represents a widespread lack of recognition of the value of streams.

The Single Purpose Alternative

It is probable that a majority of the stream corridor management programs will, in contrast to the fully comprehensive program described below, have a modest beginning. This is perfectly appropriate. It reflects the fact that not all communities have the technical or financial resources, nor do they necessarily have the need to implement a comprehensive program.

A stream management program initially may be a reactive response by a community, or groups therein, to a single, site-specific problem along a stream. For example, a highway supervisor may have his staff stabilize an eroding road bank contributing to stream sedimentation. A sportsmen's group working with landowners may establish a buffer strip along a stream by erecting fencing and planting suitable plant species to provide shade to the stream; or boy or girl scouts or 4H clubs might conduct a litter campaign aimed at keeping the stream free of debris. Although the above examples are illustrative of a modest beginning, they are nevertheless important initiatives to build upon. Furthermore, such single purpose initiatives may be all that is required to rehabilitate or enhance a stream.

Comprehensive Stream Conservation Program

A community may decide to implement a comprehensive stream conservation program to protect and enhance a stream which has unique features and attributes, or which could provide important benefits. A comprehensive approach may be essential when the stream has a variety of problems and management needs which demand action on a number of fronts. For example, there may be a need to:

- protect and enhance water quality to restore, protect, or improve a fishery or water supply
- preserve historic and scenic resources along the stream corridor
- develop recreational opportunities in the stream corridor
- enhance wildlife habitat

Also, there may be an opportunity to combine some of the above needs with an urban restoration and rehabilitation initiative.

By themselves, the above needs may arouse little community support. On the other hand, when taken together, the collective benefits that a community can derive by addressing stream problems may provide the kind of support needed to successfully initiate and implement a comprehensive stream corridor management program. Such a program would result in the preparation of an implementation plan for the entire course of a stream or a major segment thereof. The plan would fully consider the range of stream conservation options in Chapter 5 and it would identify those BMPs in Chapter 6 needed to either restore, protect, or enhance the stream and stream corridor.

EXPERIENCES IN STREAM CONSERVATION

A number of stream corridor management programs have been initiated by various communities and groups in New York State as well as in other parts of the country. The following case examples illustrate a few of the program initiatives that have been taken and some accomplishments to date.

The Little Hoosic Greenbelt Project

SPORTSMEN'S ORGANIZATION — A KEY FACTOR IN THE SUCCESS OF THE LITTLE HOOSIC GREENBELT PROJECT.

The Little Hoosic watershed is located along the eastern edge of New York's Rensselaer County. Although the Little Hoosic supports a rainbow trout population, fisheries habitat has been impaired largely through the elimination of pools in the stream, and from erosion and sedimentation. These problems have been aggravated by the removal of riparian vegetation which has destabilized the stream's banks, and by unlimited access of livestock to the stream which has contributed to streambank sloughing. Hydrologic modification also has impacted fisheries habitat in the Little Hoosic. Installation of a number of in-stream flood control structures, necessitated by ill-advised development in flood prone areas of the watershed, has further served to eliminate pools and spawning habitat in the stream.

In recognition of these nonpoint source problems, a "greenbelt" demonstration project was initiated along the Little Hoosic in 1980 by the Rensselaer County Soil and Water Conservation District, the Clearwater Chapter of Trout Unlimited, the Rensselaer County Conservation Alliance, and the Regional Fish and Wildlife Management Board. The purpose of this project is to protect and enhance water quality and fisheries habitat through the establishment of a vegetative buffer strip along much of the stream. Additional BMPs including control of barnyard runoff, stabilization of critical areas, conservation tillage practice, and proper timber harvest practices will be encouraged where necessary to protect soil resources and the stream.

The Rensselaer County Soil and Water Conservation District is taking the lead role and is working with riparian landowners and other groups involved in the project. During 1984, the Clearwater Chapter of Trout Unlimited was awarded a grant of over $3,200 from the National Offices of Trout Unlimited to carry on greenbelting work in the Little Hoosic watershed. Trout Unlimited members are donating several weekends each year to erect streambank fencing and planting willows and other species along impaired segments of the Little Hoosic needing such treatment. Other organizations participating in the project include USDA's Soil Conservation Service and Agricultural Stabilization and Conservation Service, and the Department of Environmental Conservation. This project points out that a number of organizations and resources can be mobilized to solve a stream problem. A brochure describing the Little Hoosic greenbelt project is available upon request from the Rensselaer County Soil and Water Conservation District, County Office Building, Troy, New York 12180.

The greenbelt project for the Little Hoosic was initiated on the Robert Bentley farm. Mr. Bentley provided over 150 feet of marginal pasture land on each side of the stream for buffer strip development. The site was fenced by Trout Unlimited in 1980 and planted in 1981. Note the cattle and equipment crossing located midway in the buffer strip. The Regional Fish and Wildlife Management Board and Rensselaer County Conservation Alliance contributed $1,000 and $500 respectively for the initial greenbelt work undertaken on the Little Hoosic. It may take ten or more years of growth before riparian vegetation can be expected to have a positive influence on the stream. (John Goerg Photo — DEC)

In 1984, members of Trout Unlimited planted willows and other species on several farms along the Little Hoosic. Trout Unlimited plans to install several thousand feet of fencing each year along impaired segments of the Little Hoosic to limit trampling of streambanks by livestock. (Photo Courtesy of Clearwater Chapter-Trout Unlimited)

The City of Troy Initiates A Stream Corridor Management Program on the Wynantskill

In 1975, the Environmental Conservation Commission of the City of Troy, New York proposed the Wynantskill Corridor Plan with a partial grant from the Ford Foundation. As mandated by the City Council, the Commission's preeminent duty was to "advise the City Mayor on matters affecting the preservation, development, and use of the natural and man-made features and conditions of the city insofar as beauty, quality, biological integrity, and other environmental factors are concerned and in the case of man's activities and developments, with regard to any major threats posed to environmental quality, so as to enhance the long-range value of the environment for the people of the city".

Recognized by numerous residents as one of Troy's most valuable natural resources, the Wynantskill corridor was considered endangered as a result of "ill advised, unplanned development proposals". In view of the threats to the Wynantskill corridor, and within the context of the above mandate, the City Council authorized the Commission to study and prepare a corridor management plan for the Wynantskill.

The planning study examined such factors as topography, slope, soils, land use, zoning, water quality, and flora and fauna. Environmental and social problems, although few in number, were found to be serious. Sewage, vandalism, and litter were among the most serious problems cited in the study. The plan recommendations fell into four major categories: land use controls, traffic and access improvements, pollution abatement, and recreation and development programming.

To date, several recommendations have been implemented. The city has acquired land in the stream corridor. A nature trail system has been constructed. SEQR is rigorously implemented for projects which might impact the stream corridor, and an ad hoc task force established within Troy's Planning Department is currently preparing conservation zoning guidelines which the City Council may enact to further protect the stream corridor. Inquiries concerning the Wynantskill Corridor Program should be directed to the City of Troy Planning Department, City Hall, Troy, New York 12180.

This aerial photograph shows the relationship between the Wynantskill Corridor and the City of Troy. The Burden's Pond area, located in the top right of the photograph, has been acquired by the City.

The Wynantskill enriches the City of Troy with scenic amenities. The Wynantskill Corridor is regarded as an "environmental park" which provides the residents of Troy with passive recreation.

The Inspiring San Antonio (Texas) Riverwalk[1]

Throughout its history, the San Antonio River has been, for the most part, a quiet stream, spring-fed and meandering. A town grew up on its banks, the same way towns all over the world were built — near water resources.

As San Antonio grew, the river was ignored. As a consequence, the San Antonio River received the backyards of houses and backs of buildings. There were few exceptions to the general rule and, as growth occurred, higher densities and greater urban development simply resulted in taller buildings which backed up to the stream. Urbanization was accompanied by a deterioration in water quality.

At one point, there was serious talk of covering the stream with concrete and making a street above, with the bed serving as a sewer. Fortunately, this did not occur. In its place, a flood prevention program was launched and, in 1938, the full aesthetic potential of the river in the town was recognized. With strong support of elected officials and a group of citizens, leadership was provided for what was to become the first real development of the river. In these early years, a landscape architect was commissioned and the results of the designs can be seen today. These include the broad walks, the arched bridges, and the steps from street to river level which all were accomplished during this time.

Up until the mid-1960's, no significant business ventures and/or tourist attractions were established along the river walk. However, in 1961, a concept emerged for developing the stream's economic potential. With the support of the San Antonio Chamber of Commerce, the City Council, in 1962, passed an ordinance which established a River Walk Commission consisting of seven members appointed by the City Council. The Commission was empowered to review and advise the director of the Department of Housing and Building Inspections concerning "the appearance of proposed construction, color texture of materials, and architectural design of buildings whereby it is proposed to alter, modify, repair, or construct improvements, as well as install signs, or proposed lighting arrangements". A master plan study then was carried out resulting in the preparation of a community comprehensive general plan. The master plan resulted in a land-use plan, a planning districts recommendation, and a capital improvement program for development, both in the public as well as the private sector, and was presented in the form of drawings and text and a large model.

Because of the importance of architectural rehabilitation to the realization of the plan, a sequence of sketches was prepared to illustrate the overall plan concept.

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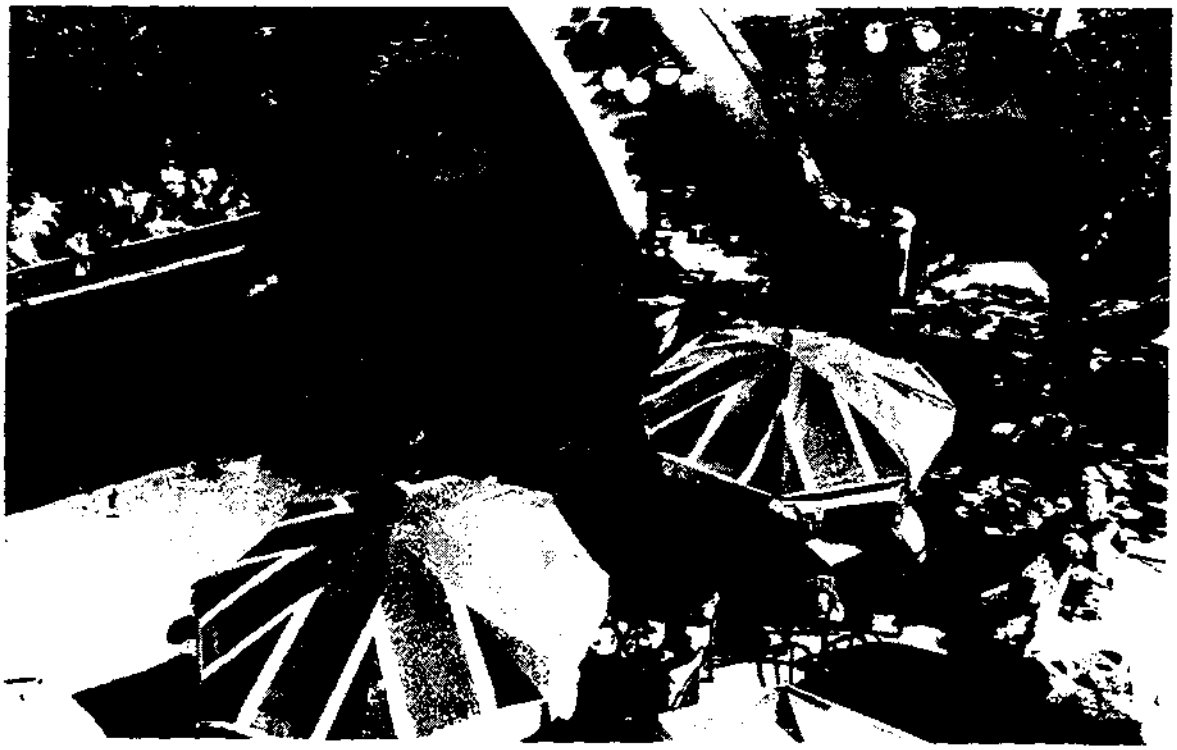
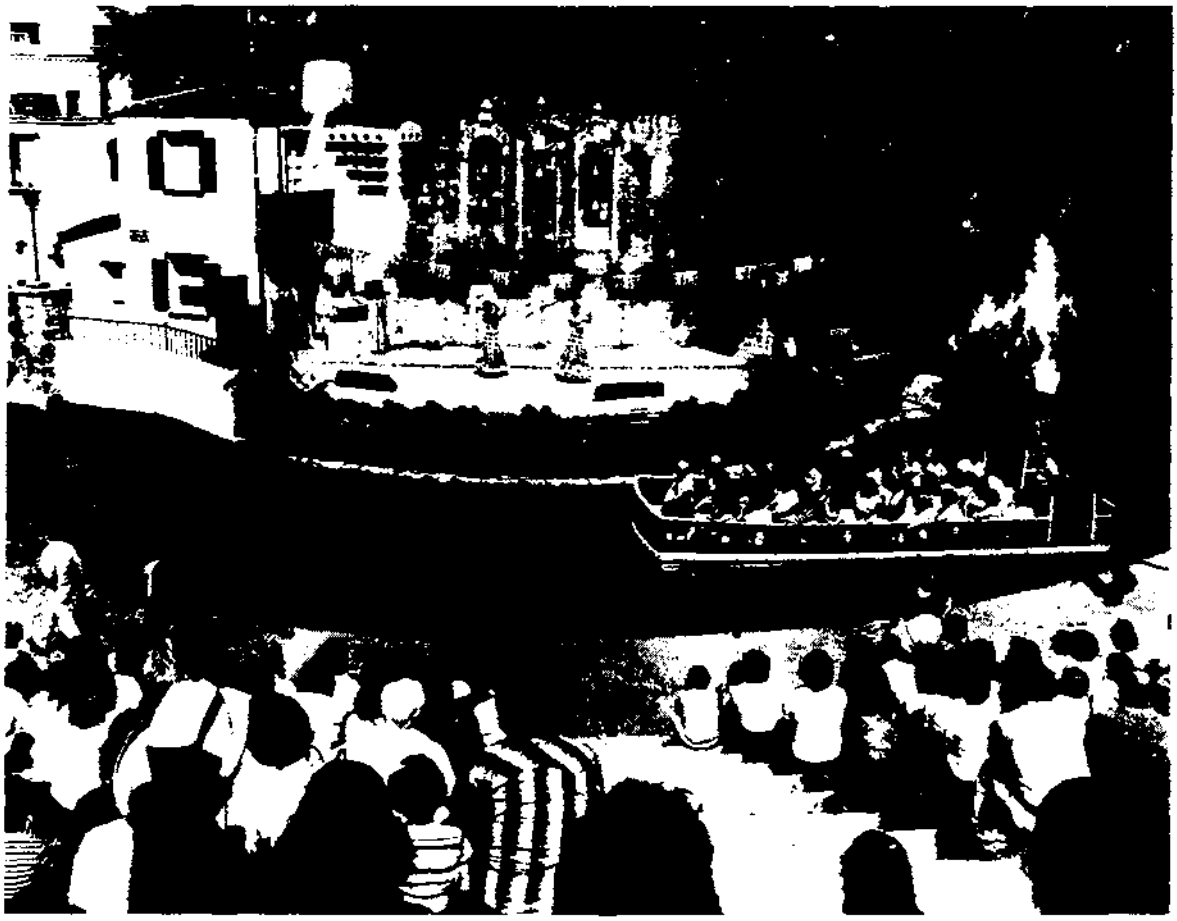
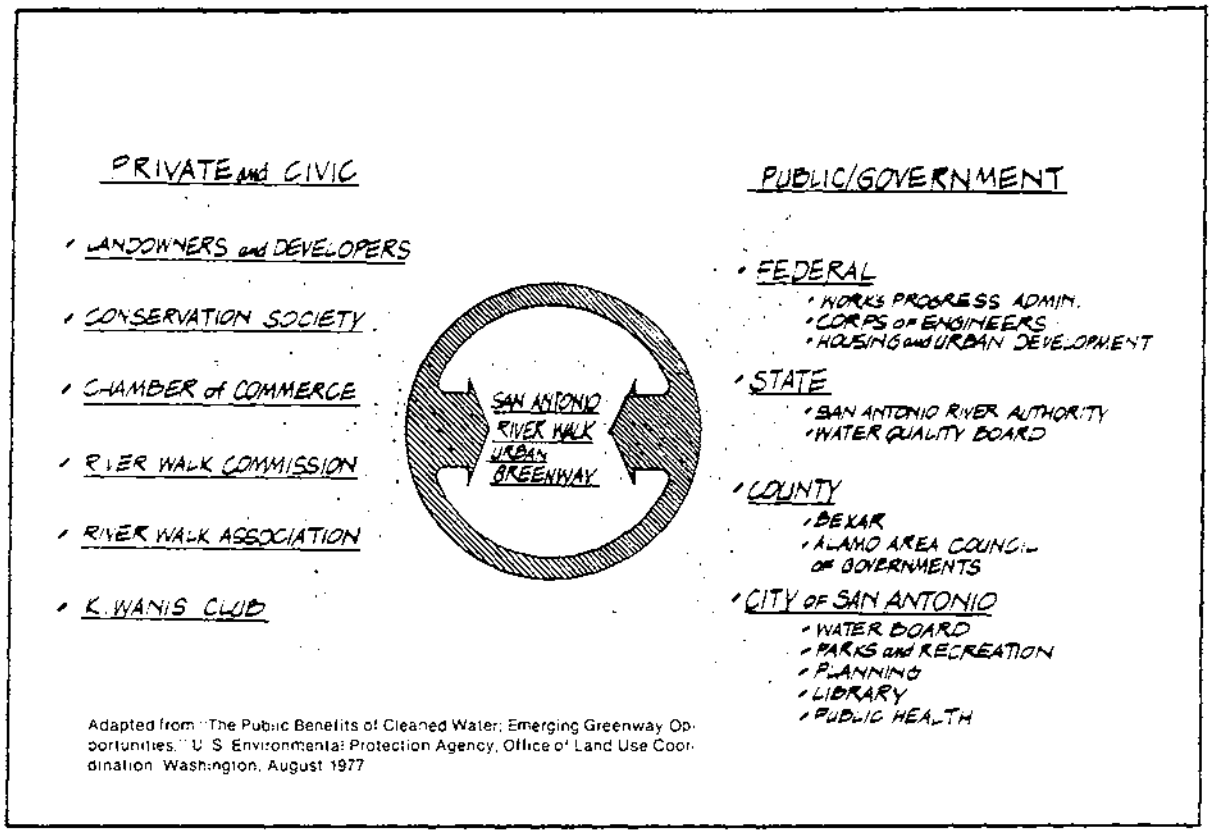
[1] Information on the San Antonio Riverwalk, courtesy of the San Antonio, Texas Convention and Visitor's Bureau.





Planners, turned salesmen, presented drawings, text, and model to meeting after meeting of stream corridor property owners, potential business tenants, civic leaders, garden clubs, and any organized group willing to listen. Business activity began to stir. The public sector began to landscape much of its stream corridor property. In the private sector, architects were commissioned to prepare preliminary designs for remodeling and rehabilitation consistent with the master "concept" plan. The photos on the preceding pages show how an urban stream can serve as a focal point for urban restoration and economic revitalization.



Adapted from "The Public Benefits of Cleaned Water: Emerging Greenway Opportunities." U. S. Environmental Protection Agency, Office of Land Use Coordination. Washington, August 1977

While the San Antonio River Walk provides an excellent example of urban stream corridor planning and management, it is an equally good illustration of cooperative teamwork. This diagram shows a creative combination of private and civic groups working with all levels of government. It incorporates and responds to a wide range of community values from flood control to historic preservation and has been over forty (40) years in the process.

THE TRAGEDY OF THE COMMONS

As common property resources, streams (and lakes) are "everybody's property, but yet nobody's property." Streams are the common property of society where their use is available to everyone, and if no one is required to take into account the effect of their use upon others, the resource will tend to become overused. Therein lies the tragedy of the commons.

"The Tragedy Of The Commons"

"The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast way below the carrying capacity of the land. Finally, however, comes the day of reckoning; that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy.

As a rational being, each herdsman seeks to maximize his gain. Explicitly, more or less consciously he asks, "What is the utility to me of adding one more animal to my herd?" This utility has one negative and one positive component.

1) The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly plus 1.

2) The negative component is a function of the additional overgrazing created by one or more animals. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of minus one.

Adding together the common partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to the herd. And another: and another.... But this is the conclusion reached by each and every rational herdsman sharing the commons. Therein lies the tragedy. Each man is locked into a system that compels him to increase his herd without limit — on a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in the commons brings ruin to all".

Garret Hardin
"The Tragedy of the Commons"
Reprinted by Permission of Science 162., December, 1978, pp.1243-1248. Copyright 1968 by the American Association for the Advancement of Science.

In a reverse way, the tragedy of the commons reappears in problems affecting streams. Here it is not a question of taking something out of the commons, but of putting something in — sedimentation and nutrients through mismanagement of land resources, heat through removal of riparian vegetation, and increased peak flows leading to flooding through creation of impervious areas related to urban growth and development. Problems such as these are distinctly of a social nature in that they impose costs upon others external to those responsible for creating them. Within this context, government, particularly at the local level, has a key role to perform in the formulation of policy, plans and implementation strategies for addressing common property resource problems associated with streams within their jurisdiction. This manual has sought to provide guidance which landowners, organizations, and public administrators may draw upon to protect and enhance streams for the benefit of the community. Having this manual in hand, the next step is up to you.

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GLOSSARY

Antecedent Rainfall — Rainfall that occurred prior to the particular rain storm under consideration.

Base Flow — Precipitation which percolates through soil to the ground water table and eventually seeps into a stream and which constitutes all the natural dry-weather flow.

Best Management Practices (BMPs) — The most environmentally, socially and economically appropriate in-stream or land treatment measure which can be applied to control a nonpoint source water quality problem.

Biota — Plant and animal life from a given area.

Buffer Zone — An area situated between two areas which are a possible conflict. The objective of the buffer zone is to reduce the possibility of adverse impact land use on water quality.

Dissolved Oxygen — Gaseous oxygen which becomes soluble and is absorbed by water.

Eutrophication — The natural aging process which occurs in lakes and leads to their eventual extinction. Cultural eutrophication is the accelerated fertilization of impoundments, streams, and lakes arising from pollution associated with population growth, industrial development, and intensified agriculture.

Floodplain — Land that normally is dry which becomes inundated by any flow greater than the base flow.

Hazardous Substance — Chemical substances or compounds which may be toxic to humans and animals, volatize and create nuisance odors, be persistent and bioaccumulate, pose fire or explosion hazards, be corrosive to structures or underground utilities, or react with other substances to produce hazards.

Hydrologic Modification — Any alteration of the terrain which results in change in movement, distribution, flow or circulation of surface or groundwater such as construction of dams, stream channelization, or paving extensive areas of land.

Lag Time — Referring to runoff of rainfall, the time the center of mass, or beginning of rainfall to the peak, or center of mass, of runoff.

Nonpoint Source — Noncontinuous diffuse inputs of pollutants above the inputs from undeveloped land of similar genesis.

Nutrient — Referring to water quality, elements, including nitrogen but particularly phosphorus, which stimulate algal growth and other plant growth so as to change the trophic condition of a lake.

Organic Matter — Any part of any substance which once had life. Organic matter, then, consists of any animal or vegetable waste or by-product.

Pathogenic Organism — Any microorganism or virus that can cause disease.

Peak Flow — The maximum instantaneous rate of flow during a flood.

pH — A symbol for the degree of acidity (values from 0 to 7) or alkalinity (values from 7 to 14).

Phytoplankton — Free floating microscopic plants in bodies of water.

Point Source — A pollutant reaching a receiving water by a pipe or man-made conveyance from a discrete source.

Rill Erosion — Rill erosion occurs when sheet flow moves down fairly steep slopes, forming small channels with depths up to 1 ft., fairly evenly spaced across a slope.

Riparian Vegetation — Vegetative growth along the banks of a stream.

Rip-Rap — Large stones, rocks or boulders placed along a stream or lake to protect the banks from scouring and erosion.

Sediment — Eroded soil particles which are transported by wind or water and settle to the bottom of a stream or lake.

Sheet Erosion — Removal of a fairly uniform thin layer of soil from the land surface. Erosion associated with runoff that is flowing like a sheet over the ground.

Snagging — Removal or clearing logs, trees, tree stumps or other debris from a stream channel.

Total Alkalinity — A term used to represent the content of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates in water. Indirectly the well-being of fish may be affected by total alkalinity, because waters with low values are generally biologically less productive than those with high values.

Trophic Condition — In lakes and rivers, refers to the dissolved oxygen content and nutrient concentrations. Oligotrophic lakes are nutrient poor and biologically unproductive. Typical examples are deep, cold-water, and spring-fed lakes exhibiting transparent water, limited plant growth, and low fish production. A small increase in nutrient level results in a mesotrophic lake with some aquatic plant growth, greenish water, and moderate populations of sport/fish. Eutrophic lakes are nutrient rich with lush growths of aquatic weeds, blooms of algae, and large population of tolerant fish. The latter trophic level often exhibits water quality undesirable for water supplies, human health, fisheries, and recreation.

Turbid — A condition of water due to fine visible material supervision, which may not be of sufficient size to be seen as individual particles by the naked eye but which prevents the passage of light through the water.

APPENDIX

An appendix separate from this manual has been prepared which contains specific, detailed information of various aspects of stream corridor management. The following is a list of material which can be requested from the Bureau of Water Quality Management, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233*

A. New York State Environmental Conservation Director

B. Radz Methodology for Predicting Stream Temperature Change in Response to Alterations in Riparian Vegetation.

C. Sample Overlay Zoning Provisions

D. Sample Provision for Cluster Zoning

E. Sample Planned Unit Development (PUD) Provisions

F. Sample Provisions for Incentive Zoning

G. Sample Provisions for Special Permits

H. Sample Provisions for the Transfer of Development Rights

I. Sample Provisions for Site Plan Review

J. Measures for Flood Loss Reduction

K. Sample Local Flood Damage Prevention Law

L. City of San Antonio (Texas) River Walk Ordinance

M. Model Erosion and Sediment Control Ordinances

   Monroe County Model
   Orange County Model
   Lake George Basin Model

N. Model Stormwater Management Ordinances

O. New York County Law — Special Districts for Lake Protection and Rehabilitation

P. Draft Rules and Regulations for Administration and Management of the Wild, Scenic and Recreational River Systems in New York State

Q. Information on the Effectiveness of Various Practices for Controlling Selected Nonpoint Source Pollutants

R. Sample Land Use Standards for a Stream Corridor Management (Overlay) District

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*NOTE: This appendix should be considered open-ended in that the list will be expanded as additional material related to stream corridor management becomes available.

April 1985

REGION 6
State Office Building
317 Washington Street
Watertown, N.Y. 13601
(315) 785-2236

SUB-OFFICES
30 Court Street
Canton, N.Y. 13617
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Utica, N.Y. 13501
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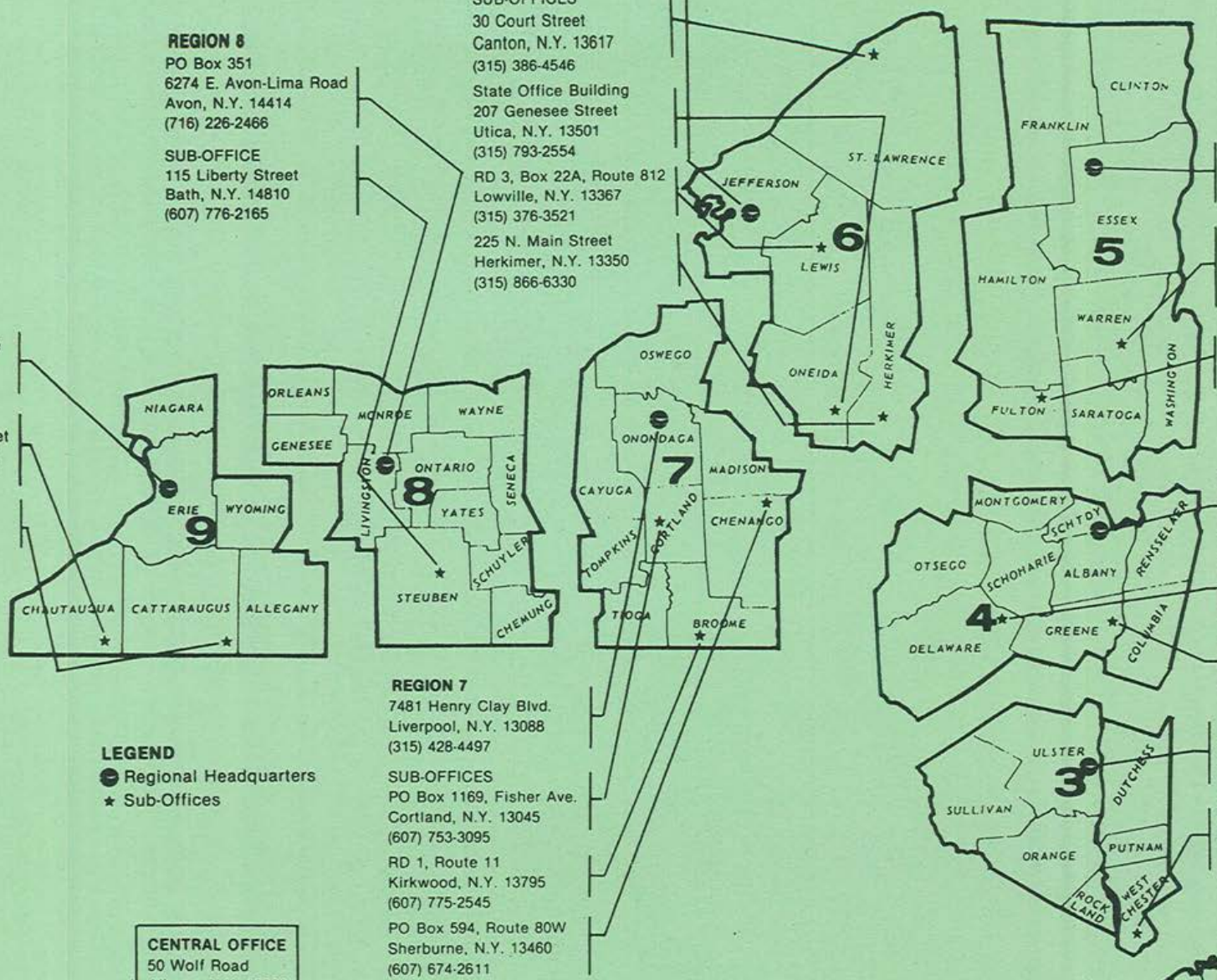

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Northville, N.Y. 12134
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Schenectady, N.Y. 12306
(518) 382-0680

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PO Box 430, 439 Main St.
Catskill, N.Y. 12414
(518) 943-4030

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21 South Putt Corners Road
New Paltz, N.Y. 12561
(914) 255-5453

SUB-OFFICE
202 Mamaroneck Ave.
White Plains, N.Y. 10601
(914) 761-6660

REGION 7
7481 Henry Clay Blvd.
Liverpool, N.Y. 13088
(315) 428-4497

SUB-OFFICES
PO Box 1169, Fisher Ave.
Cortland, N.Y. 13045
(607) 753-3095

RD 1, Route 11
Kirkwood, N.Y. 13795
(607) 775-2545

PO Box 594, Route 80W
Sherburne, N.Y. 13460
(607) 674-2611

LEGEND
● Regional Headquarters
★ Sub-Offices

CENTRAL OFFICE
50 Wolf Road
Albany, N.Y. 12233

Department of Environmental Conservation

REGION 2
Two World Trade Center
61st Floor, Room 6126
New York, N.Y. 10047
(212) 488-2755

REGION 1
SUNY Campus
Building 40
Stony Brook, N.Y. 11794
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