Executive Summary

SUSTAINABLE WATERSHED MANAGEMENT

A MODEL PROGRAM TO BALANCE WATER RESOURCES AND LAND DEVELOPMENT IN THE FRENCH AND PICKERING CREEKS WATERSHEDS

Chester County's French and Pickering Creeks are renown for their exceptional water quality, natural beauty and rich historical heritage. Both watersheds are relatively undeveloped. However, growth pressures are increasing, with urbanization radiating out from central Philadelphia over the past sixty years, and projections anticipate a dramatic increase in development. The implications for water resources are significant, with greater demands for groundwater withdrawals and impacts on stream systems, as land use changes increase runoff and nonpoint source pollution, and wastewaters burden water quality. The Green Valleys Association, a regional watershed organization with a long history of support and guidance to local government, has undertaken a program which is intended to allow development with minimal impact on water resources, by changing how development takes place within the watersheds. The present system of land use allows random development, limited only by zoning and land use regulation, and water resource impacts are seldom considered with respect to the local drainage system.

The fundamental resource management objective proposed here is to measure the tolerance limits of the natural system and balance the human use of these land and water resources so that we live within the carrying capacity of these natural systems. This concept takes the form of a program we call Sustainable Watershed Management. The following water resource management objectives have been established based on this concept, with modeling methodologies developed to achieve these objectives:

- Maintain stream base flow, in particular during drought periods (Q_{7-10}).
- Maintain groundwater levels in order to protect existing and future wells.
- Assure that stream flooding is not increased.
- Prevent groundwater contamination, particularly from nitrate.
- Minimize additional point and nonpoint source pollutant inputs into surface waters.

To quantify the critical links between land development and water resources, Cahill Associates has developed a series of "models" for application on a watershed basis. In this program the different impacts on the hydrologic cycle are described by different but overlapping models, such as the Low Flow Maintenance Model, the Dry Year Nitrate Impact Model, the Cumulative Flooding Model and the Impervious / Pervious Runoff Impact Model. The Model Program includes a variety of both technical and institutional objectives and related work tasks, all of which are designed to provide the local government with the capability to evaluate potential impacts of development, and more importantly to modify any given proposal to mitigate that impact. In subsequent planning, the GVA is working with the 17 townships to modify and revise their regulatory documents in order to incorporate this resource impact data, and require mitigation measures as part of the development process. Thus the Program will be a dynamic process, anticipating resource impacts and preventing them before they occur.

SECTION 1.0 INTRODUCTION

SUSTAINABLE WATERSHED MANAGEMENT

A MODEL PROGRAM TO BALANCE WATER RESOURCES AND LAND DEVELOPMENT IN THE FRENCH AND PICKERING CREEKS WATERSHED

1. INTRODUCTION

1.1. Program Purpose and Goals

Chester County's French and Pickering Creeks are renowned for their exceptional water quality, natural beauty, and rich historical heritage. Both watersheds are relatively undeveloped, with much of the existing development clustered around the Borough of Phoenixville at the eastern end of the watersheds, plus expanding urbanization from the Exton area in the headwaters of the Pickering. The balance of the two watersheds is rural and low density residential, with a substantial amount of state forest land and other open space in the headwaters of the French Creek. However, growth pressures are increasing, and population projections for the municipalities throughout the two watersheds confirm that substantial new development will occur. Furthermore, this new development is presently occurring in patterns that are less dense and more land consuming than ever before. Average lot size in many Chester County developing municipalities has increased dramatically in the past 60 years, such that more and more watershed area is "consumed" by fewer and fewer people on a per capita basis.

This diffusion of urbanization is a reflection of changing land use patterns on a regional basis. Over the past sixty years, the higher density residential communities of the metropolitan region have decreased, while the four suburban counties surrounding the city center have experienced a more diffuse pattern of development and growth along major transportation corridors. Figure 1-1 illustrates this pattern of growth pressures radiating out from central Philadelphia over the period, with the French and Pickering Creeks highlighted. Given these trends, the Year 2020 development projection can be expected to reflect a dramatic increase.

What are the implications for water resources? The additional population translates into demand for new water supplies, primarily groundwater-derived, construction of on-site sewage systems or community wastewater treatment plants, and conversion of natural vegetation into a mosaic of impervious surfaces and chemically maintained landscapes. The resultant water resource effects will be both quantitative and qualitative. The impacts on water quantity include reduced stream base flow during dry weather, a corresponding lowered groundwater table with depletion of small wells and springs, increased stormwater runoff and resultant flooding impacts downstream, and other disruptions of the hydrologic balance. Water quality impacts include the pollution discharged as part of the stormwater runoff, generated from both new impervious and pervious surfaces (lawns), increased runoff velocities creating worsened streambank scouring and sediment erosion, wastewater discharges to both surface and groundwater, malfunctioning on-site septic systems, and other pollution inputs to streams which are magnified by the diminished stream flow.

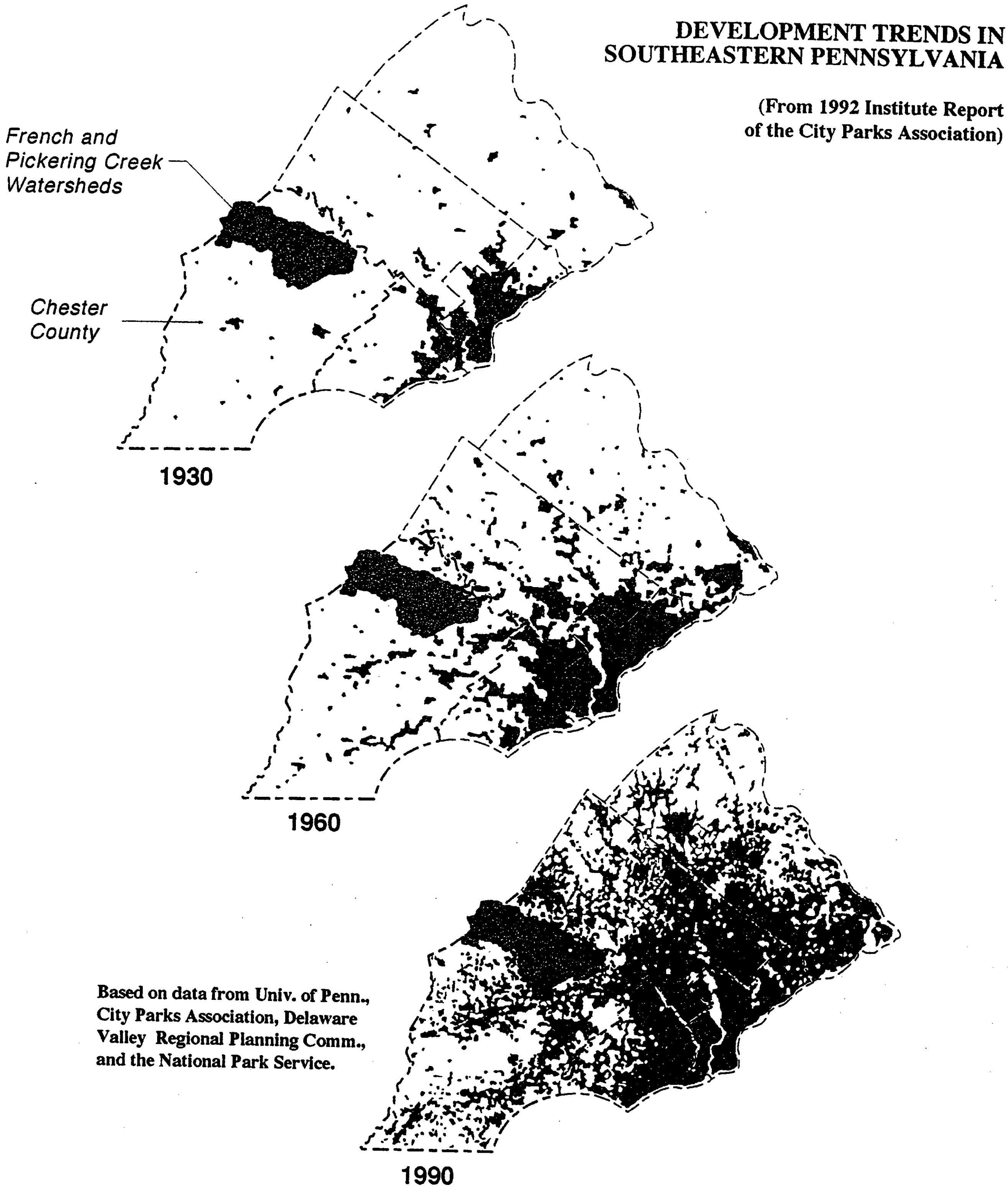

Figure 1-1 Urbanization in the Delaware Valley

To date, most interest in pollutant production from urbanization has focused on the relationship between stormwater quality and the new impervious surfaces resulting from land development, implicit in the image of Figure 1-1. However, pollutant loads also are generated from pervious maintained areas--the ever increasing lawns and landscaped areas that accompany sprawling suburban growth. The current trend of reduced density development also necessitates, on a per capita or per dwelling unit basis, increased road construction, more and longer travel trips, and a variety of other adverse impacts on air, water and other elements of the environment. Given these growth trends and land development realities, it becomes apparent that the essential values so sought after by the new residents in the French and Pickering watersheds are in jeopardy as a result of this growth.

1.1.1. Municipal Decisions on Land Use

What can be done? Can we live on the land without threatening the very water resources on which our land use is dependent? This sustainable development program advocates measures by which these threats can be avoided, not by prohibiting development, but by changing how new land uses occur throughout the Watersheds. This means carefully locating and concentrating new land development, in patterns which function within the limits of the available water resources. This concept is key: to measure and define the tolerance limits of the water resources which exist within our political and hydrologic units and live within those limits. The present system of land use allows development to take place randomly within large land areas, limited only by municipal zoning and land development criteria, which usually have little to do with the local hydrology. The water resource impacts of new development is seldom considered with respect to the small drainage system in which it takes place, or the natural capacity of that system.

Because much of this land use planning needs to be accomplished from an area-wide drainage or watershed perspective, transcending municipal boundaries, the traditional municipal focus of planning must be extended. But how can each individual municipality, with its limited jurisdiction, staff and budget, be expected to analyze watershed-wide problems so vastly exceeding municipal capabilities? This Program is intended to analyze these vital water resource problems, identify optimal solutions, and define a workable strategy to implement sustainable development on a watershed basis. That strategy must then ultimately be translated from a watershed concept to fit within the 17 municipal boundaries which comprise the watershed (plus small portions of three other municipalities), as illustrated in Figure 1-2. This figure clearly illustrates the potential for conflict between the frameworks for land use decision-making and water resources, with the actions of local government frequently at odds with the water decisions made at the state, regional and federal level in the French and Pickering Creek Watersheds.

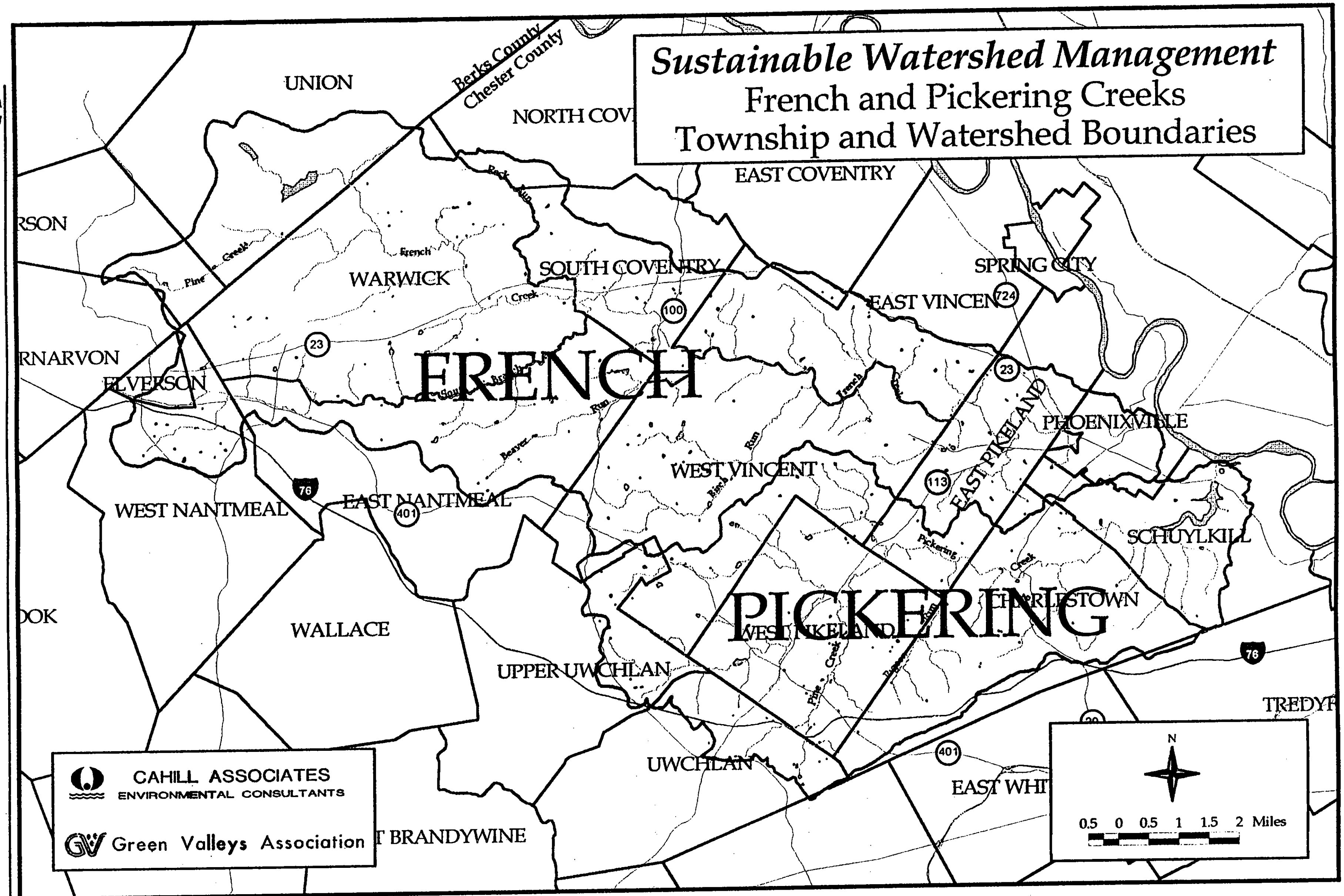

Figure 1-2 Township and Watershed Boundaries

1.1.2. County and State Decisions on Water Resources

By comparison to the municipal land use management process, virtually all of the decisions made with respect to water resources are made at the county, state, river basin or Federal level, based on watershed boundaries. For the most part, the state, in the form of the Department of Environmental Protection (DEP) plays the key role as regulator of water quality. They permit wastewater discharges to both surface streams and groundwater (with the County Health Department implementing the state act which regulates on-site sewage systems), and also permit the withdrawal and distribution of surface water resources by the water allocation process. Quantitative limits of groundwater withdrawals are not regulated by the state, although portions of the watersheds are partially regulated by the Delaware River Basin Commission (DRBC), and this regulation may increase in the near future. The water quality guidance takes place within a regulatory framework created at the Federal level some twenty-three years ago (CWA, 1972) and implemented through the U. S. Environmental Protection Agency (EPA), augmenting Pennsylvania's Clean Streams Law, which goes back sixty years (1937).

The Delaware River Basin Commission (DRBC) has established limited regulation of groundwater withdrawals in certain portions of the French Creek basin, but this regional agency has generally played no major role in overall water resource management. In fact, the withdrawal and use of groundwater, as compared to a fairly specific regulation of surface waters, is largely unregulated with respect to quantity. Pending changes to the DRBC regulations in the "DRBC Groundwater Protected Area" (Figure 1-3), however, could dramatically change this situation. The proposed regulations will provide a regulatory foundation for municipal ordinances, which are consistent with and expand upon these groundwater withdrawal limits. At the present time, no municipal oversight is provided for the quantity of ground water which public or private wells withdraw.

1.2. Program Participants and Sponsors

One might ask what can a private, non-profit local watershed organization such as the Green Valleys Association (GVA) accomplish with respect to either land use or water resources management in such a complex and poorly interrelated system of decision making. The answer to that question is provided in the program outlined in this report. In a nutshell, the GVA has developed information detailing the impacts of land use change on water resources within each municipality, and offered recommendations as to how changes to the existing land use regulatory system can mitigate or prevent such loss and degradation. That is, the GVA has developed the technical linkage between land use decisions and water resources, with the intent of influencing the local decision-making process.

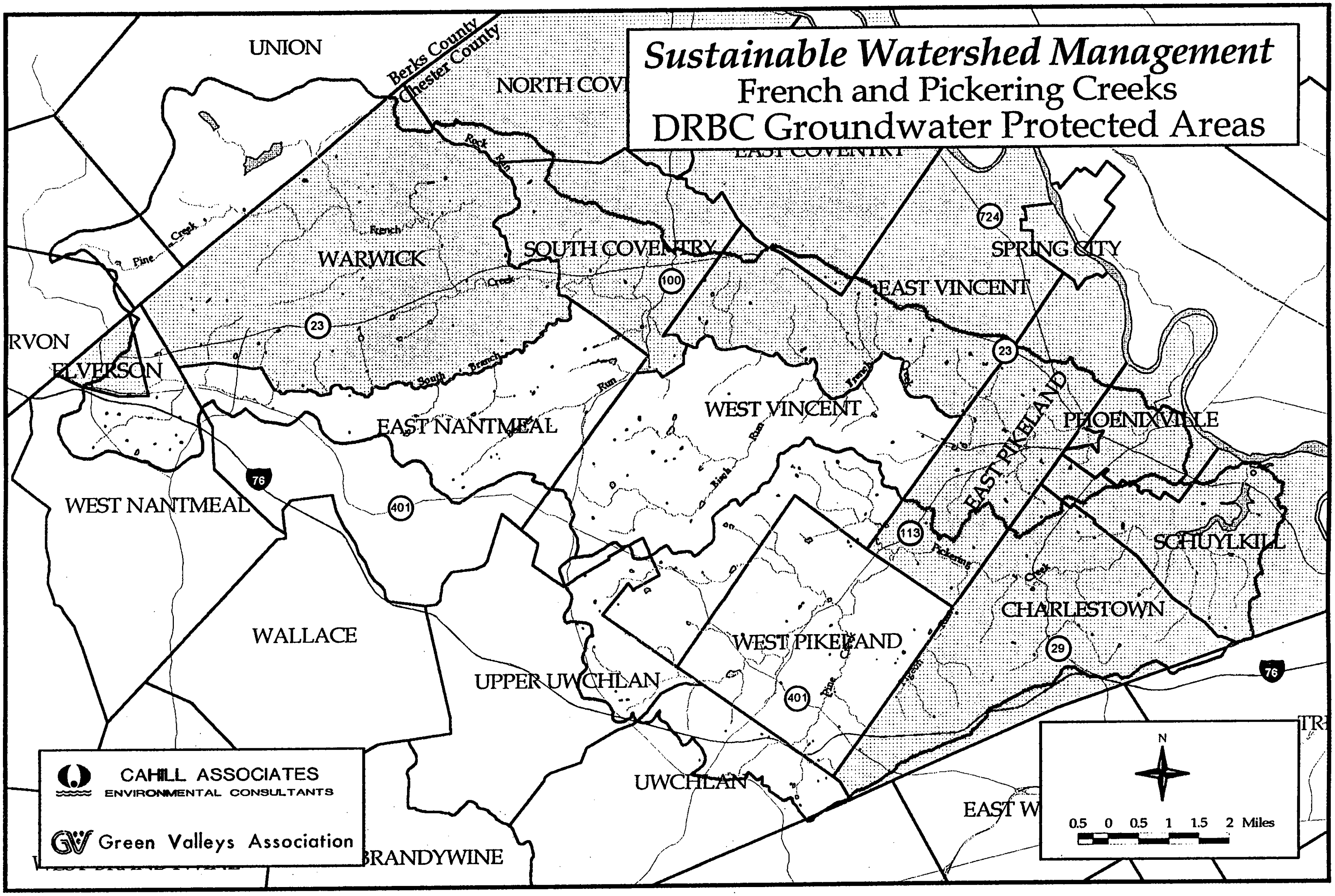

Figure 1-3 DRBC Groundwater Protected Area

Green Valleys Association developed a funding strategy for this Model Program in the spring of 1995 which included both public and private sector support. This strategy has been extremely successful. In terms of public monies, GVA has received $50,000 from Pennsylvania's Rivers Conservation Program, a new program created by the Keystone Recreation, Park and Conservation Fund Act of 1993, and administered by the Department of Conservation and Natural Resources (DCNR). This program requires 50 percent matching funds, which has been provided by private foundation support from the William Penn Foundation, with a $50,000 grant award for this project made in the Spring of 1995, and the Claneil Foundation, which provided $4,000 during the same period. Additionally, a $10,000 Legislative Initiative Grant was awarded by Pennsylvania Rep. Curt Schroeder for use in this project. Municipalities within the Watersheds also have been asked to provide financial assistance, and local financial contributions have totaled approximately $5,000. In sum, total grants received total approximately $116,000.

As part of the Model Program, GVA has strongly encouraged financial participation by all municipalities, since Program implementation is key. Although the size of these financial commitments is relatively modest, participation in funding by all of these "stakeholders", who ultimately will have implementation responsibilities, is essential. That vital sense of ownership, so strongly felt by home and property owners on the municipal level, must be extended to watersheds in order to implement the Model Program. Stakeholders must "own" the Model Program planning process--a challenging objective to be achieved through a variety of techniques.

Another important technique promoting implementation is to integrate the Model Program planning process with other related processes, either ongoing or planned. For example, a major reason for selecting the French and Pickering Creeks Watershed in the first place was the existence of the virtually unique Federation of Northern Chester County Communities (Figure 1-4). This is an example of a voluntary joint municipal organization which has undertaken numerous area-wide studies in the past and has recently completed a new comprehensive plan for its municipal jurisdiction. There has been discussion that this new plan could become the basis for inter-municipal zoning, not as yet attempted by the Northern Federation. Although Northern Federation boundaries do not exactly coincide with watershed boundaries, the Northern Federation constitutes a uniquely valuable asset for Model Program implementation.

The Chester County Planning Commission (CCPC) has also embarked on a new comprehensive county-wide planning process with the issue of "Landscapes" in 1996, and the Northern Federation Comprehensive Plan has provided major input to this county-wide effort. In addition, the Planning Commission and County Water Resources Authority (WRA) plan to undertake a multi-phased management plan for water resources. This special planning includes several sub-plan components, some of which either have been completed or are underway, including the Service and Use Report, Service Policy Report, and Water Supply Plan. Much of the actual Water Plan could borrow substantially from this French and Pickering Sustainable Watershed Program.

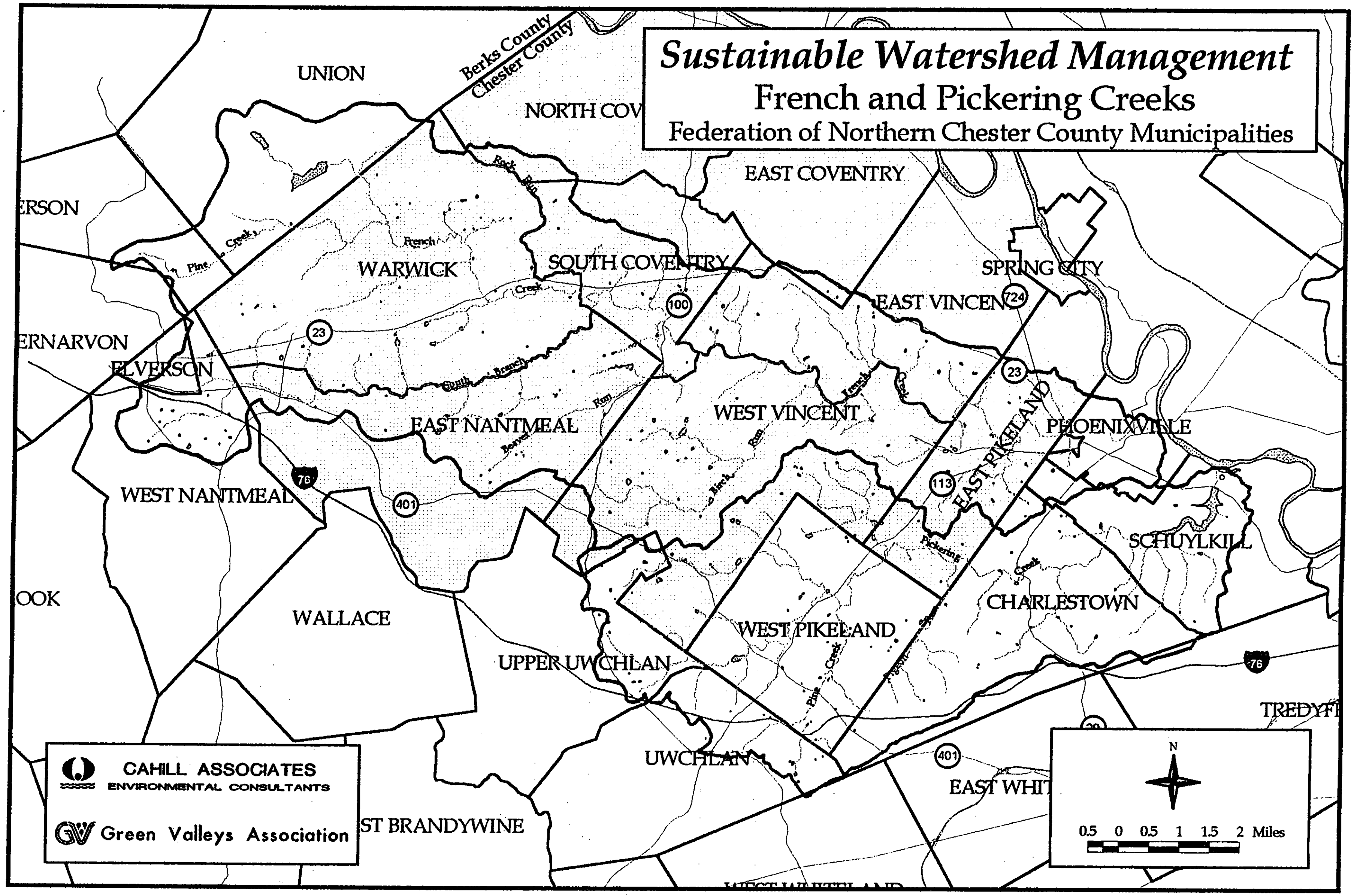

Figure 1-4 Federation of Northern Chester County Communities

In sum, development of this Sustainable Watershed Management Program should be viewed as the culmination of water resource management technology, with advancements in Geographic Information System (GIS) techniques, evolving legal and other institutional concepts, all coming together in concert with a variety of related local and county planning efforts. All of these efforts are predicated on the growing awareness that problems in watersheds are mounting--that what currently is being done to manage growth is inadequate--that "business as usual" ultimately will result in water resources crises. Perhaps, most importantly, the Model Program guarantees that these new directions for sustainable watershed management will be based on scientific analysis. With this information in hand, new interpretations of laws and regulations are made possible. As such, the Model Program is not only of compelling value for the French and Pickering Creek Watersheds, but offers the potential for application well beyond northern Chester County.

1.3. Planning Process

The Model Program includes a variety of both technical and institutional objectives and related work tasks:

- Bringing together the various agencies and institutions which must cooperate and coordinate efforts to achieve water resource protection. The precedent-setting alliances already in existence will be used to forge stronger and more effective joint watershed-wide efforts.

- Development of a Geographic Information System (GIS), including a land and water data base for the Watersheds. This GIS has been designed for subsequent application in other Chester County watersheds and elsewhere in Pennsylvania. The GIS is structured to serve existing agency needs, such as at the Chester County Planning Commission, and to exploit all existing data development, such as at the US Geological Survey, Chester County Health Department and elsewhere.

- Documentation of generic water resource impacts resulting from new land development. A computer modeling system, titled the Water Balance Model (WBM), based on the concept of maintaining balance within the hydrologic cycle has been developed to evaluate the potential impacts of land use changes. These impacts include the reduction of stream baseflow during dry periods, analyzed using a sub-routine labeled the Low Flow Maintenance Model (LFMM). A second sub-routine, the Dry Year Nitrate Impact Model (DYNIM), has also been developed to assess groundwater quality impacts resulting from new land development. A third sub-routine, the Stormwater Impact Model (SIM), estimates both increased runoff quantities and non-point source surface water quality impacts. This array of models results in a total methodology which can be used in other watersheds throughout Chester County.

- Delineation of the Baseline Future of the Watersheds, defined by the application of existing municipal zoning ordinances to developable land within the watersheds, as an evaluation of total build-out of the existing patterns of land management. For the purposes of this study, developable land is comprised of agricultural lands not under protective covenant and vacant land parcels.

- Application of the model impact analysis to the Baseline Future for watershed municipalities, and recommendation of alternatives.

- Evaluation of the existing management system that governs land development and water resources, with identification of management gaps linked to water resource impacts. Of special importance will be analysis of legal capabilities for expanded municipal action, grounded in the Pennsylvania Municipalities Planning Code (MPC), and building on the proposed revisions to the DRBC groundwater protection regulations.

1.4. Program Elements

1.4.1. Task 1: Technical Inventory and GIS Data File Development

Understanding the complexities of sustainable watershed development--what can and cannot be done--requires substantial understanding of natural systems and how they interact. In order to quantify these environmental factors, and measure the composition of each planning element in the study area, a detailed information base has been created as a Geographic Information System (GIS). The power of this GIS as a planning tool will be demonstrated in great detail in this report, but perhaps the most significant data which it can generate is the combination of factors, or "co-occurrence" of elements. These combinations of ingredients determine both the cause and potential effect of many hydrologic conditions.

The data files include:

Geology (based on USGS mapping)
Soils (by Series and Phase from SCS publication)
Land Use (based on NF area mapping by CCPC and Open Space Plans)
Land Cover (forested lands from USGS maps and aerial photographs)
Protected Lands (public lands and protected parcels)
Zoning (each municipality with aggregation)
Hydrology (drainage areas by sub-basins; 120 total within the study area)
First Order Streams - derived from Hydrology
Northern Federation Area
Groundwater Protected Area (from DRBC)
Existing Water Supply and Wastewater Systems and Service Areas
Flow Measurement and Water Quality Measurement Stations (USGS)
Stream Classifications - PADEP classification of watersheds

1.4.2. Task 2: Water Resources Sampling

The Watersheds have a reasonable water chemistry and biota record for dry weather conditions, but little or no data exists for wet weather chemistry and mass transport during storm events. Because the major influx of non-point pollutants occurs during these runoff periods, a limited runoff sampling was performed for selected locations in the Watersheds. However, since this mass transport is reflective of existing NPS sources, primarily agriculture, it has little significance in estimating the water quality impact from future urbanization. For that purpose, this study utilized published pollutant loading data from other related studies, expressed in terms of mass loading anticipated per year.

1.4.3. Task 3: Water Resources Model Development

The interrelationship between ground and surface waters is frequently neglected in water resource studies, where the total yield from a drainage area is the primary focus of analysis (as has been the case in prior studies of the Pickering Basin). The terms "safe yield" and "water budget" have also been frequently misapplied to suggest that a given amount of water can be withdrawn from an aquifer per unit area without impact. Although such concepts may be necessary as the basis for regulatory programs, the reality is that any withdrawal of a water resource, without recycling or compensation, has commensurate quantitative (and qualitative) effects elsewhere in the hydrologic system.

Sustainable Watershed Management is oriented toward the concept of water cycle balance. This is defined as a process by which incident rainfall percolates through the soil mantle and into groundwater aquifers, to be gradually discharged during dry periods as stream base flow. Maintenance of this balance-- the relationship between groundwater replenishment in order to sustain stream baseflow--becomes especially critical in smaller streams, defined as first order streams and their respective contributing watershed areas (Figure 1-5). Maintenance of this balance, furthermore, is especially critical during dry periods, defined here as "Q7-10", the lowest 7 consecutive day average daily flow to occur once every 10 years. Maintenance of this balance is designed to prevent water table lowering and related stream dry up, with resultant catastrophic aquatic biota impacts--an outcome which can occur as new land development "consumes" water for water supply purposes and also reduces natural groundwater recharge by new impervious surfaces. Maintaining this balance becomes especially critical in "Special Protection Waters," as categorized by the state (Figure 1-6).

The Water Balance Model (WBM) has been developed in this study to describe these mechanisms and to analyze how to maintain this balance in essential hydrologic cycle factors, pre- to post-development. The WBM utilizes the base flow record developed for the watershed to account for the combined effects of incident rainfall, the

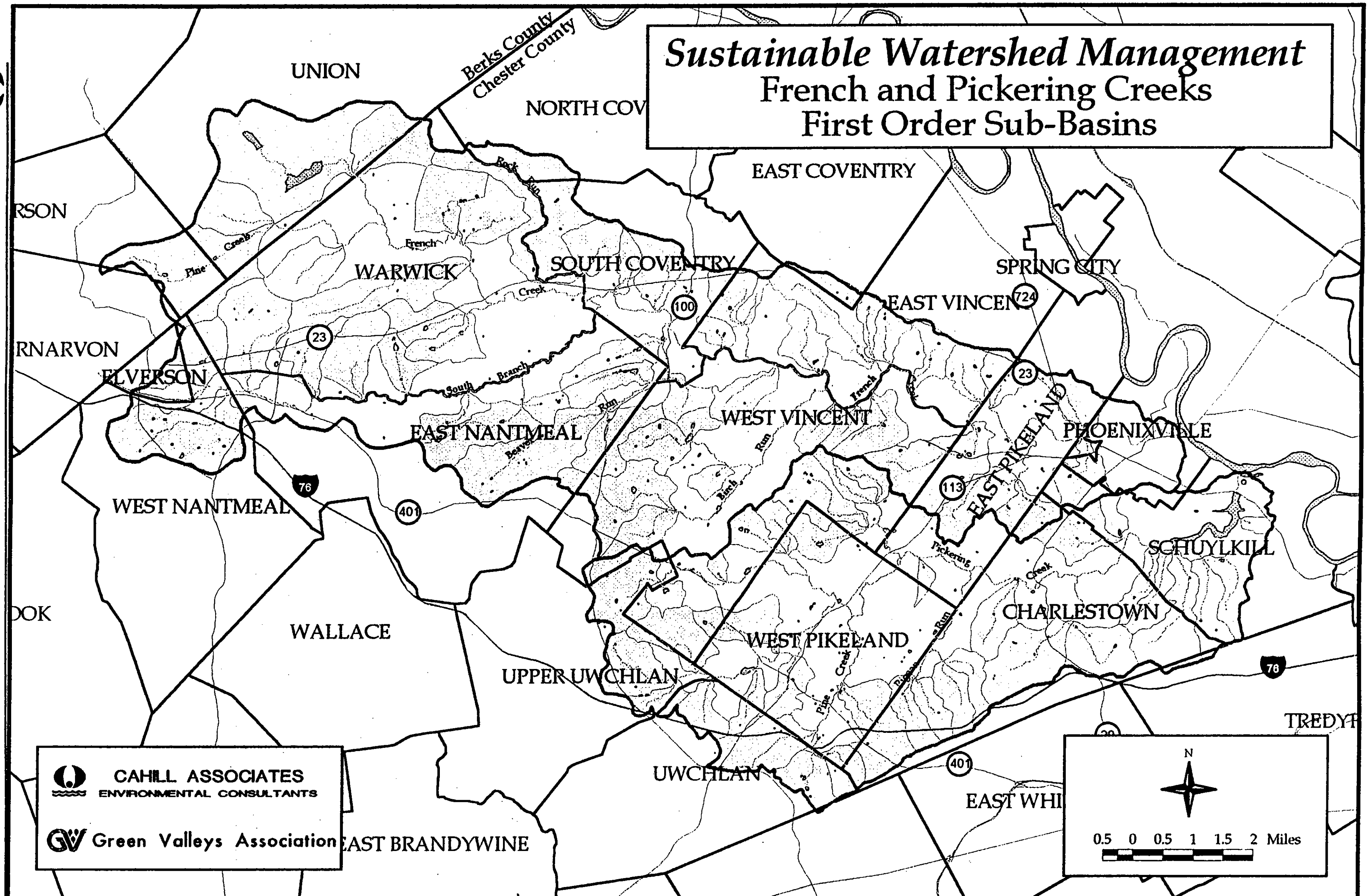

Figure 1-5 First Order Sub-basins in the French and Pickering Creeks Watershed

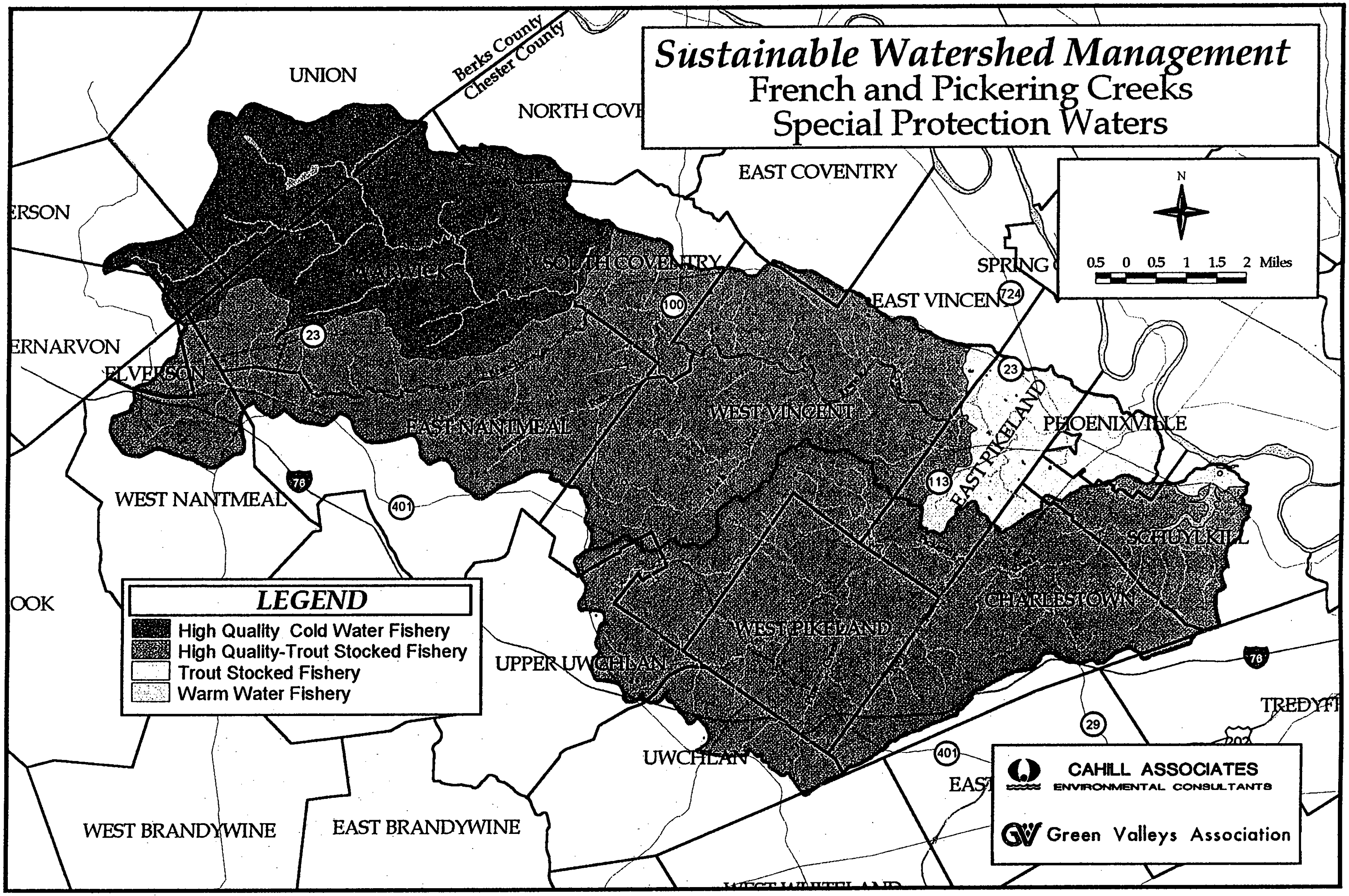

Figure 1-6 Special Protection Waters

evaporative and transpirational losses as a function of temperature and vegetative land cover, the net withdrawals from the aquifers, and the resultant impact on storm and dry weather stream flows which are produced by land surface alteration. This model reflects the total watershed balance and variability within the study area, as will be discussed in a later section. An existing land use database has been used to estimate water supply-related withdrawals (surface and ground) as well as altered surface runoff patterns.

The Dry Year Nitrate Impact Model (DYNIM) has been developed to assess groundwater pollutant levels, nitrate in particular. DYNIM is designed to evaluate these levels during dry periods as well, but uses the dry year (Q 365-10) base flow as the critical condition, rather than the Q 7-10 flow. Because so much of the Watersheds' new development is expected to be well-based, the Model also utilizes the public water supply primary health standard of 10 mg/l as a limit for new development-related nitrate loading.

Finally, the Stormwater Runoff Impact Model (SRIM) has been developed to assess both soluble and particulate non-point source pollutant loading, as well as the quantitative impacts of reduced recharge and increased runoff volumes. The objective of this analysis is to relate potential development impacts to different levels of pollutant generation. Although impacts on in-stream water quality concentrations and on the aquatic biota cannot be predicted, the comparison of different pollutant mass loading provides a useful basis for comparison of the potential applicability of stormwater management programs utilizing "Best Management Practices".

1.4.4. Task 4: "Futures" Development

In a nutshell, the objective of the Sustainable Watershed Management project is to demonstrate the water resources implications of existing land management policies. These policies will result in quality and quantity impacts, and so a part of the program is to develop alternative land management policies which reduce, minimize, and even eliminate these adverse impacts, to produce a truly sustainable pattern of growth and development on a watershed basis--Sustainable Watershed Management.

Task 4 considers the existing "baseline" or "business as usual" policies and programs, as defined by the patterns of existing zoning in each municipality. While one might argue that the time line for such total build-out is too far in the future to be of concern, the fact is that any portion of a given sub-basin can (and does) follow these growth guidelines, and so the impacts estimated can occur incrementally with each parcel development. This Future Build-out scenario also considers existing water supply systems, wastewater systems, and stormwater management systems. It does not, however, try to determine the possible limits of expansion for these systems. This question of where to establish the end of the sewer or water line is a critical question in the watersheds and one that will be a point of many discussions in the future.

1.4.5. Task 5: Water Resources-Related Impact Analysis

The impact methodologies/models developed in Task 3 were applied to the Future Build-out program developed in Task 4, in order to generate water quality and water quantity, surface and groundwater impacts. Modeling for the Low Flow Maintenance Model focussed on first order stream sub-watersheds, where water balance principles are especially critical. Modeling for the Dry Year Nitrate Impact Model was undertaken in all sub-basin areas, especially where on-site septic systems or other land-based systems are contemplated. Modeling, as part of the Pervious/Impervious Runoff Impact Model, occurs throughout the bulk of the Watersheds where Special Protection Waters classifications are in force and/or in those drainage areas flowing into water supply reservoirs.

1.4.6. Task 6: Recommended Sustainable Watershed Management

The Recommended Water Resources-Linked Sustainable Watershed Management Program does not take the form of a detailed and refined comprehensive plan per se, including all aspects of transportation, public facilities, and other comprehensive plan elements. However, the Program does provide an essential framework to be incorporated by municipalities in the Watersheds. Furthermore, specific actions have been identified for implementation by the Northern Federation of Chester County Municipalities and by various Chester County agencies in their water planning and comprehensive planning processes.

The implementation of this Program will require two further steps: the formulation of a Comprehensive Water Resources Ordinance, to be adopted and implemented by each municipality, and the dissemination of the GIS resource data base to the participating municipalities. The proposed Ordinance will include details on water supply guidance, both quantitative and qualitative, wastewater system selection (installation and application is covered by DEP/CCHD guidelines) and stormwater BMP applications. This Ordinance Program can be expected to require a complex array of new and modified management actions on the municipal level. These management recommendations will be tiered by type of municipal management technique (i.e., comprehensive plan, zoning ordinance, subdivision regulations, Pennsylvania Act 537 wastewater plan, water supply plan, and so forth). In many cases, alternative techniques will be provided, with final choices made by the implementing municipality.

Implementation can be expected to be challenging, and has been facilitated in the public participation process which occurred during the final phase of this Program. In a series of meetings, municipal officials and other stakeholders in the Watersheds participated directly. Implementation will also be boosted tremendously by the existing Northern Federation organization. Thus the Rivers Conservation Plan will be a dynamic rather than a static process, with the potential impacts on water resources anticipated and avoided, or at the least mitigated sufficiently to preserve the water quality and quantity which make this area such a special place.

SECTION 2.0 EXISTING ENVIRONMENTAL CONDITIONS

2. Existing Environmental Conditions

2.1. Geology

2.1.1. Geologic History and Formations

A major portion of the French Creek and all of the Pickering Creek basin is underlain by felsic and intermediate gneiss, with the contact running in east -west alignment through the watershed (Figure 2-1). Much of the northern portion of the French Creek basin is formed on a series of Triassic formations. In the upper portions of the French Creek, igneous intrusions have formed diabase outcroppings which create yet a third major structural unit. A detailed description of these structural units, their geologic history, and other attributes are well documented in several references (Bascom and Stose, 1935; Sloto, 1994).

For the purposes of this analysis, certain physical, structural, and hydrogeologic properties are extremely important. As a structural unit, the felsic gneiss is quite old (pre-Cambrian, probably more than 8 hundred million years old), very dense (having been subject to extensive metamorphosis over time), and relatively thick in this location (estimated at over 600 feet). This bedrock is not a particularly good aquifer. In general, water contained in the formation occurs primarily, though not exclusively, in fractures in the upper 200 feet of the formation. Figure 2-1 provides some detail on incidental structural features, such as faults, formed by igneous intrusions over geologic history. These faults are generally comprised of very dense rock, classified here as metadiabase (md) and pegmatite (pg).

The larger French Creek watershed is not nearly as uniform as the Pickering in bedrock geology. The Triassic formations, including extensive areas of the Stockton formation, have aquifer characteristics which are generally better for storing and will yield greater amounts of water. This relative difference must be considered when utilizing stream base flow data developed in the French Creek for application in smaller sub-watersheds. Table 2-1 and Figure 2-2 summarize the geologic composition of the two watersheds by major formation, as derived from the GIS.

2.1.2. Hydrogeologic Properties

The fractures in the gneiss bedrock may be roughly identified by close analysis of surface features and discontinuities and are most evident in air photo evaluation of the region. In many cases, the linear features of the landscape which form the dendritic pattern of the stream network are, not surprisingly, underlain by these fractures. Over the years, more highly fractured areas have been more easily eroded, have lent themselves to flow pathways, and have become the framework for the stream system. For this reason, the ability of water to move through the rock, or its transmissivity, is

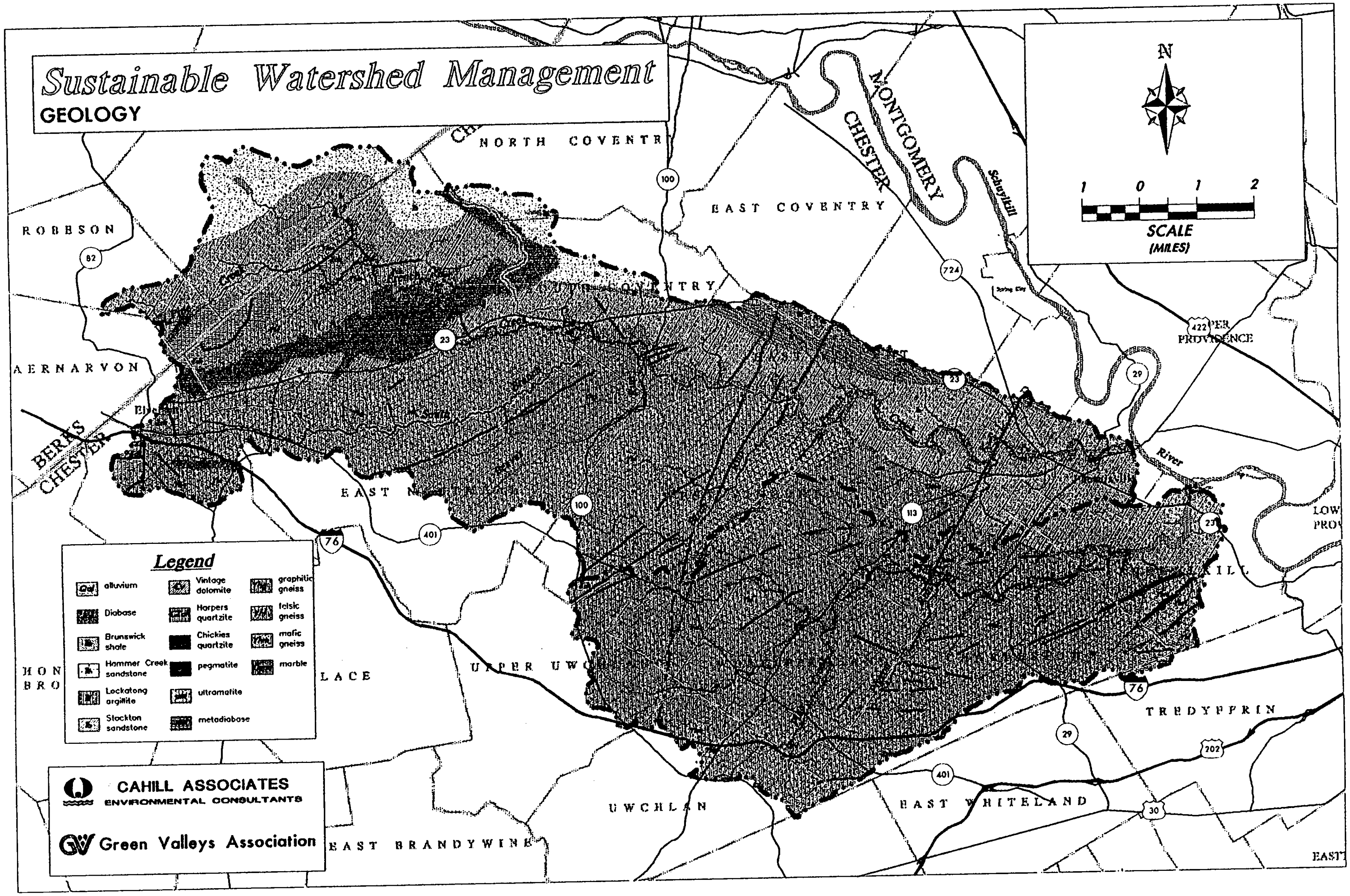

Figure 2-1 Watershed Geology

Symbol	Geologic Unit	Acres	Percent
	QUATERNARY (Overlay)		
Qal	Aluvium	3,502	
	JURASSIC		**4.5%**
Jrd	Diabase	3,121	4.5%
	TRIASSIC		**30.1%**
Trb	Brunswick Group	404	0.6%
Trh	Hammer Creek Formation	3,115	4.5%
Trl	Lockatong Formation	1,301	1.9%
Trs	Stockton Formation	16,174	23.2%
	PROTEROZOIC (PRECAMBRIAN)		
	Quartzite		**3.2%**
CZah	Antietam and Harpers Formations	25	0.0%
Zch	Chickies Quartzite	2,196	3.1%
	Igneous Formations		**0.6%**
pg	pegmatite	251	0.4%
um	ultramafite	31	0.0%
md	metadiabase	162	0.2%
	Gneiss		**61.6%**
Yhfa	felsic gneiss, amphibolite facies	1,161	1.7%
Yhga	graphitic felsic gneiss, amphibolite facies	12,472	17.9%
Yhia	felsic and intermediate gneiss, amphibolite facies	8,967	12.9%
Yhma	banded mafic gneiss, amphibolite facies	839	1.2%
Yhfg	felsic and intermediate gneiss, granulite facies	14,417	20.7%
Yhgg	graphitic felsic gneiss, granulite facies	3,055	4.4%
Yhm	marble	13	0.0%
Yhmg	mafic gneiss, granulite facies	2,050	2.9%
	Total	**69,754**	

Table 2-1 Geologic Formations and Composition

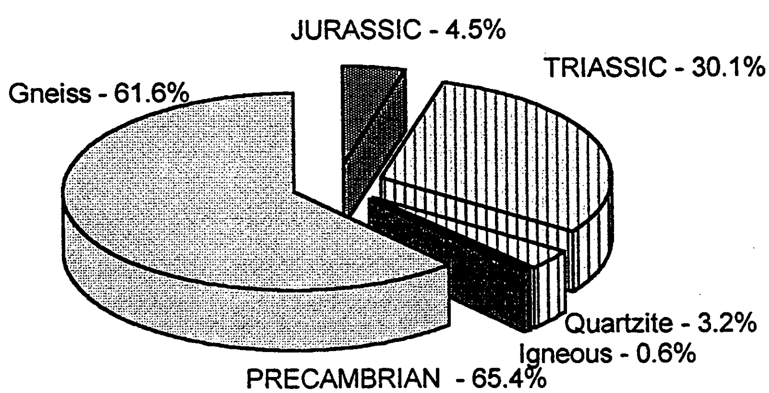

Figure 2-2 Geologic Composition in the Watershed

found to be greater in close proximity to the stream network where fracturing tends to be the greatest. In a US Geological Survey (USGS) study of the Pickering Creek Watershed (McGreevy and Sloto, 1980), the importance of transmissivity was underscored. A computer model documented a great variation in transmissivity in this geology which again closely correlated with the stream system pattern.

It is important to note here that for a hypothetical well developed in a better yielding and more highly fractured zone, the zone of contribution that recharges groundwater for ongoing replenishment may extend hundreds or possibly even thousands of feet distance in a linear direction (see Figure 2-3). Depending on property parcel size and boundaries, groundwater pumped in these situations may originate from a larger zone of contribution, certainly from other properties. Proper technical and legal groundwater management should strive to prevent one well owner from "mining" water contributed from contiguous parcels, even if undeveloped at present.

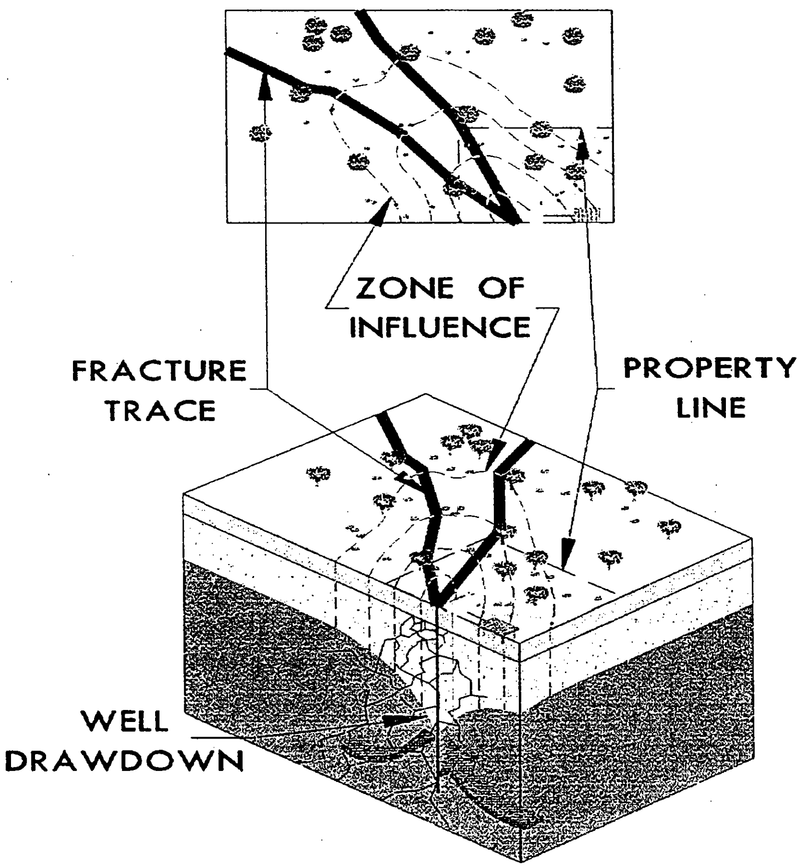

Figure 2-3 Zone of Influence for Wells in Fractured Rock Aquifers

2.1.3. Aquifer Capabilities

Well data from various sources has been reviewed during the course of this study. In general, the existing well record for the French and Pickering Creeks Watersheds suggests moderate aquifer capabilities, when wells are properly located. Again, the best producing wells are situated along fracture traces. Although it must be stressed that such groundwater withdrawals along fractures can affect a much larger zone of contribution, depending upon pumping rates. Given the importance of this fracture system, development of a well field network based on a uniform grid system and an expectation that uniform withdrawals could be made from the aquifer would not be appropriate. A single large well strategically located could effectively control the capacity of large aquifer sub-areas.

Comparability between the geology of the two watersheds is important, and many similarities in bedrock do exist. The larger French Creek does contain some better aquifers, in terms of their ability to store and transmit water, such as the Stockton Triassic formation. However, as will be discussed in a later section, the discharge of aquifers into the surface stream system is quite uniform, suggesting that both watersheds should be considered to be a single geologic unit, in terms of aquifer characteristics and hydrologic cycle elements.

2.2. Topography and Landform

The combined French and Pickering Creeks include an area of 109 square miles (Figure 2-4). The French Creek, with a drainage area of 70.2 square miles, drains in an easterly direction from its headwaters, situated in eastern Berks and western Chester County at an elevation of 900 feet, National Geodetic Vertical Datum (NGVD), to its confluence at the Schuylkill River at Phoenixville at elevation 100 NGVD, a difference of some 800 feet. Principal tributaries are second order streams and include Pine Creek, South Branch, Beaver Run, Rock Run, and Birch Run. While numerous small ponds and lakes, most of which are artificial, exist within the French Creek, the stream is basically a free-flowing system with several small run-of-the-river dams. Many of these structures are remnants of historic mills, granaries and industrial sites, such as iron foundries (PA Dept. of Forests and Waters, 1965).

The adjacent Pickering Creek lies directly to the south of French Creek, but is smaller in size (38.8 square miles) and shorter in length. The Pickering also drains into the Schuylkill River, at a point of confluence not far south of the French Creek. Here the change in relief is some 500 feet, from elevation 600 feet, NGVD, along the ridge line forming the south side of the watershed to about 100 feet, NGVD, at the mouth. The Pickering has only two major tributaries, Pine Creek and Pigeon Run, and is characterized by a large man-made impoundment, Pickering Creek Reservoir, situated just above the confluence with the Schuylkill River. This impoundment was constructed by the Philadelphia Suburban Water Company (now PSC) in the 1920s, and contains a pool of 380 million gallons impounded by a 40-foot high dam. Pickering Creek

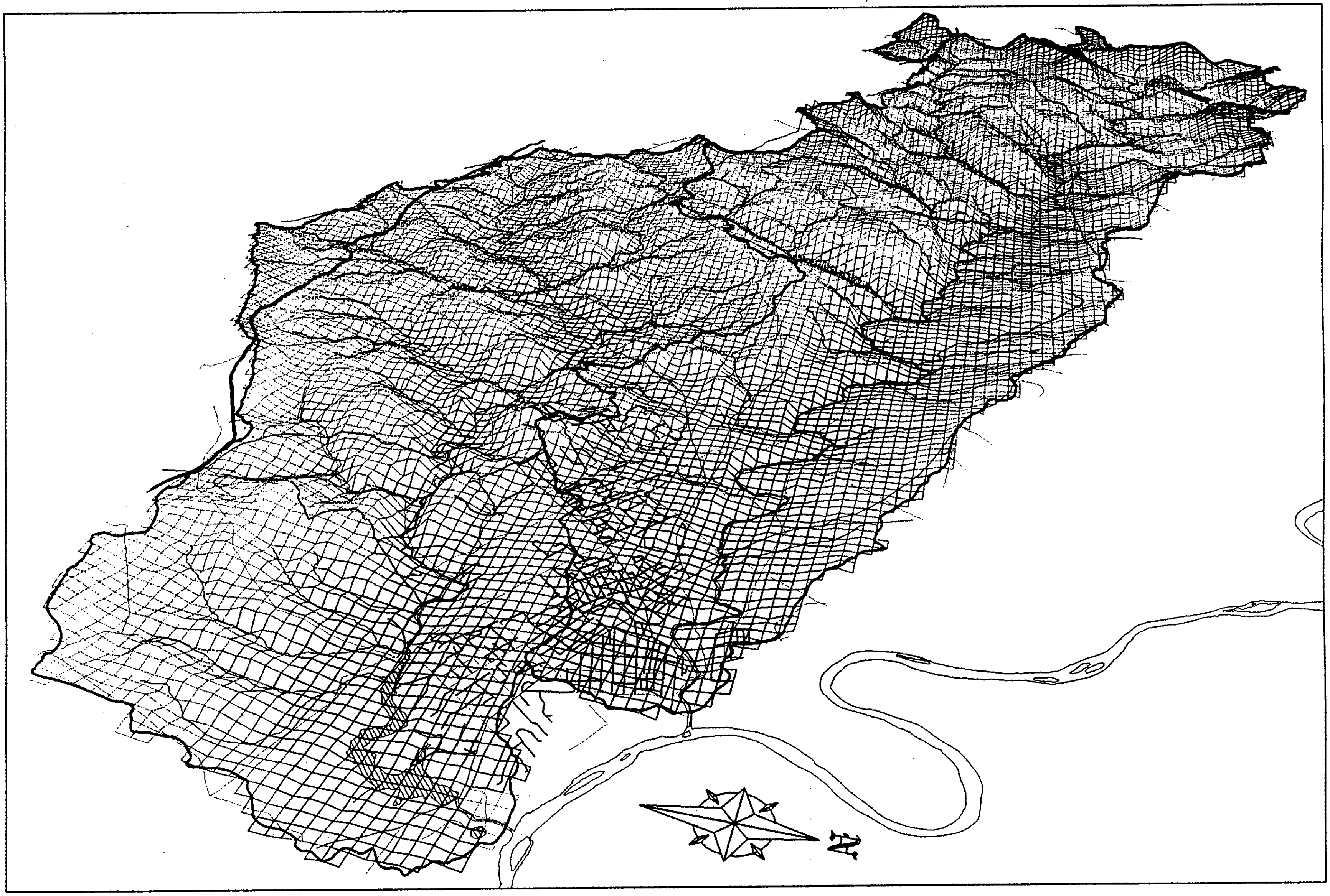

Figure 2-4 Perspective of the French & Pickering Creeks Watershed

Reservoir has a surface area of 170 acres, and offers no recreational opportunities under present management policies. PSC owns all of the land immediately adjacent to the Reservoir and prohibits fishing or any form of contact recreation. This Reservoir system presently has an allocation for withdrawal of 15 mgd from the Watershed, most of which is utilized in the PSC service distribution system to the east and south of the Watershed. PSC is known to be an aggressive water purveyor, working to expand its service system in Chester County and adjacent counties. In addition to serving the Phoenixville and Schuylkill Township area, as well as portions of the upper Pickering watershed in Uwchlan and Upper Uwchlan Township, a small portion of Charlestown is also served by PSC.

2.3. Soils

The soils in the Watershed (Figure 2-5) reflect the weathering process of the parent bedrock geology and are influenced by the drainage characteristics discussed above. The upland areas are formed by well drained silt loam soils (Glenelg and Chester), with transitional soils in lower elevations (Glenville) which have the same physical properties but are impacted by high water table conditions on a seasonal basis. One soil characteristic, the Hydrologic Soil Group (HSG) classification (Figure 2-5a), is important in explaining the relationship between water resources and land development impacts. Rated as A through D, this parameter describes the physical drainage properties of a soil series, including texture and permeability, as well as certain physiographic properties, such as depth to bedrock and water table. Group A, which is not represented in the Watershed, is well-drained while Group D, usually a floodplain or hydric soil, is at the other end of the spectrum. The HSG rating is also of importance in determining the feasibility of using infiltration or recharge-oriented Best Management Practices (BMPs) for stormwater management, as well as land-based technologies for wastewater effluent application and recycling, all of which are critical here.

Other soils with poorer drainage characteristics also exist. The lowlands along stream valleys are comprised of extensive hydric soils (Worsham) which reflect a constant saturation condition. It is of interest to note that the extent of these wetland soils in the Sub-Watershed is much greater than might be expected in comparable watersheds, and is indicative of the poor drainage properties of the bedrock in low areas. That is, incident rainfall drains relatively quickly through the upland soil mantle and saturates the lower horizons at the rock interface. Movement of water into the bedrock occurs at a lower rate and produces saturated conditions at topographic depressions along the drainage network.

Table 2-2 summarizes the soil series, properties, and composition of the Watershed. For the major soils, the suitability for certain water resource related uses is shown in Table 2-2 with characteristics constraining the potential use identified in general terms. For example, the use of on-site septic systems in the Glenville soil may be generally cited as being constrained by the seasonal high water table conditions; however, it is possible that some sub-areas of Glenville can be located which do allow for successful on-site septic system development.

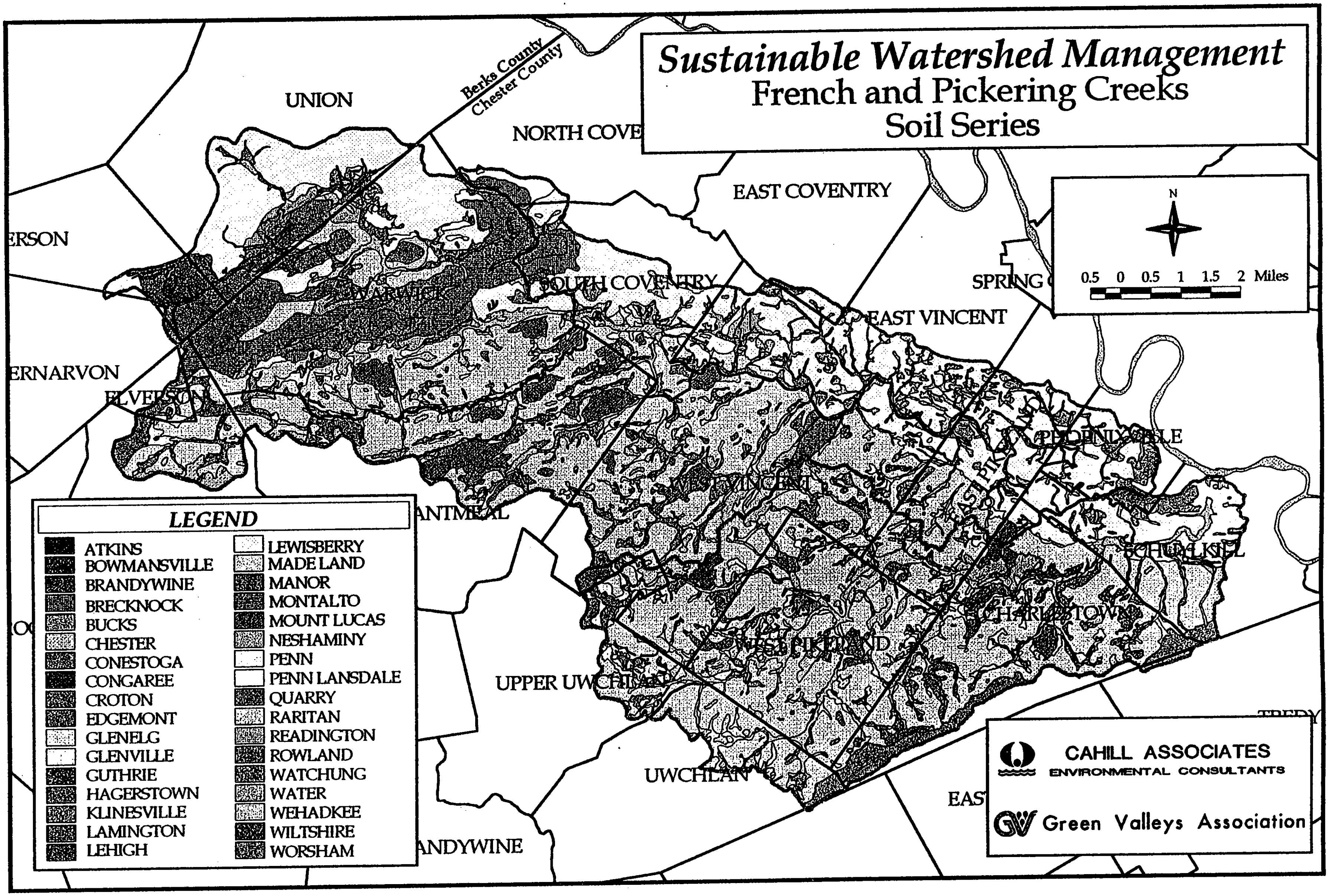

Figure 2-5 Soil Series in the French and Pickering Creeks Watershed

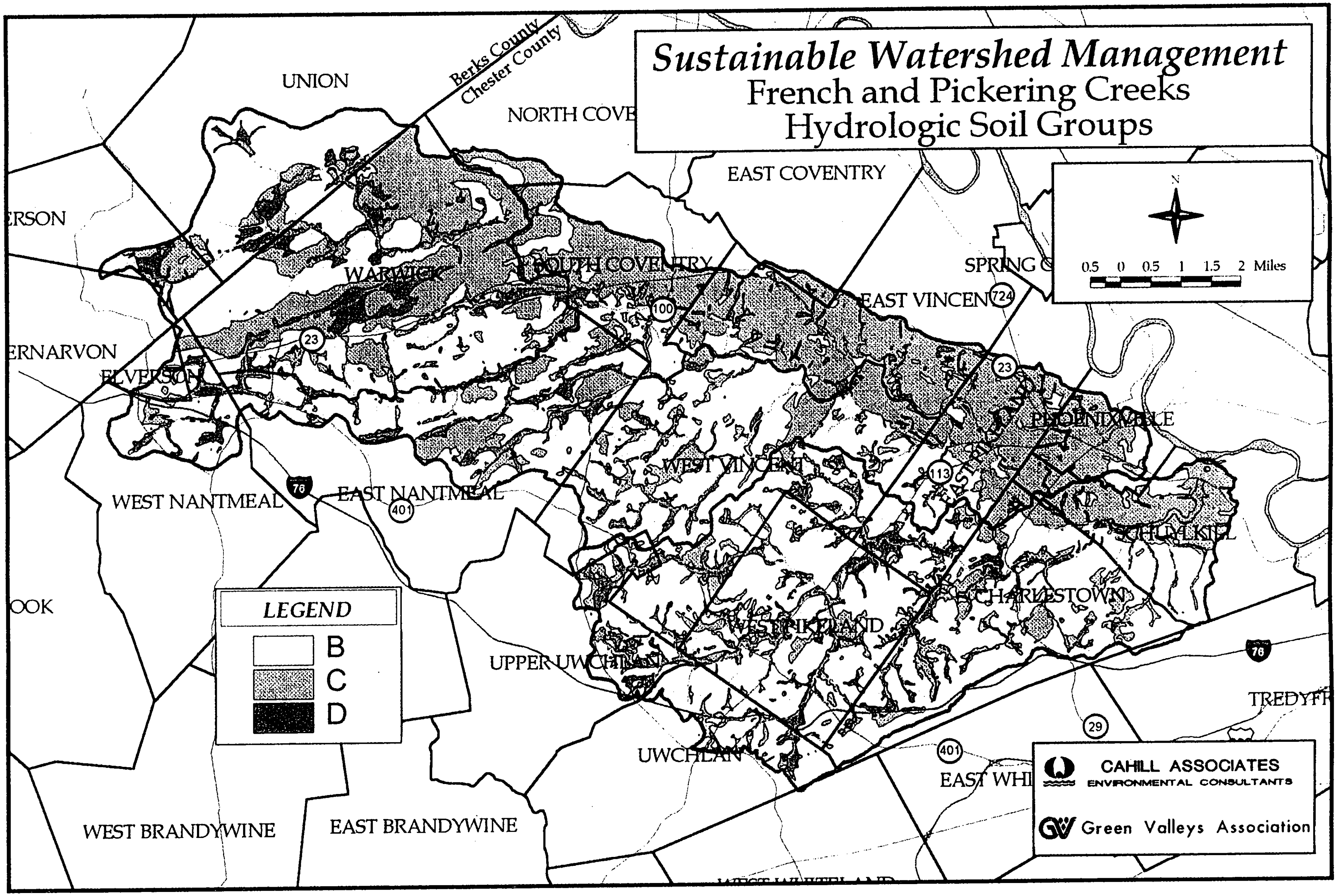

Figure 2-5a Hydrologic Soil Grouping

Soil Series	Symbol	Description	Permeability (inches/hour)		Depth to Seasonal High Water Table (feet)		Depth to Bedrock (feet)		Hydrologic Group	Recharge Suitability (CA)†
			low	high	low	high	low	high		
Atkins	Au	silt loam	0.2	2	0.0	0.5	3.0	35.0	D	4
Bowmansv	Bo	silt loam	0.63	2.0	0.0	1.5	3.0	6.0	B	4
Brandywine	Bs, Br	stoney loam	0.63	2.0	>10.0		3.0	6.0	C	1
Brecknock	Bt, Bv	silt loam	0.63	2.0	>5.0		3.0	4.0	B	1
Bucks	Bx	silt loam	0.63	2.0	>5.0		3.5	8.0	B	1
Chester	Cd	silt loam	0.63	2.0	> 5.0		5.0	8.0	B	1
Conestoga	Cm	silt loam	0.63	2.0	> 5.0		4.0	6.0	B	1
Congaree	Cn	silt loam	0.63	2.0	>3.0		3.0	6.0	B	3
Croton	Cr	silt loam		<0.2	0.0	0.5	3.0	5.0	D	4
Edgemont	Ec	channery loam	0.63	2.0	> 5.0		3.0	6.0	B	1
Glenelg	Ge, Gg	ch silt loam	0.63	2.0	> 5.0		3.0	8.0	B	1
Glenville	Gn	silt loam	0.63	2.0	1.0	1.5	3.0	6.0	C	4*
Guthrie	Gu	silt loam	0.2	0.63	0.0	0.5	3.0	5.0	D	4
Hagerstown	Ha	silt loam	0.63	2.0	> 5.0		4.0	6.0	C	1
Klinesville	Kl	shaly silt loam	2.0	6.3	>3.0		1.0	1.5	D	4
Lamington	Lg	silt loam		<0.2	0.0	0.5	4.0	20.0	D	4
Lehigh	Le	silt loam	0.63	2.0	1.5	3.0	3.5	6.0	C	3
Lewisberry	Lr, Ls	sandy loam	2.0	6.3	>3.0		3.5	10.0	B	1
Made Land	Me	granite & gneiss			> 3.0		> 4.0		C	2
Manor	Mg, Mh, Mk	ch loam	2.0	6.3	> 5.0		3.5	10.0	B	1
Montalto	Mo, Mr	silt loam	0.63	2.0	>5.0		4.0	8.0	C	1
Mount Lucus	Ms	silt loam	0.63	0.2	1.0	2.0	4.0	8.0	C	4
Neshaminy	Na, Ne, Ns	silt loam	0.63	2.0	>3.0		4.0	6.0	B	3
Penn	Pe, Pm, Pn, Ps	silt loam	2.0	6.3	>3.0		2.0	3.5	C	2
Penn Lansdale	Pt	sandy loam	0.63	2.0	1.5	3.0	3.5	8.0	C	3
Quarry	Q	quarry	n/a	n/a	n/a	n/a	n/a	n/a	D	n/a
Raritan	Ra	silt loam	<0.2		1.5	3.0	3.5	20.0	C	4
Readington	Rd	silt loam	0.63	2.0	1.5	3.0	3.5	8.0	C	3
Rowland	Ro, Rp	silt loam	0.63	2.0	1.5	3.0	3.5	7.0	C	3
Watchung	Wa, Wc	silt loam	0.2	0.63	0	1	3.5	8	D	4
Water	W.	water	n/a	n/a	n/a	n/a	n/a	n/a	D	n/a
Wehadkee	We	silt loam	0.63	2.0	0.0	1.0	5.0	8.0	D	4
Wiltshire	Ws	silt loam	<0.2		1.5	3.0	3.8	8.0	D	4
Worsham	Wo	silt loam	0.2	0.63	0.0	1.0	3.0	5.0	D	4

† Recharge Suitablity
1 - Permeability > 0.63 all horizons; Depth to SHWT > 5'; Depth to Bedrock > 3'; CEC > 10
2 - Permeability > 0.63 A horizons; Depth to SHWT > 5'; Depth to Bedrock > 3'; CEC > 10
3 - Permeability > 0.63 A horizons; Depth to SHWT > 1.5'; Depth to Bedrock > 3'; CEC > 5
4 - Alluvial Soils; Permeability > 0.2 A horizons; Depth to SHWT > 1'; Depth to Bedrock > 1'; CEC > 5
4* - Permeability > 0.2 A horizons; Depth to SHWT > 1'; Depth to Bedrock > 1'; CEC > 5
With potential restrictions, but may be overcome by design.

Table 2-2 Soil Series - Characteristics and Suitability

2.4. Hydrology

2.4.1. General Regional Hydrology - The Hydrologic Cycle

In order to put this particular Watershed in perspective, it is necessary to first consider a more comprehensive basis for the movement of water through its complete natural system, or hydrologic cycle. Hydrologic cycle describes the various natural (and human influenced) steps which account for the movement of rainfall through the land system and back again into the atmosphere. It is important to note that there is tremendous variability in this cycle over time, both on a seasonal basis and also from year to year.

For example, all regions experience periods of significant variability in precipitation, with hot and cold cycles of climate change impacting and controlling these patterns. In any given region, however, an estimate of the average conditions experienced in the hydrologic cycle can be developed, based on the record of rainfall and corresponding stream flow or runoff, if properly gaged. A recent study (Sloto, 1994) proposed a set of values for an average Chester County hydrologic cycle, based on a record from 1975 to 1988. Other periods of record have suggested somewhat different values for some hydrologic cycle components. Figure 2-6 illustrates a representative cycle specific to the French Creek Watershed, based on the long term rainfall averages of climatologic data stations in and around northern Chester County, developed by CA.

2.4.2. Precipitation

The hydrologic cycle begins with rainfall, and in order to assess the extremes of this cycle, drought and flood, the questions of how and where we measure rainfall becomes important. Although several climatological stations operate in the general vicinity of the study area, of most interest is a rainfall record which distinguishes individual storm events over the period, and collects bi-hourly (every two hours) rainfall data. Two such stations exist which bracket the Sub-Watershed very well, providing a good to excellent data base for analysis. One rainfall recording station has been operating at Glenmoore, just to the west-southwest of the Sub-Watershed mid-point, since 1971 (see Figure 2-9). A much longer record station has operated at Phoenixville, at the east end of the French Creek basin, since 1948.

A comparison of the average annual rainfall for the two stations is shown in Figure 2-8. The average rainfall statistic is flawed for some years due to significant data gaps, although the long term annual average rainfall of 45 inches is comparable with other estimates. An examination of both stream flow and rainfall records indicates that an eleven year period (1971 to 1982) exists when simultaneous stream and precipitation measurements were made, providing a good data period for analysis. This period also offers a good mix of wet and dry conditions, with 1980 reflecting an extreme drought period (31 inches rainfall), 1979 reflecting a very wet period (59 inches rainfall), and

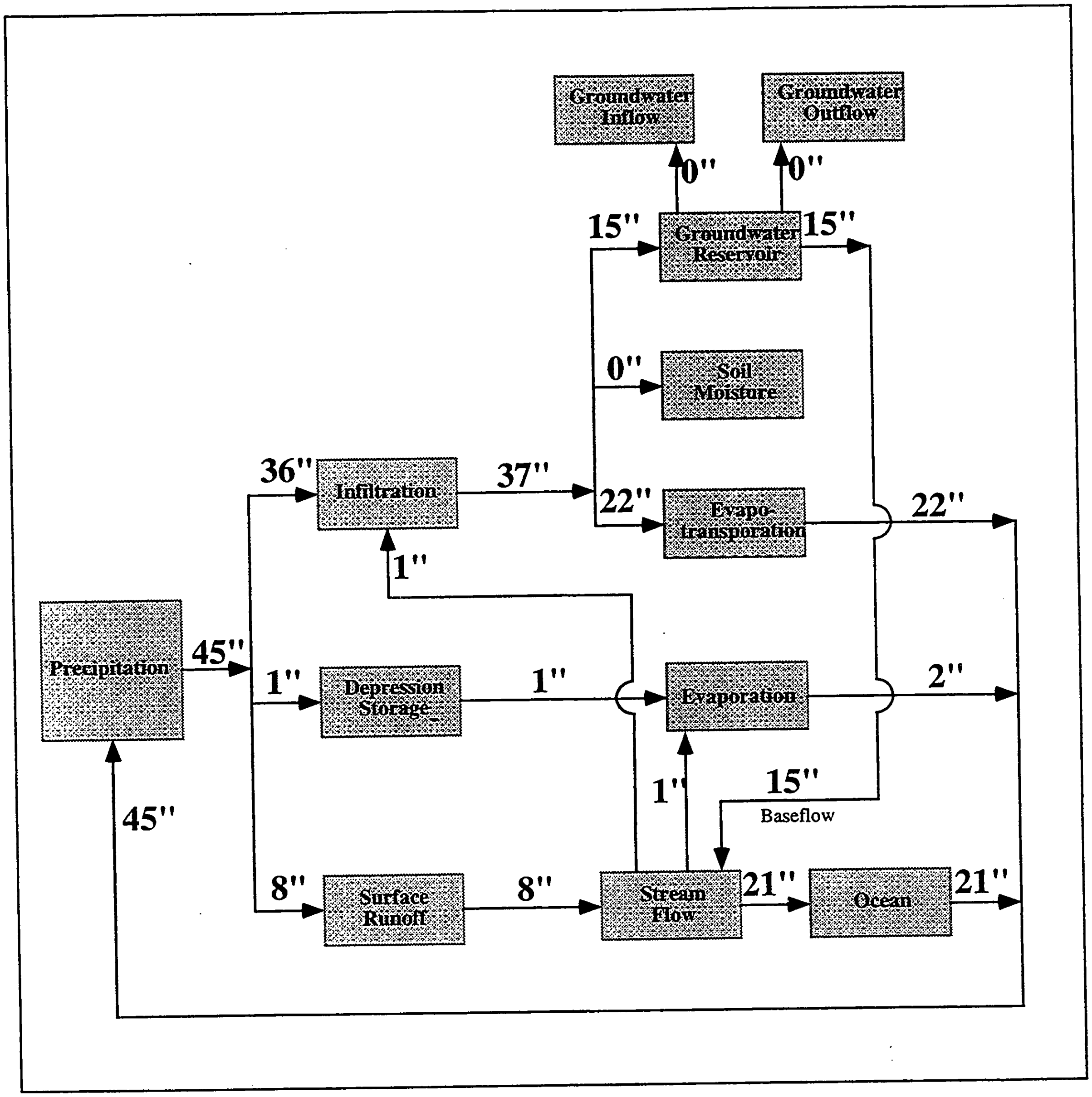

Figure 2-6 Hydrologic Cycle in The French Watershed

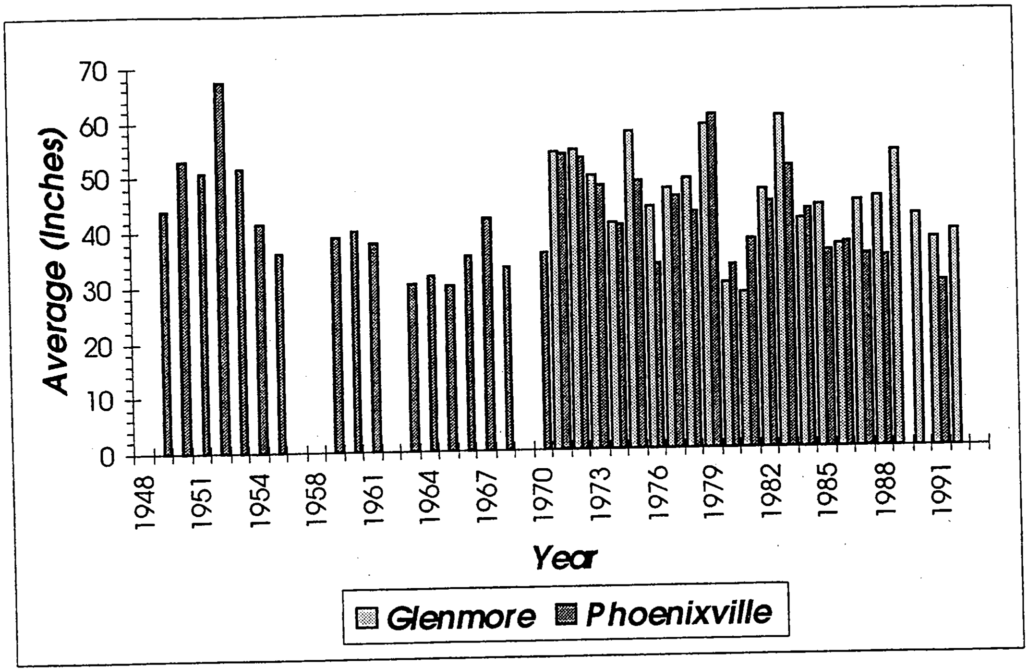

Figure 2-8 Average Annual Rainfall, Phoenixville and Glenmoore

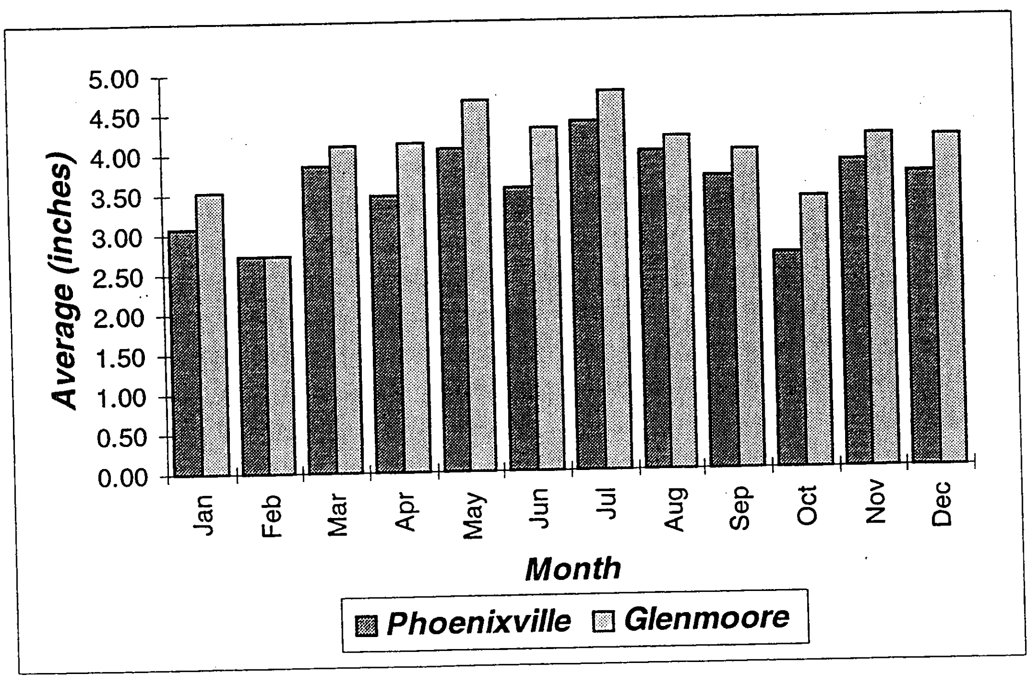

Figure 2-9 Average Monthly Rainfall at Phoenixville and Glenmoore

PHOENIXVILLE and GLENMOORE Daily Total Rainfall					
Station	Period of Record	Total # Storms	1" or less	1.1" to 3.2"	3.3" or greater
Phoenixville	1949-1992	4107	3663	444	18
Glenmoore	1971-1992	2145	1888	257	12

Table 2-3 Storm Event Distribution and Magnitude

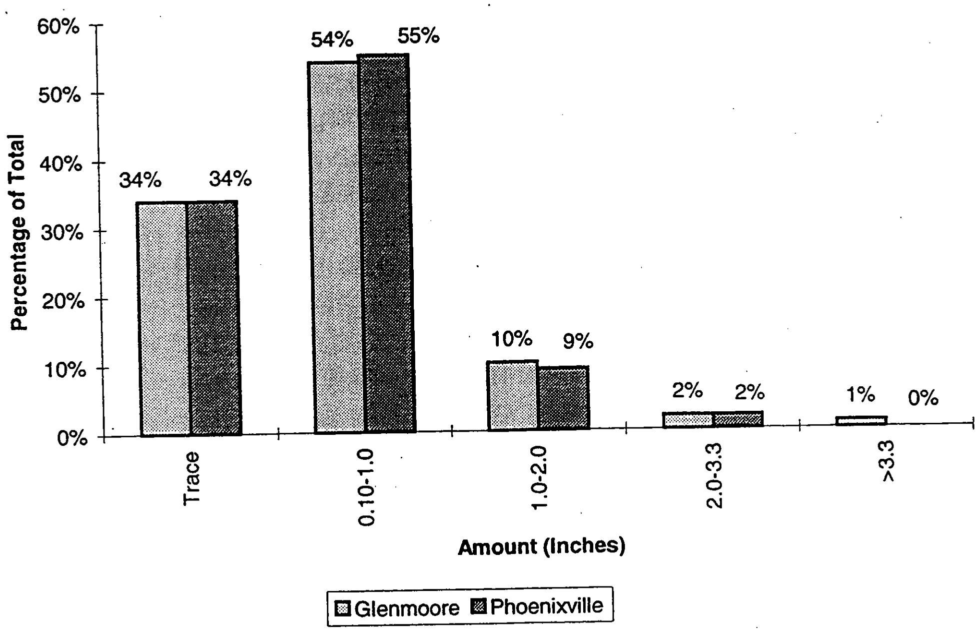

Figure 2-10 Rainfall Event Distribution in the French and Pickering Watershed

2.4.3. Infiltration

The onset of significant rainfall results in the infiltration of some portion of incident precipitation into the soil. This variability of infiltration is very much related to soil characteristics such as texture and soil particle size (e.g., large particle sandy soils have rates of permeability which are much greater than small particle clay soils), but it is also a function of where the soil is situated on the landscape. The more shallow the water table or less permeable the soil, the more rapid the runoff process. Depending upon all of these variables, virtually all of the rain which falls during the beginning of the storm will soak into the soil. This initial infiltration is described as the "initial abstraction," because it does not become part of the runoff volume, but is initially deducted from the total rainfall when considering potential runoff. As the soil becomes saturated, the rate of infiltration decreases, and the process of runoff begins. For example, those soils which lie along streams and drainage swales are most likely to produce runoff sooner and in greater amounts than upland soils during a given storm event. The application of this theory, described as "partial area hydrology" (Dunne, 1974) has not yet found translation into a computer model with broad applicability, because the full array of factors relating to the spatial and temporal variability of runoff in a given watershed is extremely difficult to model.

As rainfall continues, infiltration diminishes over the duration of the storm. The fraction of total rainfall which manages to infiltrate into the soil mantle decreases as rainfall events themselves grow larger, because there is a finite limit to any soil's natural rate of permeability or infiltration capacity. Figure 2-11 illustrates the relationship between Curve Number (CN), which is the combination of soil properties, vegetative cover, and impervious surface used in the SCS Cover Complex method to assess hydrologic response, and the amount of infiltration which results from different amounts of rainfall. For example, a relatively undeveloped watershed which has a mix of land uses (woodland, agriculture) with reasonably well drained soils might have a CN of 65. For the 2-year rainfall of 3.3 inches in 24 hours, the resultant infiltration would be about 2.8 inches, or 85 percent of the total rainfall. For a much larger storm of far less frequency (i.e., the 100-year storm of 7.2 inches in 24 hours), the infiltration is 4.4 inches, or 61 percent of the total rainfall. We frequently think of this infiltration portion of rainfall as "lost" when land development covers the landscape, effectively preventing infiltration from taking place and resulting in a loss of this recharge to the soil and aquifer groundwater system. Of course, the lost infiltration is converted into increased runoff volume, which in most cases is considered to be a negative impact on water resources.

These infiltration mechanisms are important in understanding the total hydrologic cycle and have bearing on the impact of precipitation patterns. This response of the soil mantle to incident rainfall also calls into question the role and importance of larger storm events. Not only do the larger storms (defined here as a rainfall of 3 inches or greater) comprise less than 5 percent of the total rainfall, but the net impact on groundwater recharge and stream base flow maintenance associated with these major storms is even less than 5 percent. For major rainfall events, the largest fraction of infiltration is reached within the initial rainfall period, and the major portion of subsequent rainfall translates into surface runoff even in the undeveloped (pre-development) condition. In other words, the environmental benefit of attempting to recharge these larger, less frequent rainfall events completely is minimal, in terms of maintaining the hydrologic balance.

2.4.4. Evapotranspiration

The greatest portion of incident rainfall is returned to the atmosphere through the process of evapotranspiration (ET). This net return of moisture back into the atmosphere includes several distinct physical processes which vary greatly over seasons and with different land cover conditions. Included here is the evaporation process, which is constantly taking place as a function of air temperature and moisture content or humidity. Evaporation is accelerated after a rainfall when surface puddles, large and small, are exposed to the atmosphere. Evaporation is defined as:

> *.....the rate of liquid water transformation to vapor from open water, bare soil, or vegetation with soil beneath* (Shuttleworth, in Handbook of Hydrology, 1993)

Transpiration is somewhat more complex. Rainfall percolates into the surface of the soil mantle and some portion is generally taken up by vegetative roots. During the process of photosynthesis, CO2 is transformed into oxygen and rainfall is then given off in the biochemical process of transpiration. The net result of this process is the loss of moisture from vegetative surfaces into the atmosphere. In this sense, each large tree might be viewed as a giant water pump, returning many gallons of water a day back into the atmosphere. Transpiration is defined as:

> *......that part of the total evaporation which enters the atmosphere from the soil through the plants* (Shuttleworth, in Handbook of Hydrology, 1993)

Both of these mechanisms--evaporation and transpiration--are very much dependent on temperature and season and vary greatly over the course of a year. When one considers the hydrologic cycle on a monthly basis, the periods of maximum biomass growth (spring) and maximum evaporative opportunity (late summer) produce the extremes of water return to the atmosphere. As far as any given watershed is concerned, the net impact of altering land use will have some net change on evapotranspiration. Actual measurement of the evapotranspiration component of the hydrologic cycle is generally not feasible and is arrived at through the process of subtraction, by measuring basin input as rainfall and output as stream flow, and the net difference (about 25 inches a year) is lost as ET, with variation due to land cover, precipitation timing and intensity, and temperature.

2.4.5. Stream Flow

Stream flow, like rainfall, represents the observable portion of the hydrologic cycle. Stream flow is measured at a fixed cross-section in a stream channel. Here, a relationship is developed using a series of measurements of the height (or depth) of stream flow (over a range of flow conditions) and the rate of discharge in cubic feet per second (cfs). This "rating curve" for a given point within a drainage network provides an easy reference system, so that any mechanical device which measures the depth of water in the channel can provide a continuous record of stream flow discharge. Such systems and devices have been in use for several decades by government agencies, especially the USGS, at selected locations within the region. As needs and conditions change, some stations are discontinued as data gathering locations.

Within the French Creek Watershed and the neighboring Pickering Creek Watershed to the south, a number of stream flow measurement stations have been operated by the USGS over the past 35 years (Figure 2-12 and Table 2-5). Most of these locations have had stream discharge measurements made on an individual basis as part of a temporary data gathering process, without installation of any permanent hardware and recording instrumentation, and no permanent flow measurement and recording on a continuous basis have been developed.

The most complete long term (27 years) continuous stream flow record for French Creek is based on the gage situated on French Creek Road, located 7.1 miles upstream from the mouth, with a drainage area of 59.1 square miles (sm). This drainage area represents 84 percent of the total French Creek Watershed. This record indicates an average daily discharge or flow of 90.7 cfs at this point in the Watershed, which amounts to 20.78 inches of average annual yield (wet and dry flows) from the Watershed. For a similar stream gage operated on the Pickering Creek near Chester Springs (drainage area of 5.98 sm) from Jan., 1967 to 1982, the record shows an average discharge of 10.3 cfs, or 23.33 inches of average annual yield, although the base flow statistic is subject to question, based on changes in the cross-section (C. Wood, USGS, 1995). The annual summaries published by the USGS express these stream flow records for the period of measurement in both average cfs per day and in inches per year. A later section discusses this flow record and the variability in stream flow throughout the drainage during non-storm flow periods.

2.4.5.1. Hydrograph Analysis

In order to evaluate the impact of proposed land development on the water resources of a drainage system, the development must be considered in the context of the natural conditions of rainfall and runoff which have been observed in that or similar drainage systems. In order to measure potential impact, however, that evaluation must be made by considering the system in the extreme. For certain impacts, such as nonpoint source pollutant production, the major fraction of pollutant input to the stream occurs during periods of heavy rainfall and runoff, when pollutants are scoured from the land

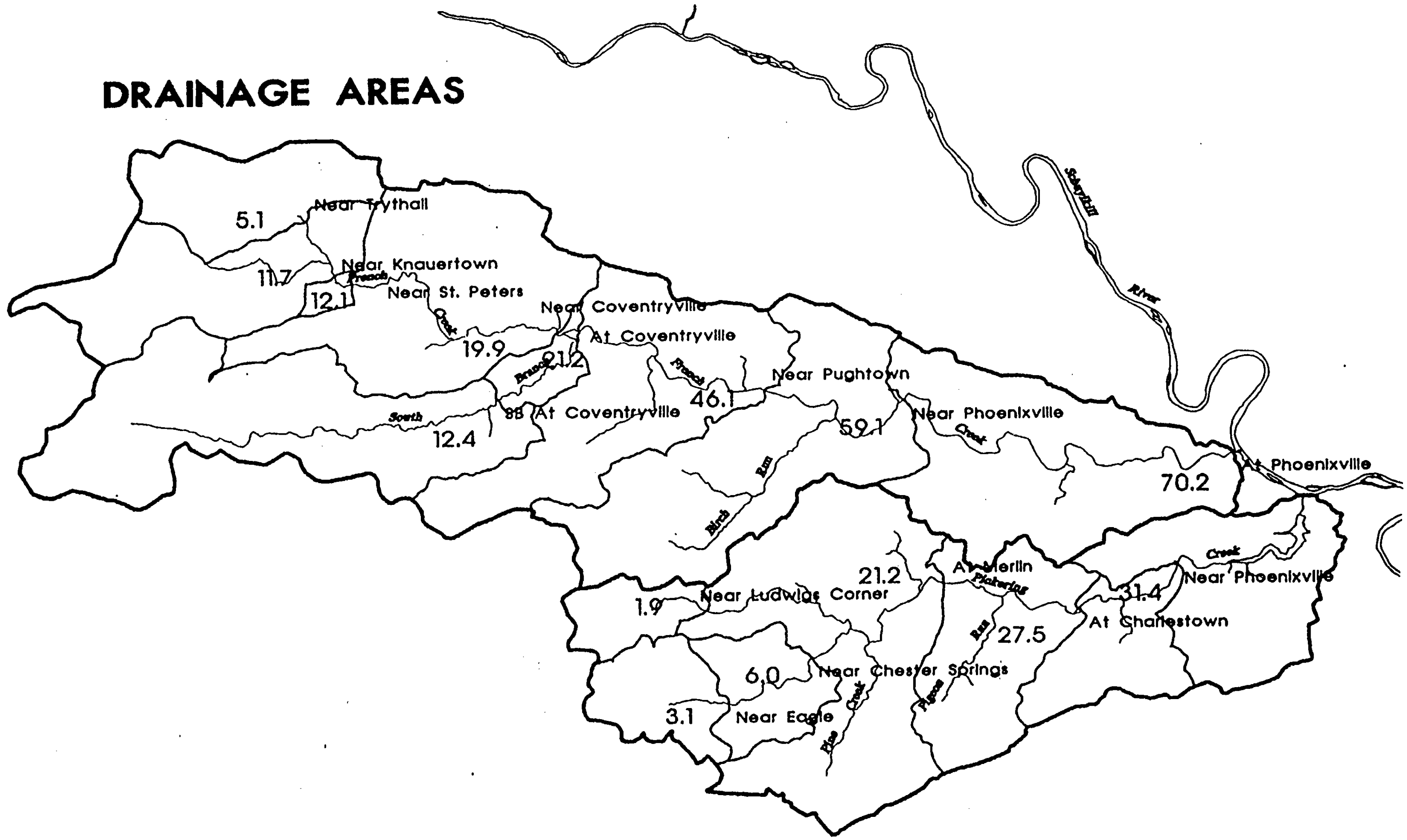

Figure 2-12 Stream Gaging Stations and Drainage Areas Above Each Station

2.7. Aquatic Biota Surveys and Monitoring

While the chemical sampling record provides great insight into the ambient water quality throughout the drainage, especially when measured at a number of locations during dry flow periods, it is still a record developed by single observations once a year. A far better indictor of ambient water quality is the composition and diversity of benthic (bottom dwelling) macroorganisms which live in the stream. Their type, absolute numbers and diversity of species reflect the changing water quality habitat over a full range of flows, seasons and chemical conditions. Fortunately, the same stations where flow is measured and chemically sampled have also served as biota sampling stations since the early 1970's by the USGS (in cooperation with the Chester County Water Resources Authority).

While the original data is extensive, it is possible to derive indicator parameters from the record. The USGS used the Kendall Test on benthic invertebrate diversity indices to show trends in water quality of French Creek (Moore, 1987). At all five stations on French Creek the water quality improved from 1970 to 1991. At all stations above Kimberton the indices have been at the unstressed level (3.0 - 4.0) except for 1987. The full data set is documented in other references, but Figure 2-27, French Creek at the continuous recording flow gage, illustrates the general improvement over the period of record. Only one station, the French Creek in Phoenixville near the Schuylkill River confluence, shows signs of continuing water quality degradation. In general, the biota data supports the conclusion that the two watersheds are of good to excellent water quality throughout their reaches.

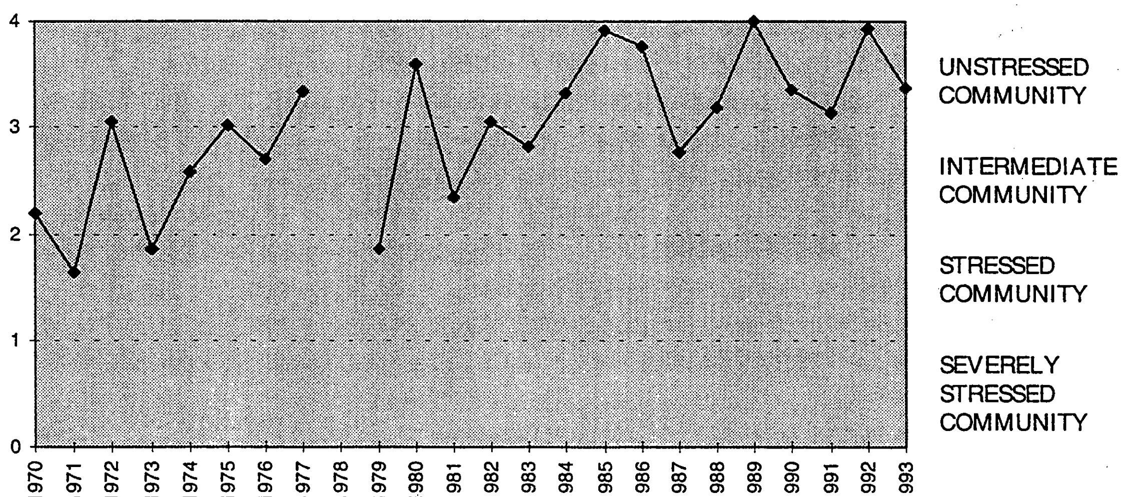

Figure 2-27 Biota Diversity Index - French Creek near Phoenixville

The PA DEP (formerly the DER) has also performed chemical and biota sampling in the watershed over the past two decades. According to the study of French Creek by PADER (1980) for scenic river designation, the water quality of French Creek ".. *should be capable of meeting minimum criteria for desired types of recreation except when such criteria would be exceeded by natural background conditions.*" The PADER study concluded that the French Creek currently met water quality standards and supported a good trout fishery. This report also pointed out that Pine Swamp in the French Creek headwaters supported the only natural stand of White Pine in Chester County. Heister (1971) found some enrichment of the water throughout its length; however, biotic and diversity indices of fish and macroinvertebrates reflected high chemical water quality and broad diversity of life.

A nutrient-related use impairment survey done for PADERs Bureau of Water Quality Management concluded that the water quality of French Creek in general was very good (Steele, 1988). No Chapter 93 Water Quality criteria were exceeded on the day of the survey and all observations supported the conclusion that French Creek was not use impaired as the result of excessive algae growth.

PADER also released an Aquatic Biology report on French Creek, conducted on July 9 and 10, 1992. Water quality at all stations surveyed on the French Creek above Kennedy Bridge in Kimberton was rated as good or excellent.

2.7.1. Water Quality Evaluations by PADEP

A summary of existing water quality was prepared for GVA's recent petition for upgrading the water quality classification of the French Creek. Based on this documentation, French Creek was determined to have water quality better than applicable water quality standards from the stream's juncture with West Vincent, East Vincent and East Pikeland to its headwaters. This conclusion is based on a review of all available studies of French Creek from 1969 to 1992. Only six point source discharges to French Creek existed on May 16, 1994 (Mr. Boyer, personal communication). Five of these point sources discharged sewage. All but one were in general compliance, with the one exception being out of compliance due to flow only. Based on a Stream Enrichment Risk Analysis Susceptibility Ranking Procedure in the Final Implementation Guidance for Section 95.9, Phosphorus Discharge to Streams, PADER found that *"... the stream is categorized as being at high risk and would require phosphorus controls on point source discharges."* Given the lack of point source phosphorus sources at present, this assessment would suggest that nonpoint sources of phosphorus are potentially problematic.

The available record of water quality in the French and Pickering Creeks Watershed reflects a stream system relatively free of the impacts of wastewater discharges and other less obvious pollutant inputs to the system, such as malfunctioning septic systems, barnyard drainage and livestock. Certainly the stormwater pollutant loads, although undocumented, are substantial, but make themselves felt primarily in the large and small impoundments, from private ponds to Pickering Reservoir.

2.8. Existing Land Use in the Watershed

The issue of land use--existing and future--is central to this study. Sustainable Watershed Management is driven by the recognition that land use is changing rapidly in the Watershed and will undergo significant change in the future. Given the many ways in which land use impacts water quality and quantity, the issue of land use--and how land use is managed in the future--becomes essential to Watershed sustainability.

The French and Pickering Creeks Watershed has undergone extensive clearing of woodland during the past three hundred years, primarily for cultivation. The larger expanses of remaining woods lie within State Game Lands and other protected lands and parks, or on the steeply sloping crests of ridges, where the soil was too thin and poor and the land too steep to allow cultivation. The valleys of the watershed have been planted or used for livestock grazing for the past two centuries. Residential use has been largely confined to small villages clustered at road intersections, with only the Schuylkill River community and industrial town of Phoenixville providing significant urban land use. New residential development over the past three decades has been generally large lot single family residential, although a few trailer parks, townhouse developments and other high density communities have been developed. These are mostly clustered around the Phoenixville area or in the upper Pickering watershed, and spill over from the expanding Exton region in Uwchlan Township.

The current patterns of land use, with open countryside, rolling farm fields and wooded hilltops, create an appealing setting which attracts new residents, and sets the stage for future land development. The major portion of the watershed is clearly in agricultural use, while the amount of land in urban use is quite limited, however, there has been a gradual transition of farm fields to residential subdivision for two decades.

2.8.1. Historical Patterns of Land Use

In many ways, the French and Pickering Watershed is a microcosm of the story of growth which has occurred in the entire Philadelphia metropolitan area. Prior to European settlement, the Watershed was virtually completely forested--a reality which had important ramifications for both water quality and water flows. Although we lack a data record for this period and water quality and water flows can only be surmised, streams did run clear, characterized by a teaming trout population and a vibrant aquatic community associated with an undisturbed setting. Flooding occurred only rarely. Given the substantial quantities of precipitation which would have naturally infiltrated into the forest floor to recharge groundwater, stream base flows even during dry periods would have been considerably greater than flows today. In short, the pre-colonial picture was of a balanced healthy stream system. Much of the French Creek Watershed's upper portions remain in forested cover and provide a good sense of the quality of this pre-European settlement watershed and its exceptional water resources.

With European colonization, the Watershed changed dramatically. First of all, colonization resulted in rapid land clearing to enable land cultivation and what was to become a prominent agricultural orientation over the years--an orientation still very much in existence today. And although the soils and topography were not as ideally suited for agriculture as those found farther south and west, large zones of what we now call prime agricultural soils allowed farming to flourish, especially in the stream valleys. This clearing of forests also provided lumber used to construct the ever expanding colonies. And then, of course, once built, the buildings had to be heated. Wood was the heat source, and more trees had to be cut.

Presence of iron ore deposits in the upper northwestern reaches of the French Creek Watershed gave rise to the nation's first iron processing facilities. A series of iron furnaces quickly developed in what was to become known as Early Iron Country. Samuel Nutt started the iron industry in 1717 in a meadow below what is now known as Coventryville--the first forge in Chester County and the second in the Pennsylvania. This mill was followed by Rock Run Furnace (1726), Coventry Steel Furnace (1732), Redding Furnace (1736), Warwick Furnace (1737), and the Vincent Steel Works (1737). In 1770, Mark Bird developed an iron furnace at what is now Hopewell National Historic site. In most cases, these furnaces relied on water-power and so were constructed in compounds along the stream. In short order, operators improved and enlarged their mills. Early on Warwick Furnace could produce five tons of pig iron each week, supplying Coventry and several other nearby forges. The iron produced was used for manufacture of Franklin Stoves, as well as kettles, irons, and clock weights. With the Revolutionary War, this industry became a critical source of weaponry and supplies (Morris, 1971).

Mining of various ores was associated with development of a variety of settlements such as St. Peters Village. In time, copper and granite would be mined. The French Creek Black Granite Company eventually would provide stone for Belgian block-paved streets in many cities, for the Whitney Museum in New York, and other important buildings throughout the world. In sum, the Watershed came to be distinguished by an industrial base that would be rekindled many years later with the rise of the steel industry and other manufacturing in Phoenixville.

As colonial development proceeded, a network of villages--tight concentrations of residences and businesses--developed throughout the Watershed. Coventryville, Nantmeal Village, Knauertown, Pughtown, Bucktown, Kimberton, St. Peters, and others grew up and are still very much in evidence today. Covered bridges were built. Schools and seminaries, historic Yellow Springs, manor houses, large farmsteads with massive barns--all are a wonderful reminder of the remarkable heritage which distinguished the evolution of European settlement in the Watershed. Through the diligent work of the French and Pickering Creeks Conservation Trust, many municipal historic preservation societies, and other dedicated groups, a tremendous number of these historic structures now are listed on both the State and National Register of Historic Places and are recognized as valuable cultural resources in the life of the Watershed.

Development in the Watershed of course continued after colonial times. The focus moved downstream to industrialization in and around Phoenixville in the 19th and early 20th centuries. In fact, Phoenixville and other Schuylkill River cities became thriving industrial centers. As was occurring in Philadelphia and other rapidly growing cities, rows of single houses, twin houses, and row houses were constructed at what now seems to be incredibly high gross densities--10 to 15 units per acre, to serve a rapidly growing middle class. The neighborhoods that resulted, complete with places to shop and eat and a mix of many different uses, still exist today (and in fact are the types of places which observers like Thomas Hylton point to as examples of successful communities which should be used as guides for the future). During this period, the bulk of the Watershed changed relatively little, land use-wise, even though populations were ballooning near the River. Agriculture continued to expand. The vast expanse of the Watershed remained rural, dotted with the colonial villages which had grown up in earlier years.

The 1950's post-World War II era triggered a modest wave of suburbanization, mostly in lower portions of the Watershed surrounding Phoenixville. Houses of 1200 sq. ft--3 bedrooms, perhaps 1 or 2 baths--on a quarter or maybe a half acre lot came to typify the era--the American Middle Class Dream. In addition, some scattered houses were constructed along Watershed roads, house by house, but few large residential subdivisions were constructed. The Pennsylvania Turnpike sliced its way through the bottom of the Pickering with an interchange at Downingtown. But even with the new highway, little development was stimulated in this period. Even through the 1960's and '70's, the rural atmosphere prevailed. It was not until the massive real estate boom of the 80's and 90's with its rampant land speculation and dramatic redefinition in development configurations and types that development would fully impact the Watershed.

2.8.2. Growth Projections, Dynamics, and Trends

What's happening now? Why worry about growth? The threat for sudden and widespread change in Watershed conditions has arisen due to a coming together of a variety of factors, all of which create the potential for rapid-fire change in Watershed land use, and therefore, impacts to water resources. These factors include, but are not limited to:

- general substantial gross increases in population, related very much to migration of both people and jobs from already developed metropolitan areas

- specific highway developments such as the 422 Expressway, expansion of the 202 High Tech corridor, "Extonization" and reconstruction of the Downingtown Turnpike Interchange

- a sudden and stark redefinition of the middle class dwelling unit, from the Post War mode to houses often twice or three times the total square footage, situated on 2-acre and much larger lots, even as numbers of children and average household size has plummeted. These dynamics have enormous bearing on the future of this and other undeveloped watersheds in the Philadelphia metropolitan area.

One indicator of growth and development is change in population, though clearly population is, strictly speaking, only an indicator of residential development. Population statistics for the Chester County municipalities comprising the Watershed are presented in Table 2-9, excluding the small populations in the Berks County municipalities (Union and Robeson Townships). Table 2-9 lists the percentage of each municipality lying within the Watersheds. CA has used these percentages combined with more specific knowledge of the Watershed distribution of development and applied adjusted factors to the 1990 US Census population counts (as well as Year 2020 population projections discussed below). Based on this adjustment, population of the Watershed in 1990 tallies to 41,900. Even including the older and denser development in and around Phoenixville, this population base translates to a low overall density of 383 persons per sq. mi. If Phoenixville is excluded from the calculation, the overall Watershed density drops significantly to about 250 persons per sq. mi.

Population projections are less important in this study than might otherwise be the case in other conventional planning processes. The methodology here is based on the very important assumption that, regardless of any agency's projections for any particular year, the critical test to be undertaken is build-out of remaining undeveloped areas in the Watersheds. On the one hand, build-out in many municipalities such as a West Nantmeal or Warwick seems unlikely, even by Year 2020. Nevertheless, many Chester County municipalities (e.g., Uwchlan, East and West Whiteland, and others) have approached build-out with surprising speed, such that development of the bulk of the remaining area is not at all a remote reality.

Another important point to be made in this discussion is that water resource systems--watersheds--must be viewed over the longer term, well beyond a 20-year 2020 planning horizon. Impacts are cumulative and span decades. Effective planning therefore must also span decades. All of this is to say that conventional population projections are being de-emphasized here. Lack of emphasis notwithstanding, we have presented these projections in Table 2-9. These projections have been developed by the Chester County Planning Commission which projects a county-wide population growth of from 376,396 in 1990 to 489,300 in Year 2020 (App. 6, Draft Water Resources: Use and Service in Chester County, 1996).

Of even greater importance to this study is the fact that although these population projections do suggest considerable growth and development, development has undergone dramatic change. In stark contrast to turn-of-the-century Phoenixville with their 10 to 15 dwelling units per acre and perhaps 100 persons per acre resultant population densities, the current 2 or 3 or 4 acre lot for 2 or 3 or 4 person households means that a projected population of another 10,000 or 20,000 requires vastly greater Watershed area. And the concept of build-out does become a concern for many

POPULATION SUMMARY FOR THE FRENCH and PICKERING WATERSHEDS (CHESTER COUNTY ONLY)									
Derived from CCPC/WRA Report, 1990 Census, CCPC									
MUNICIPALITY	LAND AREA TOWNSHIP Acres	LAND AREA WATERSHED Acres (GIS)	% of TWP in WATERSHED %	% OF TOTAL WATERSHED AREA	POPULATION in WATERSHED	POPULATION in WATERSHED (Adjusted by CA)			
YEAR					1975	1990	2000	2010	2020
Charlestown Twp.	8019	6993	0.87	0.10	1927	2700	2931	3127	3343
East Coventry Twp.	6995	151	0.02	0.00	57	200	224	250	271
East Nantmeal Twp.	10515	5000	0.48	0.07	521	700	846	1059	1378
East Vincent Twp.	8793	4200	0.48	0.06	672	2000	2331	2874	3297
East Pikeland Twp.	5644	4341	0.77	0.06	2662	4200	4377	4701	4982
Elverson Boro	640	271	0.42	0.00	3	200	349	421	472
North Coventry Twp.	8588	200	0.02	0.00	6	300	300	317	328
Phoenixville Boro	2374	1828	0.77	0.03	11852	15000	15502	15800	16099
Schuylkill Twp.	6041	3454	0.57	0.05	3493	3500	3609	3710	3786
South Coventry Twp.	5030	3200	0.64	0.05	878	1100	1190	1229	1275
Tredyffrin Twp.	12652	74	0.01	0.00	0	200	207	210	212
Upper Uwchlan Twp.	7756	1786	0.23	0.03	380	1100	1504	1682	1839
Uwchlan Twp.	6694	1908	0.29	0.03	750	3000	3642	3741	3801
Warwick Twp.	12166	11526	0.95	0.17	2090	2500	2874	3282	3864
West Nantmeal Twp.	8582	1808	0.21	0.03	108	600	702	837	1020
West Pikeland Twp.	6323	6400	1.01	0.09	1630	2300	2861	3208	3475
West Vincent Twp.	11161	10827	0.97	0.16	1347	2200	3025	3647	4221
West Whiteland	8249	12	0.00	0.00	0	100	123	134	138
TOTAL (CC)	136222	63979		0.92	28376	41900	46596	50228	53803
TOTAL -WS		69687							
Developable Acres as of 1977		33454							

Table 2-9 Population by Municipality in the Watershed and Growth Projections

Watershed municipalities. Furthermore, although any one individual municipality may be able to moderate its population growth through reducing density wherever it can, such a strategy from a total Watershed perspective consumes land area at an astounding rate, even under moderate growth scenarios.

2.8.3. A Critical Growth Dynamics: the Changing Nature of Development

The relatively sudden decline in development densities on the fringe of metropolitan areas is not peculiar to the French and Pickering Creeks Watershed, or to Chester County or to the Philadelphia metropolitan area for that matter. The same phenomenon has been reported in virtually all major metropolitan areas. The Delaware Valley Regional Planning Commission (DVRPC) in its ongoing planning process for a new land use plan for the Philadelphia metropolitan region (Direction 2020) has produced a variety of analyses which document these dramatic changes in development patterns, even in a region which seems relatively static from a total population perspective. Although total regional population changed negligibly between 1970 and 1990, the region added another 400,000 homes, largely in developing fringe areas. In the recent Draft Regional Land Use Plan for the Northern Federation, several important points directly and indirectly relate to this growth dynamic area are discussed in some detail:

> *...agricultural and vacant lands noticeably decreased from 1977 to 1994. Agricultural lands decreased by 22 percent and vacant lands recorded nine percent less of the land area. Residential and Commercial/Industrial have experienced the most growth; they have more than doubled in area. These*

patterns generally typify events that have been occurring in the Northern Federation Region and across Chester County. Farmlands and vacant lands are being developed into residential and other uses.

Significant amounts of land have changed uses within this 17 year period. An estimation of the residential consumption of the land can be made by comparing the 1977 (14,600, not including Pennhurst residents) and 1993 (17,620) population estimate for housing units. The total increase from 1977 to 1993 in population for these five Federation municipalities is about 3,000 people. From 1977 to 1994 the increase in residential land was 3,300 acres. Therefore, on average, the per capita consumption of residential land is about 1.1 acres. Over this same period, the average household size was about 2.8 persons. This equates to about 3.0 acres per new household or new housing unit.

Farmland conversion is occurring at an alarming rate due to several factors. The well-drained and nearly level soils of the region are desirable areas to construct residences and other types of uses. The real estate value of the land presents alternative opportunities for farmers. Profits can easily be achieved by selling land rather than using it for agriculture. When agriculture profits are low, the land is more valuable as real estate which can be sold. Also, the development potential of farmland often serves as the retirement security for farmers.

Municipal practices are also encouraging farmland conversion. Zoning within many agricultural areas requires that residential lots be much larger than is necessary to support on-site sewer and water systems. Such zoning promotes a rapid loss of farmland." (Draft Regional Land Use Plan, 1995, pp. 1-15 and 16)

2.8.4. Recent Trends in Land Use Change

This land use reality is consistent with other studies done by other agencies. In a recent USGS study (Hardy, Wetzel & Moore, 1995), land use changes in the French and Pickering Creeks Watershed were evaluated to assess trends between 1967 and 1987. This study was based on measurement of land use above selected watershed locations, consistent with the water quality sampling stations discussed previously and did not include the entire Watershed. The statistics for land use change in the two watersheds over this twenty year period are illustrated in Figures 2-28 and 2-29. They clearly illustrate a significant conversion of farmland to residential uses and are consistent with the statistics developed in this study. For example, agricultural uses declined from 53 percent of the total area measured in 1967 to 37 percent in 1987, with residential uses increasing from 2 to 20 percent. The obvious trend of decreasing farmland and pasture and increasing residential land use is borne out and certainly has continued, if not accelerated, during the past nine years.

2.8.5. Current Land Use in the Watershed

Existing land use as developed in this study has been based on several sources. For the Federation of Northern Chester County Municipalities, CCPC compiled land use for each Federation municipality based on field examination of 1990 aerial photographs, current to 1993/4. The data was mapped by CCPC on a parcel by parcel basis and transferred to original color maps. These maps were digitized by CA into the GIS. For the remaining non-Federation municipalities (principally the Pickering Creek Watershed), existing land use had been developed in similar fashion as part of the municipal open space planning process. Coincidentally, local planning consultant Comitta Associates had prepared all of the plans for the outstanding municipalities and provided existing land use mapping for digitization by CA. For both sets of data, the original map classifications were generalized as follows.

In terms of the land use categories themselves, Open Space includes all the area in municipal, county, state, federal park and recreation ownership, as well as all areas secured in some form of easement (in perpetuity). These easements may be publicly held either through the state or county farmland preservation program, or may be held by one of the many different private conservancies (French and Pickering Creeks Conservation Trust, Natural Lands Trust, Brandywine Conservancy, and others). The point here is that this land is <u>not</u> subject to development in the future. The Agriculture category includes all forms of agriculture, including horticulture and orchards. Pasture is included as well. Industrial and Commercial are both relatively "small" categories. Industrial uses change rather dramatically in character from the older "brownfield" heavy industries of Phoenixville to the high tech "light industrial" uses at the top of the Pickering such as Uwchlan's Pickering Industrial Park. Commercial uses vary from scattered crossroads gas stations and convenience stores to a few commercial strip centers; there are no major commercial centers or regional malls in the Watershed. Utilities/Transportation is straightforward. Community/Institutional includes municipal buildings, schools (public and private), retirement facilities, and the like.

Of all of the "developed" land use categories, the broad category of residential is most prevalent within the Watershed and therefore deserves further division. Four sub-categories were developed to reflect variations in density: Low Density includes residential uses on lots larger than 1 acre; Medium Density includes half to 1-acre lots; High Density includes lots smaller than half an acre. In those areas where villages exist and in those distinctly urbanized zones such as Phoenixville, the Urban/Village category has been assigned. Also, some situations existed with a combination of residential and commercial uses (Mixed Use/Commercial).

Detailed existing land use data for each municipality is contained in the computer files. Table 2-10 and Figure 2-30 summarizes existing land use for the Watershed, as shown in Figure 2-31. Although extensive clearing of woodland has occurred in the Watershed, large expanses of forest remain, lying either within State Game Lands and other protected lands and parks in the upper Watershed portions, or on the steeply sloping ridges, where the soil is too poor for cultivation and other uses. Forested areas

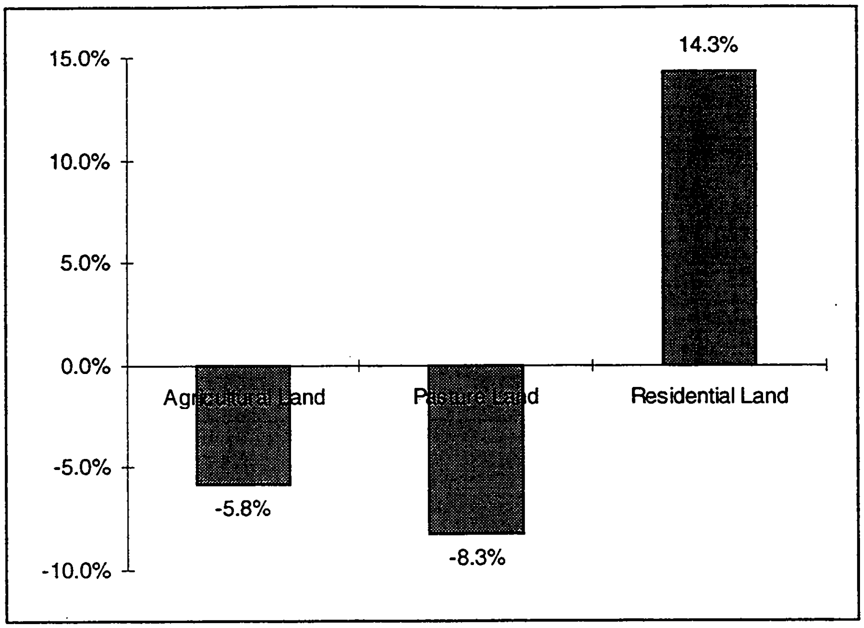

Figure 2-28 Changes in Land Use - 1967 to 1987 - French Creek near Phoenixville (USGS)

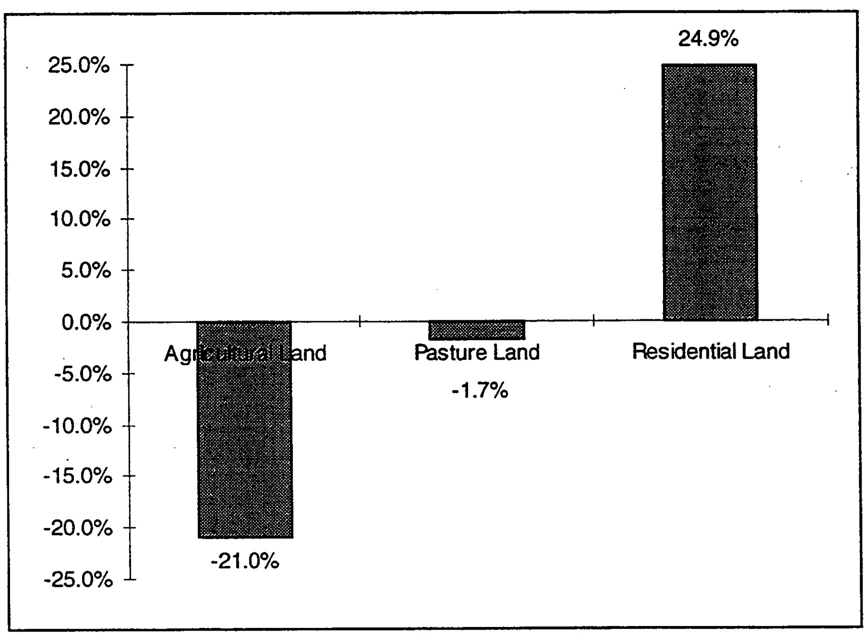

Figure 2-29 Changes in Land Use - 1967 to 1987 - Pickering Creek above Phoenixville (USGS)

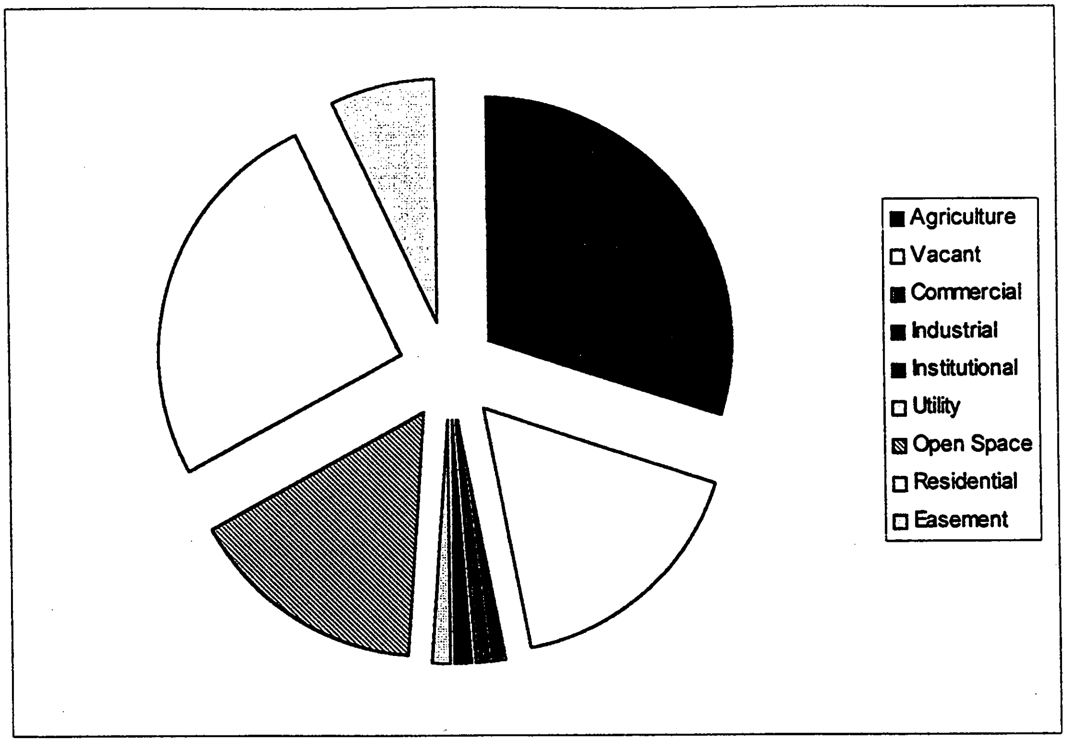

Figure 2-30 Existing Land Use: Pie Chart

Landuse	Acres	Percent
Agriculture	20,982	30%
Vacant	11,902	17%
Commercial	546	1%
Industrial	612	1%
Institutional	642	1%
Utility	657	1%
Open Space	11,388	16%
Residential	18,375	26%
Easement	4,583	7%
Total	69,687	100%

Table 2-10 Existing Land Use Summary

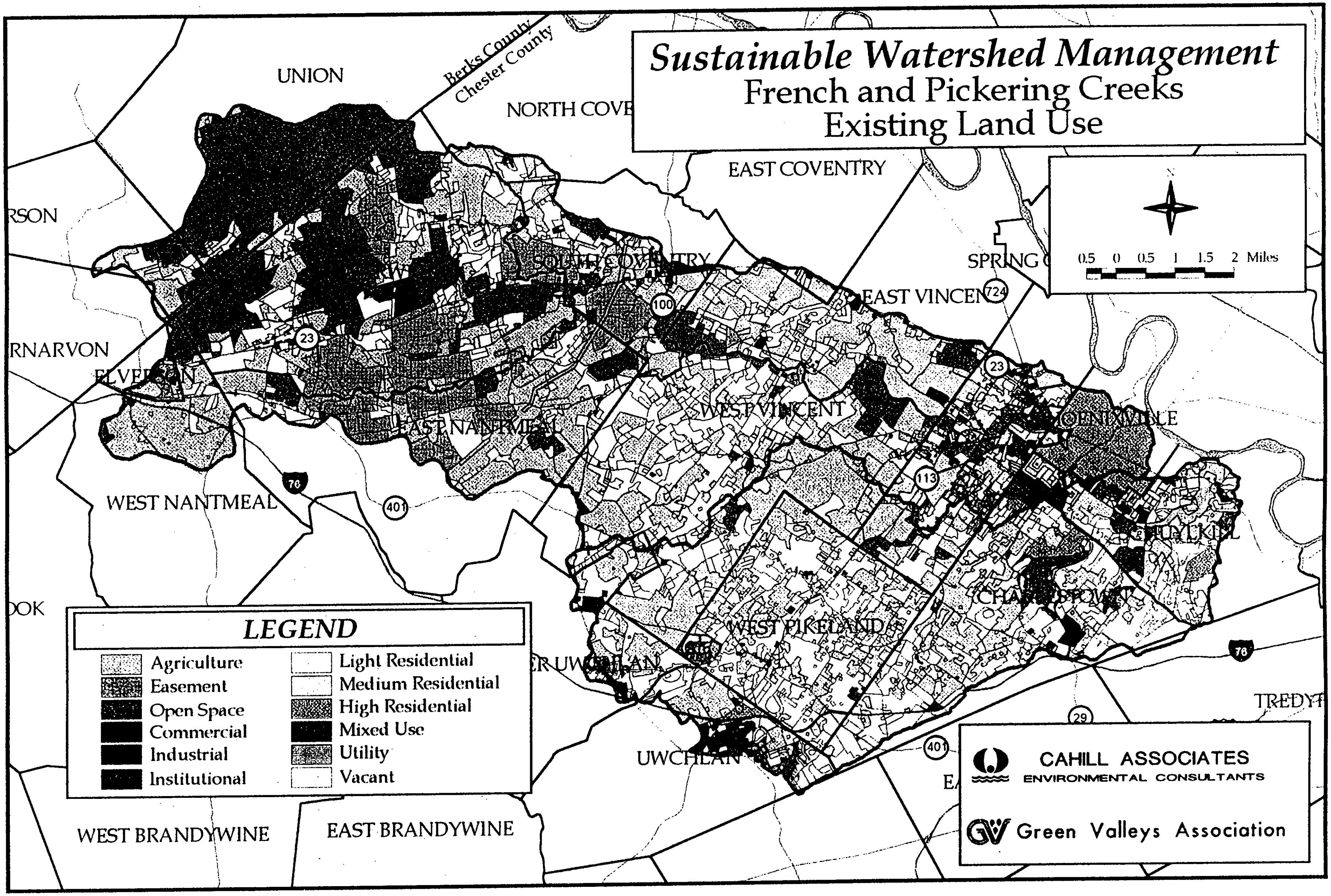

Figure 2-31 Existing Land Use in the French and Pickering Creeks Watershed

have been included in either the Vacant (17 percent) or Open Space (16 percent) categories, although it should not be assumed that all of Vacant and Open Space is forested (significant portions of Vacant consist of scrub growth or open fields not appearing to be used for pasturing).

Over the years, cultivation and livestock production understandably has been focused in Watershed valleys. Based on the GIS data base, total agricultural uses have declined to 33 percent of the Watershed. As shown in Figure 2-31, agricultural uses continue to be scattered throughout the Watershed, with the exception of the extreme lower and extreme upper Watershed portions. Prime agricultural soils and major agricultural enterprises flourish in the South Branch French Creek in East and West Nantmeal, and Warwick and continue downstream through West and East Vincent in particular. Historically, the upper portions of the Pickering were also characterized by agricultural uses; however, substantial conversion to various categories of residential uses (some at quite high densities) and both commercial and industrial complexes is accelerating. There has been a recent proliferation of growth along the Route 100 corridor from Exton to Eagle, the related extension of growth along Route 113 and 401, and the enhanced attractiveness of the Turnpike Interchange. Kravco's proposed new 5-anchor 1,000,000+ sq. ft regional mall at an interchange site perfectly illustrates the pressures bearing down on the upper Pickering.

Residential uses in total have risen to 25 percent of the total Watershed area, with the majority of residential uses being in the lowest density category (greater than 1 acre lot size). Although low density residential uses (21 percent of total Watershed; 84 percent of total residential) are scattered along both major and minor roads throughout the Watershed, low density subdivisions are now much more evident in the central to lower portions--Charlestown, Schuylkill, West Pikeland, Upper Uwchlan, for example. Higher density residential uses (only 4 percent of the Watershed total) are clustered in and around Phoenixville, East Pikeland and Schuylkill, with some high density uses in Uwchlan as well. Historically, residential use has been largely confined to small villages clustered at road intersections, with only the river community and industrial town of Phoenixville providing any major urban land use. New residential development over the past three decades has been generally large lot single family residential, although a few trailer parks and other high density communities have been developed, mostly clustering around the Phoenixville area or in the upper Pickering watershed, spilling over from the expanding Exton region in Uwchlan Township.

Perhaps the most interesting GIS data is the presentation and measurement of land in the watershed which is available for future development. Developable Land is presented in Figure 2-32, and is the combination of the Vacant and Agricultural land use categories. Developable Land becomes central to the evaluation of build-out, as discussed in detail in Section 4. All Developable Land is subject to the existing zoning classification of the respective municipality in which it is located, and detailed summaries by municipality are available. Total Developable Land in the Watershed is 32,884 acres.

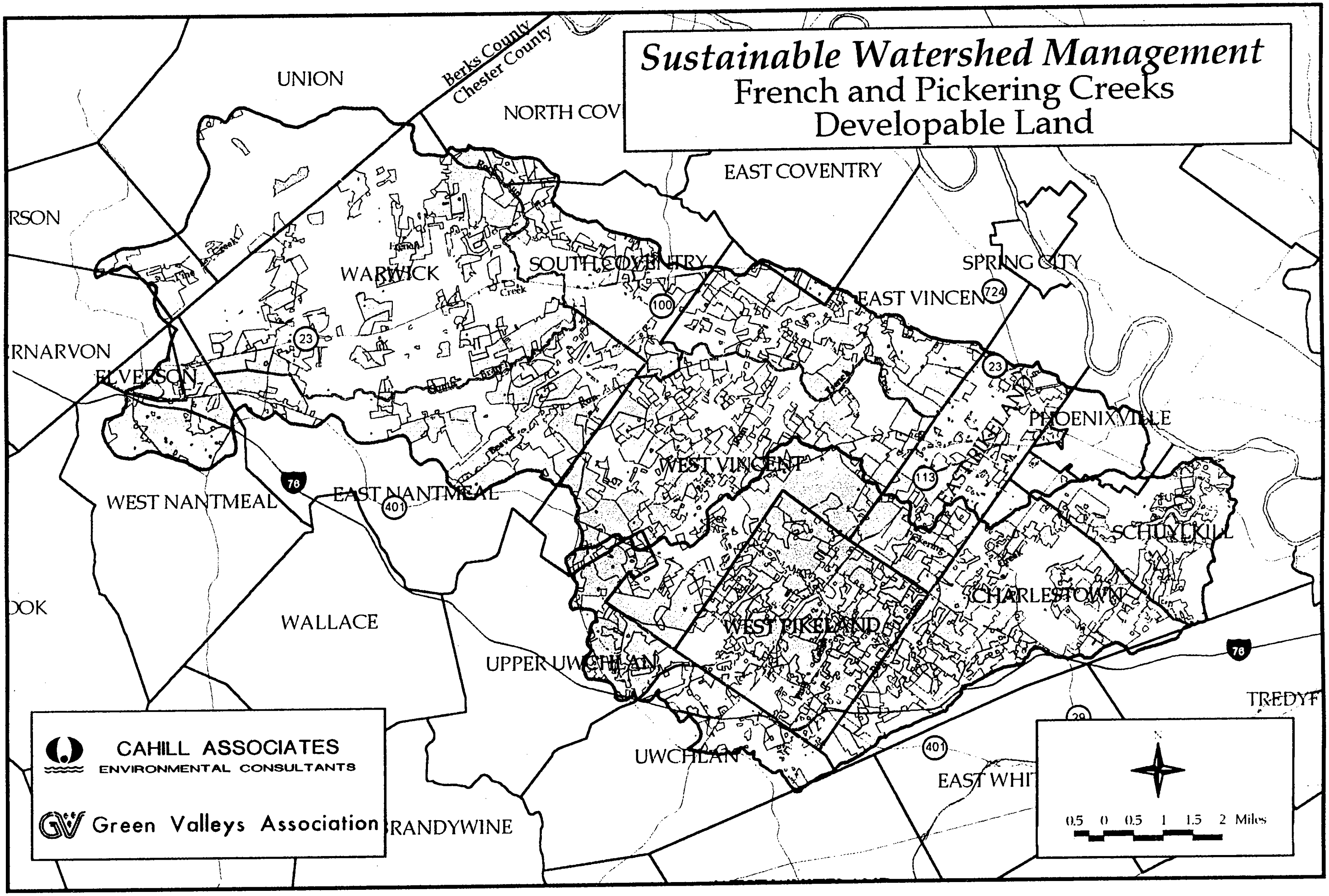

Figure 2-32 Developable Land in the French and Pickering Creeks Watershed

2.9. Existing Water Systems

While the majority of the French and Pickering Creek watershed area is not currently served by public water supply, that portion which is served includes a major fraction of the existing resident population. The Phoenixville system and the surrounding PSC service area in Schuylkill and East Pikeland, as well as the PSC area in Upper Uwchlan and Uwchlan, plus the Citizens service in East Pikeland, provide water to about 26,000 people in the watershed municipalities, as shown in Figure 2-33 and Table 2-11. While the precise number of connections which lie within the study area is not distinguished in this Table, it is possible to roughly divide the service population by municipality and basin.

The source of the water provided to these residents of the watershed is a bit more complicated. The Schuylkill serves as the Phoenixville system source. The PSC system uses multiple sources which include both the Schuylkill and the Pickering watershed drainage, as well as Perkiomen drainage which is piped under the Schuylkill and delivered to the PSC treatment plant in the Pickering watershed. In the Upper Uwchlan and Uwchlan systems recently acquired by PSC, the primary supply is drawn from wells in the Brandywine basin, with interconnection to system elements from the eastern portion of the Valley Creek basin. The Citizens system also draws water from the Schuylkill, but most of its present service demand is in Montgomery County. Within Chester County, several wells supplement the recently enlarged supply from the river, and the limited service area in Chester County is a mix of sources.

It is assumed in this study that major new public systems will not be developed in the foreseeable future, and that there will be limited expansion of these exiting public systems in the watershed. Consequently, it is assumed that water will be supplied by individual or smaller community systems, all groundwater-based, which means that water will be pumped from the aquifers and reduce stream base flow. Although water consumption has been reduced to some extent by the adoption of new water-conserving plumbing codes in the Watershed, water use can be considerable for different land uses and activities and often increases during the warmer weather months when stream flow is already at its lowest point.

The recent publication by the CCPC, titled "Water Resources - Use and Service in Chester County (1995), provides a detailed inventory of public water systems by purveyor and municipality, based on data from 1990 through 1992. The expansion and transfer of ownership of these systems changes some of the information by 1997.

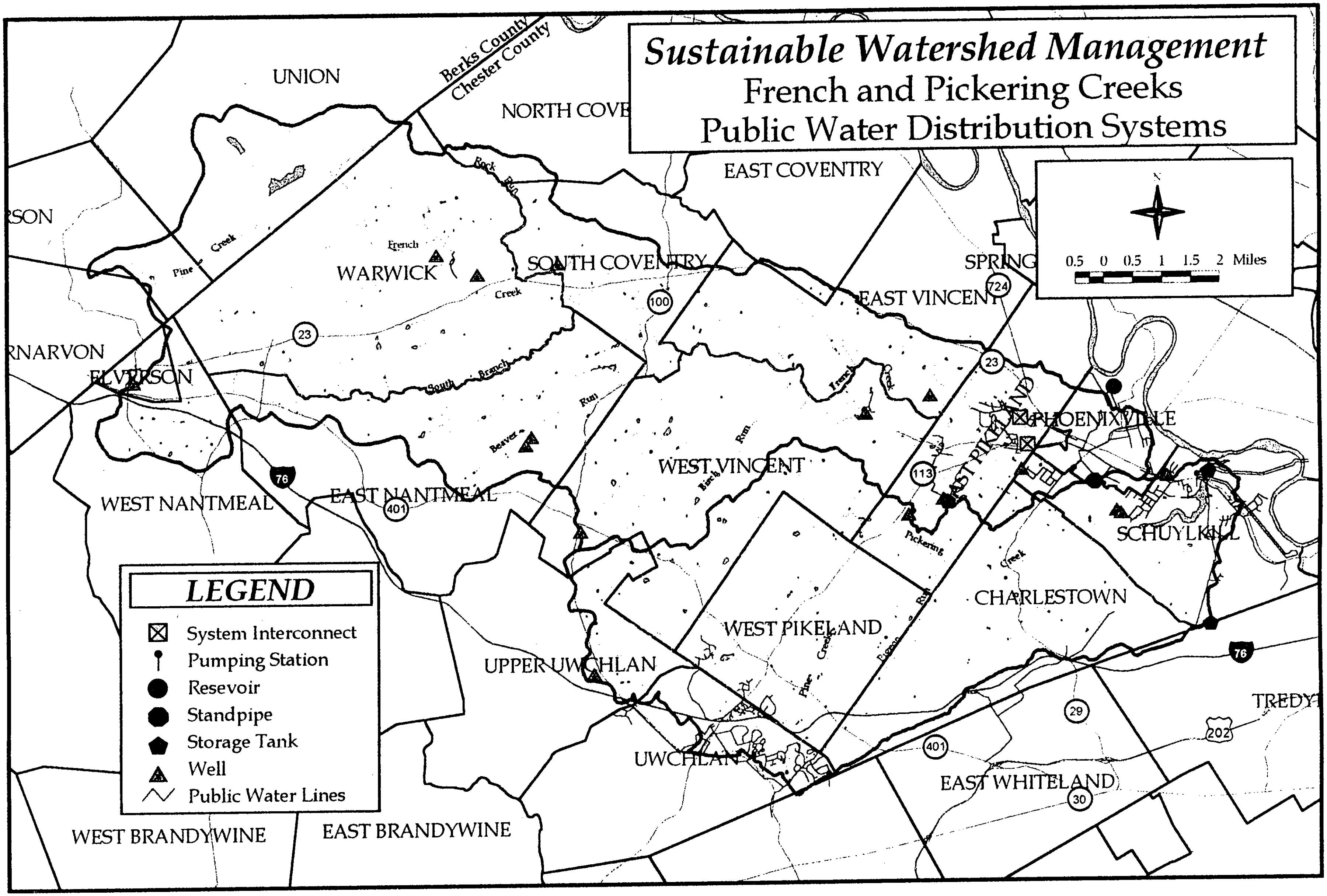

Figure 2-33 Public Water Supply Systems in the Watershed

PUBLIC WATER SYSTEMS in the WATERSHED										
TOTAL by MUNICIPALITY										
Derived from CCPC/WRA Report, 1990 Census, CCPC Prpj.										
MUNICIPALITY	PSC	PSC	CITIZENS	CITIZENS	Phoenixville		Pottstown		Other (MHPs, Schools)	
	Connections	Pop. Served	Connections	Pop. Served	Connections	Pop. Served	Connections	Pop. Served	Connections	Pop. Served
Charlestown Twp.	27	84								
East Coventry Twp.									118	342
East Nantmeal Twp.									1	70
East Vincent Twp.			217	586					88	435
East Pikeland Twp.			362	1050	202	586			188	544
Elverson Boro									42	109
North Coventry Twp.							532	1383		
Phoenixville Boro					6547	15058				
Schuylkill Twp.	841	2187			597	1552			10	27
South Coventry Twp.									1	65
Tredyffrin Twp.										
Upper Uwchlan Twp.	411	1315							103	330
Uwchlan Twp.	4466	12058							15	41
Warwick Twp.									20	54
West Nantmeal Twp.									43	170
West Pikeland Twp.	153	428								
West Vincent Twp.									1	65
West Whiteland										
TOTAL (CC)	5898	16072	579	1636	7346	17196	532	1383	630	2252

Table 2-11 Public Water Supply Systems in the Watershed

2.10. Existing Wastewater Systems

Only four significant point sources or wastewater discharges presently operate in the French Creek, and none are presently situated in the Pickering basin. Table 2-13 summarizes these wastewater treatment facilities, and offers some indication of their pollutant loading to the drainage, in terms of nutrients. Overall, they have only minor impact on existing water quality within the study area.

However, wastewater collection systems serve a significant fraction of the existing watershed population, and convey these wastewaters to sewage treatment facilities outside the drainage. The Phoenixville Borough system and the Valley Forge Regional Sewer Authority system serve a significant population in the eastern portion of the drainage, and discharge effluent into the Schuylkill River. For those portions of the service area in which the water supply source is withdrawn from the groundwater, this conveyance and discharge outside of the watershed is a significant negative depletion of water. Most of the areas served, however, are also provided with Schuylkill River water as a potable source, and so the net impact is one of import and export within the study area. In the headwaters of the Pickering, water supply is imported from the PSC system and most of it is pumped back into the regional Downingtown Sewage system, again a net zero sum impact on the watershed.

Like water supply, the future wastewater needs are anticipated to be served by land-based wastewater treatment systems, such as on-site septic systems, community on-lot disposal systems, and spray irrigation. These should mitigate the adverse impacts of new development on aquifers and stream flow, but portions of the water use can also be lost or depleted through evaporation and other means even under the most ideal conditions. Although spray irrigation, for example, can have significant environmental benefits such as the removal of Nitrates, depletive losses can be 50 percent or greater. If conventional wastewater treatment plants with centralized collection systems and stream discharged effluent are employed as expansion of existing systems, water can be completely "lost" to the immediate watershed area. Perhaps even more important are the various water quality impacts related to stream discharge of wastewater effluent if that alternative is applied in the use of smaller "package" treatment plants.

POINT SOURCES										
NUMBER (NPDES)	NAME	LOCATION	TYPE	SERVICE POPULATION	DESIGN CAPACITY	CURRENT LOAD	EFFLUENT CHEMISTRY NO3-N		TOTAL PHOS.	
					(MGD)	(MGD)	(mg/l)	(#/day)	(mg/l)	(#/day)
FRENCH CREEK BASIN										
42927	O. J. Roberts High School	French Cr. @ Pughtown	Ext. Aeration	2000	0.039	0.0151	45 (Assumed)	3.75	8 (Assumed)	0.67
		South Coventry Twp	30 yrs. old							
42935	French Cr. Elem. School	SB French Cr. abv. conf	Ext. Aeration	250	0.004	0.0016	45(Assumed)	0.37	8 (Assumed)	0.06
		South Coventry Twp	32 yrs. old							
50474	Warwick Drainage Co.	St. Peters Village	Ext. Aeration		0.012	0.0092	45 (Assumed)	3.38		
	(Knauer/Carr)	Warwick Twp	22 yrs. old	47 conn.						
50512	Birchrunville General Store	Birchrunville	Act. Sludge		0.001	0.0004				
	j. Milner	Birchrunville, W. Vincent	18 yrs .old	2 conn.						
51951	Chapman Residence	Nr. Warwick								
51942	Brower Residence	Nr. Warwick								
54968	Sun Refining Co	South Coventry				0.0007				

Table 2-13 Wastewater Treatment Facilities

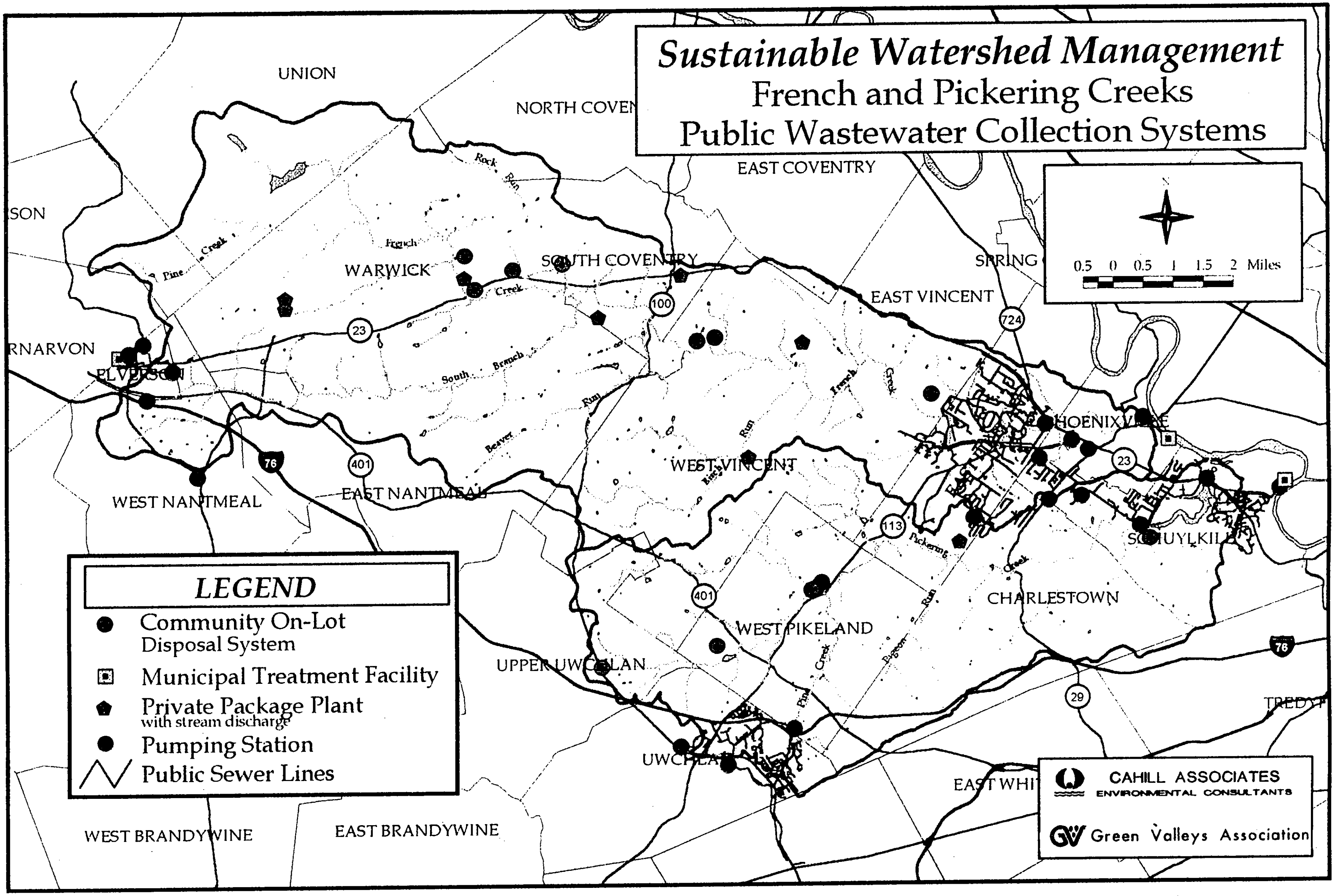

Figure 2-34 Wastewater Treatment Facilities

SECTION 3.0 EXISTING REGULATORY AND MANAGEMENT SYSTEMS

3. EXISTING REGULATORY AND MANAGEMENT SYSTEMS

The issue to be considered here is the existing set of regulatory and management controls dealing with land and water within the watershed. Virtually every law, regulation, ordinance and criteria which exist at various levels of government deal with one resource or the other, but none directly interrelate both resources. On the other hand, various planning documents have considered, described and identified the impacts of one upon the other; unfortunately, these various reports and studies carry little weight in the judicial or quasi-judicial forums in which most decisions are made concerning land and water use in Pennsylvania. Bridging that regulatory gap begins with an understanding of exactly how the various land and water management systems function, from municipal to county, regional, state and federal levels.

The relationship between land and water resources in the French and Pickering Creeks Watershed has been studied from a hydrologic and hydrogeologic perspective in Section 2. It will be further evaluated in terms of the net impact of potential change in one system following changes in the other in Sections 4 and 5. Deciding if such change is in our best interest however, is a more difficult issue.

Over time, we have developed two distinct systems for managing land and water resources in the Commonwealth of Pennsylvania. They have had little interrelationship, other than the common recognition that the ways in which we use one system greatly effects the other. In large measure, this lack of interdependency in resource management is due to the strong cultural tradition that all resources are to be used or exploited by man; for community development, enrichment, progress or any of the other descriptive terms which have been applied to justify our collective actions for the past two centuries. The self-image of citizens clearing the forests, tilling the land and building new cities out of the wilderness is well rooted in the American heritage.

The existing system of governance in Pennsylvania is founded on local control, and all key decisions concerning how and where the land is used for a given purpose are made at the municipal level. Virtually all water resource decisions are made at the state level, and the intermediate county governments are fairly weak, by design. This is in sharp contrast with much of the country beyond the northeast, and in most other states, the county government makes land use, infrastructure and water resource decisions, not necessarily in a more comprehensive fashion but at least with a greater capacity to control and guide development on a larger scale. For the foreseeable future, the management of land in the Watershed will remain in the hands of municipalities, and it is there that the water resource management systems must be integrated in order to have any impact. That system is now structured by Zoning and implemented by Development Ordinances, with some broader overview provided by various plans (Comprehensive, Sewer, Open Space) which have limited regulatory implications but serve as valuable management tools.

3.1. Municipal

3.1.1. Existing Zoning

The 17 municipalities (and small portions of three others) which in whole or part comprise the Watershed have created Zoning designations which are similar in form and structure. They are generally built on the patterns of land use created before zoning was instituted, with a preferred future use of land for large lot, single family residential purposes. In anticipation of need or perhaps legal challenge, many of the municipalities have established zones for higher density and types of residential use, as well as relatively small commercial, industrial and other uses, frequently situated contiguous to existing similar uses or following transportation corridors and junctures. All of this zoning has been carried out with virtually no consideration of water resources, not out of a sense of neglect, but rather because the existing landform, topology, drainage and composition had little direct input into the zoning process. Certainly the original settlement patterns along the Schuylkill River valley as a transportation corridor, and at or near mill sites on the tributaries, created the basic skeleton of communities and interconnecting roadways. This land use was guided by the drainage system and the ridge lines which divide the watersheds, with gentle sloping valleys cultivated because of the richness of soil and topologic accessibility. As Zoning districts were imposed on this landform, however, it was applied in a flat, geometric pattern, defined by ownership lines and existing land use. Some streams became municipal boundaries, and therefore zoning boundaries, only because they offered definitive limits to land.

Within the 17 municipalities in the two watersheds, some 132 Zoning categories have been established, which create a patchwork quilt covering the watershed, if each zone is considered as distinct. In reality, these zones can easily be combined into seven general zoning categories, as shown in Figure 3-1. The zoning categories are not identical within the grouping, as detailed in Table 3-1, but are reasonably consistent across the category. The figure reinforces the controlling elements described earlier, with the urbanization patterns of higher densities extending out from the Phoenixville area and north along Route 100 from Exton. The largest portion of zoned land is large-lot residential, reflecting the collective opinion of existing municipal governments that if development must take place, it be residential in form of the least density which can legally be justified.

3.1.2. Subdivision Regulations

All of the municipalities in the watershed have adopted Land Development Ordinances, setting out specific criteria to be applied in the land development process. Most such guidance respects the sensitive land areas on a given parcel, such as floodplains and steep slopes, and all municipalities have some form of a stormwater management ordinance in place which requires that the post-development runoff peak not exceed the pre-development condition. A few of the townships have made this criteria more

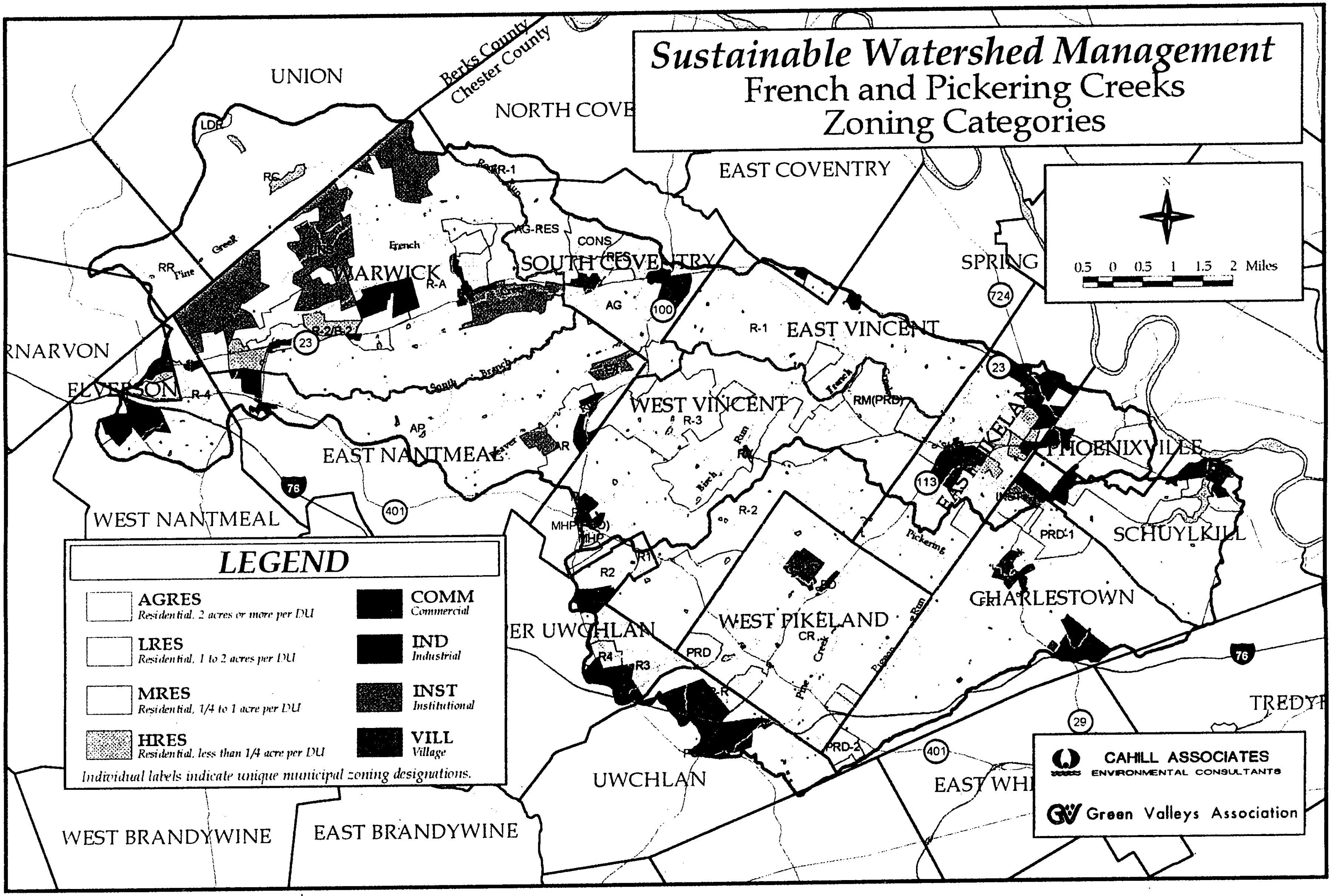

Figure 3-1 Zoning in the Watershed

Municipality	Mun_Symb	Uni_Symb	Description
Charlestown	FR	AGRES	Farm Residential
	H	VILL	Historic (Charlestown Village)
	I	INST	Institutional
	L-I	IND	Limited Industrial
	N-C	COMM	Neighborhood Commercial
	PRD-1	MRES	Planned Residential Development-1
	PRD-2	MRES	Planned Residential Development-2
	PRD-3	MRES	Planned Residential Development-3
	R-1	LRES	Residential
East Coventry	FR	AGRES	Farm Residential
	NC	COMM	Neighborhood Commercial
	R-1	LRES	Residential
East Nantmeal	AP	AGRES	Agricultural Preservation
	AR	LRES	Agricultural/Residential District
	C	COMM	Commercial District
	E/I	INST	Educational/Institutional District
	IA-1	IND	Industrial/Agricultural District
East Pikeland	C	COMM	Commercial
	HI	IND	Heavy Industrial
	KR	COMM	Kimberton Retail
	LI	IND	Light Industrial
	R-1	AGRES	Farm Residential
	R-2	MRES	Residential
	R-3	HRES	Residential
East Vincent	C-1	COMM	Neighborhood Commercial District
	R-1	AGRES	Rural Conservation District
	R-2	LRES	Low Density Residential District
	R-3	MRES	Medium Density Residential District
Elverson Borough	I	IND	Office-Industrial District
	R-1	MRES	Residential District
	R-2	HRES	Residential District
	R-3	HRES	Residential District
	RR	LRES	Rural Residential District
	VC	COMM	Village Center District
North Coventry	FR-1	AGRES	Farm Residential
	FR-2	AGRES	Farm Residential
Phoenixville Borough	APT	HRES	Apartment
	PHOE	PHOE	Pheonixville Borough
	CO	COMM	Commercial Office
	D/COMM	COMM	Downtown Commercial
	FCE	HRES	French Creek East
	FCW	COMM	French Creek West
	HC	COMM	Heavy Commercial
	INS	INST	Institutional
	LC	COMM	Light Commercial
	LIO	IND	Light Industrial
	LICO-1	IND	Light Industrial/Commercial Office
	LICO-2	IND	Light Industrial/Commercial Office
	NCR-1	HRES	Neighborhood Residential
	NCR-2	HRES	Neighborhood Residential
	NCR-3	HRES	Neighborhood Residential
	NCR-4	HRES	Neighborhood Residential
	MR	HRES	Mixed Residential
	PFZ	INST	Public Facility
Schuylkill	APO-1	HRES	Apartment/Professional Office District
	APO-2	COMM	Apartment/Professional Office District
	A-R	IND	Administrative & Research District
	C	COMM	Commercial District
	FR	AGRES	Rural Density Residential District
	I	IND	Industrial District
	I/LI	IND	Industrial District
	NO	COMM	Neighborhood Office District
	R-1	LRES	Low Density Residential District
	R-2	MRES	Medium Density Residential District
	NC	COMM	Neighborhood Commercial District
	LI	IND	Limited Industrial District

Table 3-1 Municipal Zoning Classes and Related Watershed Zones

3.1.3.7. North Coventry Township

Because so little of North Coventry lies within the Watershed, importance of many of these issues is minimized from this perspective. However, the township is a vital part of the Northern Federation, and as such is of great interest. Within that small portion of North Coventry within the Watershed, planning and zoning categorization is uniformly low density and rural. Changes in the township's "tools" are warranted, but these changes have most relevance for the adjacent Pigeon Creek watershed, which will be the subject of future resource management analysis.

The Comprehensive Plan (1988) is similar to the East Vincent plan in its approach to loading future growth in North Coventry. Broad zones of higher density where public facilities (sewer and water) are provided have been designated. There is discussion of importance of villages; however the Future Land Use plan shows us no villages. Furthermore, the provisions in the Plan addressing villages are not relevant to development of villages. Natural resources goals and objectives focus largely on zoning and SLDO provisions. Planning-related provisions developed for sustainable Watershed Management should be integrated.

3.1.3.8. Schuylkill Township

Probably no other township in the watershed faces stronger growth pressures than Schuylkill Township. Although much development already has occurred, much undeveloped land does exist, especially within the watershed portion of Schuylkill. Therefore, rigorous management is critical here. Schuylkill's most recent planning efforts, as demonstrated by the Comprehensive Plan and Open Space Plan, together with their efforts to amend the SLDO, reflect their intent to manage growth carefully and in ways compatible with Sustainable Watershed Management. Improved SLDO provisions in particular are critical, as well as much more rigorous sensitive areas protection in the zoning ordinance. Planning and zoning which allows for large-lot build out of the Watershed should incorporate comprehensive and rigorous clustering. More far-reaching development rights transfer would be preferable.

The Comprehensive Plan (1991) and Open Space Plan (1992) both provide a basis for Sustainable Watershed Management recommendations. The Comprehensive Plan includes extensive inventorying of natural features and, in particular, water resources, which are accorded high priority in the discussion. A variety of relevant statements are made in the Planning Implications and Goal statements.

The Future Land Use map depicts configurations of uses and densities quite consistent with the Zoning Ordinance Map. The Watershed is classified largely in rural categories at a density of 2 to 4 acres per dwelling. Major zones of environmental constraints (natural and conditional) are established for either preservation or limited development, relating to floodplains, wetlands, steep slopes, woodlands, and other soils constraints. Continuation of large-lot subdivision throughout the Watershed is consistent with Plan recommendations. Because lack of provision of sewer and water lines is enormously important in the implementation of Plan recommendations in the watershed, the plan should articulate this position forthrightly. Unfortunately, the specific language relating to extension of sewer and water lines is somewhat vague. The language relating to stormwater management is quite general and does not address critical stormwater management issues of recharge and nonpoint sources.

3.1.3.9. South Coventry Township

Given its location, South Coventry is a keystone municipality for the Watershed. Although many Watershed municipalities have recently been wrestling over ways to improve their management "tools," perhaps none has been more involved than South Coventry, where a comprehensive planning process has been ongoing for some time. After substantial controversy, a revised Draft Plan (1995) has been prepared. The Statement of Goals and Objectives seems quite consistent with Sustainable Watershed Management recommendations.

- *Reduce the overall allowed amount of residential development in the township to between 800 and 1,000 units from the more than 4,000 units possible under existing zoning.*

- *Reduce potential development in agricultural areas of the township to approximately one dwelling unit per every 10-15 acres of farmland.*

- *Reduce impacts of development in the most environmentally sensitive portions of the township by "netting out" environmentally constrained resources from lot calculations and by requiring that developments be concentrated in small areas, allowing retention of up to 80 percent in permanent open space.*

- *Concentrate commercial and other non-residential uses in the most appropriate parts of the township, near existing infrastructure.*

The township's most recently revised Act 537 Wastewater Facilities Plan (1991) generally adheres to a policy of land-based wastewater systems, whether individual or community in nature and scope. Both community seepage beds and spray irrigation are discussed for effluent management. Stream discharge is not discussed as an option, all of which is consistent with Sustainable Watershed Management recommendations.

3.1.3.10. Warwick Township

The Comprehensive Plan expresses a strong desire to keep the township relatively undeveloped. Warwick's planning documents consistently state the intent to protect environmentally sensitive areas (floodplains, wetlands, habitat, etc.) and protect open space for aesthetic beauty. The Open Space and Recreation Plan states:

"...the Zoning Ordinance was the tool used to implement the Comprehensive Plan recommendations, thereby strengthening the environmental protection standards such as floodplain and steep slope regulations."

3.1.3.11.West Vincent Township

In the Open Space and Recreation Plan (February, 1993) West Vincent adopted a variety of goals and objectives which relate directly to this study. Protection and maintenance of water resources includes actions ".... to recharge the groundwater reservoir." Specifically, the Plan states:

"The Township may wish to consider more comprehensive approaches to management of the limited groundwater resource. Examples may include requirements for demonstration by developer/applicants of "no net loss" in groundwater recharge post-development, along with careful review and possibly revision of impervious surface limits, landscape standards, erosion and sedimentation requirements and stormwater management standards. To do so will require further study of West Vincent's "water budget", looking in depth at well inventories, aquifer testing, rainfall patterns, evapotranspiration rates, stormwater runoff patterns, stream flow condition, existing groundwater recharge patterns and analysis of drought cycles. 1989 changes to the Municipal Planning Code, as encompassed in Act 170, specifically allow for the inclusion of definitive water resource studies as part of comprehensive planning and zoning efforts, including the establishment of density criteria based on groundwater availability."

In addition, the Comprehensive Plan update of 1985 and the Zoning Ordinance of 1987 enumerate the same goals *"...to protect the quality and quantity of ground and surface water resources."*

3.2. County

3.2.1. Chester County Health Department

The Chester County Health Department (CCHD) has regulatory responsibility and performs resource management for several key water resource laws and programs in the Watershed. Created under enabling State legislation in 1966, the CCHD has primary control over on-site sewerage systems, including both permitting and construction inspection. For larger Community On Lot Disposal Systems (COLDS), the DEP has oversight responsibility, and for most larger systems (greater than 10,000 GPD) the state assumes primacy in permit issuance, with the option of considering smaller systems of special concern. For single family residential systems, the CCHD is the only regulator, but for larger systems the division of responsibility is unclear and varies over time as agency programs are modified. In both of these programs, there is recognition that the application of septage has the potential to impact groundwater, and elevate concentrations of Nitrate above 10 mg/l, limiting local water supply withdrawals. For the larger onsite effluent application systems, testing of groundwater quality is now required, and in many cases continuing monitoring has been included in the permit. For the individual residential systems, however, only limited testing is required.

The planning process for community or regional wastewater system development has traditionally been implemented through the requirements of Act 537, the state law governing sewage facilities planning. The CCHD plays an important part in encouraging, supporting and reviewing the preparation of these plans and assuring compliance with them following adoption by the municipality, but the lead agency is the DEP. The on-going conflict between land use change and water quality is most apparent in these plans and their formulation, as both local government and county and state regulators have lacked the capacity to estimate future impacts of resource management. Issues of water balance exacerbated by basin transfers, sewage export and regional groundwater pollution are considered but seldom enter into the final plan development. The pressures created by existing system failures, new land development applications and other socioeconomic and political factors make the question of where to define the "end of the sewer" a very difficult issue.

The Chester County Health Department has also maintained a permit/regulatory program for new well drilling throughout Chester County since 1983. This program is administered by DEP in other counties lacking a health department. Permitting requirements vary, depending upon water supply classification (private vs. public, for example), with requirements increasing as size of the well and usage increases. Even for private domestic wells, CCHD requires that in addition to the DEP New Well Drillers Log information, water must be tested for 10 quality parameters (turbidity, color, threshold odor, pH, nitrate/nitrite, iron, manganese, chloride, MBAS, total coliform).

It should be noted that the existing record of well development, with associated hydrogeologic properties, is maintained by both the CCHD and the DEP. The DEP requires the documentation of well construction and development by local well drillers (commonly referred to as the Well Drillers Log). This source, while known to be somewhat inconsistent and lacking in quality control, does provide limited information on well drilling in a particular rock type and in the Watershed. Drillers complete these forms in the field; information includes well depth, water levels before and after the well test, well yield in gallons per minute, drawdown, basic geological information, and a variety of other questions. This record is kept both at PADEP in Harrisburg and is copied to the Chester County Health Department.

3.2.2. Chester County Conservation District

The Chester County Conservation District (CCCD) plays a vital role in water resource management and the land development process from a regulatory perspective. Evolving from a traditional role as technical advisor to the farming community, the CCCD now implements Section 102 of the state water quality regulations concerning Erosion and Sediment Control for new development applications, and reviews the associated stormwater management controls designed for such developments. In many municipalities, ordinances have been enacted which parallel this role, with review and approval control mandated to the municipal engineer. In most cases, the management controls are identical, with the primary design criteria of stormwater facilities being the attenuation of runoff peak flows.

The CCCD has become the lead technical agency in all aspects of stormwater management, providing guidance to the municipalities and promulgating the current guidance, standards and methods of the state. As an institution, the District is more comfortable in the role of technical advisor, and the occasional enforcement aspects of the E & S program are more difficult. Much of the good advice offered by the DEP and federal agencies with respect to stormwater management is directed through the District and the supporting federal agency, the Natural Resources Conservation Service (NRCS) formerly the Soil Conservation Service (SCS). Some of this guidance recognizes the basic resource management conflicts of allowing increased runoff at the cost of diminished groundwater recharge, but by and large the focus is on direct stormwater impacts.

Current Best Management Practices (BMPs) advocated by the District and NRCS recognize the importance of controlling Nonpoint Source (NPS) pollution, both before and after development. However, nothing in the current management guidelines requires recharge of stormwaters as a basic policy for both quantity and quality considerations, and the requirement of BMPs for new development, while recommended and encouraged, is not yet a part of the management system. That is, specific criteria for NPS load reduction have not yet been included in the design guidelines.

3.2.3. Chester County Planning Commission

The Chester County Planning Commission (CCPC) has long preached a gospel of land planning with resource protection, and all of their reports have reflected a sensitivity for the environmental quality which is held in great esteem within the county. The numerous documents prepared under various aspects of community support reflect this understanding and advocacy, and the current County Comprehensive Plan (1996), titled *"Landscapes"* and the related Draft Regional Land Use Plan (1996) prepared for the Northern Federation continue to recognize the interrelationship between land and water resources. The recent inclusion of the Chester County Water Resources Authority (CCWRA) within the administrative framework of the CCPC should further reinforce this policy.

Given the inherent weakness of county government in Pennsylvania, much of this advice is not given adequate consideration by municipal governments, and does not find translation into specific ordinances, zoning changes or other management actions. To compensate for this lack of direct political control, the county provides financial support to municipalities to "do the right thing" in local planning efforts, supported technically by the CCPC. Some of these regional planning programs have been successful for Pennsylvania, and the 22-year old Federation of Northern Chester County Communities (FNCCC) stands as a success story within the county for inter-municipal planning efforts.

The state considers the various related planning documents as is and when a water permitting issue is specifically identified, but seldom uses the county programs as guidance for any type of comprehensive regulatory program. The future efforts by PADEP under federally-mandated Total Maximum Daily Load (TMDL) permitting may be influenced by future planning on a county or regional basis, but the current linkage is poor to non-existent.

3.3. Federation of Northern Chester County Communities

This consortium of municipalities in northern Chester County formed in 1974, with East Pikeland, East Vincent, South Coventry, Warwick and West Vincent Townships as the originating municipalities. It was expanded several times since 1974, and currently, there are nine municipalities. North Coventry joined in 1982, East Coventry joined in 1989, Spring City joined in 1992, and finally East Nantmeal joined in 1993. The original focus of the Northern Federation was the protection of water quality and quantity in the French Creek, a mission which still remains a key objective.

The Federation of Northern Chester County Communities (Northern Fed), has participated in and given final approval to several plans and planning studies undertaken by the CCPC on their behalf over recent years and which have major water resources management importance. The *Surface Water Runoff Study (1991)* recommended that Northern Fed municipalities pursue a more ambitious program for managing surface water resources. Many of the recommendations made in the *Surface Water Study* also pertain directly and indirectly to groundwater and total watershed management. A sampling of recommendations includes:

> *"Link surface water runoff concerns with land use.*
>
> *Examine and amend existing zoning provisions to ensure that the natural watershed drainage is not overburdened by the types and intensities of uses permitted by the ordinance.*
>
> *Utilize innovative land use practices (lot clustering, lot averaging, transfer of development rights, agricultural zoning, performance zoning, etc.) to protect the sensitive environmental features in a given watershed.*
>
> *Encourage or require recharge of surface water runoff where the conditions of the site permit recharge This will aid in maximizing infiltration of rainfall for the purposes of preserving groundwater supplies and stream flows. " (Surface Water Runoff Study,* pp. 137-143.)

These recommendations are directly supported by this study, and offers a mechanism to achieve the forward-thinking goals and objectives which already have been embraced by the Northern Fed municipalities. The technical task will be to translate the guidance into specific changes and additions to the Zoning, Ordinances and Planning documents of each of the member municipalities.

3.4. Regional

3.4.1. DRBC Groundwater Protected Area

The Delaware River Basin Commission (DRBC) regulates development of new wells where well usage is expected to be large (100,000 gallons per day) based on average 30-day usage in all areas excepting the Special Groundwater Protected Area (see Figure 1-3), where the 100,000 GPD threshold is reduced to 10,000 GPD. As shown in the figure, much of the Watershed is not located within this Special Groundwater Protected Area. The DRBC permitting process requires much more complex technical evaluation, including more detailed hydrogeologic studies and pump test analysis of the new well being permitted, as well as an evaluation of the potential impacts on adjacent wells. However, until the current time, no specific quantity withdrawal limits have been imposed on any new well applicant, regardless of the current and future anticipated use of that aquifer, or the existing and planned wastewater effluent discharge programs, including the net impact of the export of wastewaters from a given basin.

The DRBC has long recognized the importance of maintaining base flow in stream systems, and the original reason for the establishment of the Groundwater Protected Area was a very important study of stream base flow, performed for the DRBC by R. E. Wright Assoc.(Wright, 1981). The work was titled *"Special Groundwater Study of the Middle Delaware River Basin, Study Area II"*. The Wright study considered available groundwater data for the middle portion of the Delaware basin, including the French and Pickering watersheds. The study considered a number of factors which influence well yield in various formations, such as lithology, topologic setting, degree of fracturing, and other conditions. It gave detailed consideration to the Triassic Formation, and the differences among three major rock types, all of which are found in the northern portion of the French Creek watershed. The Neshaminy basin in Bucks and Montgomery Counties was the location for analysis of these formations, and water budget data was developed for this well-studied watershed, as well as the gneiss formations found in the Upper West Branch of the Brandywine Creek. As in the Sloto study for the French Creek, hydrograph separation provided information on base flow statistics, although the data set was not as well developed.

Wright estimated the differences in base flow from watersheds comprised of different mixes of both geologic formations and land use. Stream flow records from five or more watersheds were compared, and estimates made of base flow variability. It should be noted that this study distinguished between base flow and groundwater recharge, by including the groundwater evapotranspiration loss (ET), estimated to be 20 to 30 percent of base flow. Also of interest is the period of flow record, which generally is a decade earlier than considered in this study. The dry year of record considered by Wright was 1966, when the annual base flow in the Neshaminy Creek was 3.1 inches, or 146,000 GPD/sq. mi. Table 3-2 summarizes the formation-specific annual low flow values developed for the 10 year recurrence interval.

The development of this data concerning possible depletion of base flow and subsequent dewatering of streams in the Delaware River basin during drought resulted in specific regulations by DRBC concerning development of new wells. In 1996, the DRBC Groundwater Advisory Committee proposed amendments to the Groundwater Protected Regulations which would use the Average Annual Base Flow of 10-year frequency (Q 365-10) as a limit to withdrawals in the protected area. The pilot studies supporting these proposed regulations were performed in the Neshaminy basin, a watershed whose Triassic aquifers are substantially overdrawn by urban demands, with several major streams which dried up during the drought period of 1995.

Aquifer Type	**Annual Base Flow**		**Annual Groundwater Recharge**	
	(GPD/SM)	(GPD/Ac)	(GPD/SM)	(GPD/Ac)
Shale & Sandstone	53,000	83	100,000	156
Igneous & Metam.	300,000	469	510,000	797
Sandstone	350,000	547	580,000	906
Carbonate	650,000	1015	690,000	1078

Table 3-2 Base Flow Values Developed by Wright (DRBC, 1981)

It is the intention of the DRBC to extend the regulations to the entire Groundwater Protected Area following further study by the USGS during 1997, in developing base flow statistics. More importantly, the currently proposed rules allow local groups of municipalities (such as the Northern Federation) or Counties (such as Chester) to adopt more stringent withdrawal regulations where high quality stream systems have been designated. Thus these DRBC regulations can offer a technical support and regulatory foundation for any effort to apply base flow limits to groundwater withdrawals in the study area.

3.4.2. Delaware Valley Regional Planning Commission

The potential role of the DVRPC in relating land use to water resources has significantly changed over the past decade, as diminished funding for water related planning has forced the agency to focus on transportation issues. During the 1970's, the agency played a key leadership role in formulating a series of studies of land and water in the Delaware Valley, under the Section 208 program of the Federal Clean Water Act (CWA). That work and the resultant guidance fell into disuse during the 1980's, as the

DVRPC withdrew from any substantial role in local land use issues related to water resources. Potentially, they could reinforce the county planning effort in basins which include multiple counties, and should be included in the watershed planning process.

3.4.3. Delaware Estuary Comprehensive Management Plan

Over the past five years, the Region III office of USEPA has directed significant funding into the Delaware Estuary program, funded under the CWA. The thrust of this program is to recognize the regional implications of water quality management within the Estuary and its associated drainage, with a portion of the lower tributary area identified as the planning region of concern. Within this drainage, which includes the French, Pickering and other tributaries of the Schuylkill River, the importance of reducing pollutant inputs from nonpoint sources has been recognized, and the issue of land use management is clearly identified as one of the most important elements of the program to restore and maintain water quality in the Estuary.

Having incorporated these ideas into the program, the Federal agencies which are guiding this effort with support from state (PA, NJ and DE) and regional agencies (DRBC) are extremely cautious to venture into the area of land use controls. Clearly the objectives of the Estuary program cannot be implemented without land use management programs which substantially reduce the discharge of NPS pollutants from existing agricultural and urban land. Actual implementation of the *Management Plan for the Delaware Estuary* (EPA, 1996) must develop strategies which prevent such inputs during future land use change, which is generally from agricultural to urban, as the regional population spreads further and further into the surrounding counties. Projects such as this GVA program are receiving close scrutiny by the EPA to determine if the linkage between water resources and land use can be defined sufficiently to alter and influence land use management.

3.5. State

3.5.1. Water

The PA Department of Environmental Protection (DEP) and its sister agency and former partner the Department of Conservation and Natural Resources (DCNR) have a great deal to do with water resource management in the watershed, but little to do with land use, except where lands are under the direct ownership or control of the state, as is the case with significant portions of this watershed. Formerly combined as one institution created in the 1970's and separated in 1996, the regulatory functions fall largely with the DEP. Building on the original PA Clean Streams Law (1937), this agency implements all of the programs mandated under the Federal Clean Water Act, including the permitting of all wastewater discharges (NPDES), the Safe Drinking Water Act, and related environmental legislation, such as the Clean Air Act and other laws which give general control over most environmental pollution issues. As such, it is the primary water quality regulator, as well as the regulator of surface water quantity, and regulates groundwater in a qualitative sense (discharges and withdrawals). It has traditionally avoided any regulatory limits on groundwater quantity, a void which the DRBC regulations have partially filled. While the DEP has clearly recognized that land use is often the root cause of many of the water quality problems which it confronts, it has carefully avoided any direct intrusion into what is considered the exclusive domain of local government.

Many of the programs and laws which DEP currently enforces within the French Creek and Pickering Creek Watersheds are partially or largely derived from or based on Federal legislation, and partially supported by Federal funding through USEPA. This funding support and the degree of control exercised by the EPA over DEP has varied over time, with the current cycle characterized by reduced funding and lessened control. Without attempting to document each and every specific program, those aspects of key programs which have direct bearing on the land and water resource management issues identified here will be considered.

Perhaps most prominent is Pennsylvania's Environmental Amendment to the State Constitution:

> *"The people have a right to clean air, pure water, and the preservation of the natural, scenic, historic and aesthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."* (Pennsylvania Constitution, Article I, Section 27)

More specifically, the Clean Streams Law (Act 394 of 1937; P. L. 1987) has been enacted *"...to preserve and improve the purity of the waters of the Commonwealth for the protection of public health, animal and aquatic life, and for industrial consumption, and for recreation."* (Preamble to Act 394). In Section 4. Declaration of Policy, the Legislature has specified several objectives of the Clean Streams Law which are supported and furthered by the proposed management program here (an exclusive focus on water quality notwithstanding):

> *"(1) Clean, unpolluted streams are absolutely essential if Pennsylvania is to attract new manufacturing industries and to develop Pennsylvania's full share of the tourist industry;*
> *(2) Clean unpolluted water is absolutely essential if Pennsylvania are to have adequate out-of-door recreational facilities in the decades ahead;*
> *(3) It is the objective of the Clean Streams Law not only to prevent further pollution of the waters of the Commonwealth, but also to reclaim and restore to a clean, unpolluted condition every stream in Pennsylvania that is presently polluted;*
> *(4) The prevention and elimination of water pollution is recognized as being directly related to the economic future of the Commonwealth; and*
> *(5) The achievement of the objective herein set forth requires a comprehensive program of watershed management and control."*

Furthermore, Section 401 of the Clean Streams Law states:

> *"It shall be unlawful for any person or municipality to put or place into any waters of the Commonwealth, allow or permit to be discharged from property owned or occupied by such person or municipality into any waters of the Commonwealth, any substance of any kind or character resulting in pollution as here defined. Any such discharge is hereby declared to be a nuisance."*

Although this language appears to be far-reaching in its scope, the specific programs enacted for pollution control have not been as encompassing. Over time, the implementation of the Clean Streams Law and subsequently the Federal CWA has focused almost exclusively on the direct discharge of wastewaters to surface streams, as currently operationalized under the NPDES program. As discussed in Chapter 2, only four such permits are currently in place within the Watershed, although wastewaters generated within the watershed are collected and discharged outside.

In addition to the NPDES program and the Chapter 102 E&S program enforced by the CCCD, the state does have various specific laws and regulations related to water resources, including the Stormwater Management Act, the Floodplain Management Act, Dam Safety and Encroachments Act, Wastewater Facilities Plan Act, and others, which are in various ways furthered by land and water resource management. Sustainable Watershed Management provides a mechanism to achieve the goals and objectives which have been adopted on the state level for most of these laws, but the existing laws presently have little bearing on land use.

Special note should be made of the concept of antidegradation on the state level. The federal government requires that states develop and implement programs for antidegradation of streams which enjoy high quality, exceeding existing water quality standards. Pennsylvania's program of antidegradation has been controversial and in fact has been litigated, with a variety of parties contending that current program elements are inadequate. PADEP has promulgated a *Special Protection Waters Implementation Handbook (1992)* which identifies a variety of measures to be implemented in order to properly protect and conserve stream values. To date, most attention for special management has been in the area of point source control, although the *Handbook* does identify other actions beyond point source management which should be considered for Special Protection Waters management in order to prevent significant degradation. The management actions proposed here constitute a significantly more rigorous approach to antidegradation and could provide a potentially useful model for management of these special resources across the state.

3.5.2. Land Use

With respect to the laws which regulate land use at the state level, the *Pennsylvania Municipalities Planning Code* (MPC) provides the legal framework for land use planning and management for all levels of government in Pennsylvania. Recent amendments (Act 170) to the MPC added several water-related provisions:

603. Zoning ordinances may permit, prohibit, regulate, restrict and determine: (1) uses of land, water courses and other bodies of water. (5) protection and preservation of natural resources and agricultural land activities. (d) Zoning ordinances may include provisions regulating the siting, density and design of residential, commercial, industrial and other developments in order to assure the availability of reliable, safe and adequate water supplies to support the intended land uses within the capacity of available water resources.

604. (1) The provisions of zoning ordinances shall be designed: To promote, protect and facilitate any or all of the following...the provision of a safe, reliable and adequate water supply for domestic, commercial, agricultural or industrial use, and other public requirements; as well as the preservation of the natural, scenic and historic values in the environment and preservation of forests, wetlands, aquifers and floodplains. (MPC, Reenacted and Amended December 21, 1988 by P. L. 1329, No. 170)

The implications of these water-related provisions in most cases are not totally clear and certainly have not been court-tested. Nevertheless, the water resource management concepts proposed in this study are consistent with these new provisions. It is worthy of note that in most cases the MPC water-related provisions enable, but do not mandate, municipalities to take into account these water concerns in their overall planning.

3.5.3. French Creek Scenic River Designation

Pursuant to the French Creek Scenic Rivers Act, the French Creek stream system has been designated part of Pennsylvania's Scenic Rivers System in an effort to help local governments and landowners manage and protect the special aesthetic, ecological, and cultural resources which characterize French Creek. The state's Scenic Rivers Program was created in 1972 to preserve and protect the outstanding water resource-linked values found across the state, the importance of which transcends municipal boundaries. The *French Creek Scenic River Management Guidelines* (1984) recommends that special management actions be taken by municipalities within a scenic corridor, as defined in the *1980 French Creek Study* (the scenic corridor is defined as either the limit of the viewshed or a 500-foot radius from the streambank, whichever is less). Primary and secondary corridor delineations have been mapped with varying management recommendations developed for both corridors. Several municipalities have worked to incorporate Scenic River management recommendations into their codes and ordinances.

GVA plans to petition the DCNR to designate the French and Pickering Creeks for inclusion in the *Pennsylvania Rivers Conservation Registry* at the completion of this current study.

3.6. Federal

The Federal Clean Water Act, Safe Drinking Water Act, and other legislation which is implemented within the state by DEP is limited to environmental protection of water resources, and has little or nothing with land use directly. The only exception to this is the Federal Wetlands Protection Act, which specifically prevents the disturbance of land which meets specific criteria defined (and redefined) in guidance developed by the Corps of Engineers, aided by EPA and US Fish and Wildlife. While the methodology to define a "regulated wetland" has been debated and litigated over the past decade, the end result has been to avoid, to a large degree, any significant further loss of wetlands in most watersheds. In terms of land use policies, the reality of land development applications has come to include a careful delineation of regulated wetlands as a part of every such application before a municipality, with no actual filling or development proposed or allowed on these lands. Those lands so identified within the watershed can expect to remain undisturbed for the foreseeable future.

SECTION 4.0 BASELINE FUTURE DEVELOPMENT

4. BASELINE FUTURE DEVELOPMENT AND ANALYSIS

An array of management objectives have been formulated to guide water resources management for the French and Pickering Creeks Watershed. These objectives reflect a philosophy of Sustainable Watershed Management, of balancing human use of natural systems within the tolerance limits, or carrying capacity, of those systems. This philosophy is at the heart of the Green Valleys Association total mission. These management objectives are established based on this goal and structure the analysis which follows.

Next, an analytical system--a methodology--is developed to achieve these objectives. This analysis process utilizes a series of equations, or models, to evaluate the impact of future development on the quantity and quality of water resources within the study area. These models are then run under different sets of assumptions. The baseline scenario is the development of all vacant land following the existing zoning criteria, with consideration of different levels of water use controls imposed. The intent of this is to test the merits of such controls, specifically in terms of water resource impacts.

4.1. Water Resource Goals and Objectives: An Underlying Philosophy

The underlying goal upon which this study is based is to develop a management program which ensures that development will be sustainable from a water resources perspective. Driving the Sustainable Watershed Management goal being proposed here are several objectives:

- **Maintain quality and quantity of water resources, both ground and surface.**
- **Water resources used should be returned within each watershed.**
- **Maintain stream base flow, and in particular stream low flow at Q7-10.**
- **Maintain groundwater levels in order to protect existing wells and springs.**
- **Assure that stream flooding is not increased.**
- **Minimize additional point and nonpoint source pollutant inputs.**

These objectives can be achieved through innovative comprehensive planning techniques and through a variety of water resource technologies . This report does not begin to suggest some master plan to meet the water needs and mitigate the impacts of a future which current zoning would create, but rather offers insight into the consequences of such buildout on the water resources of the region, and proposes better ways to plan land use and water.

4.1.1. Study Goals and Objectives: GVA Philosophy

The goal of Sustainable Watershed Management and the proposed management concepts developed in this study reflect the basic mission of the Green Valleys Association:

> *"GVA Vision: By long tradition, GVA's purpose has been to protect the watersheds of Stony Run, Pickering, French, Valley and Pigeon Creeks....GVA advocates and promotes planned growth as a positive course which allows for development, respects the environment, protects present resources and sustains the area's history.*
>
> *GVA Missions: 1. Advocate environmental guidelines for the evolving community that are consistent with GVA's mission. 2 Protect the natural and rural character of the community through education and advocacy. 3. Educate the residents to heighten environmental awareness in the community."* (*Stream Lines,* Fall 1993)

The goal of Sustainable Watershed Management, though a worthy goal for all watersheds, is very much related to the special values which characterize the French Creek system. The GVA has committed much effort to preservation and conservation of as many of these special values distinguishing the French Creek Watershed as is possible. This commitment is embodied by GVA's ongoing campaign to elevate the existing High Quality stream classification for French Creek to Exceptional Value status.

The special values of the French Creek stream system are well-known and documented and are important not only to Watershed residents and other stakeholders, but to a larger community as well. These values include a host of recreational benefits, relating to the importance of the French Creek as a recreational fishery, and have significant economic implications through increased tourism, enhanced land values, and other positive effects.

4.1.2. Stream Base Flow Maintenance

Sustainable Watershed Management must be operationalized into workable objectives in order to develop the management concepts being proposed in this study. The first objective focuses on maintaining stream base flow, in particular stream low flow or Q7-10. As discussed in Section 2, the French Creek stream system is maintained most of the time by base flow--water flowing out of the Watershed's underground aquifers. This base flow is crucial to the life of the stream and must be maintained. Declines in volume of base flow can be expected to lead to reduced habitat, benthic impacts, temperature changes, and a host of other effects. For pollutant sources which are continuous, reduced base flow translates into lesser pollutant dilution and effectively increased in-stream pollutant concentrations. All of these concerns are important issues for watershed management.

4.1.3. Stream Low Flow Maintenance

Although maintaining average daily base flow quantities in streams is vital, making sure that the stream literally does not cease flowing during dry low flow periods is absolutely essential (Figure 4-1). If drying up occurs or is approached, stream impacts are dramatic (Figure 4-2). The aquatic community is destroyed. The potential for drying up in most stream systems is greatest the farther up in the stream system one goes. In other words, in the headwaters or first order streams, potential for drying up is greatest. Management measures, therefore, should be most stringent in first order streams in order to prevent elimination of stream flow.

One factor available to assess this issue of substantially diminished and even eliminated stream flow is the statistic, Q7-10, as discussed in Section 2 . In the French Creek system, the Q7-10 value has been estimated at 11.26 cfs by USGS at the stream gage near Phoenixville (59.1 square mile drainage area) . This value of 11.26 cfs is obviously quite low, when contrasted with average annual base flows of 88 cfs at this same point in the watershed. On a unit area basis, this low base flow translates into 192 gpd/acre, if all portions of the drainage are assumed to contribute uniformly. Although not an absolute worst case value, Q7-10 represents stream flow in a very reduced and substantially stressed state. **In terms of management objectives, actions should be avoided and prohibited which serve to significantly reduce this low flow quantity. Low flow should not be worsened, with "worsening" defined both as reduction in low flow values as well as increase in frequency of low flow.**

Is it reasonable to apply a uniform criteria for base flow throughout the study area? There is a limited amount of information relating to continuous flow elsewhere in the French Creek and Pickering Creek Watersheds, although the partial record stations are quite useful for this low flow question. The flow measurements made at these various locations were generally done during October or November, and indicate a fairly consistent or uniform base flow throughout the watershed. This more or less uniform base flow takes place regardless of the specific geologic formations which comprise the source of base flow storage. One might assume that variations in geological formations, soils, topography and many other factors would interact to make the Q7-10 flow value highly variable within the watershed--sometimes higher and sometimes lower than has been measured at the continuous recording gage on a unit area basis. However, no such evidence is apparent in the flow record. It would appear that the energy gradient in the various sub-basins is the determining factor in groundwater discharge rates, rather than the net storage volume within the aquifers.

It is important to note that the measurement station for the low flow of 11.26 cfs is located well down in the French Creek stream system. With such a low flow occurring this far down, it is possible that flows in first order streams would be lower, if not nonexistent in certain areas, and no record exists of such flow conditions in these streams. In other words, maintaining this Q7-10 low flow in no way constitutes an environmentally optimal or impact-free outcome.

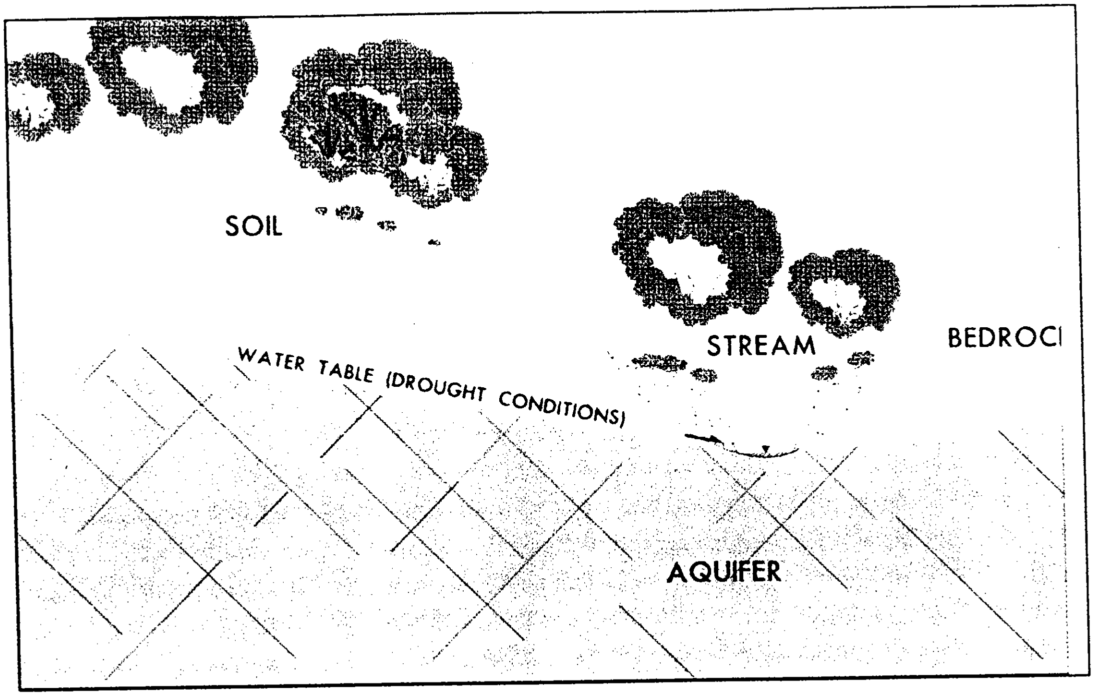

Figure 4-1 Impact of Drought on Groundwater Table and Stream Base Flow

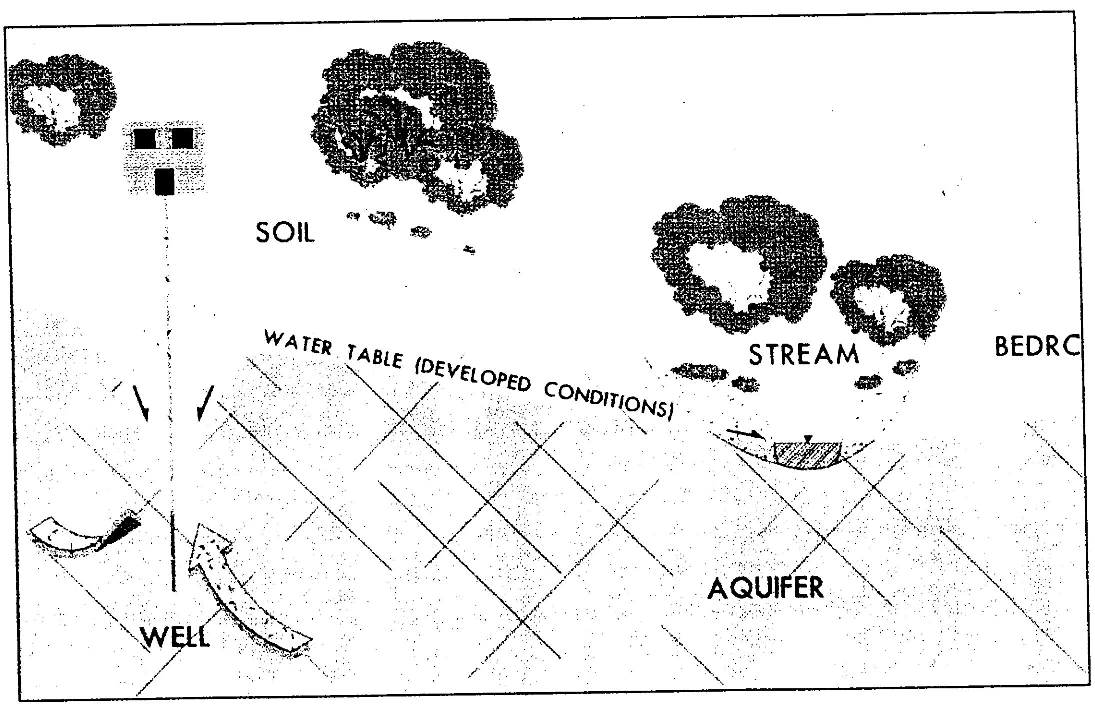

Figure 4-2 Impact of Development on Groundwater Table and Stream Base Flow During Drought

Another major qualification is that by using this Q7-10 value for the French Creek as the condition not to be significantly impacted or altered, the assumption might be that the watershed was in a relatively undeveloped or pristine watershed condition during this period of record. In fact, although the area tributary to the French Creek gage is not significantly urbanized, this area nevertheless has experienced significant amounts of forest clearance and conversion to agriculture of different types, all of which would serve to reduce aquifer recharge over the years. All else being equal, a Q7-10 from an undisturbed condition would be higher--stream base flow should have been greater before land clearance commenced. In sum, impacts already have occurred in the watershed such that use of the existing Q7-10 record does not constitute an extreme and unreasonable environmental objective.

4.1.4. Maintenance of Existing/Future Groundwater Supply

Sustainability also must be thought of in terms of all those properties and property owners and all that existing development supported by existing wells already present in the Watershed. Because much of the Watershed is reliant on private on-site wells for water supply, **an important management objective must be to respect and maintain this system of existing wells (and springs). New development has the right to develop water which reasonably can be understood to be within the domain or limits of a particular property, but at the same time, new development has no right to remove or diminish an adjacent property's water resources.** Without belaboring the points and the presentation here, critical concepts for management are legal in nature, as well as technical. Furthermore, the ultimate management system must not only function to prevent interference with existing wells, but must anticipate certainly a much greater level of groundwater development in the future. Given the extremely low densities and relative lack of development in many portions of the study area, considerably more well development is inevitable. Potential for well interference therefore becomes much greater.

Protection of wells, both existing and future, is best accomplished through making sure that the water table is not altered (i.e., lowered). Maintaining the water table in turn means that pre-development inputs to the water table--aquifer recharge--are essentially not reduced. Consequently, aquifer recharge must not be significantly reduced. In other words, if the groundwater table is maintained, stream base flow and stream low flow by definition will be maintained. These objectives functionally become one and ultimately can be achieved through the same management techniques.

4.1.5. Prevention of Increased Flooding

At the other extreme of the hydrologic cycle is the problem of flooding, bringing with it its own set of goals and objectives for Sustainable Watershed Management. The conventional stormwater management practice in the watershed is the detention basin, a strategy that at best serves only the single goal of peak flow management at a development site and creates significant increases in total stormwater runoff volumes discharged. The detention strategy applied across broader watershed areas with ultimate buildout translates into multiple detention basins at multiple development sites with multiple discharge volume increases. Experience has demonstrated that these volumes can combine and worsen flooding downstream, in turn worsening the full array of flooding-related socioeconomic and environmental impacts. **Consequently, the management objective clearly is to prevent worsened flooding with all of its related socioeconomic and environmental costs.** Reliance on the same infiltration techniques, used to maintain stream low flow and to maintain the water table and existing wells, will accomplish flooding prevention as well.

4.1.6. Protection of Water Quality

Sustainable Watershed Management must provide careful attention to the maintenance of water quality, in both surface and groundwater. Attention to quality is of paramount importance, given the Special Protection Waters classification issues at stake here, the concerns related to Pennsylvania's designation of this stream system as a Scenic River, and so many other interests. Both the use of water and use of land result in the introduction of pollutants which must be physically removed and chemically transformed as the hydrologic cycle continues.

This mix of different pollutants is of basically two types: particulate and soluble. The pathways they may take through the land and water systems, and their potential impact on the use and reuse of that water, are a function of the methods applied for either wastewater or stormwater treatment. One fundamental objective is to eliminate the traditional practice of using surface waters to complete the pollutant removal process. Conventional wastewater treatment systems--mechanical treatment plants with stream discharge--have never been completely effective, with approximately fifteen percent of the organic wastewater load and ninety percent of the nutrient load discharged as effluent to a receiving surface stream. Land-based wastewater treatment technologies which apply wastewater effluent to the soil and/or to vegetative systems eliminate entirely the practice of direct stream discharge of these pollutant loadings. They are considered to be the only feasible approach for wastewater treatment within the French Creek Watershed, if quality objectives are to be achieved. Furthermore, these systems also provide critical return of water to the aquifers.

Nevertheless, these land-based systems are not free of impacts. They generate nitrate loading problems and must be managed carefully. Groundwater quality must not be degraded, given exclusive reliance on groundwater for drinking water in many parts of the study area. **Consequently, accepted standards such as the PADEP drinking water limit for nitrate in public water supply (10 mg/l) should be a criteria in the Watershed.**

Stormwater-related nonpoint pollutant loadings also loom large as a potential problem in the Watershed. However, reliance on infiltration BMPs as already discussed will effectively mitigate this pollutant loading and accomplish this water quality objective as well, given the superior pollution removal effectiveness of these infiltration techniques.

In so far as conventional detention basin designs continue to be built, the increased flow and NPS loading become a major management issue, and so the WBM estimates this impact for each sub-basin under build-out conditions.

4.2. Methodology for Quantitative Analysis

4.2.1. Low Flow Maintenance Model (LFMM)

The critical water quantity objective of this management study is maintenance of low base flow. This is done to both prevent first order streams from drying up and to assure continued use of water supply wells and springs. Both of these objectives are served by utilizing stream low flow, defined here as Q7-10, as the yardstick by which to measure compliance. This low flow condition of Q7-10 is also used by federal, state and many other agencies across the country for regulatory purposes, often to assess worst case assimilative capacity for streams when evaluating pollutant loads from wastewater treatment plants. In this case, Q7-10 will serve as the basis for the proposed water management program. This criterion is the keystone of what is described here as the Low Flow Maintenance Model (LFMM), a method used to evaluate the limits and constraints to water use and return within any given hydrologic unit, or sub-basin.

The LFMM Model includes several steps:

Calculation of Q7-10: At the request of GVA, the USGS performed a special analysis to calculate Q7-10 for the French Creek, based largely on the flow record from the Phoenixville gaging station, shown in Table 2-7. Pro-rating or averaging this low flow discharge across the entire watershed, a unit area yield of 192 gallons per day per acre was then calculated by CA. The pro-rating process introduces a certain amount of uncertainty, but development of comparable statistics specifically for each and every sub-basin would require a significant stream gaging effort over a period of many years, and is not warranted based on available data.

The explanation of this base flow on a unit area basis requires some illustration. First, we might consider exactly how a typical acre of watershed (Figure 4-3) would function in terms of the water cycle discussed earlier. The surface vegetation is underlain by a layer of soil mantle, probably 5 to 10 feet thick, over the bedrock. The thickness of this soil varies, and the transition zone from soil to rock is frequently comprised of a layer of weathered rock, or Saprolite. For much of the watershed, underlain by the dense Gneiss bedrock, the boundary is well defined, and within the fractured bedrock, groundwater is stored in the fractures, rather than in the pores of the rock itself, as is the case with the Stockton or Hammer Creek sandstone in the Triassic region of the northern study area.

The water cycle as it applies to this acre of land is illustrated in Figure 4-4. The relative components of rainfall, runoff, infiltration and base flow are variable within the study area, dependent on the vegetative cover of the land surface and the permeability of the soil. During an average year, this water cycle can be estimated as shown in Figure 4-5, with the base flow discharge to the surface stream system estimated as 13 inches a year, or some 967 gallons per day per acre (gpd/ac). Various studies estimate this value in the range of 12 to 15 inches per year, on average. When we occupy that acre with development, of course, we alter that water balance by withdrawing groundwater, returning most of it to the soil mantle in a septic system (or losing it by conveying it downstream in a public sewer). We also increase the amount of runoff which occurs with each rainfall (Figure 4-6), and correspondingly decrease the amount which percolates into the soil and rock, depending on how much impervious cover is applied.

Given that all of the criteria which we seek to develop for the study can best be understood in terms of the water balance for a typical acre (in gallons per day per acre), those units will be applied in the following discussion and illustrations. For the drought period represented by the Q 7-10 flow conditions, the water balance illustration is greatly changed (Figure 4-7). Here the acre of ground has gone through a period of prolonged drought, with no significant rainfall (and therefore no runoff), but with continued evapotranspiration by thirsty trees and crops, which reach ever deeper into the soil mantle to draw up the diminishing groundwater. The value used in this example is 625 gpd/acre, and is withdrawn from storage in the soil mantle and the water table. The discharge from storage within the aquifer to local stream flows is also greatly reduced, to a fraction of the normal discharge, providing only the Q 7-10 base flow of 192 gpd/acre. Our management goal, then, is to assure that whatever uses we make of the groundwater or disturbances to the land surface, we continue to maintain this low flow discharge to surface waters.

Calculation of Low Flow Margin Factor: To be reasonable and provide for future development, a further reduction of this low flow will be allowed for consumptive uses by our activities on the surface, on the order of 50% of the low flow, or 96 gpd/acre, in first order sub-basins. Some might argue that total consumptive use of the low base flow is reasonable, effectively squeezing every last drop out of the aquifer before it goes dry, but such an approach has proven disastrous in other watersheds and is considered unreasonable here. Thus the "no significant impact" goal will be further defined by applying this factor. In other words, a decrease of up to 50 percent would be allowed--a kind of low flow margin or "allowable impact" factor. The argument for a margin factor reflects a variety of real world conditions, the most important of which is a need to be reasonable in proposing limits on groundwater withdrawals. It reflects an intent to balance the need to be flexible in regulation, while guaranteeing critical water resource protection.

It is not unreasonable to consider even more stringent criteria for base flow protection, and in the initial model analysis for this study a value of 10% was applied as a low flow margin factor. The net result was a potential regulatory criteria which would translate into a dwelling unit density of about 3.2 DUs per acre in situations with individual wells

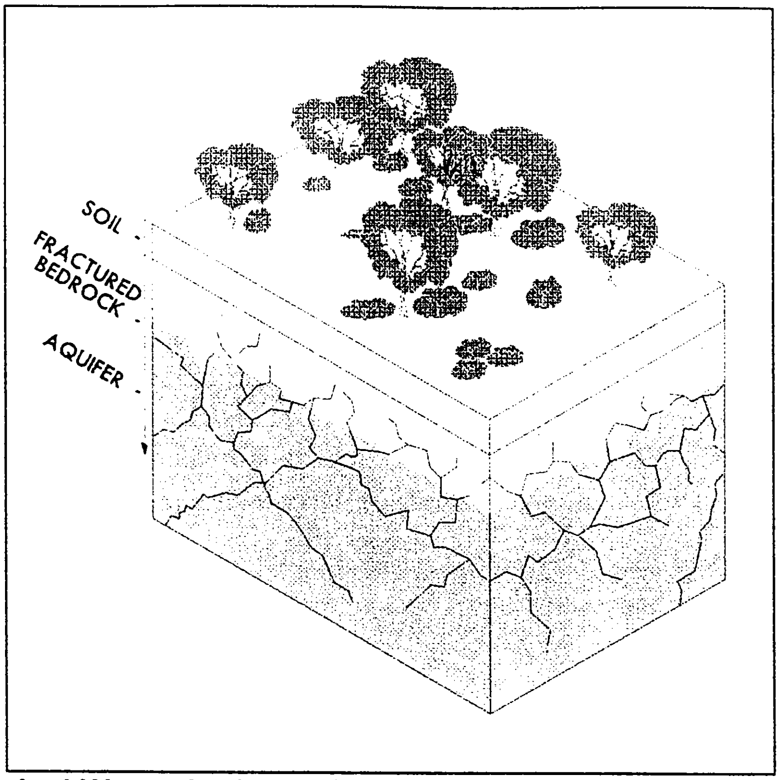

Figure 4-3 Typical Watershed Acre in Fractured Bedrock

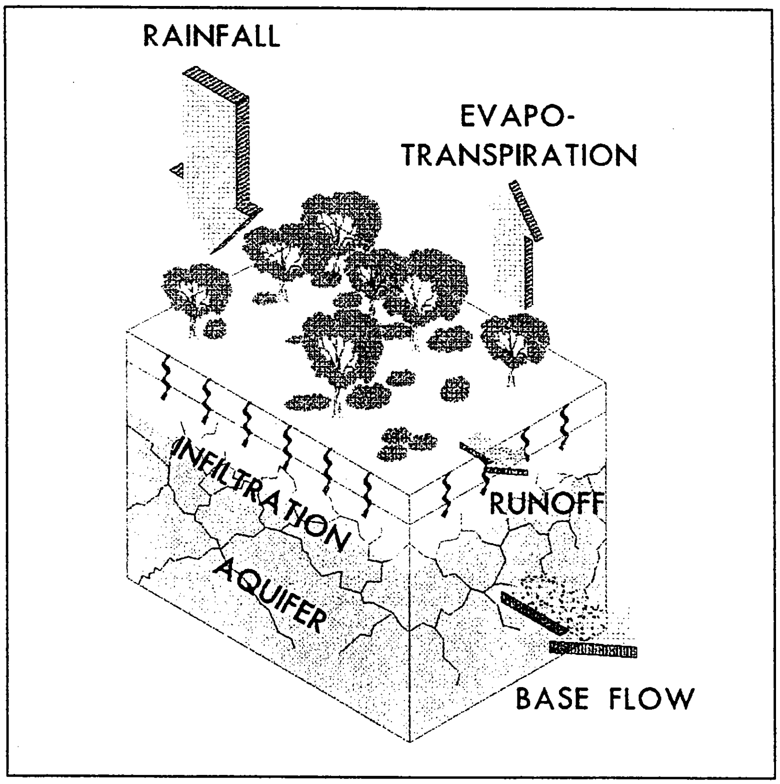

Figure 4-4 Natural Hydrologic Cycle on a Unit Area

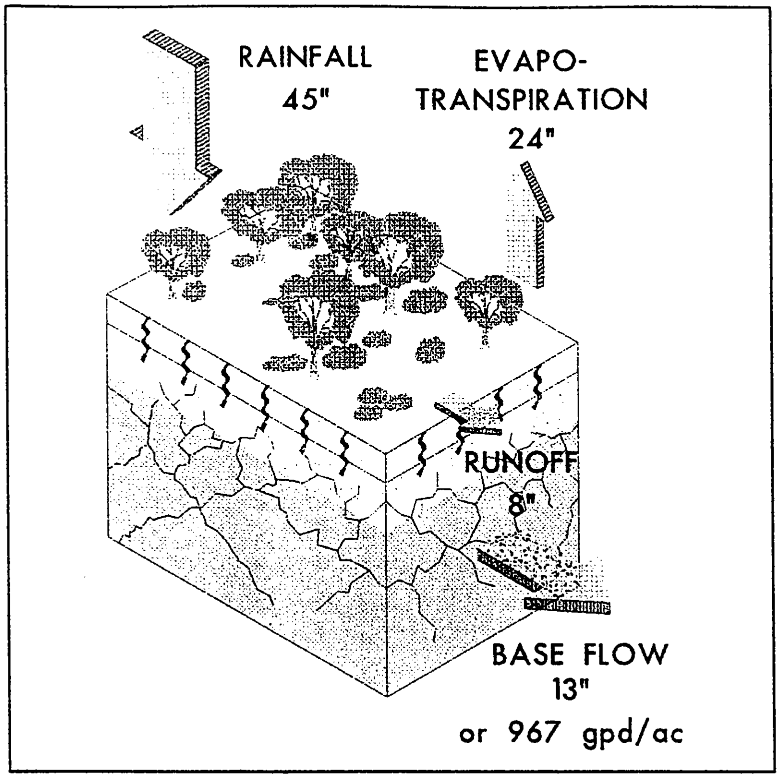

Figure 4-5 Annual Hydrologic Cycle for an Average Year

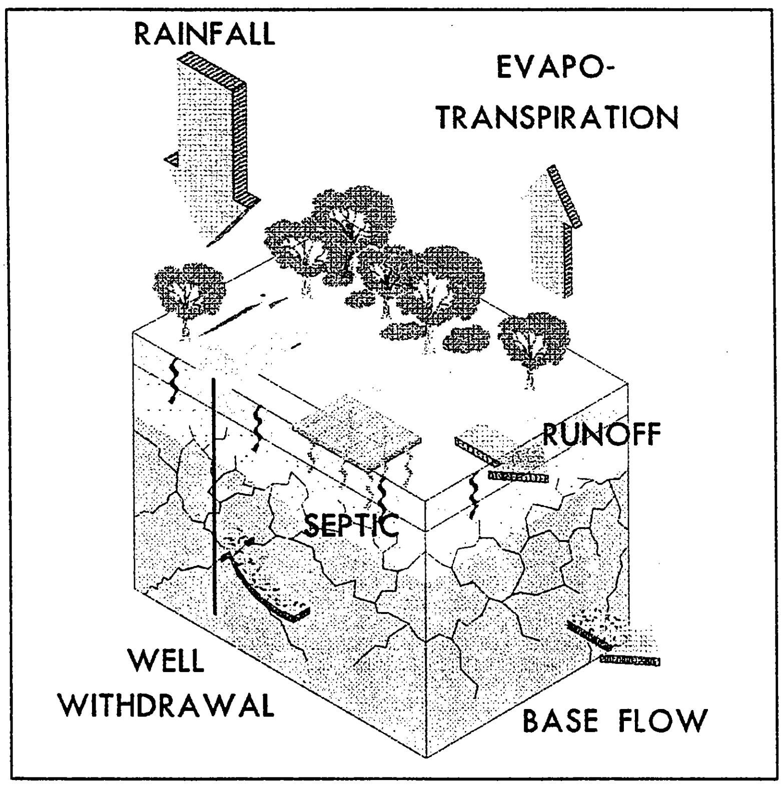

Figure 4-6 Altered Hydrologic Cycle with Development

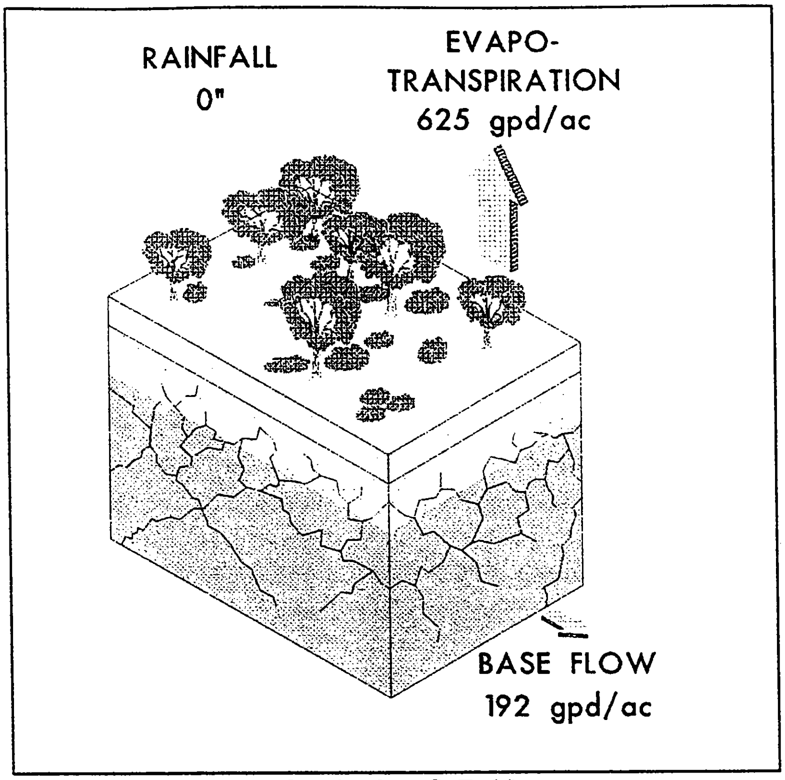

Figure 4-7 Annual Hydrologic Cycle for Q 7-10

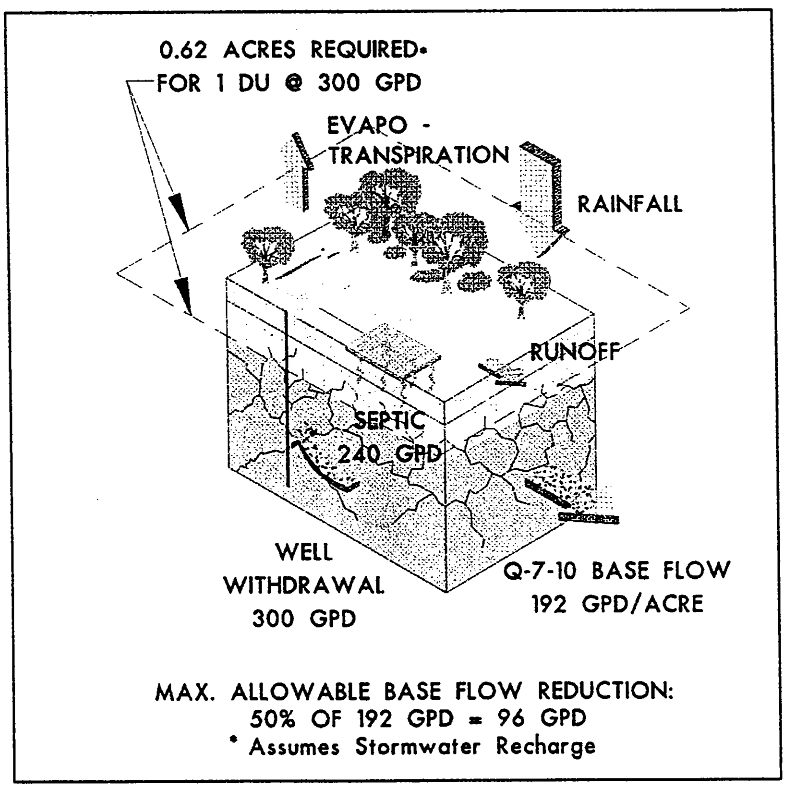

Figure 4-8 Low Flow Maintenance Model

and on-site sewage. In detailed discussions with the municipalities, it was concluded that this level of base flow maintenance might be considered as restrictive, especially in light of court decisions in PA which had previously struck down large lot zoning of more than two acres per dwelling unit. The application of the Water Balance Model to the sub-basins under build-out development at this criteria also showed that the vast majority of the drainage would not be able to meet this criteria in the future.

If the specific management objective to be achieved is maintaining the specified low flow contribution from each acre, then the corollary becomes: a maximum of 50 percent of the Q7-10 value, or 96 gpd/acre, is available for manipulation/loss as the result of new land development, under low flow conditions. When applied across a total watershed or sub-watershed area, the resulting calculation constitutes a kind of available "loss" which can be used to gage maximum development-related water depletion, conceptually on the "demand" side of the equation.

Figure 4-8 illustrates the application of this criteria to the hypothetical acre with a single DU and on-site water and sewer. The allowable depletive loss is 50% of 192 GPD, or 96 GPD /Acre. The consumptive loss by the DU is 20% of 300 GPD, or 60 GPD. Thus the maximum density is (60/96 =) 0.625 Acres/DU. As mentioned earlier, if a value of 10% is used for the LFMM, the net result is a density of 3.1 Acres/DU. The more restrictive value (10%) was initially proposed, but many municipalities felt that it might be inconsistent with prior court decisions concerning minimum lot size. The townships may elect to consider other factors in future analysis with the WBM.

It is important to keep in mind that this low flow objective is to be established as a regulatory limit. Although this limit is derived from the entire watershed, it is proposed here that the limit first be applied in the most vulnerable small watersheds of first order streams. Ideally, such an objective should be applied throughout the drainage system, and that may be appropriate when the full implications of this water management objective are evaluated. While designed to protect water quality and quantity under extreme low flow conditions, it should be noted that the measures to be employed to satisfy this Q7-10 criterion, including a variety of land-based wastewater treatment systems as well as infiltration-design stormwater management BMPs, plus manipulation of land use densities, also work in important ways to maintain average stream base flow. Therefore, the low flow criterion supports and enhances aquatic values throughout the year--not just during most severely stressed low flow periods.

Translation of Low Flow Margin Factor into Development Uses and Densities: The implications of this criterion for guiding new land development are significant. Any development will impact Q7-10 by withdrawing groundwater for water supply use and not returning all of this water to the aquifer, as the result loss experienced during wastewater treatment. In addition, the creation of new impervious land surfaces reduces the amount of rainfall which would otherwise recharge the groundwater. Factors of importance in applying this criterion include:

- volume of water withdrawn from aquifers for water supply

- wastewater treatment approach utilized and percentage of water returned to the aquifer (i.e., a return efficiency factor)

- stormwater management techniques applied and extent to which pre- to post-development recharge volumes are held constant

The Model is very much driven by return or recycling efficiencies of wastewater and stormwater techniques. In fact, the stormwater objective of holding pre- to post-development recharge volumes constant is most readily met. Though not common in Chester County (or Pennsylvania for that matter) at present, recharge-oriented BMPs include an array of infiltration techniques which are finding application throughout the country. In the Watershed, analysis of soil properties indicates that 77 percent of the soils are Hydrologic Soil Group B, and have a permeability well-suited for infiltration techniques. In sum, recharge should be quite feasible throughout the drainage, such that post-development stormwater recharge volumes do not have to be reduced by the land development process.

Wastewater treatment technologies, on the other hand, are all less than 100 percent efficient. Several assumptions regarding water use and wastewater treatment have been made as part of the Model. First, experience and innumerable wastewater treatment studies have demonstrated that a modest percentage of water supplied to most urban/suburban uses is consumed or depleted from the system, generally through evaporative loss. Setting aside the issue of agricultural irrigation or special case water-intensive industries, typical residential water uses involve some amount of incidental water use such as car washing or lawn and shrub watering where evaporation and evapotranspiration may be significant. This depletion factor is likely to be quite seasonal, with maximum quantities occurring during warmer months and, in fact, dryer months by definition. Over the year, the Model assumes a **consumptive water use loss of 10 percent** as the result of these various mechanisms.

Additional losses or return inefficiencies result from the wastewater treatment system. These inefficiencies are more difficult to estimate, because relatively little research exists which focuses on this particular issue. For conventional on-site septic systems, seepage beds are designed to distribute septic tank effluent in broad patterns. During warmer and dryer periods, portions of the effluent can be expected to be lost by evaporation and transpiration, which invariably occurs. In the Model, depletion factors for different wastewater treatment technologies have been estimated as follows:

on-site septic systems	10 percent
sand mounds	40 percent
community on-lot disposal systems	10 percent
spray irrigation with lagoons	50 percent
stream discharge	0 to 100 percent

Sand mounds can be expected to result in significantly greater depletive losses, by design. Although warm weather dry period losses can be expected to be much greater than 40 percent, an average of 40 percent is appropriate for the Model. Properly constructed COLDS systems can achieve excellent efficiencies/minimum depletion, similar to onsite septic systems. Therefore, only modest depletions of 10 percent have been assigned. Spray irrigation with lagoon treatment, an excellent environmentally-superior approach to "public" sewage treatment and stream discharge systems, does experience considerable evapotranspirational loss. Again, depletion will be much greater during warmer and dryer periods for a variety of reasons. Depending upon the specific spray technique utilized, this loss can vary greatly. Systems such as the Hersheys Mill spray facility which uses spray applications to irrigate and fertilize golf course turf, will experience larger losses. Barring some different technology, an average of 50 percent is assumed as a depletive loss for these systems.

The alternative of stream discharge of wastewaters can produce a depletion which is widely variable. To the extent that the wastewater treatment plant is located downstream in a given watershed, and the discharge point is well below the first order or even second order stream under consideration, the loss would be 100 percent. To the extent that treatment plant discharge is pumped or returned to the head of the first order stream (highly unlikely), the depletive component could decrease to virtually zero. While this could solve the low base flow problem in the stream, the net impact on groundwater levels and dependent wells would still be significant, and the groundwater system would be completely short-circuited.

4.3. Methodology for Qualitative Analysis

Water quality impacts from new land development are customarily thought of in terms of wastewater and stormwater discharges to surface waters, and when we apply these waters to the soil mantle the pollutants must be mitigated by processes within the soil. In addition, a certain amount of pollution is also discharged into the groundwater system as a result of our activities on the land surface, especially fertilization and chemical applications. Given the proposed criteria for quantitative impacts of development on water resources discussed above, parallel criteria for quality must also be considered.

4.3.1. Wastewater

Because land-based systems can be expected to be used as the primary approach to wastewater treatment in the Watershed, the major water quality concern here focuses on those pollutants remaining in land-applied wastewater effluent, including septic tank discharges into seepage beds. This concern centers on pollutants which are soluble in form, not physically filtered by the soil mantle, chemically removed by ion exchange, or biochemically altered by micro-organisms. The nitrate form of nitrogen, the result of transformations of the organic and ammonia forms of nitrogen, is present in domestic wastewater effluent in significant amounts, and for this example constitutes the major soluble pollutant of concern, serving as a chemical surrogate for a less significant group of wastewater constituents. Excessive levels of nitrate can lead to a variety of health-relate problems, including, in the extreme, occurrence of "blue baby" syndrome.

Under the Safe Drinking Water Act, PADEP has assigned a criterion of a maximum of 10 mg/liter nitrate (NO3-N) for drinking water. **Consequently, 10 mg/liter NO3-N maximum limit will be used as an important groundwater quality management objective for Sustainable Watershed Management.**

Different wastewater treatment technologies generate different levels of nitrogen or nitrate removal, but in general the nitrogen in wastewaters simply changes form, rather than undergoing any significant removal. In its various regulatory programs, PADEP assumes that wastewater effluent discharged from properly functioning onsite septic systems, as well as other types of subsurface systems, has a nitrate concentration of 45 mg/liter NO3-N. Spray irrigation system effluent, depending on the lagoon design criteria, can be expected to have lesser concentrations, and through a carefully designed application program on harvestable crops, nitrogen loadings to the groundwater system can be substantially reduced.

4.3.2. Dry Year Nitrate Impact Model

In order to illustrate the concept of pollutant concentration build-up in the groundwater, the Nitrate contained in a residential septic system will be evaluated. In Figure 4-9, we again assume a single family residence served by an on-site well and a septic system, both of which are constructed on the same parcel of land in relatively close proximity to each other. We wish to continue to use the aquifer as a source of potable water supply without treatment, at a rate assumed to be 300 gallons per day. Therefore, we are concerned that the constant discharge from our septic system, estimated to be this same amount reduced by 20% consumptive loss (60 gpd), or 240 gpd, at a Nitrate concentration of 45 mg/l, will increase the groundwater concentration of nitrate to greater than 10 mg/l, the health limit. We assume that the initial or background concentration of NO3-N in the aquifer is 2.0. Current groundwater chemical analysis (Sloto, 1994) indicates a median concentration of Nitrate at 3.3 mg/l in the Gneiss and 2.7 mg/l in the Triassic aquifers.

The issue of concentration changes in the aquifers is somewhat different from the low base flow model, where the Q 7-10 flow conditions were used to simulate the water balance. In the case of groundwater chemistry, the movement of infiltrating rainfall and percolating groundwater, and the dispersion and dilution of any soluble pollutants contained within a discharge plume, as from a septic system, takes place over a fairly long time. Therefore, any analysis of concentration changes should consider the system dynamics over a longer period of time, such as a year. For this reason, the chemical model applied will be driven by the Q 365-10, or annual base flow value of 446 gpd/acre. This reflects the dry year rate of infiltration into groundwater aquifers, which decrease from the average of 13 inches per year to only approximately 6 inches per year, or 162,500 gallons/acre/year. Based on these assumptions of annual water balance, the water quality management objective can be translated into land development densities as follows. If a 10 mg/liter or ppm nitrate concentration maximum is allowed on any particular acre and if 45 mg/liter or ppm is assumed to be

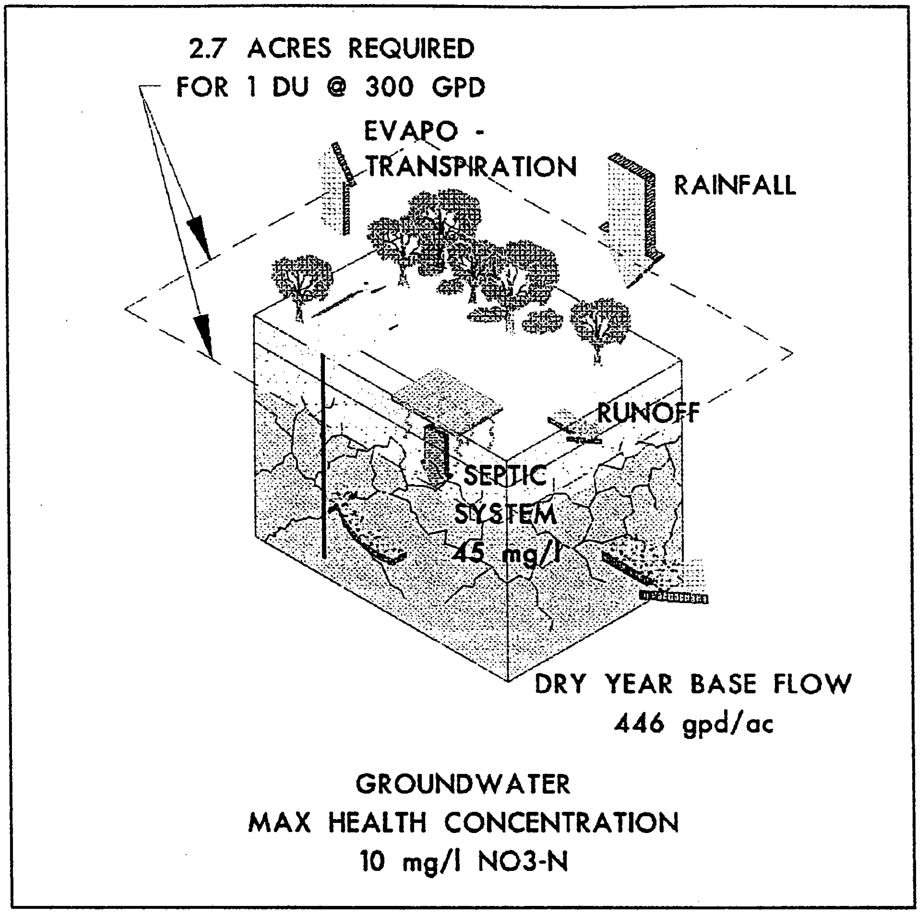

Figure 4-9 Dry Year Nitrate Impact Model

discharged as wastewater effluent, the question is how much wastewater effluent can be discharged per acre per day, so as not to exceed the allowable limit over time?

The following calculations develop this statistic:

$$\frac{[162{,}500 \text{ gallons/ac}]\ [10 \text{ ppm } NO_3\text{-}N]}{45 \text{ ppm } NO_3\text{-}N} = \frac{36{,}111.1 \text{ gals/ac per year}}{65 \text{ days per year}} = 98.9 \text{ gpd/ac}$$

Thus 98.9 gallons of sewage effluent per acre per day at a 45 mg/liter or ppm concentration can be discharged to the subsurface without exceeding the groundwater quality criterion of 10 mg/l. If a typical single-family dwelling unit is expected to use 300 gallons of water per day, less the 10 percent total of evaporative loss during use, then the maximum allowed density would become:

270 gpd/98.9 gpd per acre = **2.7 acres needed for each dwelling unit**

This calculation is driven by the need to maintain the 10 mg/liter nitrate concentration during the dry year. Similar densities can be developed for other land uses, densities and wastewater application strategies, again all reflective of their wastewater flows.

These calculations, of course, are highly generalized in nature. Assumed in the approach is that precipitation will not contain nitrate. Actual rainfall sampling data from Marsh Creek suggests that precipitation is currently in the range of 1 mg/l NO3-N, and that the soil mantle is not receiving any other inputs of NO3-N (no fertilization of any sort), all very liberal, development-favoring assumptions. Adding contributions of nitrate from these other sources would force a reduction in the sewage effluent-related loading, such that net allowable densities would decrease significantly. On the other hand, the assumption that effluent concentration reaches groundwater at 45 mg/liter is somewhat conservative, in that processes do take place in the soil mantle which transform NO3-N into other forms, released into the atmosphere (NOx) or otherwise not transported to the groundwater system. Furthermore, this simple methodology does not take into account a host of real world factors such as variation in rainfall, differences in soils and geology, and any number of other factors which would influence actual nitrate concentrations within the groundwater. Nevertheless, a quantifiable basis is provided in order to structure land use and density decisions on the land's surface.

4.4. Methodology for Stormwater Analysis

The issue of water resource impacts produced by stormwater runoff from new development has two dimensions: quantity, or increased runoff produced by new impervious surfaces and/or altered vegetative cover conditions, and quality, generally considered under the label of nonpoint sources, as discussed in Section 2. While the two impacts are directly related, with the increased pollutant loads transported in the increased stormwater runoff, they are generally evaluated and mitigated separately, almost as if they were two distinct issues. In large measure, this is due to the technology which has evolved over the last twenty-five years to deal with the problems of stormwater runoff. Recognition of the hydraulic effects of new development on natural drainage systems led to control strategies which focused on volumetric storage. These impacts included enlargement of the area inundated by the floodplain and accelerated peaks of flow, which eroded channels, The most simple solution available to the agency delegated the prime responsibility for erosion control, the Soil Conservation Service, was the traditional farm pond. Such structures had been applied in agricultural settings for several decades to contain sediment runoff, and the engineering was simple and familiar. As regulatory programs evolved in the early 1970's for control of runoff peak velocities, the stormwater detention basin became the technique of choice on an almost universal basis, with each new subdivision required, under municipal or county regulation, to build one or more such structures. This earthen basin collected a portion of the surface runoff generated from a development and detained this volume for a period of several hours, slowly releasing the stormwaters through a control structure which gradually emptied, usually within a day or two following the rainfall. The science of stormwater management has continued to evolve over the past two decades, with superior design solutions developed and tested, but the regulatory system and general construction practices have not evolved with the technology. The construction of detention basins, sized to assure that the rate of discharge (in cubic feet per second, cfs) is no greater than the flow created by conditions prior to development, is still the rule in most municipalities.

The qualitative impacts of stormwater has received far less attention and virtually no regulatory control. While nonpoint source pollution has been recognized as comprising a significant, if not major share of current water quality pollutant inputs (EPA, 1995), no regulatory controls have been established at the federal, state or local government level. In a few high profile lakes and estuaries, such as Lake Erie, the Chesapeake Bay and other water bodies, the implementation of NPS control measures have been underwritten with major federal funding and financial incentives, while local government regulation has been quite limited. Reduction of NPS pollutant inputs from industrial sites and large metropolitan combined and storm sewer discharges has found regulation under the NPDES program, but the effort to reduce NPS inputs from urban/suburban sources is yet to find translation into local government regulation. For the most part, state and federal agencies are hesitant to develop any regulatory program which suggests interference with and involvement in local land use controls.

4.4.1. The Stormwater Model - Quantity

Estimating the quantitative impacts of stormwater runoff from development has relied on a hydrologic analysis method developed by the SCS called the "Cover Complex" method, introduced in Section 2. This method is driven by an equation which evaluates the ability of incident rainfall to infiltrate into natural soils, a process which varies with soil properties, vegetative cover, timing and intensity of precipitation. The method has found application in the design and sizing of stormwater runoff control structures, from large dams to detention basins for developments. While much of the procedure is concerned with the timing and magnitude of resultant runoff peaks, it is the basic analysis of how runoff is produced that is of interest. The limitation with this methodology is that it is singular event specific (one storm), and does not analyze the annual water balance for a given year, as is required in the WBM.

The placement of impervious surface over soil, be it rooftop, driveway or roadway, effectively prevents any incident rainfall from percolating into the soil mantle, and converts this rainfall into immediate and direct runoff. Thus one can estimate the net addition to runoff by simply multiplying the total impervious surface of a development by the total rainfall. For example, a residential site which created new impervious surface would effectively produce 45 inches of runoff per square foot as total annual stormwater flow, or a net increase of 36 inches (assuming that before development this same soil would naturally produce 8 inches per year and allowing 1 inch for evaporation). This additional runoff volume per square foot is estimated as follows:

(36 inches/12 inches/ft) = 3 cubic feet (cf) of additional runoff per year

In a watershed which is zoned to undergo development, with the amount of new impervious surface directly related to the type and density of zoning permitted, the resultant runoff increase (and corresponding groundwater loss) can be estimated in the same fashion. In a watershed of 1 square mile (640 acres) which will urbanize at a zoning density of medium residential, one can assume a resultant net impervious area of 15% (including roadways and related supporting uses), with a corresponding annual runoff increase of:

(640 ac)(43,560 sf/ac)(3 cf)(0.15) = 12.5 million cubic feet /SM

This is additional runoff generated from that land, now made impervious (15%). In the French Creek basin, a square mile of watershed currently produces an average runoff of about 8 inches per year, or

(640 ac)(43,560 sf/ac)(8/12 f) = 18.6 million cubic feet

and so the new total runoff is 85% of this value (15% has been changed), plus the impervious runoff of 28.3 million cubic feet, for an increase of 152%. The assumptions of impervious cover used in the WBM for Future Land Use by Zoning is shown in Table 4-1. As the hydrologic sub-areas were analyzed for potential impact under future development scenarios, the net impact of total runoff increase was estimated and summed by major tributary.

There are many variables in this simple model when a real suburban landscape is considered, including the actual change in vegetative systems, be it lawn, meadow or sparsely vegetated and compacted soil, and the addition of features which might alter the cycle, such as ponds and lakes. In general, the more urbanized the landscape, the more elaborate the stormwater infrastructure system developed to convey runoff to surface streams (or the enclosure of these streams as storm sewers), and thus the greater the impact.

Zoning Category	Factor
AGRES (Residential, 2 or more Acres/DU	0.04
LRES (Residential, 1 to 2 Acres/DU)	0.08
MRES (Residential, 1/4 to 1 Acre/DU)	0.15
HRES (Residential, less than 1/4 Acre/DU)	0.3
COMM (Commercial)	0.6
IND (Industrial)	0.7
INST (Institutional)	0.1
VILL (Village, Urban)	0.5

Table 4-1 Impervious Cover Factors for Future Land Use by Zoning (Percent of Impervious Surface per Acre)

4.4.2. The Stormwater Model - Quality

As the runoff travels across the impervious surface, it scours the particulate and soluble pollutants from the surface and conveys them with the stormwater. On the pervious surfaces, which are the lawns and landscaped areas surrounding structures, the soil reaches saturation after a certain amount of rainfall and also produces runoff, containing the phosphorus-laden sediment and other soluble pollutants such as Nitrate, and adds this load to the total runoff. The relative pollutant production for a proposed development is thus a function of the total volume of runoff from impervious surfaces plus the additional volume generated from pervious surfaces, which do not usually produce a major increase in runoff volume but do produce NPS pollutants. Of course, if a wooded tract has been cleared and turned into lawn, the volume increase can be significant. Distinguishing between these different NPS sources and increased runoff volumes is quite difficult, given the methods which have been developed to quantify NPS pollutant generation, or mass loading, from urban runoff.

These methods have taken several forms, both theoretical and empirical. The observation of stormwater runoff, and the pollutant concentrations contained therein, has been an ongoing process for twenty years. For the most part, these observations have been qualitative, in that the chemistry of urban runoff has been measured in a number of settings. A limited number of studies have measured both concentration and runoff rate to produce mass transport estimates associated with a given land use or rainfall amount. In a series of studies during the early 1980's, the EPA performed sampling of urban runoff at locations across the US, known as the National Urban Runoff Program (NURP), and have used this data in much of the subsequent program analysis for NPS management. The NURP data has been reformulated in several forms, but basically is described in terms of relative concentration of the representative NPS pollutants produced in runoff from different urban land densities. The problem with such data is that one must estimate the amount of urban stormwater produced in a given year. As summarized in the previous discussion of net runoff produced, such runoff volumes have been estimated in the WBM Model.

Other NPS studies have translated runoff chemistry into representative pollutant production, in terms of mass per unit area per year (kg/ha/yr). With this data, one can apply such values to the proposed new urban landscape and estimate the mass load of pollutants produced in a representative year. As one examines the various data sets illustrated in this table and the significant variability between studies and even within a given study, it is apparent that this estimating approach suggests the use of such data only within the watershed in which it is gathered, or in very similar watersheds.

In this study, a representative group of NPS pollutants was selected and used in the stormwater subroutine to estimate a future NPS load generated by sub-basin. Table 4-2 shows these NPS Loading Factors, or average concentrations, in stormwater runoff. Because of the method by which the original data was collected, it is more applicable to the WBM estimates of stormwater runoff increases in volume for an average year.

4.5. Existing Land Use Impacts on Water Resources

Application of the Water Balance Model to each sub-basin requires that we first evaluate existing conditions in terms of development impacts on water resources, using our three "parameter" approach - water quantity, water quality and stormwater. Since we have combined the existing land uses for all municipalities into eight categories, these categories must be described in terms which can readily be translated into water resource impacts. This means that the land uses measured in a given municipality and sub-basin, in terms of acres of a given type, must be expressed as typical dwelling units at a uniform density for that category. Of course, none of the watershed is truly uniform in dwelling unit type, size or density, nor does the zoning at a specific density (1 DU per acre) seldom translate into that same density. For the purposes of this model analysis, however, it is reasonable to assume a certain consistency across the broad categories of identified land use. Table 4-3 is a set of densities applied to the eight existing land use categories, and used in the WBM analysis to estimate existing water resource impacts. The alternative to this process is a detailed count of dwelling units for each watershed, an imperfect process at best and accurate only for the point in time when the available aerial photography is taken. All of the subsequent analysis discussed in Section 5 uses this data to develop existing impacts (but not future impacts). As the Table suggests, two different values were considered for some uses.

Zoning Category	Factors				
	NO3 mg/l	TP mg/l	COD mg/l	Pb mg/l	Oil/Gr mg/l
AGRES	1.5	0.6	100	150	3
LRES	1.8	0.7	100	180	5
MRES	2	0.8	100	200	5
HRES	1	0.6	100	250	10
COMM	0.8	0.4	80	200	15
IND	0.9	0.2	60	100	20
INST	0.5	0.8	50	50	3
VILL	1	0.4	90	250	10

Table 4-2 NPS Factors for Future Land Use by Zoning (Concentration of Total Runoff, not Impervious Surface)

Existing Land Use Category	Initial Factor	Final Factor
AG (Agricultural)	0.02	0.02
IN (Institutional)	0.1	0.1
RA (Residential, 1 Ac. or more/DU)	0.5	0.3
RB (Residential, 1/2 Ac. / DU)	2	1.5
RC (Residential, 1/4 to 1/2 Ac./DU	4	3
RD (Residential, Village, Urban)	8	5
VA (Vacant)	0	0
CO (Commercial, Industrial)	0	0.2
OS (Open Space)	0	0
EA (Easement)	0	0
UT (Utility)	0	0

TABLE 4-3 Existing Land Use Factors Applied in Water Balance Model Equivalent Dwelling Units per Acre (Equiv DU/Ac)

4.6. Build-out of Zoning Impacts

4.6.1. Assessment of Developable Areas

As initially discussed in Section 2, the combination of lands currently in agricultural use and vacant lands provides a reasonable estimate of the total parcels in a given municipality which might be developed in the future. For the purposes of this build-out analysis, that future has no specific timetable, although it is both possible and reasonable to project a phased development schedule and test the model under alternative conditions. As the GIS measures the combinations of these parcels in their respective zoning districts, and sums them by sub-basin and municipality, it is again necessary to translate the acreage of a given vacant land-zoning combination into an estimate of equivalent dwelling units. Table 4-4 is the set of "factors" developed for this estimate. The categories of Zoning are obviously different from the existing Land Uses of Table 4-3, and the factors have little direct relationship to each other. Some discussion was required in the selection of these values, and it is fair to say that further analysis using somewhat different values would be of interest.

Zoning Category	Factor
AGRES (Residential, 2 or more Acres/DU)	0.5
LRES (Residential, 1 to 2 Acres/DU)	0.75
MRES (Residential, 1/4 to 1 Acre/DU)	2
HRES (Residential, less than 1/4 Acre/DU)	5
COMM (Commercial)	0.4
IND (Industrial)	0.5
INST (Institutional)	0.1
VILL (Village, Urban)	8

TABLE 4-4 Density Factors for Future Land Use by Zoning (Dwelling Units per Acre)

4.6.2. Land Use, Population and Dwelling Unit Statistics

The basic unit of analysis for the Water Balance Model is the sub-basin area, 120 in total, ranging in size from 0.13 to 3.39 square miles, with an average of 0.91 square miles (591 acres). The full computer summary of this data is somewhat overwhelming in raw data form, and so a set of illustrative tables have been prepared, covering portions of the full record. Table 4-5 identifies the 120 sub-basins in the two watersheds, using a three-digit number code derived from the last three digits in the full computer code. The original first order streams are numbered from 1 to 89, and the second and third order drainages are numbered from 100 to 131. The "ninety" series were left blank to provide additional sub-basin numbers if required, and the need for several further subdivisions have already become apparent. The discussions and case studies covered in Section 5 will follow this nomenclature by municipality.

This table is an example of the data summary by sub-basin of the existing land use data. For example, sub-basin 54 (21000054) is comprised of 7 of the existing land use categories, each of which is measured in square feet, acres and square miles. Based on the factors shown in Table 4-3, the estimated equivalent dwelling units are calculated in the WBM. For the sub-basin, the existing water use is summed and subsequently compared with a series of water resource statistics, including the Q 7-10 for the sub-basin, in the WBM.

In Table 4-6, the summary data by sub-basin is used to calculate the depletive loss, drought yield, proposed consumptive loss limit (several values were applied for this variable within the WBM) and Dry Year flow, all on a unit area (per acre) basis. Then the data was compared, and a simple yes (1) or no (2) conclusion reached for various

Hydrologic Code	Land Use Code	Sq. Ft.	Acres	Sq. Mi.	Sub-basin	Equiv DU/Ac	Estm. DUs	Water Use	SB Water Use	Q 7-10
21000054	AG	2,933,607	67	0.11		0.02	1.35	404		
21000054	IN	406,511	9	0.01		0.1	0.93	280		
21000054	RA	612,078	14	0.02		0.3	4.22	1,265		
21000054	RB	1,268,832	29	0.05		1.5	43.69	13,108		
21000054	RC	62,421	1	0.00		3	4.30	1,290		
21000054	RD	103,825	2	0.00		5	11.92	3,575		
21000054	VA	687,062	16	0.02	0.22	0	0.00	0	19,921	26,774
21000055	AG	3,331,958	76	0.12		0.02	1.53	459		
21000055	CO	103,673	2	0.00		0.2	0.48	143		
21000055	IN	2,853,429	66	0.10		0.1	6.55	1,965		
21000055	OS	184,364	4	0.01		0	0.00	0		
21000055	RA	6,908,188	159	0.25		0.3	47.58	14,273		
21000055	RB	2,611,982	60	0.09		1.5	89.94	26,983		
21000055	RC	1,403,380	32	0.05		3	96.65	28,995		
21000055	UT	266,482	6	0.01		0	0.00	0		
21000055	VA	4,785,681	110	0.17	0.81	0	0.00	0	72,819	98,949
21000084	AG	1,376,768	32	0.05		0.02	0.63	190		
21000084	OS	1,923,882	44	0.07		0	0.00	0		
21000084	RA	1,963,982	45	0.07		0.3	13.53	4,058		
21000084	VA	4,116,159	94	0.15	0.34	0	0.00	0	4,247	41,348
21000085	AG	2,737,211	63	0.10		0.02	1.26	377		
21000085	CO	75,644	2	0.00		0.2	0.35	104		
21000085	OS	5,411,154	124	0.19		0	0.00	0		
21000085	RA	2,344,921	54	0.08		0.3	16.15	4,845		
21000085	VA	3,326,148	76	0.12	0.50	0	0.00	0	5,326	61,246
21000086	AG	8,742,237	201	0.31		0.02	4.01	1,204		
21000086	CO	67,527	2	0.00		0.2	0.31	93		
21000086	IN	193,795	4	0.01		0.1	0.44	133		
21000086	OS	678,876	16	0.02		0	0.00	0		
21000086	RA	9,538,506	219	0.34		0.3	65.69	19,708		
21000086	RC	27,097	1	0.00		3	1.87	560		
21000086	VA	14,558,550	334	0.52	0.90	0	0.00	0	21,698	110,476
21000087	AG	2,808,834	64	0.10		0.02	1.29	387		
21000087	RA	6,849,615	157	0.25		0.3	47.17	14,152		
21000087	RB	33,997	1	0.00		1.5	1.17	351		
21000087	RC	1,114,642	26	0.04		3	76.77	23,030		
21000087	VA	7,727,390	177	0.28	0.66	0	0.00	0	37,920	81,695

Table 4-5 Partial Record of Existing Water Use Analysis

than 40 percent, an average of 40 percent is appropriate for the Model. Properly constructed COLDS systems can achieve excellent efficiencies/minimum depletion, similar to onsite septic systems. Therefore, only modest depletions of 10 percent have been assigned. Spray irrigation with lagoon treatment, an excellent environmentally-superior approach to "public" sewage treatment and stream discharge systems, does experience considerable evapotranspirational loss. Again, depletion will be much greater during warmer and dryer periods for a variety of reasons. Depending upon the specific spray technique utilized, this loss can vary greatly. Systems such as the Hersheys Mill spray facility which uses spray applications to irrigate and fertilize golf course turf, will experience larger losses. Barring some different technology, an average of 50 percent is assumed as a depletive loss for these systems.

The alternative of stream discharge of wastewaters can produce a depletion which is widely variable. To the extent that the wastewater treatment plant is located downstream in a given watershed, and the discharge point is well below the first order or even second order stream under consideration, the loss would be 100 percent. To the extent that treatment plant discharge is pumped or returned to the head of the first order stream (highly unlikely), the depletive component could decrease to virtually zero. While this could solve the low base flow problem in the stream, the net impact on groundwater levels and dependent wells would still be significant, and the groundwater system would be completely short-circuited.

4.3. Methodology for Qualitative Analysis

Water quality impacts from new land development are customarily thought of in terms of wastewater and stormwater discharges to surface waters, and when we apply these waters to the soil mantle the pollutants must be mitigated by processes within the soil. In addition, a certain amount of pollution is also discharged into the groundwater system as a result of our activities on the land surface, especially fertilization and chemical applications. Given the proposed criteria for quantitative impacts of development on water resources discussed above, parallel criteria for quality must also be considered.

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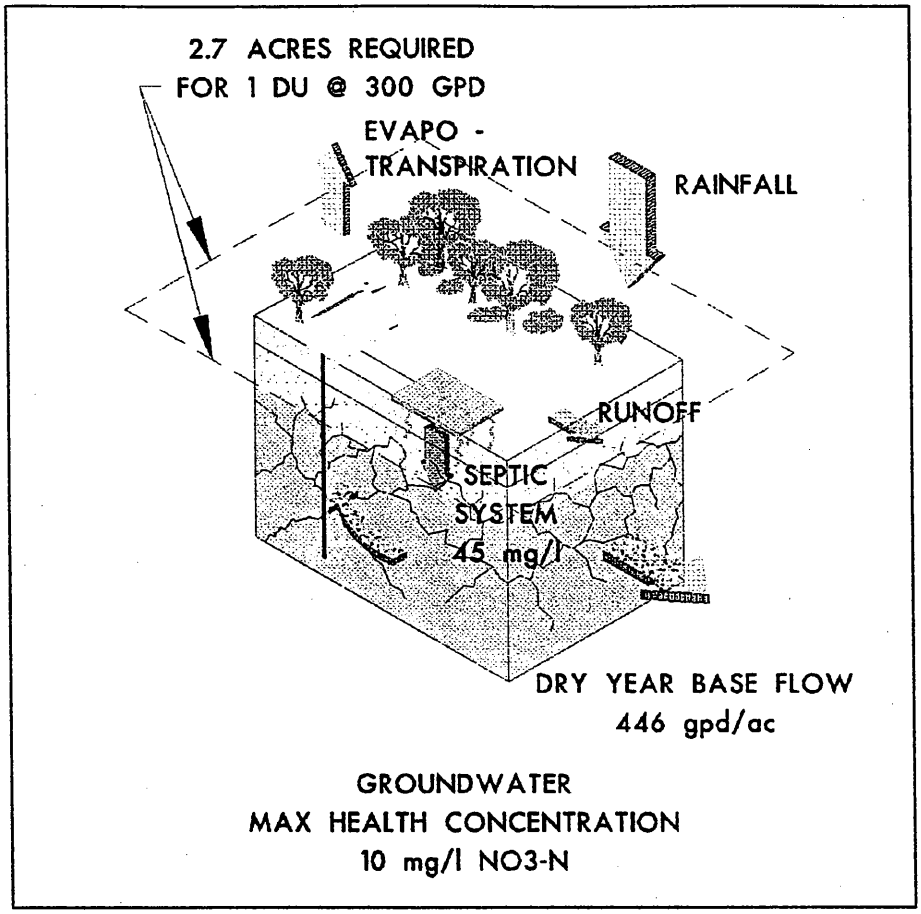

Figure 4-9 Dry Year Nitrate Impact Model

discharged as wastewater effluent, the question is how much wastewater effluent can be discharged per acre per day, so as not to exceed the allowable limit over time?

The following calculations develop this statistic:

$$\frac{[162{,}500 \text{ gallons/ac}]\,[10 \text{ ppm } NO_3\text{-N}]}{45 \text{ ppm } NO_3\text{-N}} = \frac{36{,}111.1 \text{ gals/ac per year}}{65 \text{ days per year}} = 98.9 \text{ gpd/ac}$$

Thus 98.9 gallons of sewage effluent per acre per day at a 45 mg/liter or ppm concentration can be discharged to the subsurface without exceeding the groundwater quality criterion of 10 mg/l. If a typical single-family dwelling unit is expected to use 300 gallons of water per day, less the 10 percent total of evaporative loss during use, then the maximum allowed density would become:

270 gpd/98.9 gpd per acre = **2.7 acres needed for each dwelling unit**

This calculation is driven by the need to maintain the 10 mg/liter nitrate concentration during the dry year. Similar densities can be developed for other land uses, densities and wastewater application strategies, again all reflective of their wastewater flows.

These calculations, of course, are highly generalized in nature. Assumed in the approach is that precipitation will not contain nitrate. Actual rainfall sampling data from Marsh Creek suggests that precipitation is currently in the range of 1 mg/l NO3-N, and that the soil mantle is not receiving any other inputs of NO3-N (no fertilization of any sort), all very liberal, development-favoring assumptions. Adding contributions of nitrate from these other sources would force a reduction in the sewage effluent-related loading, such that net allowable densities would decrease significantly. On the other hand, the assumption that effluent concentration reaches groundwater at 45 mg/liter is somewhat conservative, in that processes do take place in the soil mantle which transform NO3-N into other forms, released into the atmosphere (NOx) or otherwise not transported to the groundwater system. Furthermore, this simple methodology does not take into account a host of real world factors such as variation in rainfall, differences in soils and geology, and any number of other factors which would influence actual nitrate concentrations within the groundwater. Nevertheless, a quantifiable basis is provided in order to structure land use and density decisions on the land's surface.

4.4. Methodology for Stormwater Analysis

The issue of water resource impacts produced by stormwater runoff from new development has two dimensions: quantity, or increased runoff produced by new impervious surfaces and/or altered vegetative cover conditions, and quality, generally considered under the label of nonpoint sources, as discussed in Section 2. While the two impacts are directly related, with the increased pollutant loads transported in the increased stormwater runoff, they are generally evaluated and mitigated separately, almost as if they were two distinct issues. In large measure, this is due to the technology which has evolved over the last twenty-five years to deal with the problems of stormwater runoff. Recognition of the hydraulic effects of new development on natural drainage systems led to control strategies which focused on volumetric storage. These impacts included enlargement of the area inundated by the floodplain and accelerated peaks of flow, which eroded channels, The most simple solution available to the agency delegated the prime responsibility for erosion control, the Soil Conservation Service, was the traditional farm pond. Such structures had been applied in agricultural settings for several decades to contain sediment runoff, and the engineering was simple and familiar. As regulatory programs evolved in the early 1970's for control of runoff peak velocities, the stormwater detention basin became the technique of choice on an almost universal basis, with each new subdivision required, under municipal or county regulation, to build one or more such structures. This earthen basin collected a portion of the surface runoff generated from a development and detained this volume for a period of several hours, slowly releasing the stormwaters through a control structure which gradually emptied, usually within a day or two following the rainfall. The science of stormwater management has continued to evolve over the past two decades, with superior design solutions developed and tested, but the regulatory system and general construction practices have not evolved with the technology. The construction of detention basins, sized to assure that the rate of discharge (in cubic feet per second, cfs) is no greater than the flow created by conditions prior to development, is still the rule in most municipalities.

The qualitative impacts of stormwater has received far less attention and virtually no regulatory control. While nonpoint source pollution has been recognized as comprising a significant, if not major share of current water quality pollutant inputs (EPA, 1995), no regulatory controls have been established at the federal, state or local government level. In a few high profile lakes and estuaries, such as Lake Erie, the Chesapeake Bay and other water bodies, the implementation of NPS control measures have been underwritten with major federal funding and financial incentives, while local government regulation has been quite limited. Reduction of NPS pollutant inputs from industrial sites and large metropolitan combined and storm sewer discharges has found regulation under the NPDES program, but the effort to reduce NPS inputs from urban/suburban sources is yet to find translation into local government regulation. For the most part, state and federal agencies are hesitant to develop any regulatory program which suggests interference with and involvement in local land use controls.

4.4.1. The Stormwater Model - Quantity

Estimating the quantitative impacts of stormwater runoff from development has relied on a hydrologic analysis method developed by the SCS called the "Cover Complex" method, introduced in Section 2. This method is driven by an equation which evaluates the ability of incident rainfall to infiltrate into natural soils, a process which varies with soil properties, vegetative cover, timing and intensity of precipitation. The method has found application in the design and sizing of stormwater runoff control structures, from large dams to detention basins for developments. While much of the procedure is concerned with the timing and magnitude of resultant runoff peaks, it is the basic analysis of how runoff is produced that is of interest. The limitation with this methodology is that it is singular event specific (one storm), and does not analyze the annual water balance for a given year, as is required in the WBM.

The placement of impervious surface over soil, be it rooftop, driveway or roadway, effectively prevents any incident rainfall from percolating into the soil mantle, and converts this rainfall into immediate and direct runoff. Thus one can estimate the net addition to runoff by simply multiplying the total impervious surface of a development by the total rainfall. For example, a residential site which created new impervious surface would effectively produce 45 inches of runoff per square foot as total annual stormwater flow, or a net increase of 36 inches (assuming that before development this same soil would naturally produce 8 inches per year and allowing 1 inch for evaporation). This additional runoff volume per square foot is estimated as follows:

(36 inches/12 inches/ft) = 3 cubic feet (cf) of additional runoff per year

In a watershed which is zoned to undergo development, with the amount of new impervious surface directly related to the type and density of zoning permitted, the resultant runoff increase (and corresponding groundwater loss) can be estimated in the same fashion. In a watershed of 1 square mile (640 acres) which will urbanize at a zoning density of medium residential, one can assume a resultant net impervious area of 15% (including roadways and related supporting uses), with a corresponding annual runoff increase of:

(640 ac)(43,560 sf/ac)(3 cf)(0.15) = 12.5 million cubic feet /SM

This is additional runoff generated from that land, now made impervious (15%). In the French Creek basin, a square mile of watershed currently produces an average runoff of about 8 inches per year, or

(640 ac)(43,560 sf/ac)(8/12 f) = 18.6 million cubic feet

and so the new total runoff is 85% of this value (15% has been changed), plus the impervious runoff of 28.3 million cubic feet, for an increase of 152%. The assumptions of impervious cover used in the WBM for Future Land Use by Zoning is shown in Table 4-1. As the hydrologic sub-areas were analyzed for potential impact under future development scenarios, the net impact of total runoff increase was estimated and summed by major tributary.

There are many variables in this simple model when a real suburban landscape is considered, including the actual change in vegetative systems, be it lawn, meadow or sparsely vegetated and compacted soil, and the addition of features which might alter the cycle, such as ponds and lakes. In general, the more urbanized the landscape, the more elaborate the stormwater infrastructure system developed to convey runoff to surface streams (or the enclosure of these streams as storm sewers), and thus the greater the impact.

Zoning Category	Factor
AGRES (Residential, 2 or more Acres/DU	0.04
LRES (Residential, 1 to 2 Acres/DU)	0.08
MRES (Residential, 1/4 to 1 Acre/DU)	0.15
HRES (Residential, less than 1/4 Acre/DU)	0.3
COMM (Commercial)	0.6
IND (Industrial)	0.7
INST (Institutional)	0.1
VILL (Village, Urban)	0.5

Table 4-1 Impervious Cover Factors for Future Land Use by Zoning (Percent of Impervious Surface per Acre)

4.4.2. The Stormwater Model - Quality

As the runoff travels across the impervious surface, it scours the particulate and soluble pollutants from the surface and conveys them with the stormwater. On the pervious surfaces, which are the lawns and landscaped areas surrounding structures, the soil reaches saturation after a certain amount of rainfall and also produces runoff, containing the phosphorus-laden sediment and other soluble pollutants such as Nitrate, and adds this load to the total runoff. The relative pollutant production for a proposed development is thus a function of the total volume of runoff from impervious surfaces plus the additional volume generated from pervious surfaces, which do not usually produce a major increase in runoff volume but do produce NPS pollutants. Of course, if a wooded tract has been cleared and turned into lawn, the volume increase can be significant. Distinguishing between these different NPS sources and increased runoff volumes is quite difficult, given the methods which have been developed to quantify NPS pollutant generation, or mass loading, from urban runoff.

These methods have taken several forms, both theoretical and empirical. The observation of stormwater runoff, and the pollutant concentrations contained therein, has been an ongoing process for twenty years. For the most part, these observations have been qualitative, in that the chemistry of urban runoff has been measured in a number of settings. A limited number of studies have measured both concentration and runoff rate to produce mass transport estimates associated with a given land use or rainfall amount. In a series of studies during the early 1980's, the EPA performed sampling of urban runoff at locations across the US, known as the National Urban Runoff Program (NURP), and have used this data in much of the subsequent program analysis for NPS management. The NURP data has been reformulated in several forms, but basically is described in terms of relative concentration of the representative NPS pollutants produced in runoff from different urban land densities. The problem with such data is that one must estimate the amount of urban stormwater produced in a given year. As summarized in the previous discussion of net runoff produced, such runoff volumes have been estimated in the WBM Model.

Other NPS studies have translated runoff chemistry into representative pollutant production, in terms of mass per unit area per year (kg/ha/yr). With this data, one can apply such values to the proposed new urban landscape and estimate the mass load of pollutants produced in a representative year. As one examines the various data sets illustrated in this table and the significant variability between studies and even within a given study, it is apparent that this estimating approach suggests the use of such data only within the watershed in which it is gathered, or in very similar watersheds.

In this study, a representative group of NPS pollutants was selected and used in the stormwater subroutine to estimate a future NPS load generated by sub-basin. Table 4-2 shows these NPS Loading Factors, or average concentrations, in stormwater runoff. Because of the method by which the original data was collected, it is more applicable to the WBM estimates of stormwater runoff increases in volume for an average year.

4.5. Existing Land Use Impacts on Water Resources

Application of the Water Balance Model to each sub-basin requires that we first evaluate existing conditions in terms of development impacts on water resources, using our three "parameter" approach - water quantity, water quality and stormwater. Since we have combined the existing land uses for all municipalities into eight categories, these categories must be described in terms which can readily be translated into water resource impacts. This means that the land uses measured in a given municipality and sub-basin, in terms of acres of a given type, must be expressed as typical dwelling units at a uniform density for that category. Of course, none of the watershed is truly uniform in dwelling unit type, size or density, nor does the zoning at a specific density (1 DU per acre) seldom translate into that same density. For the purposes of this model analysis, however, it is reasonable to assume a certain consistency across the broad categories of identified land use. Table 4-3 is a set of densities applied to the eight existing land use categories, and used in the WBM analysis to estimate existing water resource impacts. The alternative to this process is a detailed count of dwelling units for each watershed, an imperfect process at best and accurate only for the point in time when the available aerial photography is taken. All of the subsequent analysis discussed in Section 5 uses this data to develop existing impacts (but not future impacts). As the Table suggests, two different values were considered for some uses.

Zoning Category	**Factors**				
	NO3 mg/l	**TP** mg/l	**COD** mg/l	**Pb** mg/l	**Oil/Gr** mg/l
AGRES	1.5	0.6	100	150	3
LRES	1.8	0.7	100	180	5
MRES	2	0.8	100	200	5
HRES	1	0.6	100	250	10
COMM	0.8	0.4	80	200	15
IND	0.9	0.2	60	100	20
INST	0.5	0.8	50	50	3
VILL	1	0.4	90	250	10

Table 4-2 NPS Factors for Future Land Use by Zoning (Concentration of Total Runoff, not Impervious Surface)

Zoning Category	Factor
AGRES (Residential, 2 or more Acres/DU)	0.5
LRES (Residential, 1 to 2 Acres/DU)	0.75
MRES (Residential, 1/4 to 1 Acre/DU)	2
HRES (Residential, less than 1/4 Acre/DU)	5
COMM (Commercial)	0.4
IND (Industrial)	0.5
INST (Institutional)	0.1
VILL (Village, Urban)	8

TABLE 4-4 Density Factors for Future Land Use by Zoning (Dwelling Units per Acre)

4.6.2. Land Use, Population and Dwelling Unit Statistics

The basic unit of analysis for the Water Balance Model is the sub-basin area, 120 in total, ranging in size from 0.13 to 3.39 square miles, with an average of 0.91 square miles (591 acres). The full computer summary of this data is somewhat overwhelming in raw data form, and so a set of illustrative tables have been prepared, covering portions of the full record. Table 4-5 identifies the 120 sub-basins in the two watersheds, using a three-digit number code derived from the last three digits in the full computer code. The original first order streams are numbered from 1 to 89, and the second and third order drainages are numbered from 100 to 131. The "ninety" series were left blank to provide additional sub-basin numbers if required, and the need for several further subdivisions have already become apparent. The discussions and case studies covered in Section 5 will follow this nomenclature by municipality.

This table is an example of the data summary by sub-basin of the existing land use data. For example, sub-basin 54 (21000054) is comprised of 7 of the existing land use categories, each of which is measured in square feet, acres and square miles. Based on the factors shown in Table 4-3, the estimated equivalent dwelling units are calculated in the WBM. For the sub-basin, the existing water use is summed and subsequently compared with a series of water resource statistics, including the Q 7-10 for the sub-basin, in the WBM.

In Table 4-6, the summary data by sub-basin is used to calculate the depletive loss, drought yield, proposed consumptive loss limit (several values were applied for this variable within the WBM) and Dry Year flow, all on a unit area (per acre) basis. Then the data was compared, and a simple yes (1) or no (2) conclusion reached for various model tests. The GIS was then examined for both public sewer and public sewer service within the sub-basin, and classified as fully or partially served. Those sub-basins which were totally or partially serviced were totalled for comparison purposes (some 15, 431 acres are so identified).

Next, the existing wastewater generated was estimated as shown in Table 4-7, and the associated Nitrate loading calculated, assuming that for those sub-basins without public sewer this load was now being applied to the sub-surface in septage flows. The total groundwater volume for a Dry Year condition was calculated in Million Gallons per year, and the allowable Nitrate loading estimated, based on the health limit of 10 mg/l (a more stringent safe level might also be considered and tested in the WBM). Again, a simple yes-no test was applied.

The impact of build-out on developable parcels within each sub-basin was then estimated, and is also shown in Table 4-7. Here the Zoning was overlaid or combined with the Developable Parcels in the GIS, and statistics produced for each combined area. For example, sub-basin 54 has virtually all of the existing developable land in the AGRES category (82.74 acres). The values from Table 4-4 were then applied to estimate the future equivalent dwelling units and their related water use, whch was then totaled by sub-basin.

This additional future water demand was then considered and added to the existing use and losses, as partially illustrated in Table 4-8. At the 50% of Q 7-10 consumptive loss limit, very few sub-basins will be exceeded under build-out conditions. The earlier WBM analysis, using a limit of 10%, indicated a great many sub-basins would exceed this consumptive loss under future build-out.

With respect to impacts of future loading of Nitrate to the groundwater system, the WBM analysis result was quite different. For a great many sub-basins, the build-out loading would significantly exceed the health limit for NO3, and this analysis does not even include non-wastewater sources, such as lawn fertilizers. This analysis does not have the kind of safety factor built in to it that the drought model provides, in that the potential for harm to the future resident population is much greater. One might concluded that the appropriate answer to this impact from future septage would be the public sewering and conveyance out of the watershed of all wastewaters generated, but as we have seen, that solution produces its own set of water resource impacts.

In fact, as the following case studies demonstrate, there are sub-basins in the watershed where groundwater withdrawals are totally removed from the sub-basin by public sewers, producing the most severe depletion condition possible. The conflicts between these various aspects of water use and management, under the pressures of future development, will become apparent with the examples of Section 5. The solutions, however, will evolve from careful application and testing of the WBM under various scenarios of use and management on a sub-basin basis. This suggests that the detailed planning process is yet to take place, as the GIS and related model analysis, such as the WBM or other types of evaluation, is applied to each sub-basin.

Hydrologic Code	Land Use Code	Sq. Ft.	Acres	Sq. Mi.	Sub-basin	Equiv DU/Ac	Estm. DUs	Water Use	SB Water Use	Q 7-10
21000054	AG	2,933,607	67	0.11		0.02	1.35	404		
21000054	IN	406,511	9	0.01		0.1	0.93	280		
21000054	RA	612,078	14	0.02		0.3	4.22	1,265		
21000054	RB	1,268,832	29	0.05		1.5	43.69	13,108		
21000054	RC	62,421	1	0.00		3	4.30	1,290		
21000054	RD	103,825	2	0.00		5	11.92	3,575		
21000054	VA	687,062	16	0.02	0.22	0	0.00	0	19,921	26,774
21000055	AG	3,331,958	76	0.12		0.02	1.53	459		
21000055	CO	103,673	2	0.00		0.2	0.48	143		
21000055	IN	2,853,429	66	0.10		0.1	6.55	1,965		
21000055	OS	184,364	4	0.01		0	0.00	0		
21000055	RA	6,908,188	159	0.25		0.3	47.58	14,273		
21000055	RB	2,611,982	60	0.09		1.5	89.94	26,983		
21000055	RC	1,403,380	32	0.05		3	96.65	28,995		
21000055	UT	266,482	6	0.01		0	0.00	0		
21000055	VA	4,785,681	110	0.17	0.81	0	0.00	0	72,819	98,949
21000084	AG	1,376,768	32	0.05		0.02	0.63	190		
21000084	OS	1,923,882	44	0.07		0	0.00	0		
21000084	RA	1,963,982	45	0.07		0.3	13.53	4,058		
21000084	VA	4,116,159	94	0.15	0.34	0	0.00	0	4,247	41,348
21000085	AG	2,737,211	63	0.10		0.02	1.26	377		
21000085	CO	75,644	2	0.00		0.2	0.35	104		
21000085	OS	5,411,154	124	0.19		0	0.00	0		
21000085	RA	2,344,921	54	0.08		0.3	16.15	4,845		
21000085	VA	3,326,148	76	0.12	0.50	0	0.00	0	5,326	61,246
21000086	AG	8,742,237	201	0.31		0.02	4.01	1,204		
21000086	CO	67,527	2	0.00		0.2	0.31	93		
21000086	IN	193,795	4	0.01		0.1	0.44	133		
21000086	OS	678,876	16	0.02		0	0.00	0		
21000086	RA	9,538,506	219	0.34		0.3	65.69	19,708		
21000086	RC	27,097	1	0.00		3	1.87	560		
21000086	VA	14,558,550	334	0.52	0.90	0	0.00	0	21,698	110,476
21000087	AG	2,808,834	64	0.10		0.02	1.29	387		
21000087	RA	6,849,615	157	0.25		0.3	47.17	14,152		
21000087	RB	33,997	1	0.00		1.5	1.17	351		
21000087	RC	1,114,642	26	0.04		3	76.77	23,030		
21000087	VA	7,727,390	177	0.28	0.66	0	0.00	0	37,920	81,695

Table 4-5 Partial Record of Existing Water Use Analysis

Hydrologic Code	Land Use Code	Sq. Ft.	Acres	Sq. Mi.	Sub-basin	Equiv DU/Ac	Estm. DUs	Water Use	SB Water Use	Q 7-10
21000054	AG	2,933,607	67	0.11		0.02	1.35	404		
21000054	IN	406,511	9	0.01		0.1	0.93	280		
21000054	RA	612,078	14	0.02		0.3	4.22	1,265		
21000054	RB	1,268,832	29	0.05		1.5	43.69	13,108		
21000054	RC	62,421	1	0.00		3	4.30	1,290		
21000054	RD	103,825	2	0.00		5	11.92	3,575		
21000054	VA	687,062	16	0.02	0.22	0	0.00	0	19,921	26,774
21000055	AG	3,331,958	76	0.12		0.02	1.53	459		
21000055	CO	103,673	2	0.00		0.2	0.48	143		
21000055	IN	2,853,429	66	0.10		0.1	6.55	1,965		
21000055	OS	184,364	4	0.01		0	0.00	0		
21000055	RA	6,908,188	159	0.25		0.3	47.58	14,273		
21000055	RB	2,611,982	60	0.09		1.5	89.94	26,983		
21000055	RC	1,403,380	32	0.05		3	96.65	28,995		
21000055	UT	266,482	6	0.01		0	0.00	0		
21000055	VA	4,785,681	110	0.17	0.81	0	0.00	0	72,819	98,949
21000084	AG	1,376,768	32	0.05		0.02	0.63	190		
21000084	OS	1,923,882	44	0.07		0	0.00	0		
21000084	RA	1,963,982	45	0.07		0.3	13.53	4,058		
21000084	VA	4,116,159	94	0.15	0.34	0	0.00	0	4,247	41,348
21000085	AG	2,737,211	63	0.10		0.02	1.26	377		
21000085	CO	75,644	2	0.00		0.2	0.35	104		
21000085	OS	5,411,154	124	0.19		0	0.00	0		
21000085	RA	2,344,921	54	0.08		0.3	16.15	4,845		
21000085	VA	3,326,148	76	0.12	0.50	0	0.00	0	5,326	61,246
21000086	AG	8,742,237	201	0.31		0.02	4.01	1,204		
21000086	CO	67,527	2	0.00		0.2	0.31	93		
21000086	IN	193,795	4	0.01		0.1	0.44	133		
21000086	OS	678,876	16	0.02		0	0.00	0		
21000086	RA	9,538,506	219	0.34		0.3	65.69	19,708		
21000086	RC	27,097	1	0.00		3	1.87	560		
21000086	VA	14,558,550	334	0.52	0.90	0	0.00	0	21,698	110,476
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21000087	RB	33,997	1	0.00		1.5	1.17	351		
21000087	RC	1,114,642	26	0.04		3	76.77	23,030		
21000087	VA	7,727,390	177	0.28	0.66	0	0.00	0	37,920	81,695

Table 4-5 Partial Record of Existing Water Use Analysis

Developable area by Watershed and Zoning (Includes both vacant & agricultural)			WATER SL						
					Equiv. DUs Per Acre	Equiv. Dus	Water Use at 300 GPD/DU	Sub-basin Totals	Imper-vious
FREQ	**Sub Wshd**	**Zoning**	**AREA (SF)**	**AREA (AC)**		**DUs**	**GPD**	**GPD**	**Factor**
4	21000054	AGRES	3,604,207	82.74	0.5	41.37	12,411		0.04
1	21000054	MRES	16,461	0.38	2	0.76	227	12,638	0.15
11	21000055	AGRES	3,190,100	73.23	0.5	36.62	10,985		0.04
1	21000055	COMM	6,356	0.15	0.4	0.06	18		0.6
2	21000055	LRES	26,139	0.60	0.75	0.45	135		0.08
11	21000055	MRES	4,895,020	112.37	2	224.75	67,425	78,562	0.15
11	21000084	AGRES	5,492,918	126.10	0.5	63.05	18,915	18,915	0.04
12	21000085	AGRES	6,063,370	139.20	0.5	69.60	20,879	20,879	0.04
25	21000086	AGRES	23,301,340	534.93	0.5	267.46	80,239	80,239	0.04
19	21000087	AGRES	10,506,910	241.21	0.5	120.60	36,181		0.04
1	21000087	LRES	29,313	0.67	0.75	0.50	151	36,332	0.08
11	21000088	AGRES	4,714,179	108.22	0.5	54.11	16,233		0.04
5	21000088	LRES	199,167	4.57	0.75	3.43	1,029	17,262	0.08
2	21000089	LRES	537,526	12.34	0.75	9.25	2,776		0.08
5	21000089	MRES	71,022	1.63	2	3.26	978	3,755	0.15
25	21000121	AGRES	14,843,470	340.76	0.5	170.38	51,114		0.04
10	21000121	COMM	1,581,619	36.31	0.4	14.52	4,357		0.6
9	21000121	IND	2,370,348	54.42	0.5	27.21	8,162		0.7
24	21000121	LRES	7,122,627	163.51	0.75	122.63	36,790		0.08
17	21000121	MRES	1,660,514	38.12	2	76.24	22,872	123,296	0.15
2	21260018	AGRES	515,730	11.84	0.5	5.92	1,776		0.04
2	21260018	INST	5,038	0.12	0.1	0.01	3	1,779	0.1
4	21260019	AGRES	883,619	20.29	0.5	10.14	3,043		0.04
5	21260019	LRES	1,611,542	37.00	0.75	27.75	8,324	11,367	0.08
1	21260102	AGRES	976,244	22.41	0.5	11.21	3,362		0.04
1	21260102	INST	1,095	0.03	0.1	0.00	1	3,362	0.1
1	21290020	AGRES	542,510	12.45	0.5	6.23	1,868	1,868	0.04
12	21290021	AGRES	16,366,210	375.72	0.5	187.86	56,357		0.04
3	21290021	LRES	1,354,996	31.11	0.75	23.33	6,999	63,356	0.08
13	21290022	AGRES	9,865,591	226.48	0.5	113.24	33,972		0.04
6	21290022	INST	279,537	6.42	0.1	0.64	193	34,165	0.1
9	21290101	AGRES	7,533,462	172.94	0.5	86.47	25,942		0.04
6	21290101	INST	213,072	4.89	0.1	0.49	147	26,088	0.1
9	21290103	AGRES	8,635,672	198.25	0.5	99.12	29,737		0.04
7	21290103	INST	78,678	1.81	0.1	0.18	54	29,791	0.1
1	21300106	AGRES	2,102	0.05	0.5	0.02	7	7	0.04
8	21380014	AGRES	3,438,677	78.94	0.5	39.47	11,841		0.04
7	21380014	LRES	2,176,007	49.95	0.75	37.47	11,240		0.08
1	21380014	MRES	130,271	2.99	2	5.98	1,794	24,875	0.15
32	21380015	AGRES	23,196,810	532.53	0.5	266.26	79,879		0.04
15	21380015	LRES	12,597,470	289.20	0.75	216.90	65,070		0.08
1	21380015	MRES	1,505	0.03	2	0.07	21	144,969	0.15
17	21380016	AGRES	14,919,060	342.49	0.5	171.25	51,374		0.04

Table 4-7 Future Water Use by Zoning Category

Developable area by Watershed and Zoning WATER SL
(Includes both vacant & agricultural)

FREQ	Sub Wshd	Zoning	AREA (SF)	AREA (AC)	Equiv. DUs Per Acre	Equiv. Dus DUs	Water Use at 300 GPD/DU GPD	Sub-basin Totals GPD	Imper-vious Factor
4	21000054	AGRES	3,604,207	82.74	0.5	41.37	12,411		0.04
1	21000054	MRES	16,461	0.38	2	0.76	227	12,638	0.15
11	21000055	AGRES	3,190,100	73.23	0.5	36.62	10,985		0.04
1	21000055	COMM	6,356	0.15	0.4	0.06	18		0.6
2	21000055	LRES	26,139	0.60	0.75	0.45	135		0.08
11	21000055	MRES	4,895,020	112.37	2	224.75	67,425	78,562	0.15
11	21000084	AGRES	5,492,918	126.10	0.5	63.05	18,915	18,915	0.04
12	21000085	AGRES	6,063,370	139.20	0.5	69.60	20,879	20,879	0.04
25	21000086	AGRES	23,301,340	534.93	0.5	267.46	80,239	80,239	0.04
19	21000087	AGRES	10,506,910	241.21	0.5	120.60	36,181		0.04
1	21000087	LRES	29,313	0.67	0.75	0.50	151	36,332	0.08
11	21000088	AGRES	4,714,179	108.22	0.5	54.11	16,233		0.04
5	21000088	LRES	199,167	4.57	0.75	3.43	1,029	17,262	0.08
2	21000089	LRES	537,526	12.34	0.75	9.25	2,776		0.08
5	21000089	MRES	71,022	1.63	2	3.26	978	3,755	0.15
25	21000121	AGRES	14,843,470	340.76	0.5	170.38	51,114		0.04
10	21000121	COMM	1,581,619	36.31	0.4	14.52	4,357		0.6
9	21000121	IND	2,370,348	54.42	0.5	27.21	8,162		0.7
24	21000121	LRES	7,122,627	163.51	0.75	122.63	36,790		0.08
17	21000121	MRES	1,660,514	38.12	2	76.24	22,872	123,296	0.15
2	21260018	AGRES	515,730	11.84	0.5	5.92	1,776		0.04
2	21260018	INST	5,038	0.12	0.1	0.01	3	1,779	0.1
4	21260019	AGRES	883,619	20.29	0.5	10.14	3,043		0.04
5	21260019	LRES	1,611,542	37.00	0.75	27.75	8,324	11,367	0.08
1	21260102	AGRES	976,244	22.41	0.5	11.21	3,362		0.04
1	21260102	INST	1,095	0.03	0.1	0.00	1	3,362	0.1
1	21290020	AGRES	542,510	12.45	0.5	6.23	1,868	1,868	0.04
12	21290021	AGRES	16,366,210	375.72	0.5	187.86	56,357		0.04
3	21290021	LRES	1,354,996	31.11	0.75	23.33	6,999	63,356	0.08
13	21290022	AGRES	9,865,591	226.48	0.5	113.24	33,972		0.04
6	21290022	INST	279,537	6.42	0.1	0.64	193	34,165	0.1
9	21290101	AGRES	7,533,462	172.94	0.5	86.47	25,942		0.04
6	21290101	INST	213,072	4.89	0.1	0.49	147	26,088	0.1
9	21290103	AGRES	8,635,672	198.25	0.5	99.12	29,737		0.04
7	21290103	INST	78,678	1.81	0.1	0.18	54	29,791	0.1
1	21300106	AGRES	2,102	0.05	0.5	0.02	7	7	0.04
8	21380014	AGRES	3,438,677	78.94	0.5	39.47	11,841		0.04
7	21380014	LRES	2,176,007	49.95	0.75	37.47	11,240		0.08
1	21380014	MRES	130,271	2.99	2	5.98	1,794	24,875	0.15
32	21380015	AGRES	23,196,810	532.53	0.5	266.26	79,879		0.04
15	21380015	LRES	12,597,470	289.20	0.75	216.90	65,070		0.08
1	21380015	MRES	1,505	0.03	2	0.07	21	144,969	0.15
17	21380016	AGRES	14,919,060	342.49	0.5	171.25	51,374		0.04

Table 4-8 Future Water Use by Zoning Category

SECTION 5.0 FUTURES ANALYSIS

5. FUTURES ANALYSIS

5.1. Water Resource Impact Analysis of Build-out

Figure 2-32 in Section 2 illustrates where the developable land parcels are situated within the watershed, and Figure 3-1 in Section 3 illustrates the current Zoning which overlies these parcels. The Water Balance Model is then applied to analyze the potential development impact on the corresponding sub-basins, if and when this development takes place. But we are interested in this "worst case" scenario of future growth only to identify sub-basins where the associated water resource impacts would be unacceptable. The entire purpose of this study is to take the measure of this potential impact and alter how we manage the land, and water, to prevent unacceptable resource damage. This Section considers the estimated impact of build-out in representative sub-basins and asks how we might alter this future.

5.2. Existing Resources

We begin the process by first summing what we know of the watershed in its present state, so that we can compare it with potential future conditions. The 109-square mile study area has been divided into 120 sub-basins (Figure 5-1), averaging 591 acres, which serve as the units of analysis. Within the entire watershed, a total of 15,626 dwelling units or equivalent units have been estimated, and an average water use of 300 gallons per day (GPD) has been assumed for each unit. This translates into 4.69 MGD of water use per day, or 1,711 MG per year. With a depletion loss of 20%, or 0.93 MGD, a sewage flow of 1,368 MG per year is returned to the water system.

But of course not all of this return is directed to the sub-surface aquifers, nor is all of it withdrawn from these aquifers. Some 24 sub-basins have partial or total public sewer and/or water, covering 15,341 acres (22%) of the watershed. Of the 24 sub-basins, 8 are totally watered and sewered, and 10 are partially so, with 6 having one or the other but not both. Since these utility systems and service areas are constantly expanding, it is reasonable to assume that this statistic is currently out of date. Whatever the exact area, a significant fraction of the existing population is served by public sewer and water, much of it imported into the sub-basin and exported from the basin, with little direct impact on the water resources.

In a dry year, these water resources produce an average base flow of 31 MGD across the watershed, and during the driest week of a 10-year drought, that base flow diminishes to 13.4 MGD. If we assume a regulatory limit of 10% of the Q 7-10 base flow, then 2 sub-basins without public water or sewer currently exceed that limit. If we apply a Q 7-10 limit of 50% ,then all non-watered and non-sewered sub-basins are currently within the loss limit.

Assuming a wastewater effluent with a concentration of 45 mg/l, the existing waste discharge equals 513,750 pounds per year. Only a portion of this current load goes to

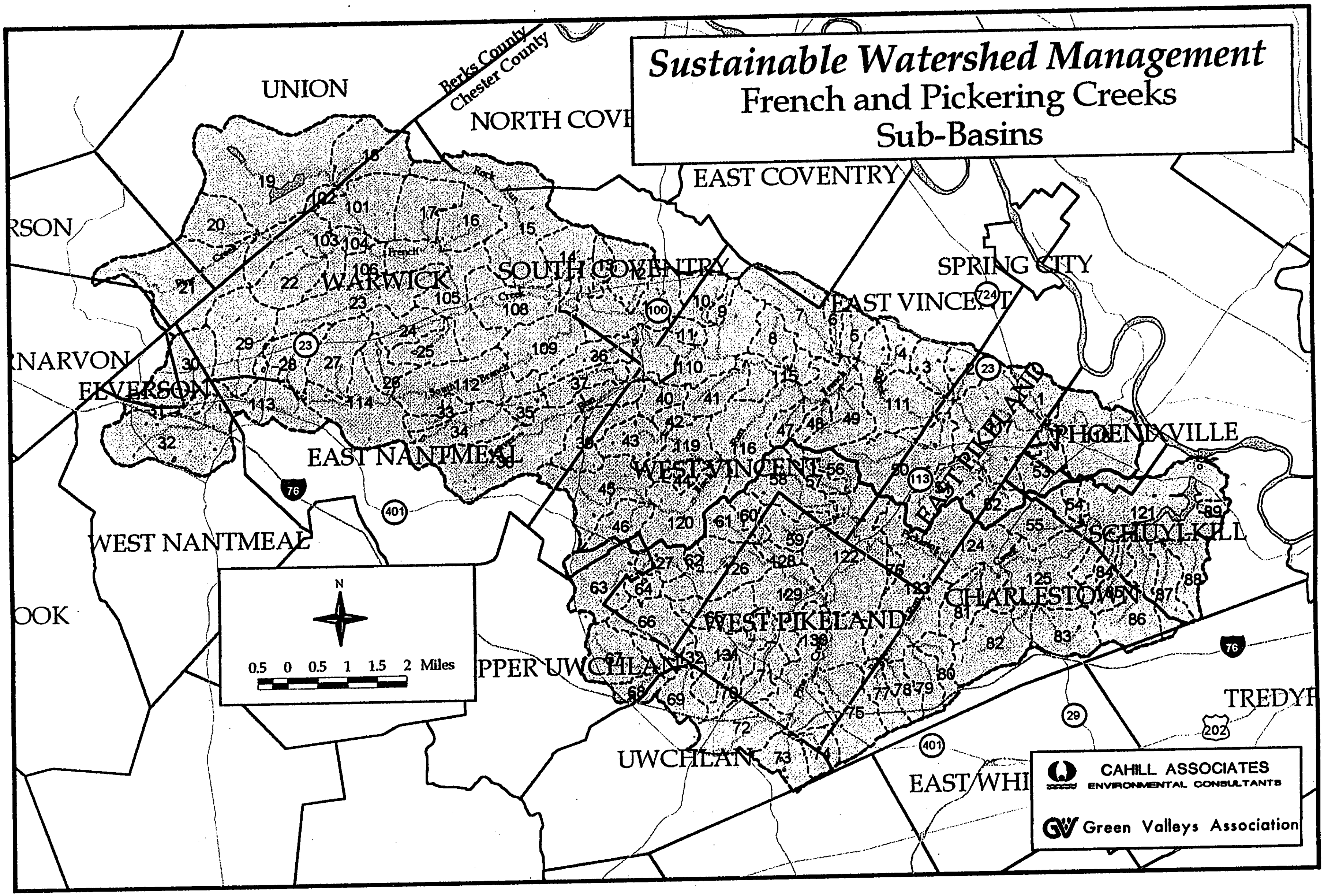

Figure 5-1 Sub-basins in the French and Pickering Creeks Watershed

the groundwater system, which during a dry year has a dilutional capacity of 11,329 MG with an assumed concentration of 2 mg/l. In sub-basins without public sewer and water, we currently exceed the groundwater dilutional capacity in 4 sub-basins (Figure 5-2), and place at risk all withdrawals from the aquifers.

Most of these conditions are not especially alarming on a watershed-wide basis, and so we might conclude that except for a few problem areas, we are living within the tolerance limits of our water resources at present. As the following case studies illustrate, however, this is not true in several situations. The existing public water and sewer systems may solve many problems from a municipal perspective, but they can also create significant water resource impacts under present conditions. And what about the future? The major issue of water export from the sub-basin in which it is withdrawn will increase as the utility systems expand.

5.3. Future Resources

The developable lands within the watershed total 32,890 acres. Various strategies were considered to allocate this development, both temporally and spatially, so that various stages of development might be considered and modeled. This is the conventional approach to planning when future development is considered, but in this case we are most concerned with evaluating the amount of development which a given sub-basin can tolerate in terms of water resources, with the intention of formulating an alternative development program which will avoid that anticipated impact. In addition, within any given portion of a sub-basin the full build-out development could (and frequently does) occur, long before the entire sub-basin.

On a total watershed basis, the build-out represents an additional 23,775 equivalent dwelling units, using 7.1 MGD of additional water for a total future demand of 11.8 MGD, with a potential evaporative loss (20%) of 2.4 MGD. Using the more conservative loss limit of 10% of the Q 7-10, future depletion would exceed the limit in 68 of the sub-basins without water and sewer. With the loss limit set at 50% of the Q 7-10, the number of impacted sub-basins without water and sewer is reduced to zero. That is, the 50% loss limit allows full build-out in all sub-basins.

However, the Nitrate loading is quite a different issue. The related future wastewater of 3,455 MGY would also produce 1.3 million pounds of Nitrate, and exceed the mass loading limit in 68 sub-basins (Figure 5-3) which currently do not have public water or sewer. This represents a major portion of the Watershed, and illustrates that the greater threat by development to water resources is groundwater contamination, not depletion.

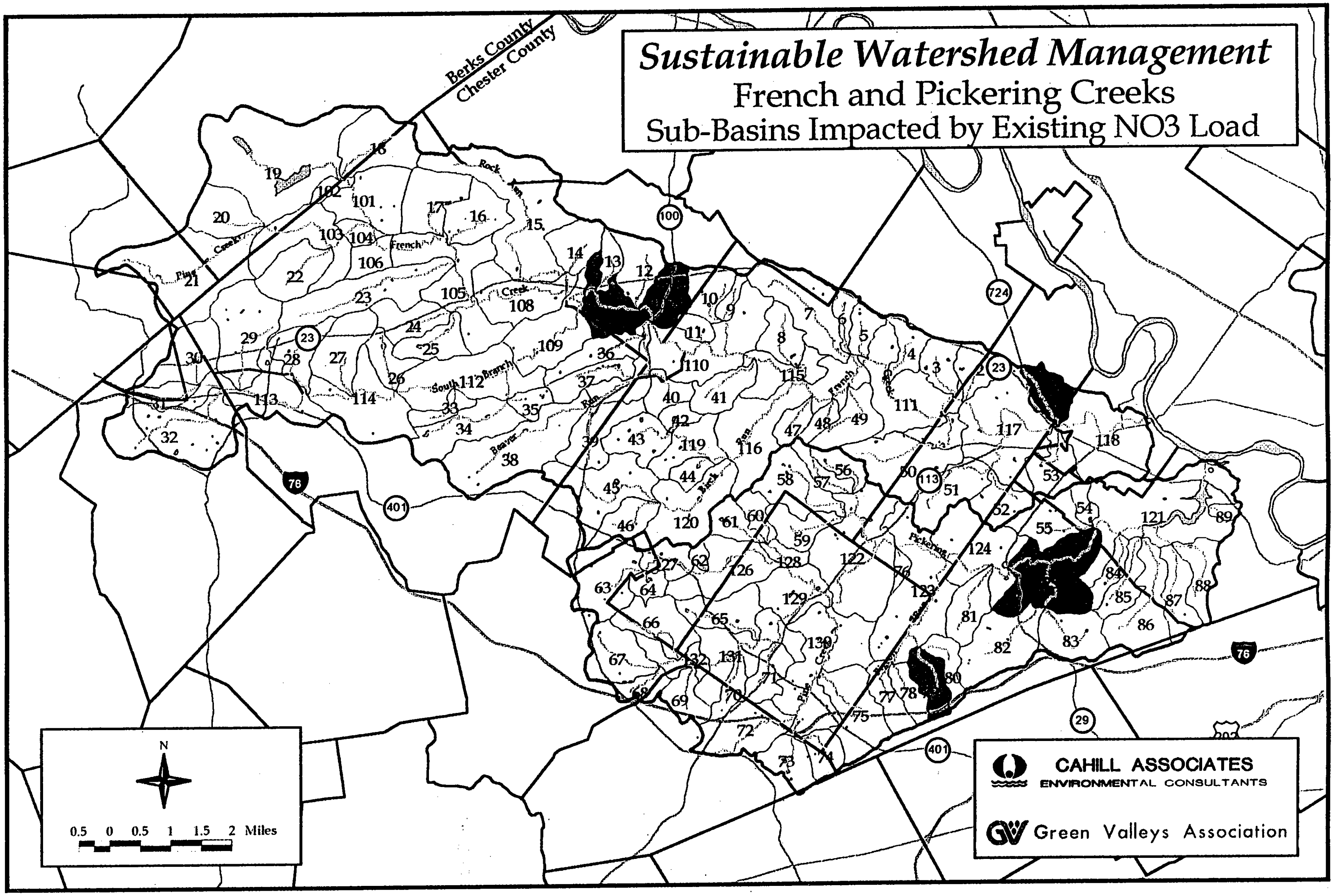

Figure 5-2 Sub-basins without Public Water and Sewer in which Wastewater Loading to Aquifers Currently Exceeds 10mg/l

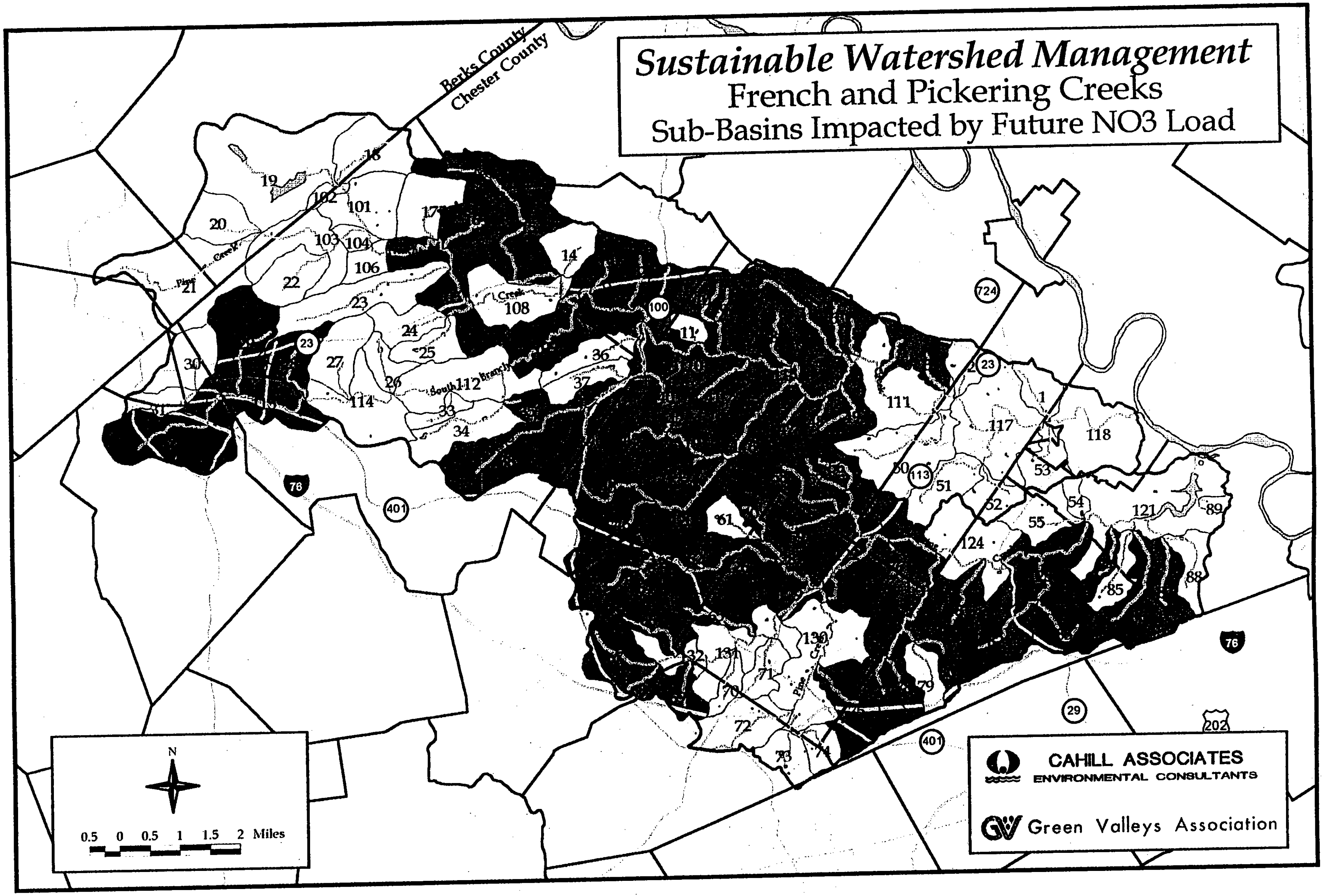

Figure 5-3 Sub-basins without Public Water and Sewer in which Wastewater Loading to Aquifers Will Exceed 10 mg/l at Build-out

Pollutant	Increase in NPS Load (pounds per year)
Nitrate (NO3-N)	126,000
Total Phosphorus	50,000
COD	8,288,000
Lead	13,800

Table 5-1 Additional NPS Loads Generated by Future Development

Of course, only a portion of the pollutants generated by new development will enter into the groundwater. A major impact to surface water quality will be the discharge of NPS pollutants with every runoff event. Taking the future development scenario one step further, the additional 3,411 acres of new impervious cover will generate 10,233 acre-feet (446 million cubic feet) of additional runoff, and more importantly will generate NPS pollutant loadings as shown in Table 5-1.

Since most municipalities are concerned primarily with their own resources, the "Futures" analysis is also intended to test the ultimate growth impact and evaluate related water resource management alternatives on a sub-basin by sub-basin basis. The statistics of the total watershed are interesting, but they are overwhelming and difficult to relate to specific conditions in a given municipality or group of sub-basins. In an effort to communicate the results of WBM analysis and describe the potential impact of development during preliminary meetings with selected municipalities, a series of Case Studies were developed for individual sub-basins. These serve to better illustrate the future impact potential, and more importantly to define the resource management alternatives.

5.4. Water Resource Impact Evaluation - Case Studies

Early in this study (1995), a preliminary pilot study was performed for the Upper Birch Run sub-basin in West Vincent Township, where a large development project was proposed. That sub-basin was revisited at the completion of the study, and a revised analysis prepared. In addition, each of the townships which have a significant portion of the township in the watershed were visited during late 1996 to review and discuss the study results. In each of the townships visited, a sub-basin was selected for detailed analysis as an example of the GIS and related WBM analysis. Many different situations and types of development were considered, and the overall process served as an important feedback to GVA. In each municipality, the GIS data was first summarized for the entire township, so that the Supervisors, Planning Commission members and other township officials could relate to the description of their municipality as a series of sub-basins, and begin thinking in these terms. For many, it was difficult to think of a specific area as a sub-basin with out detailed graphic images of the boundaries of such units with respect to other landmarks. It was apparent that in order for townships to begin using such information to make land use decisions, it would be necessary to develop an interactive capability which all municipalities could access, interrogate and download to local output devices, such as printers. This overall experience led to the recommendations outlined in Section 6.

5.4.1. Case Study No. 1. West Vincent Township Sub-Basins 45 and 46, headwaters of Birch Run

This municipality is a key township in the Sustainable Watershed Management Program. It occupies a central position in the Watershed (with 97 % of the township in the drainage), forming the south side of the middle French Creek valley, and includes in its drainage one of the most pristine sub-basins in the entire study area. This small stream system, the Birch Run, is currently under consideration for classification as Exceptional Value (EV) waters by the PADEP. Extensive in area (11,161 acres or 17.4 square miles) and relatively unpopulated (2,700 within the drainage in 1996), West Vincent is coming under significant development pressures, as growth reaches north into the Watershed along Route 100. Public sewer and water lines are tapping on the eastern boundary with East Pikeland, and PSC is poised to extend water service from Upper Uwchlan to the Ludwigs Corner area and beyond, if the service incentive warrants it. Unfortunately, the headwaters of the Birch Run lie directly in the pathway of that growth pressure.

The current Land Use within the Township drainage totals 10, 926 acres, and is shown in Figure 5-4 and detailed in Tables 5-2 and 5-3. A significant portion of the township is currently in agricultural use (4,414 acres), and the vacant land amounts to 2,036 acres, providing a total of 6,440 acres of potentially developable land within the French Creek watershed. This land is distributed over all or portions of 35 sub-basins (Figure 5-5), most of which are zoned for low density residential, or AGRES, as shown in Tables 5-4 and 5-5. Of the developable lands, almost 95 percent is anticipated to

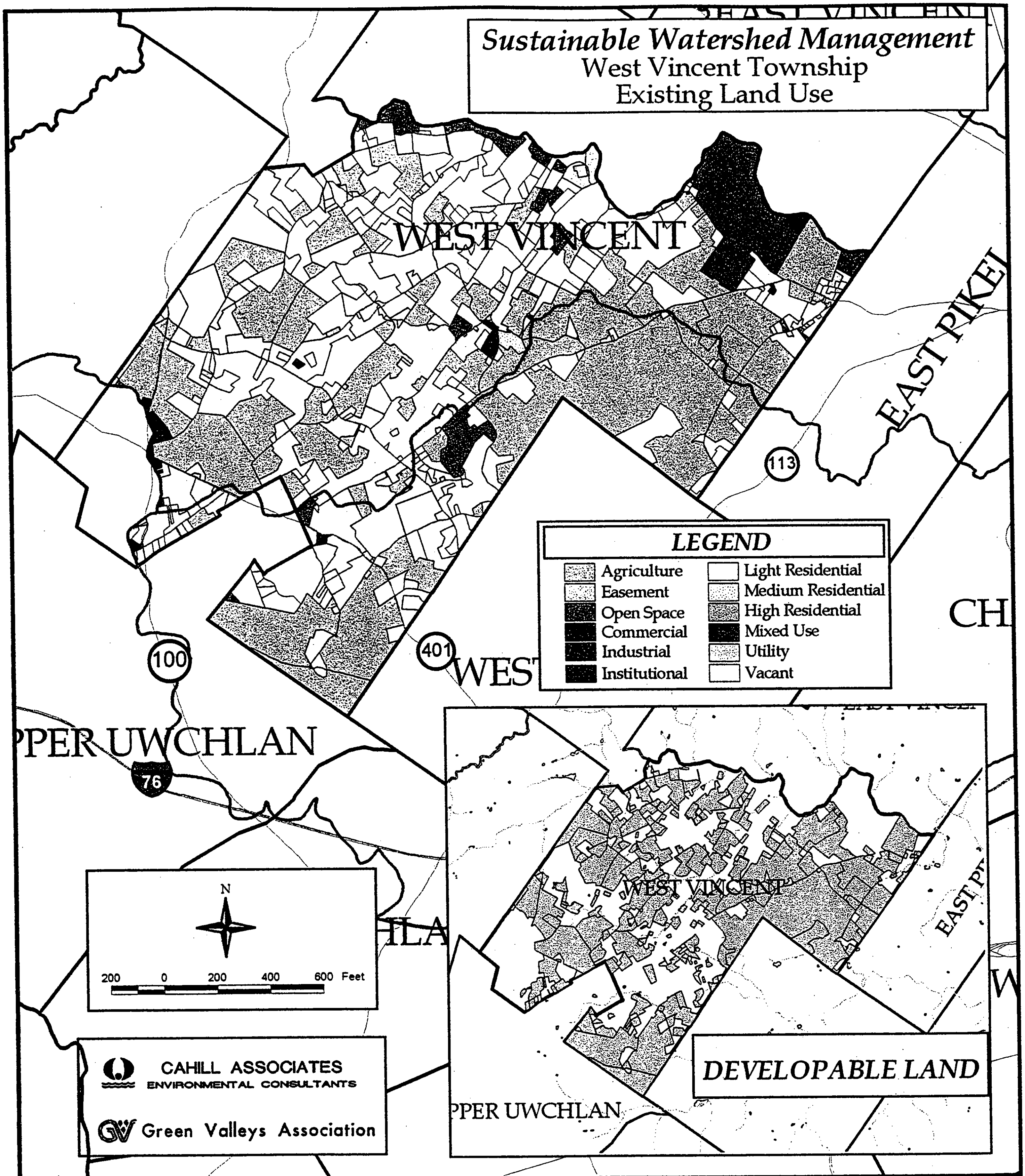

Figure 5-4 **West Vincent Township - Land Use and Developable Land**

USE	ACRES
AG	4,414
CO	66
EA	43
ID	4
IN	14
OS	718
RA	3,578
RB	47
RC	6
RD	10
UT	1
VA	2,026
TOTAL	10,926

Table 5-2 West Vincent Township - Existing Land Use Summary (Watershed only)

ZONING	DESCRIPTION	INTERPRETATION	ACRES
LI	Limited Commercial	COMM	93
M	Municipal	INST	8
MHP	Mobile Home Park	HRES	51
MHP(PCO)	Planned Commercial Overlay With	COMM	6
PC	Planned Commercial	COMM	14
R-2	Residential	AGRES	4,428
R-3	Residential	AGRES	3,377
RC	Rural Conservation	AGRES	2,252
RM(PRD)	Residential Mix With Planned Re	MRES	680
RV	Rural Village	VILL	18
TOTAL			10,926

Table 5-4 West Vincent Township - Zoning Summary

Watershed	AG	CO	EA	ID	IN	OS	RA	RB	RC	RD	UT	VA	TOTAL
21540039	66						101					100	267
21540040	42						108	2				83	235
21540110	61					60	172					92	385
21570008			0										0
21570041	51					6	198	1				125	381
21570042	60						64					20	143
21570043	227						124					80	431
21570044	78						26					63	167
21570045	345	31			4	1	292	0		3		106	782
21570046	244						66	1				36	347
21570047	38					10	114					37	198
21570048	40						5					107	152
21570049	187					150	69	0		0		55	462
21570115	12		24			45	71					91	243
21570116	234	16	19		4	99	458	22	1	0		233	1,086
21570119	57	1					229	1	1			164	452
21570120	244					2	495	2				99	843
21612004						0							0
21612050	347	2				4	77	15	4	6		74	529
21612111	106	11				245	18	0				8	389
21700066	362						24		1			13	399
21740065	94						20					0	115
21740131	1												1
21750063	76	4		4			62	0				90	236
21750064	13						98					44	155
21750127	7				6	14	157	1			1	35	220
21854056	226						5						231
21854057	207						5	1					212
21854058	438						45	0				72	556
21854059	38											21	59
21854060	107					16	20					14	157
21854061	28					67	113	1				47	256
21854062	14						59					1	73
21854122	231						37					26	294
21854126	134						245	0				91	471
TOTAL	4414	66	43		14	718	3578	47	6	10	1	2026	10,926

Table 5-3 West Vincent Township - Land Use by Sub-basin

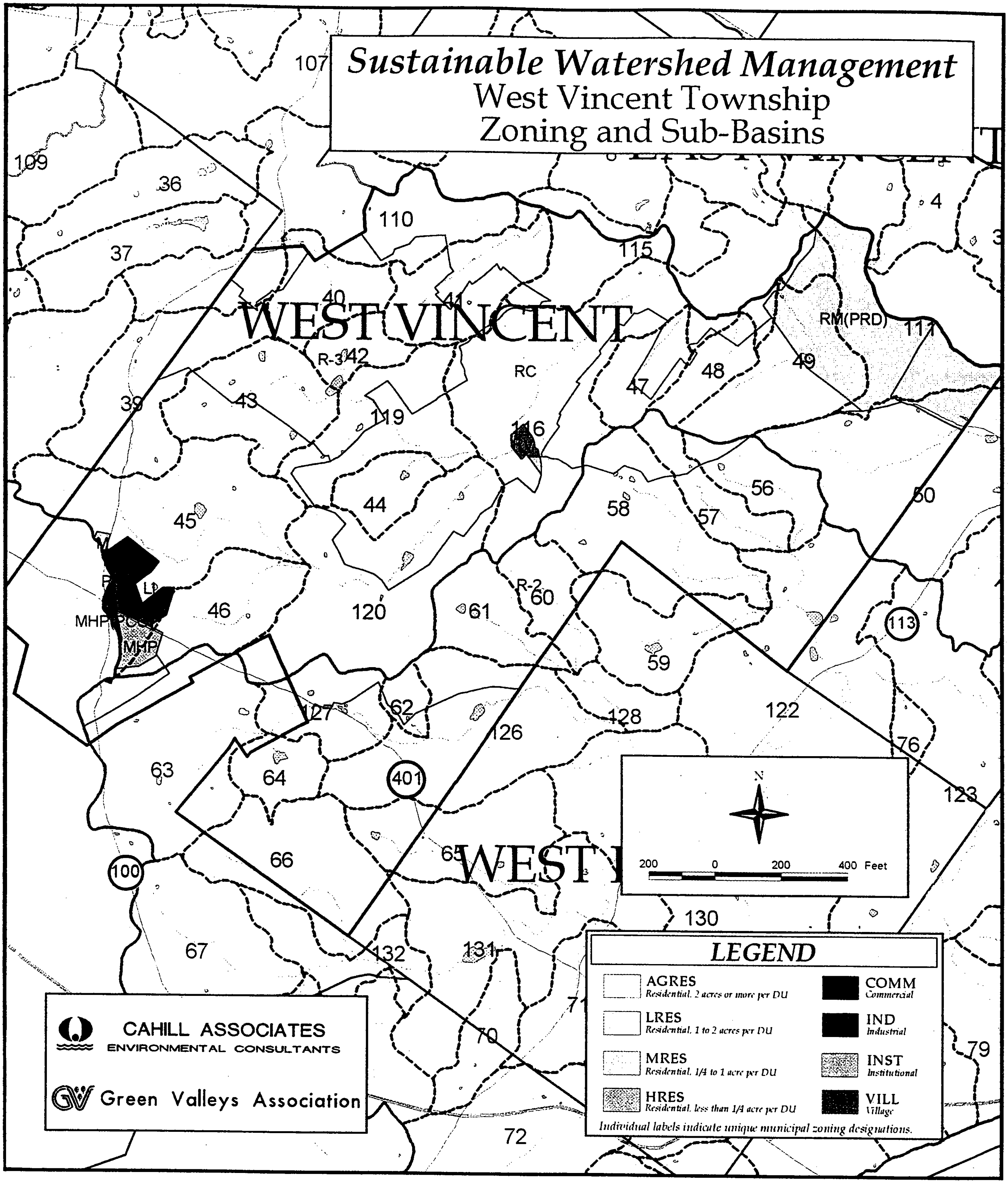

Figure 5-5 West Vincent Township - Zoning and Sub-basins

Watershed	AGRES	COMM	MRES	HRES	INST	VILL	TOTAL
21540039	166						166
21540040	125						125
21540110	153						153
21570008							0
21570041	175						175
21570042	80						80
21570043	307						307
21570044	141						141
21570045	345	81		25	1		425
21570046	261	2		17			263
21570047	75						75
21570048	147						147
21570049	189		53				242
21570115	103						103
21570116	456		4			7	460
21570119	220						220
21570120	343						343
21612004							0
21612050	389		33				421
21612111	4		111				114
21700066	375						375
21740065	94						94
21740131	1						1
21750063	166	1					166
21750064	57						57
21750127	42						42
21854056	226						226
21854057	207						207
21854058	511						511
21854059	59						59
21854060	121						121
21854061	74						74
21854062	14						14
21854122	257						257
21854126	226						226
TOTAL	6,107	84	201	41	1	7	6,440

Table 5-5 West Vincent Township - Developable Land by Zoning and Sub-basin

develop as low density residential. Of course, any landowner has the legal right to ask for a change in this Zoning criteria, which is exactly what one major property owner has done in the headwaters of Birch Run.

The location of the Upper Birch Run study area is shown in Figure 5-6 and illustrated in detail in Figure 5-7. It includes two first order streams which join to form a total drainage of 1,220 acres (1.9 square miles). The most significant existing development feature is the small crossroads community of Ludwigs Corner, at the intersection of Routes 401 and 100. The existing land use is shown in Figure 5-8, and the cross-hatched area covers a 309-acre holding currently under proposal for development, known as the Hamilton property. The current plan would modify the existing development criteria to allow a mix of higher density uses on a portion of the tract with the balance held in open space of one type or another.

Before we examine the implications and water resource impacts of that specific parcel, however, the build-out of existing zoning throughout the two sub-basins will be evaluated. Table 5-6 first considers the impact of full development of sub-basin 45, Birch Run, a sub-basin of 873 acres. The 119 EDUs which presently occupy this sub-basin presently use 35,790 GPD, and return 80 % of this to the groundwater in small septic systems. The build-out of the balance of the sub-basin would add 395 additional EDUs and withdraw an additional 118,500 GPD from the aquifer. The resultant loss experienced with individual septic systems serving this development would total 30,854 GPD, which is some 37% of the loss limit, set here at 50% of the Q 7-10. If a lower criteria were applied, then the result would be different.

The impact of effluent discharge to the groundwater, however, is very significant. The build-out loading of 16,906 pounds per year will increase the groundwater level well above the potable limit of 10 mg/l during dry periods, not even counting other sources of NO3-N.

In the other small tributary, Sub-basin 46, the story is much the same, as shown in Table 5-7. The build-out water loss, assuming on-site wastewater disposal, will not exceed the 50% limit, while the Nitrate load will more than double the safe allowable load to the groundwater. Thus the build-out scenario represents the potential for septage effluent to prevent the continued use of the aquifer for water supply.

5.4.1.1. Hamilton Tract - Ludwigs Corner Development

The 309-acre parcel shown as a hatched pattern in Figure 5-7 is currently under proposal to develop a mixed use project , as described in Table 5-8. While only some 85 acres of the parcel are to be actually developed, the 92,000 GPD water usage is equal to 306 DUs at 300 GPD, an equivalent zoning density of 1 DU/Acre. Considering only the tract acreage, the 309 acres should not have a consumptive loss of greater than 50% of the Q 7-10 flow of 192 GPD/acre, or 29,664 GPD. If the wastewater effluent were returned directly to the aquifer, this would not be a problem, but the

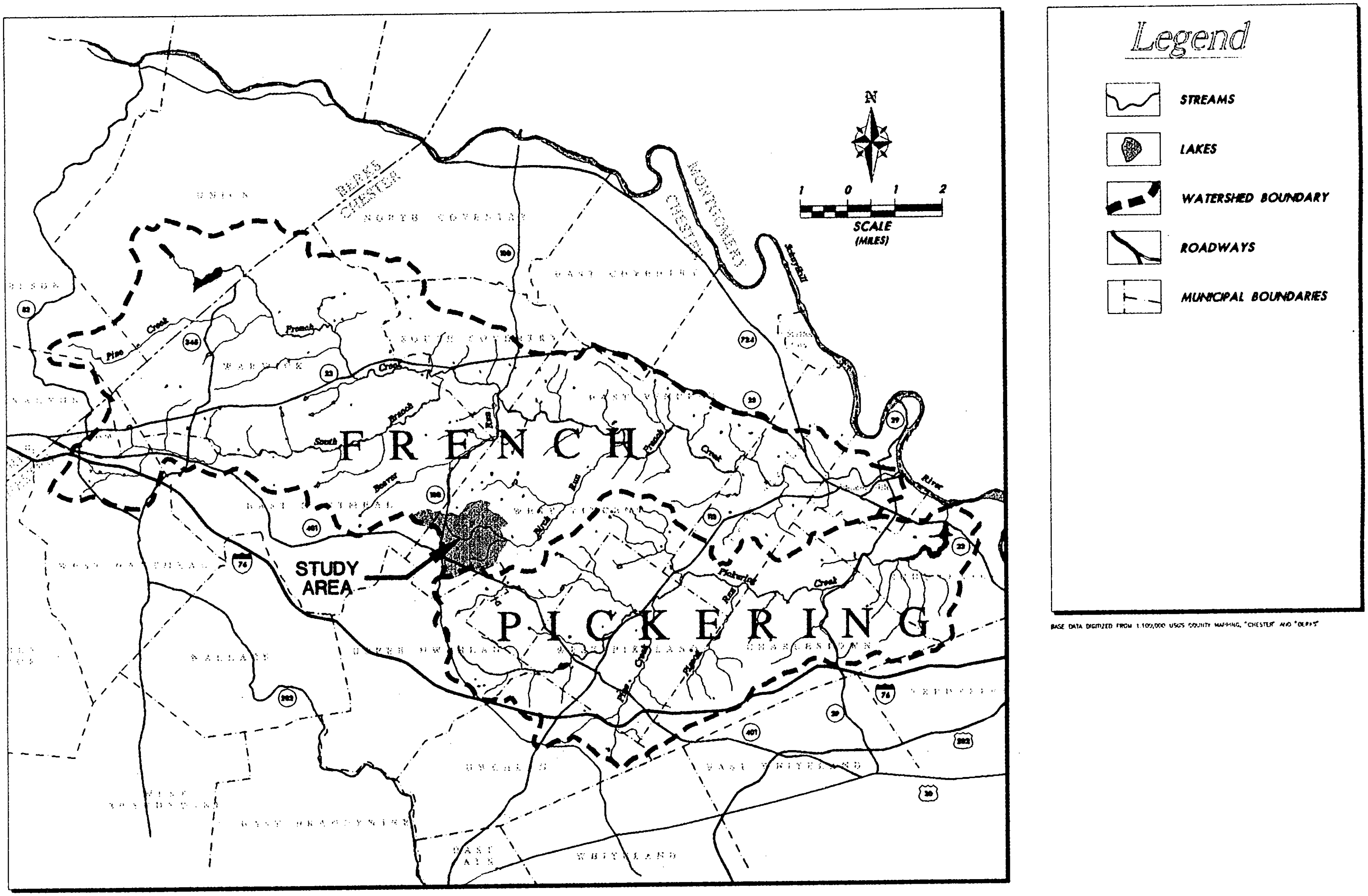

Figure 5-6 Location of Upper Birch Run Pilot Study Area

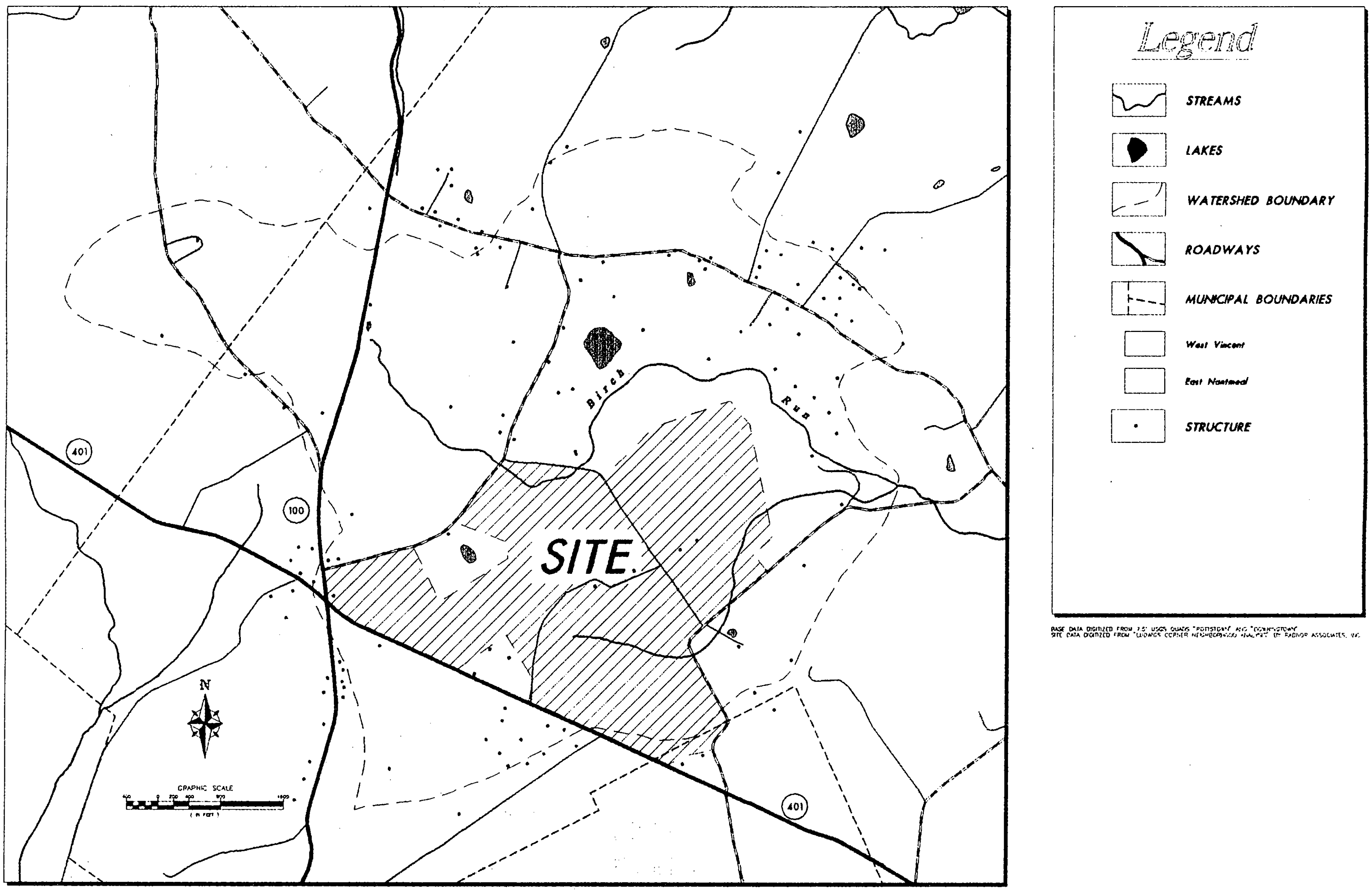

Figure 5-7 Upper Birch Run Pilot Study Area

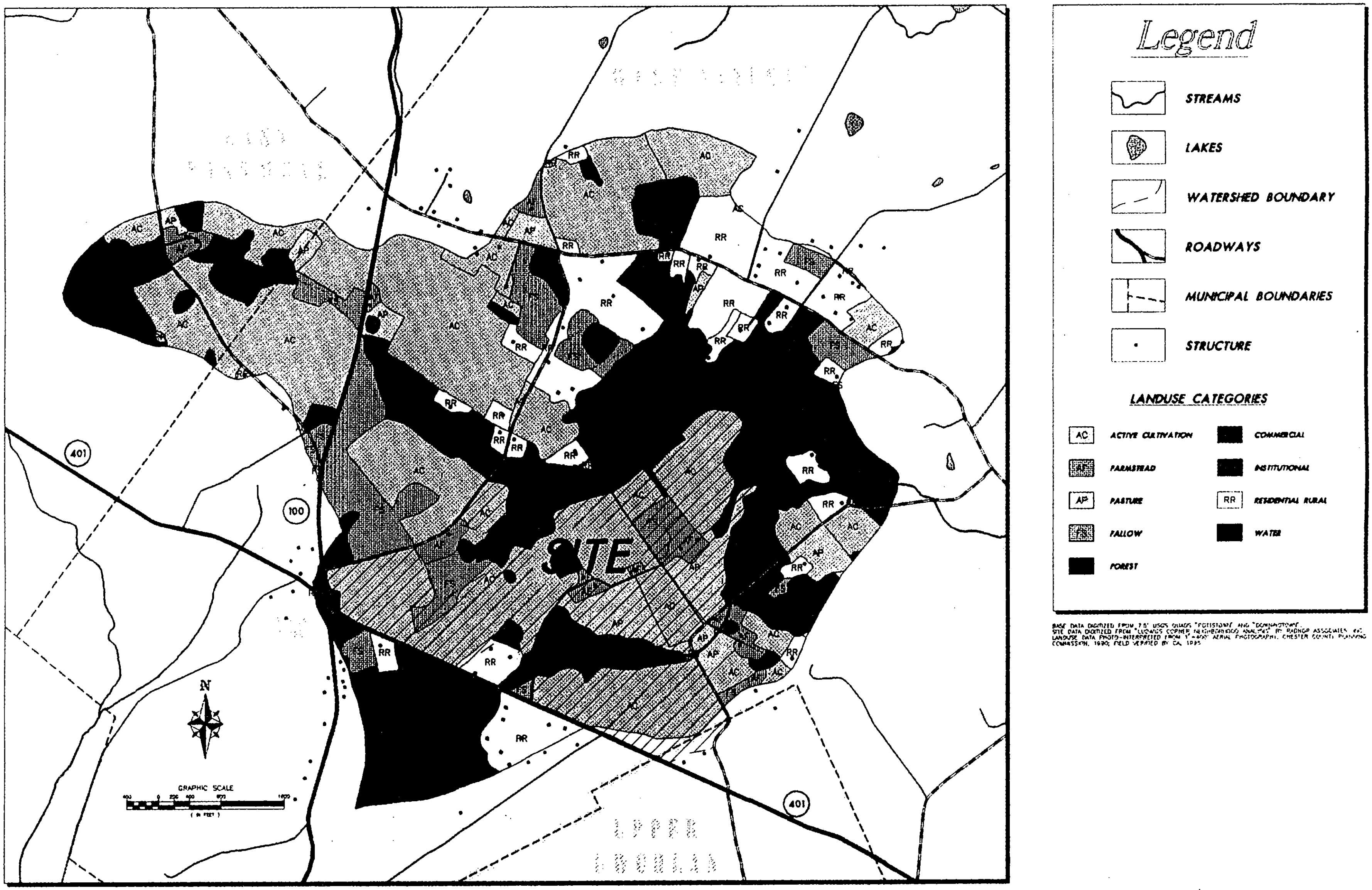

Figure 5-8 Existing Land Use in the Upper Birch Run Sub-basins

proposed development will utilize a spray system, a good idea but very water consumptive during summer months. In such operating periods, this effluent spray system can have evapotranspiration losses of 90% or more. This means that if this magnitude of loss takes place for several months during the dry year(10-year frequency), then 90% of the 82,800 GPD, or 74,520 GPD of the applied wastewater will be lost, far in excess of the proposed limit of 29,664 GPD. In effect, the withdrawal will dry up the stream elements which are totally within the parcel.

But what about the watershed in general? Some 700 acres of developable land remain in the 1,220 -acre watershed, exclusive of the Hamilton tract. Most of this remaining developable land is zoned residential (R-2 or AR), with about 49 acres in potential high density (MHP). This remaining vacant land is assumed to develop at build-out at an average of 1 DU per 2 acres in the R-2 and AR (650 acres) and 5 DU/acre for the MHP (49 acres). The estimated build-out is 325 + 245 DUs, using 300 GPD/DU in the single family and 250 GPD/DU in the high density residential. The future additional groundwater use is about 160,000 GPD.

Thus the total additional groundwater demand including both Hamilton and other future use is 92,000 GPD + 160,000 GPD = 260,000 GPD, as compared to 182,728 GPD used in the model run.

The total future water use in the watershed, including Hamilton, amounts to some 295,000 GPD. If we use the "50% base flow" criteria, we should not exceed a total consumptive loss in excess of 117,102 GPD during dry flow periods. The existing and future residential outside of Hamilton will account for 8,738 GPD (existing) plus 32,000 GPD (future), or a total of 40,738 GPD. The Hamilton system, however, will fail to recharge about 90% of its water usage during dry months of a drought, and lose about 75,000 GPD, for a total of 116,000 GPD. Thus the overall watershed criteria for base flow maintenance will be in compliance for this drought.

As for Nitrate, the Hamilton system will do a much more efficient removal of this pollutant before groundwater recharge, assumed to be an annual average of 60%, with a resultant mass input of 4,931 Lbs/Yr. to the groundwater. When added to the 4,788 Lbs/yr from existing development and the 17,450 Lbs/yr from other future development, the total loading will exceed the limit of 13,219 Lbs/yr established by the WBM. Thus the watershed is at risk from Nitrate contamination, but more so from future development than the Hamilton Development.

Drainage Area:	**873 Acres, 1.36 Square Miles**
Existing Dwelling Units:	119 EDUs
Existing Water Use:	35,790 GPD (@ 300 GPD/EDU)
Depletive Use (20%):	7,158 GPD
Drought Yield (flow):	167,597 GPD (Q 7-10) @ 192 GPD/Acre
Proposed Loss Limit #1:	16,760 GPD (10% Depletive Loss)
Proposed Loss Limit #2:	83,799 GPD (50% Depletive Loss)
Dry Year Yield (flow):	388,442 GPD (Q 365-10) @ 445 GPD/Acre
Future Adtl. DUs:	395 EDUs
Future Adtl Water:	118,500 GPD
Total Future Water:	154,269 GPD
Future Loss (@ 20%):	**30,854 GPD (Exceeds 16,760 GPD, Does not Exc. 83,799 GPD)**
Existing Wastewater:	10.45 MG/Yr.
Ex. Nitrate Load:	3,922 Lb/Yr.
Dry Year GW:	142 MG/Yr.
Allow. NO3:	9,460 Lb/Yr. (With 2 mg/l background)
Future WW:	45 MGY
Future Load NO3:	**16,906 Lb/Yr. (Exceeds 9,460 Lb/Yr.)**

Table 5-6 Water Balance Model Analysis of Sub-basin 45, Upper Birch Run

Drainage Area:	**347 Acres, 0.54 Square Miles**
Existing Dwelling Units:	26 EDUs
Existing Water Use:	7,899 GPD
Depletive Use (20%):	1,580 GPD
Drought Yield (flow):	66,605 GPD (Q 7-10) @ 192 GPD/Acre
Proposed Loss Limit #1:	6,661 GPD (10% Depletive Loss)
Proposed Loss Limit #2:	33,303 GPD (50% Depletive Loss)
Dry Year Yield (flow):	154,371 GPD (Q 365-10) @ 445 GPD/Acre
Future Adtl. Dus:	214 EDUs
Future Adtl Water:	64,249 GPD
Total Future Water:	72,148 GPD
Future Loss (@ 20%):	**14,430 GPD (Exceeds 6,661 GPD, Does not Exc. 33,303 GPD)**
Existing Wastewater:	2.31 MG/Yr.
Ex. Nitrate Load:	866 Lb/Yr.
Dry Year GW:	56 MG/Yr.
Allow. NO3:	3,759 Lb/Yr. (With 2 mg/l background)
Future WW:	21 MGY
Future Load NO3:	**7,907 Lb/Yr. (Exceeds 3,759 Lb/Yr.)**

Table 5-7 Water Balance Model Analysis of Sub-basin 46, Upper Birch Run Tributary

Total Area: 309 Acres			
Proposed Use:	Developed Parcels		
		Planned Commercial:	30 Acres
		Cont. Care Facility:	23 Acres
		Office:	
		Retirement Community:	<u>32 Acres</u>
		Sub-Total:	85 Acres
		Open Space (farm):	87 Acres
		Open Space (Ret.)	77 Acres
		Township:	<u>60 Acres</u>
		Total:	309 Acres

Total Water Use: 92,000 GPD
Total Wastewater: 82,800 GPD (Assumes 10% Loss)
Wastewater Recharge Rate, Average Annual: 49,680 GPD (60%)
" " " Dry Period (2 mos.) 8,280 GPD (10%)

Nitrate Load: Average Annual:
(0.0828 MGD)(45 mg/l)(8.34)(0.4 -60% NO_3 removal)(365)
= 4,537 Pounds/Year - NO3-N

Spray Application Reduction of NO_3-N - Annual Average of 50 to 60%

Table 5-8 Hamilton Tract Water Balance Analysis

5.4.1.2.Stormwater Impact

The Hamilton Tract will create about 39 acres of new impervious surface, preventing the infiltration of about 37" of rainfall in an average year, some 15" of which would currently find its way into the groundwater and reappear as base flow. More importantly, a unit area which now produces runoff of 9" per year will produce total runoff of all rainfall, or an increase of over 3 feet of water for each of the 39 new impervious acres, for a total of 5.1 million cubic feet (117 acre-ft) of additional runoff. This stormwater will carry with it tons of nutrients, synthetic organics, metals and petroleum hydrocarbons, scoured from the landscape of both pervious and impervious surfaces. The WBM developed an estimate of these NPS pollutant loads in the sub-basins under future build-out, but did not include the changes proposed for the Hamilton Tract, which will increase these loads. A set of five conventional detention basins, as proposed by the developer, will remove a small portion of this load, but most of these materials will find their way into Birch Run.

It is possible to design recharge systems for the parcel, especially given the good soils which underlie the planned development areas. Such systems could provide recharge

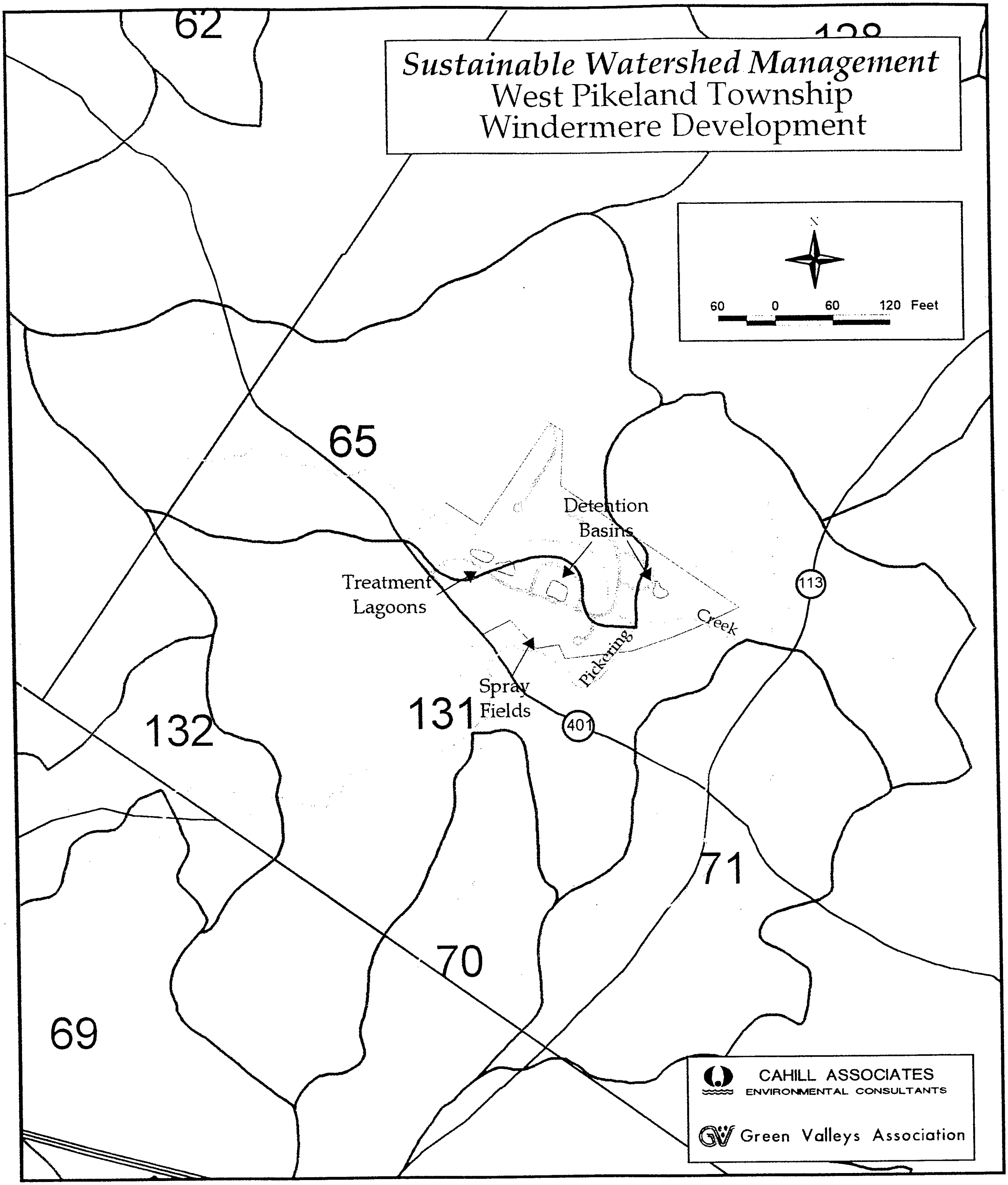

Figure 5-16 West Pikeland Township - Windermere Development
Sub-basins 65 and 131

SBARBARO TRACT "WINDERMERE" - North side of Route 401 and Byers Road

Proposed Development Plan (Consultant data)

128.3 Acre parcel, 80 lots at 3.5 residents per dwelling unit

Water Use - 19,600 GPD, based on 280 residents at 70 GPCD, or 245 GPD/ DU

Development Analysis - Situated primarily in Sub-basin 65, with portion in Sub-basin 131. The proposed development would import 19, 600 GPD. If all of the development were within WS 65, it would reduce the future demand estimate by (80 DU)(300 GPD/DU) = 24,000 GPD. The wastewater applied to the land would be a net addition to the water balance. The land application area, however, is in the adjacent watershed 131.

The system used would produce significant evapotranspirative losses, especially during the summer months, when then would approach 90%. If we assume an 80% return of effluent (19,200 GPD) with 50% loss for 9 months and 90% loss for 3 months (average loss of 60%), we will return (19,200 GPD)(0.6)(365) = 4.2 MGY. This should be added to basin 131.

The supplemental base flow would average 11,520 GPD, but given the high loss during drought periods would probably not have much of an effect on augmenting the Q 7-10 low flow in SB 131. We could also consider this as added to the Dry Year GW volume, with an average Nitrate concentration of about 10 mg/l (this would vary greatly over the season).

Stormwater Impacts

Development statistics: 128 Acres Gross, 42 Acres of developed parcels, 71 Acres of "open space", 1.47 Acres of sewage lagoons, 2.07 Acres of Stormwater facilities, 11 Acres of ROW

Assume DU footprint of 35' x 65' = 2,275 SF, allow 2,500 SF/DU of impervious surface plus driveways (10' x 60') = 600 SF, or 3,100 SF per DU; 3,100 SF x 80 DU = 248,000 SF plus 11 Acres of ROW at 50% impervious = 239,580 SF; TOTAL = 487,580 SF, use 488,000

This impervious surface will intercept an average of 45" rainfall and prevent groundwater recharge of 15" in an avg. year. Total GW loss is (15/12 ft/yr)(488000 SF)(7.48 gal/CF) = 4.56 MGY. More importantly, this new impervious surface will increase runoff from the same surfaces from 9 inches per year to 45 inches per year, scouring from the surface a mix of pollutants into the drainage. These "nonpoint" source (NPS) pollutants will be produced on both the impervious surfaces and the lawnscapes created with the new dwelling units. The most sensitive pollutant in terms of downstream water quality is Phosphorus, since all of the runoff is transported into the Pickering Reservoir (from which a portion of the PSC supply is drawn). Other pollutants (Organics, applied chemicals, petroleum hydrocarbons) will add to this load.

Table 5-29 West Pikeland Township - Windermere Water Budget

Sub-basin 65 Statistics
First Order tributary of Pickering Creek
511 Acres, or 0.80 Square Miles
Existing Water Use - 10,515 GPD
Depletive Use - (20%) 2,103 GPD
Watershed Q7-10 (192 GPD/Acre) - 98,031 GPD
Proposed GW Limit (50% of Q 7-10) -49,015 GPD
Dry Year Average Base Flow - 227, 208 GPD
Existing Wastewater - 3.07 MGY
Existing Nitrate Load - 1,152 #/Year
Dry Year Groundwater Volume - 82.93 MG/Year
Dry Year Allowable Nitrate Load (with 2 mg/l background) - 5,533 #/Yr
Future Additional Water Demand - 61,565 GPD ,about 205 single family dwelling units
Total Future Water Demand - 72,080 GPD
Evaporative Loss (Assumes on-site at 20%) - 14,416 GPD
Therefore future evaporative loss does not exceed 50% of Q 7-10
Future Wastewater - 21 MG/Year
Future Nitrate Load - 7,899 #/Year
Therefore future groundwater Nitrate concentration would exceed 10 mg/l

Sub-basin 131 Statistics
Main channel of Pickering Creek
811 Acres, or 1.27 Square Miles
Existing Water Use - 48,603 GPD
Depletive Use - (20%) - 9,721 GPD
Watershed Q7-10 (192 GPD/Acre) - 155,768 GPD
Proposed GW Limit (50% of Q 7-10) - 77,884 GPD
Dry Year Average Base Flow - 361,024 GPD
Existing Wastewater - 14.19 MGY
Existing Nitrate Load - 5,326 #/Year
Dry Year Groundwater Volume - 131.77 MG/Year
Dry Year Allowable Nitrate Load (with 2 mg/l background) - 8,792 #/Yr
Future Additional Water Demand - 94,451 GPD (about 315 single family dwelling units)
Total Future Water Demand - 143, 054 GPD
Evaporative Loss (Assumes on-site at 20%) - 28,611 GPD
Therefore future evaporative loss does not exceed 50% of Q 7-10
]
Future Wastewater - 42 MG/Year
Future Nitrate Load - 15,677 #/Year
Therefore future groundwater Nitrate concentration would exceed 10 mg/l

Table 5-30 Water Budget Analysis for Sub-basins 65 and 131.

Since the headwaters of this sub-basin are served by both public and sewer, it is not highlighted as an impacted watershed. However, the logic of extending water and sewer service down the full length of this stream channel is a critical issue, and one which warrants full consideration by WPT in the context of watershed development. In simple terms, where should the plumbing be terminated.

5.4.6. Case Study No. 6 Schuylkill Township Sub-basin 2. Unnamed Tributary to Pickering Creek Reservoir

To more or less complete the Pickering Creek watershed, it is appropriate to consider the rapidly urbanizing area around the south side of Phoenixville in Schuylkill Township, much of which drains directly to the Pickering Reservoir. With the location of both the regional wastewater system (Valley Forge Municipal Authority) and the regional water system (PSC) situated in the township's back yard, it would be reasonable to assume that these systems would be extended to serve both existing and future development. This is not entirely true in either case, but it is certainly true for most of the more developed portions of the municipality. The recent report *"Water Resources Use and Service in Chester County"* (CCPC, 1996) states that 68% of the 2,115 dwelling units in the Township are served by public water systems (this data is from 1991). Sewer service is equally extensive, but a portion of the township remains with individual wells and on-site septic systems.

The prior examples of water balance in Sub-Basins 84 (Table 5-22) and 85 (Table 5-23) also serve as useful examples in Schuylkill Township. Figure 5-17 illustrates the Existing Land Use in the township, and Figure 5-18 shows the Zoning and sub-basins, which are detailed somewhat differently in Table 5-31. Here each of the 9 sub-basins are broken out by their Existing Land Use and corresponding water use, and Table 5-32 evaluates the remaining developable parcels in each sub-basin and estimates the additional water demand. However, the more interesting aspects of this municipality are the potential impacts of stormwater in the various watersheds. To fully appreciate this, the future stormwater runoff volume is also shown in Table 5-32 based on the new impervious cover anticipated. In the second part of the table, the NPS generation from the future land use classes is estimated, based on the runoff concentrations for selected pollutants. Most of this additional pollution load will wind up in the Pickering Reservoir, if BMPs are not utilized with the new development. The message here is a warning of additional water quality degradation without land use management, going well beyond the "business as usual" development attitude.

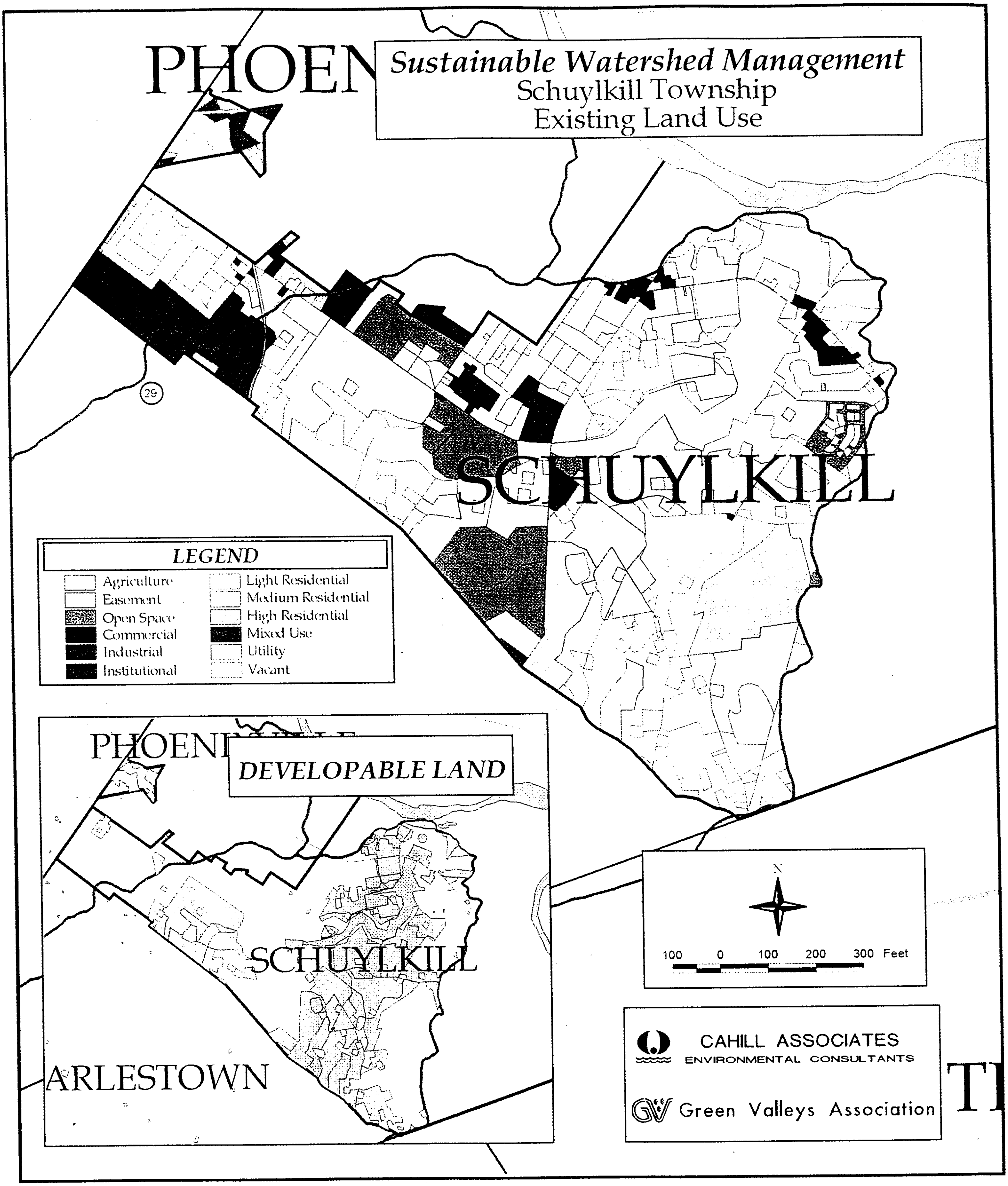

Figure 5-17 Schuylkill Township - Land Use and Developable Land

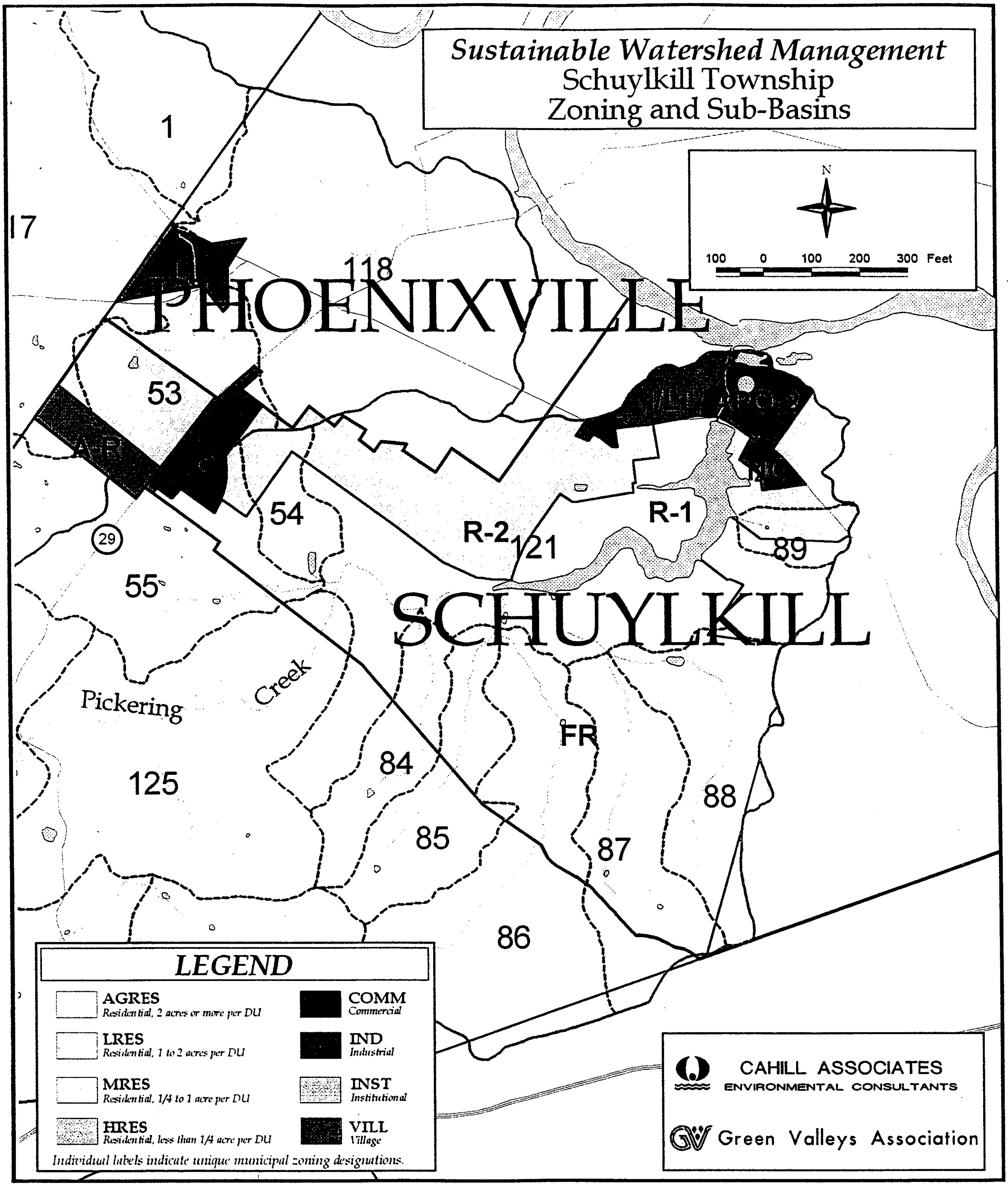

Figure 5-18 Schuylkill Township - Zoning and Sub-basins

Hydro Code	Land Use Code	Polygon Area	Area	Area	Sub-basin Total	Equiv Use DUs/Acre	Estm. DUs	Water Use @300 GPD/DU	SB Water Use	Q 7-10 192 GPD/AC
		Sq. Ft.	Acres	Sq. Mi.	Sq. Mi.		DUs	GPD	GPD	GPD
21000054	AG	2,933,607	67	0.11		0.02	1.35	404		
21000054	IN	406,511	9	0.01		0.1	0.93	280		
21000054	RA	612,078	14	0.02		0.3	4.22	1,265		
21000054	RB	1,268,832	29	0.05		1.5	43.69	13,108		
21000054	RC	62,421	1	0		3	4.3	1,290		
21000054	RD	103,825	2	0		5	11.92	3,575		
21000054	VA	687,062	16	0.02	0.22	0	0	0	19,921	26,774
21000055	AG	3,331,958	76	0.12		0.02	1.53	459		
21000055	CO	103,673	2	0		0.2	0.48	143		
21000055	IN	2,853,429	66	0.1		0.1	6.55	1,965		
21000055	OS	184,364	4	0.01		0	0	0		
21000055	RA	6,908,188	159	0.25		0.3	47.58	14,273		
21000055	RB	2,611,982	60	0.09		1.5	89.94	26,983		
21000055	RC	1,403,380	32	0.05		3	96.65	28,995		
21000055	UT	266,482	6	0.01		0	0	0		
21000055	VA	4,785,681	110	0.17	0.81	0	0	0	72,819	98,949
21000084	AG	1,376,768	32	0.05		0.02	0.63	190		
21000084	OS	1,923,882	44	0.07		0	0	0		
21000084	RA	1,963,982	45	0.07		0.3	13.53	4,058		
21000084	VA	4,116,159	94	0.15	0.34	0	0	0	4,247	41,348
21000085	AG	2,737,211	63	0.1		0.02	1.26	377		
21000085	CO	75,644	2	0		0.2	0.35	104		
21000085	OS	5,411,154	124	0.19		0	0	0		
21000085	RA	2,344,921	54	0.08		0.3	16.15	4,845		
21000085	VA	3,326,148	76	0.12	0.5	0	0	0	5,326	61,246
21000086	AG	8,742,237	201	0.31		0.02	4.01	1,204		
21000086	CO	67,527	2	0		0.2	0.31	93		
21000086	IN	193,795	4	0.01		0.1	0.44	133		
21000086	OS	678,876	16	0.02		0	0	0		
21000086	RA	9,538,506	219	0.34		0.3	65.69	19,708		
21000086	RC	27,097	1	0		3	1.87	560		
21000086	VA	14,558,550	334	0.52	0.9	0	0	0	21,698	110,476
21000087	AG	2,808,834	64	0.1		0.02	1.29	387		
21000087	RA	6,849,615	157	0.25		0.3	47.17	14,152		
21000087	RB	33,997	1	0		1.5	1.17	351		
21000087	RC	1,114,642	26	0.04		3	76.77	23,030		
21000087	VA	7,727,390	177	0.28	0.66	0	0	0	37,920	81,695
21000088	AG	380,505	9	0.01		0.02	0.17	52		
21000088	IN	27,346	1	0		0.1	0.06	19		
21000088	OS	92,757	2	0		0	0	0		
21000088	RA	2,777,269	64	0.1		0.3	19.13	5,738		
21000088	RB	4,275,375	98	0.15		1.5	147.22	44,167		
21000088	RC	4,722,644	108	0.17		3	325.25	97,575		
21000088	UT	37,358	1	0		0	0	0		
21000088	VA	4,532,214	104	0.16	0.6	0	0	0	147,552	74,250
21000089	AG	504,069	12	0.02		0.02	0.23	69		
21000089	CO	41,140	1	0		0.2	0.19	57		
21000089	OS	301,949	7	0.01		0	0	0		
21000089	RA	1,738,229	40	0.06		0.3	11.97	3,591		
21000089	RB	831,845	19	0.03		1.5	28.64	8,593		
21000089	UT	56,392	1	0		0	0	0		
21000089	VA	104,497	2	0	0.13	0	0	0	12,311	15,771
21000121	AG	14,276,450	328	0.51		0.02	6.55	1,966		
21000121	CO	1,637,088	38	0.06		0.2	7.52	2,255		
21000121	IN	3,328,805	76	0.12		0.1	7.64	2,293		
21000121	OS	6,308,759	145	0.23		0	0	0		
21000121	RA	13,154,000	302	0.47		0.3	90.59	27,178		
21000121	RB	12,199,470	280	0.44		1.5	420.09	126,028		
21000121	RC	5,753,929	132	0.21		3	396.28	118,883		
21000121	UT	10,399,580	239	0.37		0	0	0		
21000121	VA	13,301,610	305	0.48	2.88	0	0	0	278,602	354,202

Table 5-31 Schuylkill Township
Sub-basins by Existing Land Use and Water Use

		Developable area by Watershed and Zoning (Includes both vacant and agricultural)			Equiv. Dus Per Acre	WATER S Equiv. Dus	Water Use at 300 GPD/DU	Sub-basin Totals	Stormwater Imperv. Cover	Imperv. Cover
FREQ	Sub Wshd	Zoning	AREA (SF)	AREA (AC)		DUs	GPD	GPD	Factor	Acres
4	21000054	AGRES	3,604,207	82.74	0.5	41.37	12,411		0.04	3.31
1	21000054	MRES	16,461	0.38	2	0.76	227	12,638	0.15	0.06
11	21000055	AGRES	3,190,100	73.23	0.5	36.62	10,985		0.04	2.93
1	21000055	COMM	6,356	0.15	0.4	0.06	18		0.60	0.09
2	21000055	LRES	26,139	0.60	0.75	0.45	135		0.08	0.05
11	21000055	MRES	4,895,020	112.37	2	224.75	67,425	78,562	0.15	16.86
11	21000084	AGRES	5,492,918	126.10	0.5	63.05	18,915	18,915	0.04	5.04
12	21000085	AGRES	6,063,370	139.20	0.5	69.60	20,879	20,879	0.04	5.57
25	21000086	AGRES	23,301,340	534.93	0.5	267.46	80,239	80,239	0.04	21.40
19	21000087	AGRES	10,506,910	241.21	0.5	120.60	36,181		0.04	9.65
1	21000087	LRES	29,313	0.67	0.75	0.50	151	36,332	0.08	0.05
11	21000088	AGRES	4,714,179	108.22	0.5	54.11	16,233		0.04	4.33
5	21000088	LRES	199,167	4.57	0.75	3.43	1,029	17,262	0.08	0.37
2	21000089	LRES	537,526	12.34	0.75	9.25	2,776		0.08	0.99
5	21000089	MRES	71,022	1.63	2	3.26	978	3,755	0.15	0.24
25	21000121	AGRES	14,843,470	340.76	0.5	170.38	51,114		0.04	13.63
10	21000121	COMM	1,581,619	36.31	0.4	14.52	4,357		0.6	21.79
9	21000121	IND	2,370,348	54.42	0.5	27.21	8,162		0.7	38.09
24	21000121	LRES	7,122,627	163.51	0.75	122.63	36,790		0.08	13.08
17	21000121	MRES	1,660,514	38.12	2	76.24	22,872	123,296	0.15	5.72

Table 5-32 Schuylkill Township - Sub-basins by Zoning, Future Water Use, Stormwater Runoff and Future NPS Load

5.4.7. Case Study No. 7 East Nantmeal Township Sub-basin 38 - Beaver Run tributary of French Creek

The upper portions of the French Creek are fairly undeveloped, although the South Branch has extensive land presently in agricultural use. The Township of East Nantmeal reflects this Existing Land Use (Figure 5-19) in the roughly half of the township which lies in the French Creek, with the balance in the headwaters of the adjacent Brandywine Creek to the south. The Zoning (Figure 5-20) is predominantly large lot residential, but the option exists for application of TDR in the township, based on a fairly complex set of conditions. Table 5-33 summarizes the Existing Land Use, and Table 5-34 details this by sub-basin. Note the significant amount of land under protective easement of one kind or another (1,362 acres) with an additional 494 acres in open space. Only 862 acres are presently in residential development, some 15% of the watershed (9 square miles). Table 5-35 is the Zoning composition, and Table 5-36 breaks out the Developable lands by Zoning and Sub-basin. Virtually all of the developable parcels are zoned for low density residential (AGRES or LRES). There is no public water or sewer, and little likelihood of either one within any of the sub-basins.

Thus the analysis of future development impact on water resources is fairly straightforward. The WBM analysis is illustrated by consideration of one fairly large sub-basin (almost 2 square miles), the headwaters of Beaver Run, a tributary of the South Branch French Creek. Table 5-37 documents the results of build-out on water resources in this Sub-basin 38. The additional consumptive use will not exceed the 50% of Q 7-10 flow at build-out, but the Nitrate will significantly exceed the water quality limit if the pattern of individual wells and on-site septage are continued. Also calculated is the NPS pollutant load resulting from the new development. This figure does not consider the existing NPS load, which at present is comprised largely of agricultural pollutants. These would be replaced by the new development inputs at build-out.

GVA CODE	Acres
AG	2,357
CO	14
EA	1,362
IN	12
OS	494
RA	831
RB	13
RC	1
RD	17
UT	115
VA	568
TOTAL	5,786

Table 5-33 East Nantmeal Township - Existing Land Use Summary

Watershed	AGRES	LRES	COMM	INST	IND	TOTAL
21400029		46			45	91
21400032		0				
21400033	77					77
21400034	312					312
21400035	143					143
21400112	184					184
21400113	106	63	8		52	229
21400114	145			1		146
21500109	131			0		131
21540036	156			1		157
21540037	140	22		3		165
21540038	726	177	7	13		923
21540039	43	98	75			215
21540107	1			2		3
21540110	34	14	10			58
21570045	3	88				91
TOTAL	2201	507	100	19	98	2925

Table 5-34 East Nantmeal Township - Existing Land Use by Sub-basins

Watershed	AG	RA	RB	RC	RD	VA	EA	OS	UT	IN	CO
21400028								13			
21400029	91					0					
21400032	0	5									
21400033	61	12				17	104				
21400034	186	6				126	351	0	10		
21400035	130	5	1		0	13	5		20		
21400112	172	2				12	234	70	4		
21400113	169	205	2	0	8	60	26	129			3
21400114	119	37			1	26	455			7	
21500109	63	131	2		1	68	45	16	1		
21540036	149	60	1			8	41	29	44		
21540037	149	52				16		127			
21540038	786	148	7		3	137	58	94	27	1	3
21540039	157	60	1		3	58		3			3
21540107	3	0			1		23	1	9	4	
21540110	36	108		1		22	20	12			5

Table 5-35 East Nantmeal Township - Zoning Summary

ZONING	GVA CODE	AREA
AP	AGRES	2,201
C	COMM	100
IA/1	IND	98
E/I	INST	19
AR	LRES	507
TOTAL		2,925

Table 5-36 East Nantmeal Township
Developable Land by Zoning and Sub-basin

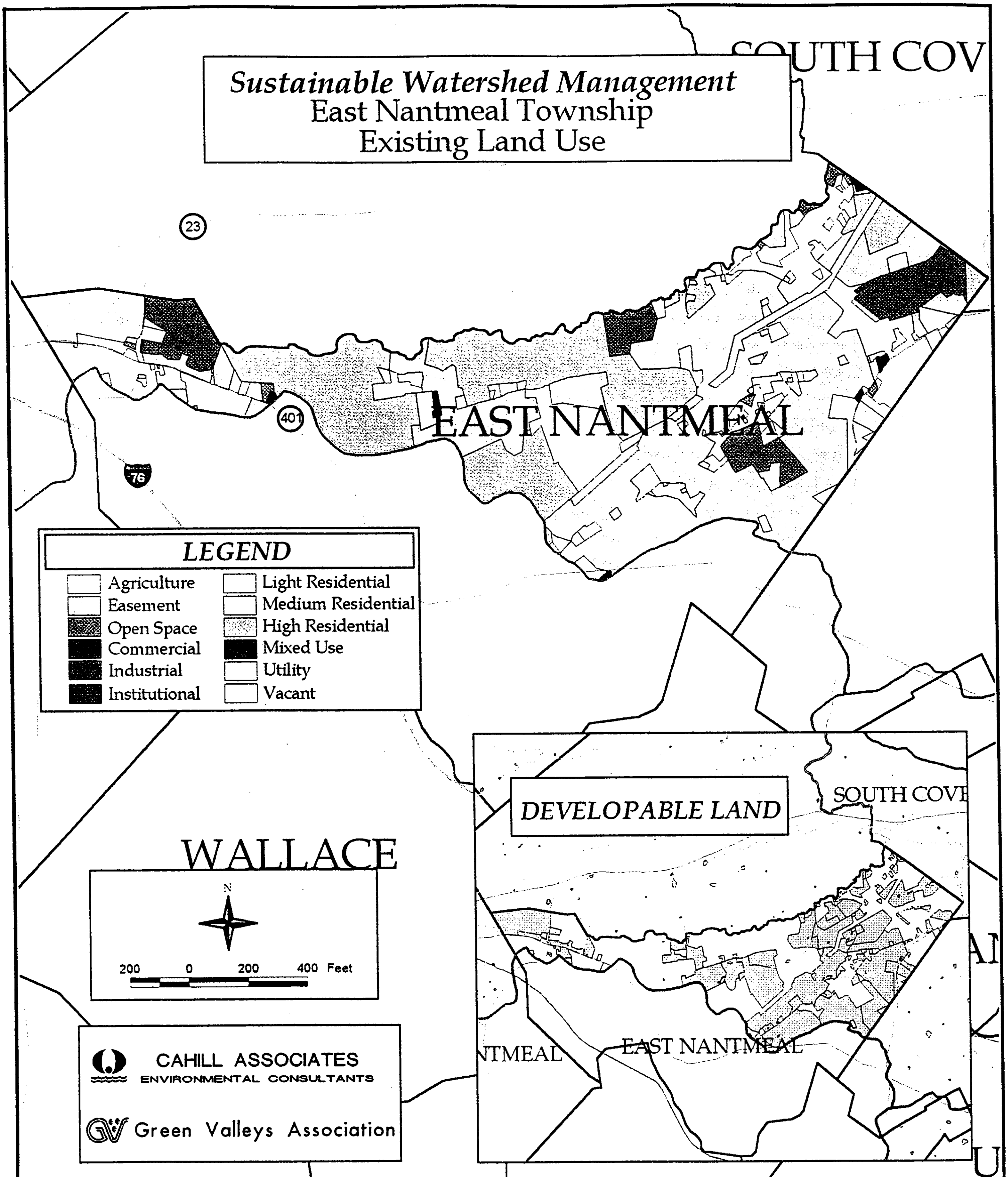

Figure 5-19 East Nantmeal Township - Existing Land Use and Developable Land

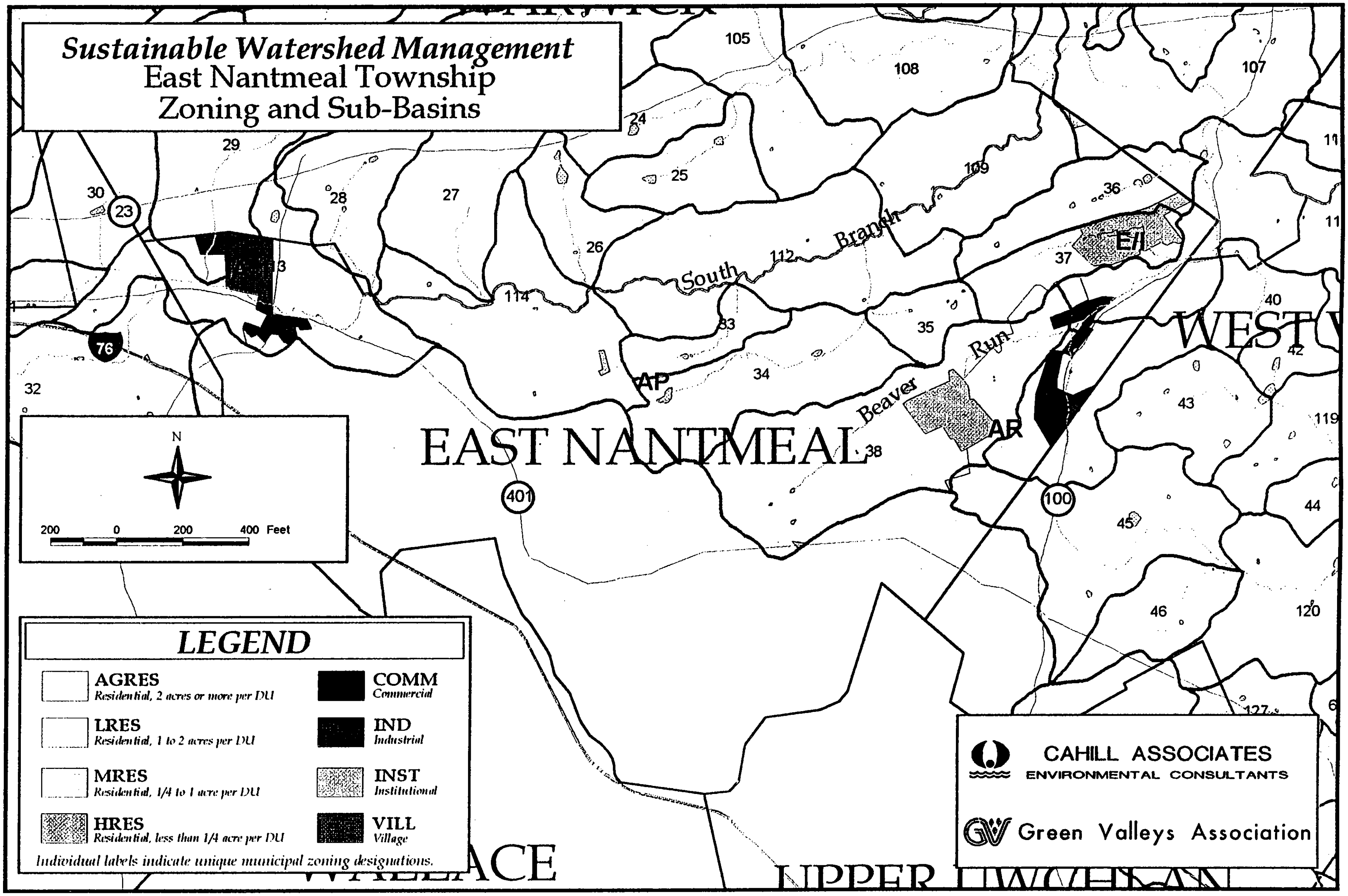

Figure 5-20 East Nantmeal Township - Zoning and Sub-basins

Watershed: 1,263 Acres, 1.97 Square Miles

Existing Water Use (@ 300 GPD/DU) = 25,904 GPD (86+ DUs)

Depletive Use (@ 60 GPD/DU) = 5,181 GPD

Base Flow (Q 7-10) = 242,496 G PD (@ 192 GPD/Acre)

Depletive Loss Limit (50% of Q 7-10) = 121,248 GPD

Dry Year Average Base Flow (@ 445 GPD/AC) = 562,035 GPD

Existing Wastewater Flow = 7.56 MG/yr

Existing Nitrate Load = 2,839 lb/yr

Dry Year Groundwater Base Flow Volume = 205.2 MG/yr

Dry Year Allowable Nitrate (NO3-N) Load(w/2 mg/l background) = 13,692 lb/yr

(8 mg/l)(8.34)(MGY) lb/yr

Developable Land = 923 Acres (AGRES = 363 DUs, LRES = 133 DUs, COMM = 3 Dus INST = 1 DU)

Equivalent DUs = 500

Adtl. Water Use (@ 300 GPD/DU) = 150,000 GPD (54.75 MGY)

Total Future Water Use = 165,904 GPD

Future Depletive Loss (@ 60 GPD/DU) = 33,181 GPD (14% OF Q7-10)

Future Depletive Loss will not Exceed 50% Q 7-10

Future Nitrate Load = 23,386 lb/yr

Future Nitrate Load will exceed Dry Year Groundwater Load Limit

Total Additional Impervious Cover = 48.9 Acres

Additional Runoff (@ 36"/yr) = 146.64 Acre-Feet

Existing Runoff (@9") = 696 Acre-Feet

Total Runoff = 802 Acre-Feet

Additional NPS Loads: NO3 = 3,341 lb/yr; TP = 1,351 lb/yr; COD = 215,448 lb/yr; LEAD = 339 lb/yr

Table 5-37 East Nantmeal Township - Water Balance Model Analysis
Headwaters of Beaver Run, tributary of French Creek - Sub-basin 38

5.4.8. Case Study No. 8 Warwick Township
Sub-basin 15 - Rock Run
Sub-basin 17 - Unnamed tributary to French Creek

Of all the municipalities in the Watershed, Warwick Township contains the greatest amount of Eased Land (2,271 Acres) and Open Space (4,092 Acres), comprising 53% of the rather large township (18.72 square miles in the drainage). This statistic would suggest that no current problems exist, and there is plenty of land (and water) for the future. Table 5-38 sums existing Land Use (Figure 5-21) with 1,820 acres currently developed and Table 5-39 shows the distribution of this land in the 26 sub-basins which comprise the municipality. Table 5-40 shows the Zoning, and Table 5-41 measures the location of the Developable Land by Sub-basin and Zoning (Figure 5-22). Some 87% of this land is zoned large lot residential.

Two sub-basins were considered for detailed evaluation. First, a small tributary of the French Creek that drains into the main channel above St. Peters Village near the Mount Carmel Church was analyzed. This sub-basin is of interest in that it is the location of a proposed spring withdrawal and bottling operation, and the issue of water export and base flow depletion is important. As shown in Table 5-42, the future depletive loss of 11,356 GPD is well below the proposed loss limit of 58,382 GPD. However, if 50,000 GPD (the proposed bottling plant use) is exported from the sub-basin, the depletive loss limit will be exceeded. In addition, the future Nitrate Load will slightly exceed the water quality limit during a dry year, but if the anticipated groundwater pool for dilution of septage is reduced by 18.2 MG a year, the impact could be much greater. Thus the loss of 50,000 GPD from the sub-basin cannot be allowed without risking a drying up of the stream during drought and greater risk to future groundwater users.

The Second sub-basin considered is Rock Run, a large sub-basin (1,703 acres, or 2.66 square miles) that is shared by three municipalities; Warwick, North Coventry and South Coventry. Warwick has 607 acres of the watershed total, or about 36%. Since Rock Run has no perennial tributaries, it is considered a first order stream, and is one of the largest in the two watersheds. Tables 5-43 shows the total sub-basin zoning, including all three municipalities, and Table 5-44 shows the various zones in each municipality, and their size.

In the Warwick portion of the sub-basin, 226 acres are developable in AGRES density, and represent about 114 new dwelling units or 34,200 GPD water need in the future. Table 5-45 details the WBM analysis for this sub-basin, and indicates that, again, the future Nitrate load puts the groundwater quality at risk. More importantly, it points out how the future of resource management in the three municipalities is intertwined, and how the actions and criteria of one impacts the other two. Obviously, any plan to manage land and water in this sub-basin must include all three townships.

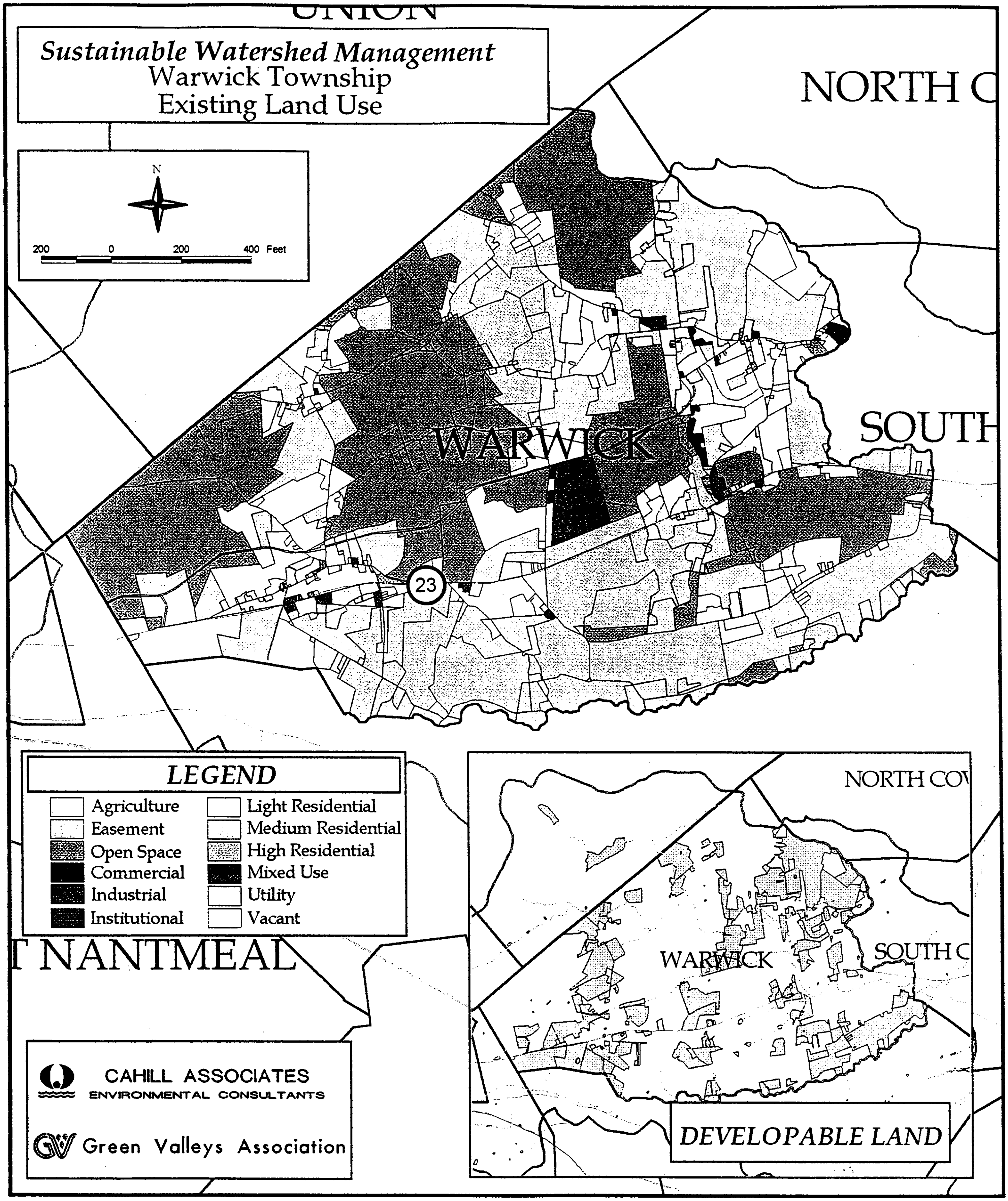

Figure 5-21 Warwick Township - Existing Land Use and Developable Land

USE	ACRES
AG	2,532
CO	53
EA	2,271
ID	138
IN	48
OS	4,092
RA	1,582
RB	66
RC	12
RD	22
UT	20
VA	1,145
TOTAL	11,982

Table 5-38 Warwick Township - Existing Land Use Summary

Watershed	AG	CO	EA	ID	IN	OS	RA	RB	RC	RD	UT	VA	TOTAL
21260018	12					272	15					0	299
21260019	1												1
21260102	22					26							49
21290021						235							235
21290022	159	1			0	261	39	3		0		74	537
21290101	134		289			194	50	2				44	712
21290103	97					480	72	1	1	2		45	698
21290104			43			115		0					158
21300106			73			161	10	2	1	0			246
21380015	135	13	141		0	82	139	2	1	1		94	607
21380016	312	1			13	5	125	7	3	3		66	534
21380017	208	1			7	181	173	3	1	1		32	608
21380023	99	6		110	1	581	88	2	1	1	11	112	1,011
21380024	26		246	25		15	39	1				55	407
21380025	37		273		3	52	6	0				3	374
21380105	329	17	48		11	262	274	11	2	4	2	148	1,108
21380108	51	0	37		4	467	118	3	1	2	2	42	728
21400026	65		120		0	4	80	1				16	287
21400027	64		329		5	102	55	2	0	1		31	592
21400028	147	13	31	2	4	14	132	15	1	7		59	425
21400029	97					389	116	4			3	232	841
21400030	14					130	17				1	25	187
21400112	154		366			31	1					18	571
21400113	48		0				1					41	90
21400114	63		219				6						288
21500109	257		59			33	27	7	0			7	390
TOTAL	2532	53	2271	138	48	4092	1582	66	12	22	20	1145	11,982

Table 5-39 Warwick Township - Existing Land Use by Sub-basins

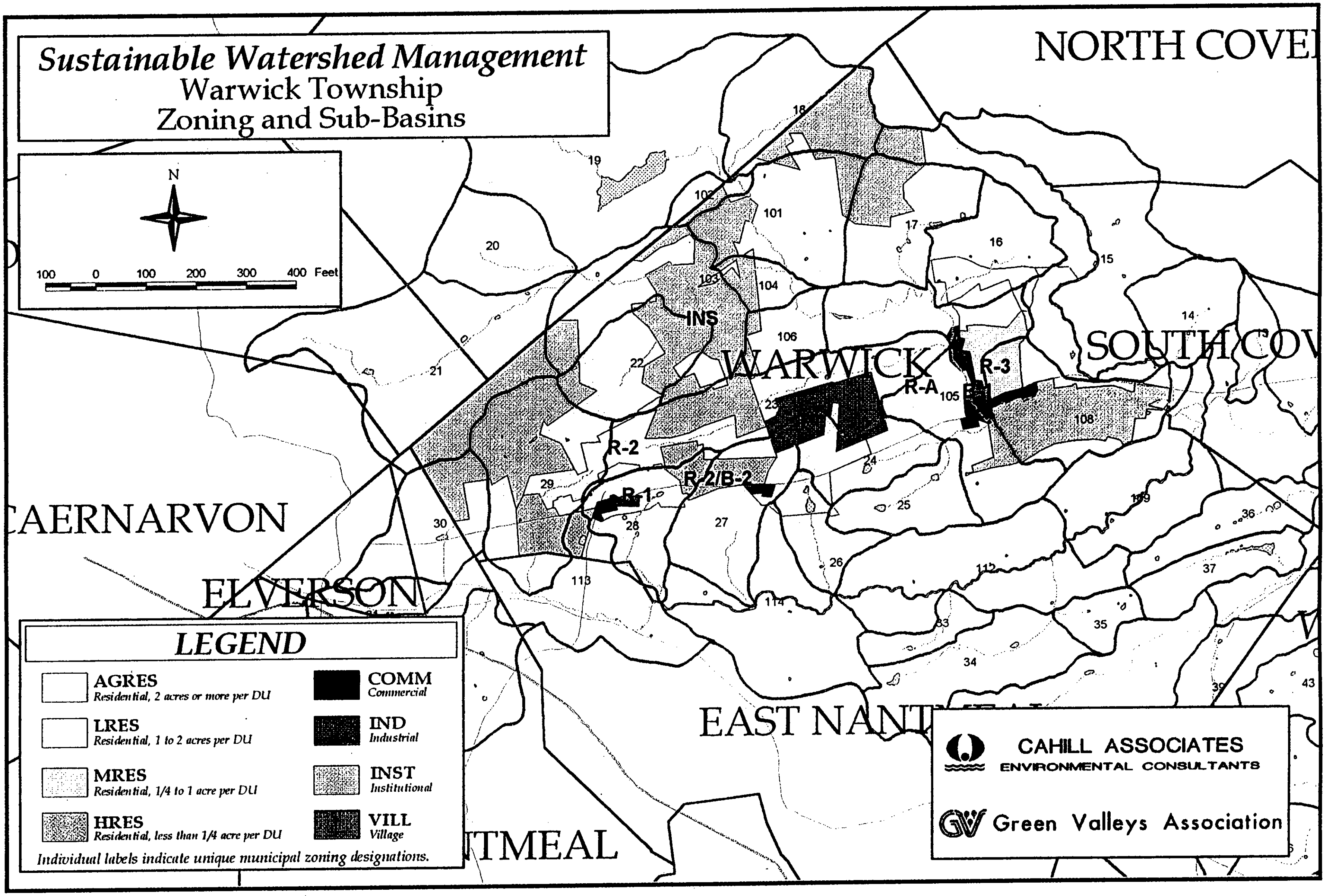

Figure 5-22 Warwick Township - Zoning and Sub-basins

ZONING	DESCRIPTION	INTERPRETATION	ACRES
B-1	Business	COMM	148
I	Industrial	IND	285
INS	Institutional	INST	2,846
R-1	Residential	LRES	325
R-2	Residential	AGRES	1,258
R-2/B-2	Village/Mixed Use	HRES	339
R-3	Residential	MRES	173
R-A	Residential-Agriculture	AGRES	6,609
TOTAL			11,982

Table 5-40 Warwick Township - Zoning Summary

Watershed	AGRES	COMM	HRES	IND	INST	LRES	MRES	TOTAL
21260018	12				0			12
21260019	1							1
21260102	22				0			22
21290021								0
21290022	226				6			233
21290101	173				5			178
21290103	140				2			142
21290104								0
21300106	0							0
21380015	226					2	0	229
21380016	342					35		378
21380017	240							240
21380023	154		29	23	0	5		211
21380024	43			37				80
21380025	40							40
21380105	407	10			0	1	58	477
21380108	76	7			5		5	93
21400026	82							82
21400027	67	0	14	14		0		96
21400028	152	4	28			23		206
21400029	206		111		4	8		329
21400030	39							39
21400112	173							173
21400113	46		42			0		88
21400114	63							63
21500109	265							265
TOTAL	3196	21	223	74	22	76	64	3,677

Table 5-41 Warwick Township - Developable Land by Zoning and Sub-basin

Drainage Area:	**608 Acres, 0.95 Square Miles**
Existing Water Use:	20,752 GPD
Existing EDUs:	69 EDUs
Depletive Use:	4,150 GPD
Drought Yield:	116,765 GPD (Q 7-10 @ 192 GPD/Acre)
Depletive Loss Limit:	58,382 GPD (50% Consumptive Loss)
Dry Year Flow:	270,627 GPD (Q 365-10) @ 445 GPD/Acre
Future Adtl Water:	36,028 GPD
Total Future Water:	56,780 GPD
Future Loss:	11,356 GPD (@ 20%)
Existing Wastewater:	6.06 MGY
Existing Nitrate Load:	2,274 Lb/Yr
Dry Year GW:	98.78 MG/Yr
Allow. NO_3:	6,591 Lb/Yr. (With 2 mg/l background)
Future WW:	17 MGD
Future Load NO_3:	6,222 Lb/Yr.

The future Nitrate Load will slightly exceed the water quality limit in a dry year.

Table 5-42. Warwick Township - Water Balance Model Analysis - Sub-basin 17

USE	ACRES
AG	468
CO	13
EA	399
IN	0
OS	113
RA	350
RB	3
RC	1
RD	1
VA	353
TOTAL	1,703

Table 5-43 Rock Run - Sub-basin 15, Total Existing Land Use Summary (Acres)

MUNICIPALITY	ZONING	DESCRIPTION	INTERPRETATION	ACRES
North Coventry	FR-1	Farm Residential	AGRES	306
South Coventry	AG-RES	Agricultural-Residential	LRES	287
Warwick	R-1	Residential	LRES	2
Warwick	R-2	Residential	AGRES	36
Warwick	R-3	Residential	MRES	0
Warwick	R-A	Residential-Agriculture	AGRES	190
TOTAL				822

Table 5-44 Rock Run - Developable Land by Zoning and Township

Drainage Area:	1,703 Acres, 2.66 Square Miles
Existing DUs:	131 EDUs
Existing Water Use:	39,485 GPD
Depletive Use (20%):	7,897 GPD
Drought Yield:	327,009 GPD (Q 7-10) @ 192 GPD/Acre
Depletive Loss Limit:	163,504 GPD (50% Q 7-10)
Dry Year Flow:	757,912 GPD (Q 365-10) @ 445 GPD/Acre
Future Adtl. Dus:	483 EDUs
Future Adtl Water:	144,969 GPD
Total Future Water:	184,454 GPD
Future Loss (@ 20%):	**36,891 GPD (Less than 163,504 GPD)**
Existing Wastewater:	11.5 MG/Yr
Ex. Nitrate Load:	4,327 Lb/Yr
Dry Year GW:	276 MG/Yr
Allow. NO3:	18,457 Lb/Yr. (With 2 mg/l background)
Future WW:	54 MGY
Future Load NO3:	**20,214 Lb/Yr. (Exceeds 18,457 Lb/Yr.)**

**Table 5-45 Warwick Township - Water Balance Model Analysis
Sub-basin 15, Rock Run (all three townships are included)**

5.4.9. Case Study No. 9 - South Coventry Township

This township sits on the north ridge of the French Creek, and its interest in land management and water resources incudes both the French Creek and the Pigeon Creek to the north, both of which face the potential impact of groundwater export. In the French Creek drainage, Existing Land Use is shown in Figure 5-23 and totaled in Table 5-46, and Zoning shown in Figure 5-24 and Table 5-47. The WBM analysis of Rock Run is illustrative for this township as well as Warwick, and the same conditions are experienced in the other tributaries, to a greater or lesser degree.

The headwaters of the contiguous Pigeon Creek have been the focus of recent concern related to another spring withdrawal with total export from the watershed, although this system has been in operation for some number of years. The current issue is the development of a well to augment the original spring system, although the projected withdrawal of 90,000 GPD is presented as equal to the existing system. As in the case of sub-basin 17, the total export of any groundwater withdrawal has very negative impacts on a given drainage, and places at risk the sustainability of the natural water balance. For the Pigeon Creek, the detailed analysis of this impact has been performed but is not included here, in that is inappropriate to venture beyond the watershed boundaries in this report. However, many of the land and water conflicts discussed in this section do not stop at the township or watershed line, and clearly demonstrate that resource management must consider the total political system, as well as the hydrologic cycle.

USE	ACRES
AG	759
CO	50
EA	872
ID	8
IN	82
OS	301
RA	567
RB	44
RC	12
RD	58
UT	71
VA	446
TOTAL	3,268

Table 5-46 South Coventry Township - Existing Land Use (French Cr. drainage only)

ZONING	DESCRIPTION	INTERPRETATION	ACRES
AG	Agricultural	LRES	282
AG-RES	Agricultural-Residential	LRES	337
C	Commercial	COMM	46
C-I	Commercial-Industrial	COMM	70
CONS	Conservation	AGRES	251
H	Historic	VILL	2
RES	Residential	MRES	217
TOTAL			1,205

Table 5-47 South Coventry Township - Developable Land by Zoning

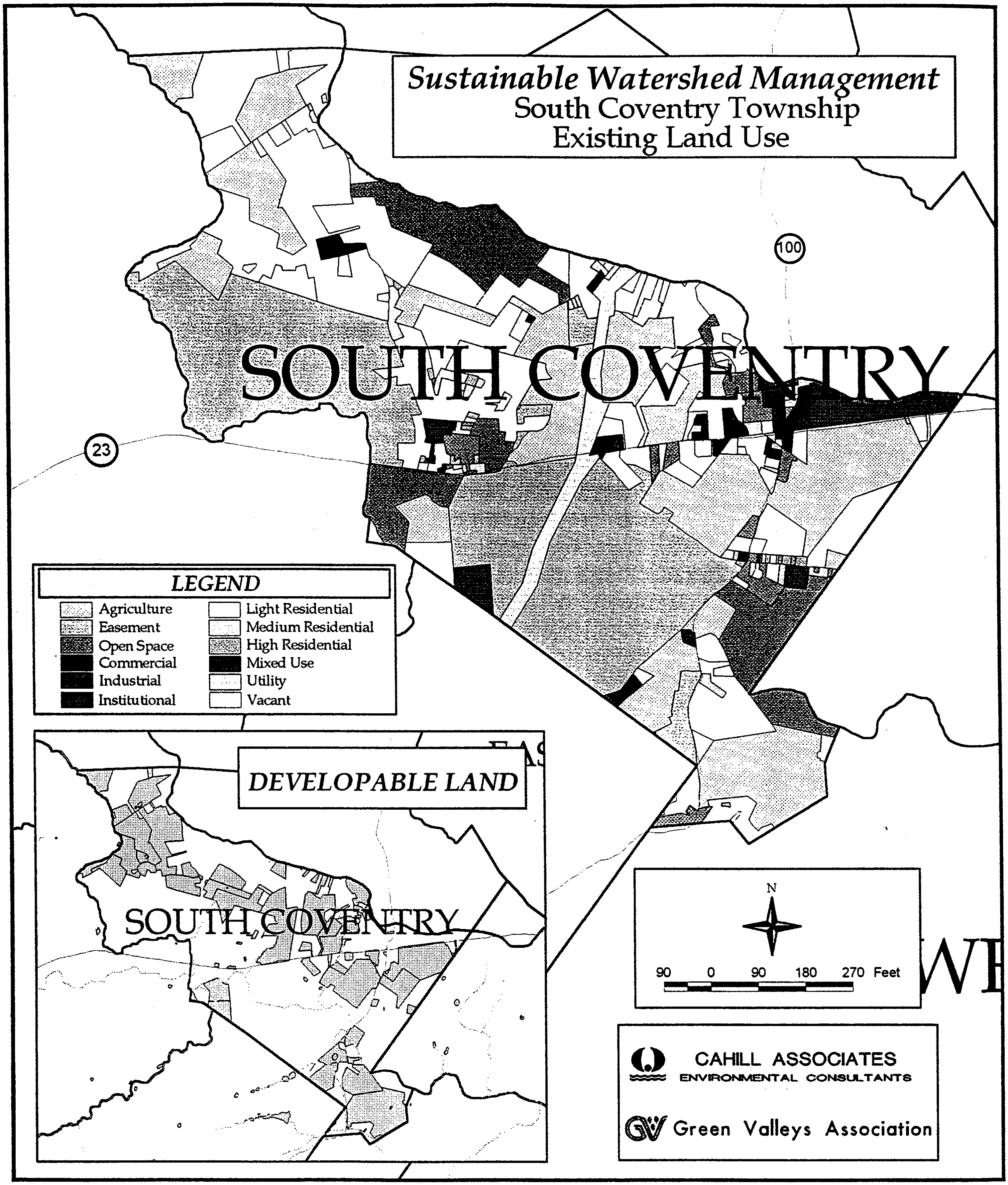

Figure 5-23 South Coventry Township - Existing Land Use and Developable Land

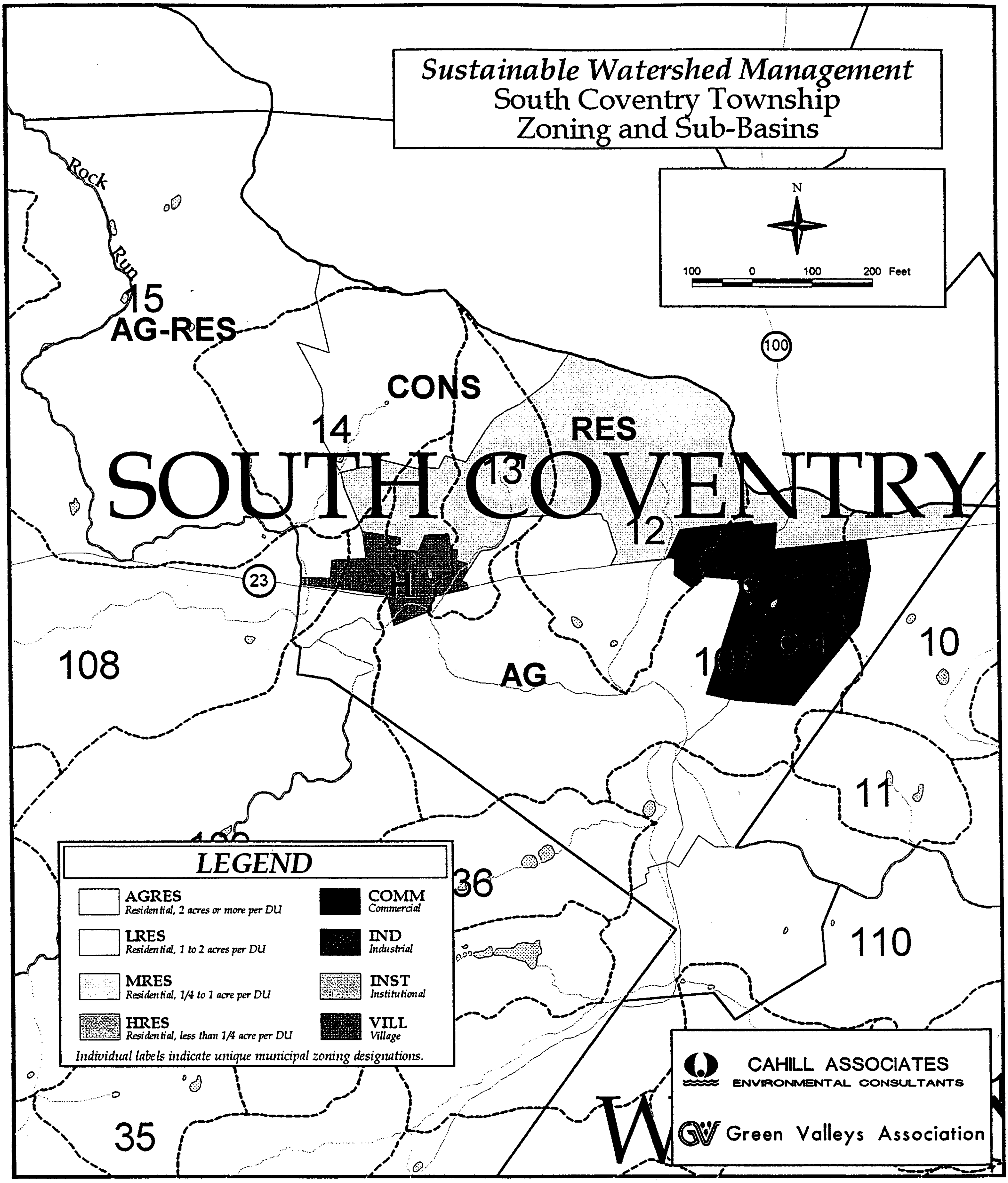

Figure 5-24 South Coventry Township - Zoning and Sub-basins

SECTION 6.0 SUSTAINABLE WATERSHED MANAGEMENT RECOMMENDATIONS: RIVER CONSERVATION PLAN

6. Sustainable Watershed Management Recommendations: River Conservation Plan

Because these two watersheds are tributaries to a major river, which has served as both source and sink for much of our water needs in the past, one could argue that we should continue to exploit that resource, within the economic limits of the utility systems. In truth, it is just this development of infrastructure (led by the roadway network) that has led the region to the patterns of urbanization discussed in Section 1. The transformation of watersheds by a combination of accessibility and plumbing is an irrefutable reality. Unfortunately, the net result of this urbanization has been a degradation of both land and water resources in most instances, although few would concede that their particular location was so impacted.

The application of sustainable watershed management analysis to the French and Pickering Creeks Watershed raises many issues, even as it quantifies the land and water resources and evaluates the potential impact of future growth. The zoning build-out is in fact only one possible scenario for the future. An infinite range of possibilities exist, subject to the variations within the land use regulatory processes, such as clustering options, increased densities with utilities, variances and special exceptions. Water resource management also has the same potential variability, with the connection to water and sewer service external to the watershed as a distinct possibility, and in some sub-basins, a strong probability. For those sub-basins containing or contiguous to existing infrastructure, this "Deus Machina" looms as an unavoidable method to accommodate all the growth that the land can hold. It suggests that water resource management plays little or no part in the final strategy for land use in these areas, except for the downstream impacts of runoff. This shortsightedness is part of the basic problem in urbanizing areas.

The stormwater impacts have previously not been a significant part of the development process or infrastructure planning, nor have the pollutant loads been of real concern to the sub-basins in which they are produced. To inform the landowners of the two watersheds that their runoff is subsequently ingested by several million neighbors down river on the Schuylkill is of passing interest, and has not altered their use of the land, or development patterns and processes. Local effects, such as the drying up of private springs and the de-watering of small first order streams are subtle processes, and have gone unnoticed, especially by the new homeowners.

So what then does sustainability mean in terms of the two watersheds? Clearly, the interior and western sub-basins are so well removed from the existing utility systems that the possibility of external water and sewer systems is remote; the opposite is true for a number of sub-basins at the eastern and southern ends, where such service seems unavoidable. It is in the transition zones where the conflict is most apparent, as the various case studies illustrate. What is learned from this analysis is that the combination of locally drawn water with exported wastewater will have a strong negative impact on the groundwater (and surface) system. For those sub-basins where both import and export are feasible, and the net water balance is zero, the decisions as to type, location and density of development will be guided primarily by the stormwater impacts, including the loss of recharge and the increases of runoff flows and NPS pollution.

6.1. Recommended Guidelines

While the best solution for sustaining our land and water resources in these two watersheds is still evolving as part of a resource management process, several important concepts are apparent and should be developed in regulatory form by the municipalities, and reinforced by county, state and basin guidance.

A. Depletive water use should not exceed 50% of the Q 7-10 base flow, especially in first order sub-basins.

B. Groundwater use should be coupled with groundwater recharge, for both individual and community systems.

C. The permitting of individual and community on-site wastewater systems must show the net impact on groundwater quality, and Nitrate concentrations must not be allowed to exceed a maximum of 10 mg/l.

D. Land development proposals must consider the water resource impact of their proposal using the Water Balance Model or comparable data, and advise the municipality of the results and suitable mitigation, if appropriate.

E. Stormwater management criteria must require recharge of all increased runoff, and detention criteria applied only as the solution of last resort. A value of 3 inches of recharge per unit area of new impervious surface is suggested (2-year rainfall).

F. Site design criteria should minimize the loss of recharge by minimizing new impervious surfaces.

G. Site design criteria should require minimum site disturbance and preservation of existing vegetation.

H. Site design criteria should avoid the use of vegetative systems which require chemical maintenance.

I. Riparian buffers of at least 75 feet should be included for all perennial streams.

J. Connection with public sewer systems which export wastewaters must be compensated by water supply import from sources external to the sub-basin.

K. The Chester County Comprehensive Plan and the Draft Regional Land Use Plan of the Northern Federation shall serve as the guideline for regional land use development.

L. That Plan, titled "Landscapes", shall be implemented in concert with all of the guidance listed above, as well as regional and municipal plans, with Zoning and Ordinances revised accordingly.

M. A program for riparian buffers shall be encouraged, including stream bank fencing, stabilization, and planting, consistent with the recommendations of the Delaware Estuary Management Plan (EPA, 1996).

6.2. Plan Selection/Approval Process

What has evolved with this sustainable resource management program is more of a planning process than a fixed plan, in which each unit of land and water are defined in terms of future use. Unlike prior programs, there is no "Master Plan" by which to implement all of the criteria described in the study and summarized above. Rather, the land and water decision-making process which will take place in the future will be guided by these criteria. Each municipality will utilize the computer-based files of spatial data (GIS) and supporting resource measurements to both revise land development guidance and respond to each new development proposal by applying a screening process derived from this guidance.

To implement this process, each municipality must be given the opportunity to have a "hands on" capability with the GIS files created, as well as the opportunity to build on this system for other purposes. The addition of parcel data, details on infrastructure, and other files could be of real interest to some municipalities. The required site screening process could be carried out by the municipality, their consultants, third parties or the applicant, as desired. The preparation of output, such as colored maps, charts, tables and other presentation materials could be generated by the same sources, as appropriate.

In any case, the net result of this study is not a set of alternative solutions from which the municipalities can select a final version of a Plan and make a selection of one or more variations. The medium is very much the message in this situation, as the planning process will lead all of the municipalities to evaluate their own available land and water resource data and apply their own interpretation to the end result for their community, jointly guided by the criteria listed above and the visions of both their own planning guidance and the county plan.

Thus the approval process envisioned in the DCNR guidance for Rivers Conservation is accomplished by endorsements from the various municipalities to participate in the watershed planning process, in consideration of the ideas and changes recommended in this study, rather than signing off on some Master Plan for the two watersheds.

6.3. Implementation of Planning Process

The implementation of the planning process will require two specific steps:

1. The development of regulatory guidance for the municipalities, in the form of a **Water Resources Ordinance.** This will be structured in a generic form which can be tailored to each township and integrated in their specific ordinances, zoning and plans. Both the Ordinance development and the work with each municipality will be a required part of the task.

2. In order for the municipalities to take full advantage of the resource data developed here and elsewhere, it will be necessary for each one to utilize computer access and in-house capabilities for data use. This will take the form of a **Watershed Data System**, based on the GIS files created in this study as well as other files and sources which become available in the future. Some municipalities presently have computer systems applied for accounting and related municipal functions and record-keeping, while others are not yet fully computer capable. Whatever the existing mix of hardware, each municipality will have to utilize a system which can access and use the available resource data.

The data itself will be kept in repository on a Web Site, either as part of the county system or maintained by an independent contractor with access user support. The contractor will provide full output capabilities, especially graphic products, and maintain the integrity of the Water Balance Model and other routines ,which will be applied on request by a municipality or applicant. For example, if a land development application was made for a specific parcel, the township would submit the application for site analysis, with fee support by the applicant.

6.4. Integration of The County Plan "Landscapes"

One of the more interesting aspects of the recent county plan "Landscapes" is the question as to what does it mean for this Rivers Conservation Planning process. Is it compatible in form and substance, or will it be in conflict with some of the guidance outlined in the previous section. The short answer to that question is that the principles advanced in the County Plan are, by and large, consistent with this study. The practical translation, however, raises some interesting issues. Like other forward-looking land use plans, including the work by the Northern Federation, the plan emphasizes the idea of building future growth in and around existing villages and communities within the county, preserving the parcels removed from existing infrastructure as low density residential and agricultural use, with heavy emphasis on the preservation of agriculture.

The implementation of this planning would ideally take advantage of the GIS system, and superimpose the translation of the plan on the sub-basin analysis. In order to quantify the plan, the vacant parcel file could be assumed to be the spatial definition of parcels to be considered, with special weight given to those parcel currently in active agriculture as less suitable for development (or conversely as candidates for protective covenant). To facilitate the process of concentrating growth in parcels in proximity to existing community centers, a method of assigning "development rights" to all development parcels could be used to effectively redistribute the build-out population within the study area to meet the vision of "Landscapes". Then the implication of the plan on water resources (as well as other considerations) could be evaluated by the municipalities, using the WBM to test this particular variation of future growth.

6.5. Evaluation of Transferable Development Rights (TDR)

The process considered above suggests the development of a TDR system for the watersheds, or possibly for groups of municipalities, such as the Northern Federation. This is a somewhat controversial step for these municipalities, and probably could not be accomplished without substantial support from the county. Based on experiences of other communities such as Montgomery County, MD, such a system is operated most effectively on a regional scale, and does not seem practical on a municipal basis. Nevertheless, it might be considered by individual townships if regional participation seems impractical or politically unacceptable. The same method of evaluating the developable parcels, currently quantified in the GIS, could be applied on an individual municipality basis.

One funding mechanism for the creation of TDRs might be for the municipalities to petition the county for matching funds under their Open Space Bond Issues Program, which has directed substantial funding into acquisition of various parcels for open space and the purchase of conservation easements on many other agricultural parcels. A partnership with the county in the development of a TDR program would seem to offer a number of definite benefits.

This option of dealing with future growth should be considered as planning analysis, given the availability of the GIS and the political cohesion of the Northern Federation, but might await the completion of the GIS and related Water Balance Model analysis for the Pigeon and Stony Run watersheds, scheduled to begin in mid-1997.

6.6. Watershed Registry

GVA plans to petition the DCNR to designate the French and Pickering Creeks and their tributaries for the Pennsylvania Rivers Conservation Registry. This petition will be in the form of a letter from GVA, a transcript of the public hearing of January 30, 1997, evidence that the final Plan and transcripts of this Public Hearing were submitted to officials of local municipalities, a copy of a resolution supporting the River Conservation

Plan from at least one municipality and a complete copy of the Final Rivers Conservation Plan.

With the timely response of the municipalities, the two watersheds will be placed by DCNR on the Watershed Registry for the Commonwealth of Pennsylvania, a process that replaces the Scenic River designation. This should take place in mid-1997. It is the intention of the GVA to seek additional funding under the Rivers Conservation Fund for program implementation, as described in Sections 6.2 and 6.3.

REFERENCES

LIST OF REFERENCES

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