ON-SITE WASTEWATER TREATMENT PROBLEMS AND ALTERNATIVES

FOR WESTERN NORTH CAROLINA

By

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DISCLAIMER STATEMENT

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ABSTRACT

This research was intended to help improve wastewater management in the western North Carolina mountains by developing a comprehensive picture of the region's on-site wastewater management practices and related problems, and provides a basis for evaluating the potential role alternative practices and programs could play in solving these problems. Four representative mountain counties -- Graham, Haywood, Jackson, and Macon -- were analyzed in detail, making it possible to identify region-wide problems and those which are unique to one county or portion of a county.

Approximately 100,000 people live in 40,000 homes within the four study counties. About three-quarters of these homes depend on individual wastewater disposal systems, primarily conventional septic tank systems. As of 1970, an estimated 4,000 homes (13%) had no flush toilet and 1,000 homes (3%) straight piped their raw sewage directly to the nearest stream. Approximately 2,500 homes (6%) have failing septic systems, due to poor siting, design, installation, and maintenance, and to the reduced amount of mountain land suitable for effective long-term septic system operation. Yet, while the availability of suitable sites for septic systems is rapidly decreasing, the pressure to build new permanent and seasonal homes which must depend on on-site wastewater disposal continues to rise.

There are indications that some health hazards and degraded water quality conditions in western North Carolina are attributable to on-site sewage treatment problems. An estimated 30% of the homes (about 10,000) have individual drinking water supplies that are bacteriologically contaminated. An alarming 68% to 78% of the springs sampled recently by sanitarians in the study area counties were contaminated. Some public water supply systems have problems due to inadequate protection from sewage and to poor design, construction, and irregular inspection and maintenance. Three of the eight municipal water systems in the study area depend on surface water sources which frequently exceed state water quality standards. Many small public well systems serving trailer parks, subdivisions, second homes and seasonal developments are in fair to poor condition. Bacterial contamination was found in the majority of the streams that have been sampled in the study area counties.
Alternatives considered for reducing these problems include upgrading and expanding central wastewater treatment and collection systems, participating in special financial assistance programs for improving on-site systems, and developing modified and alternative on-site treatment systems and maintenance programs adopted to best meet the region's needs.
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SUMMARY

The purpose of this research was to help improve wastewater management in western North Carolina by developing a comprehensive picture of the region's problems related to on-site wastewater management which provides a basis for evaluating the potential role alternative practices and programs could play in solving these problems.

Detailed information was obtained on conditions and problems in four representative western North Carolina mountain counties -- Graham, Haywood, Jackson and Macon. Information on existing on-site treatment systems was obtained from each county health department. Soils data published by the Soil Conservation Service were analyzed. Water quality data were collected from publications of the United States Geological Survey and from reports and files of the North Carolina Department of Natural Resources and Community Development. Data on community and private water supplies were obtained from the county health departments and the North Carolina Division of Health Services. Housing information was found in the 1970 U. S. Census and from each county's tax assessor and register of deeds office.

Within the four counties analyzed, examples were found of on-site wastewater treatment problems that are common throughout the mountain region. Thus, it was possible to identify region-wide problems and those which are unique to one county or a portion of a county.

Approximately 100,000 people live in 40,000 homes within the four counties analyzed in detail. About three-quarters of these homes depend on individual wastewater disposal systems, compared to 42% for the state and 25% for the nation as a whole. The average density of on-site systems in the four-county western North Carolina study area in 1970 was 12.0 homes per square mile, compared to 18.3 in the six-county Triangle J region, which includes Raleigh. Locally, densities are equal to or greater than those found in more urbanized parts of the state. The density of on-site systems in Haywood County in the study area is approximately the same as that in Orange County in the Triangle J region.

The conventional septic tank system is by far the most commonly used wastewater treatment system in the region. As of 1970, an estimated 4,000
homes (13%) had no flush toilet and 1,000 homes (3%) straight-piped their raw sewage directly to the nearest stream with no treatment. The proportion of homes straight-piping in the study area is over five times higher than the rate statewide. It is estimated that 10,000 people (10%) live near streams which receive significant straight-pipe discharges in this area. Graham, Jackson, and portions of Haywood County have the most extensive concentrations of straight-pipe discharges.

It is roughly estimated that 2,500 homes (6%) in the study area have failing septic systems, due to both poor siting, design, installation and maintenance in the past and also to the reduced amount of mountain land suitable for effective long-term septic system operation. From 69% to 93% of the land in the four study-area counties has severe limitations for conventional septic systems due to steep slopes, shallow depths to bedrock, high water tables and flooding. In comparison, between 30% and 50% of the land within the Triangle J region is unsuitable for conventional septic systems. The popular Cashiers-Highlands area includes some of the worst terrain for conventional septic systems. Yet, while the availability of suitable sites in the region for septic systems is rapidly decreasing, the pressure to build new permanent and seasonal homes which must depend on on-site wastewater disposal continues to rise. Approximately 90% of the new homes built in the study region from 1970 to 1980 utilize septic systems. The per-capita rate of new septic system installations in the four counties from 1970 to 1978 was nearly twice the rate of new installations statewide. Much of this new housing development is within subdivisions and mobile home parks. Subdivisions are most rapidly being developed in Haywood and Macon Counties, and mobile home usage is greatest in Haywood and Graham Counties.

There are indications that health hazards and degraded water quality conditions in western North Carolina are at least partly attributable to on-site sewage treatment problems. Contamination of drinking water supplies within the region is associated with inadequate sewage disposal and poorly protected or otherwise unsatisfactory well and spring facilities. An estimated 30% of the homes (about 10,000) have individual drinking water supplies that are bacteriologically contaminated. Problems with spring supplies are most severe. About half of the people on individual water
supplies in this region depend on springs, a much higher fraction than elsewhere in North Carolina. Yet, an alarming 68%–78% of the springs sampled recently by sanitarians in the study area counties were contaminated.

Community and non-community public water supply systems have problems, due to inadequate protection from sewage, as well as to poor design and construction, and to irregular inspection and maintenance. Non-community public systems are a particular concern in this region where there is a substantial number of seasonal homes. Small public well systems serving trailer parks, subdivisions and second home and seasonal developments are in the worst condition.

Excessive bacterial levels in many of the region’s streams have been documented. The monitoring stations of the Department of Natural Resources and Community Development and the United States Geological Survey, and compliance monitoring reports submitted to the state by point source pollution dischargers frequently indicated contaminated conditions. Water samples from about 70% of the monitoring sites in the four-county area which were upstream of any municipal or industrial point source discharger often showed fecal coliform levels that far exceeded the "recreational use" stream standard of 200 colonies per 100 milliliters. Contamination levels measured in many of the streams which serve as municipal drinking water supplies are a major area of concern. Three of the eight major surface source systems in the region depend on water which frequently exceeds state raw water standards for "A-II" supplies -- more than 20% of the water samples taken in a month have fecal coliform levels greater than 2,000 colonies per 100 milliliters.

Alternatives for reducing these problems include the potential to improve and expand existing wastewater treatment plant collection systems, participation in financial assistance programs for improving on-site systems management, and the development of modified and alternative on-site wastewater treatment systems and programs.

Many of the existing municipal and community treatment plants in the study area are currently overloaded and their collector systems have severe infiltration and inflow problems. However, some municipal treatment plants have recently been upgraded and have excess capacity. Densely populated
communities adjacent to these municipalities which are already served by public water supplies are likely candidates for sewer line expansions. The timing of sewage line improvements, expansions, and of new plant construction in the region has been historically slow, so it is unlikely that these alternatives will significantly reduce on-site wastewater problems in the foreseeable future. As with public water supply systems, the lack of frequent and effective maintenance is also a major problem at many of the small community wastewater treatment facilities in the region, which moreover tends to further discourage the use of this alternative for solving on-site wastewater problems.

Modifications to make conventional septic systems in the region work better include water conservation, more frequent septic tank pumping, two-compartment septic tanks, alternatives to the distribution box, the use of trenches instead of beds, and adequate drainage of the drainfield area.

Water conservation is the simplest, yet often most neglected, method of improving and maintaining any on-site wastewater treatment system. The majority of water used in the home passes through to the sewer or septic system. Excessive use of water is particularly a problem in older homes where the original septic system was not designed for accepting automatic washing machine wastewater. Eliminating wasteful habits, such as running the washing machine or dishwasher with only half a load, is the most inexpensive and effective way to save water. A variety of inexpensive devices are also available. Use of toilet dams, and flow restricting showerheads and spigots can greatly aid people's efforts to conserve water in the home and at the same time saves energy.

New technologies have been recently applied at a few sites in the region. Three low-pressure, pump-dosed systems have been successfully installed as repairs at individual homesites in Haywood County, replacing failing conventional systems. There are many situations in the mountains where the low-pressure pump or syphon-dosed distribution system may be applicable, such as in areas having only a shallow layer of soil above the water table or bedrock.

Mound systems have been installed on an experimental basis in two parts of the study region — at a poorly drained site with a high water table in Haywood County and at a shallow-depth-to-bedrock area near Highlands in Macon County. Preliminary indications are that mounds cost an excessive amount in this region due to difficulty in locating and transporting suitable fill material for mound construction.
There is an increasing interest in composting toilets in the region, although few are actually in operation. One "Clivus Multrum" system has been approved during the past year in Haywood County. The biggest disadvantage of the composting toilet is that it does not lessen the need to treat the non-toilet ("gray water") waste which still must normally be handled by a conventional septic system. Experiments designed to help develop appropriate alternatives for separate gray water treatment are underway here and elsewhere.

Effective use of both conventional and alternative on-site wastewater disposal systems is dependent on regular maintenance. While the home owner has been primarily responsible for on-site maintenance in the past, there is a growing trend nationally to implement public and private septic system maintenance programs. Two counties in North Carolina -- Guilford and Robeson -- currently operate a survey program for systematically locating and correcting malfunctioning individual septic systems countywide. These programs have been quite successful and could serve as models for counties in the study area and elsewhere interested in developing at least an initial on-site wastewater treatment system maintenance program.

RECOMMENDATIONS

The following recommended activities would help lead to improved on-site wastewater management practices in the region:

1. Developing and implementing survey programs for evaluating and eliminating home sewage treatment problems.

2. Identifying the health problems associated with contaminated water supplies and inadequate sewer systems.

3. Studying the relationships between on-site wastewater treatment problems and surface and ground water quality problems.

4. Installing and monitoring modified and innovative on-site wastewater treatment systems and further evaluating the applicability of alternative systems to the unique conditions in the mountains.

5. Evaluating alternative voluntary and regulatory institutional programs to improve the management of on-site water and sewer systems and demonstrate the applicability of feasible programs.
Western North Carolina is a unique region of the state. The vast beauty of our mountains is cherished by people throughout North Carolina and indeed throughout the world. This report considers in detail an aspect of mountain living that is not a popular subject of conversation, but affects nearly everyone who resides here or who visits the region. The mountainous terrain and relatively dispersed settlement pattern makes centralized wastewater treatment for all unfeasible. According to the 1970 Census, approximately 74% of the homes in the region depend on individual on-site wastewater treatment systems, compared to 42% for the state and 25% for the nation as a whole. Due to excessive slopes and shallow depths of soil to bedrock or to the water table, about 80% of the land area in the region has severe limitations for conventional septic systems.

The purpose of this study is to develop a comprehensive picture of the problems related to on-site wastewater management in four western North Carolina counties -- Graham, Haywood, Jackson, and Macon -- and to establish a basis for evaluating the potential role alternative practices and programs could play in solving these problems.

Detailed information is presented that is specific to each study county. Within the four counties analyzed, examples have been found of the septic system problems that are most common throughout the mountain region. Thus it has been possible to differentiate between problems that are region-wide and those which are unique to one county or to a portion of a county.

The material presented in this report was collected from a variety of sources. Detailed information on existing on-site treatment systems was obtained from each county health department. Soils data published by the Soil Conservation Service were analyzed. Water quality data were collected from publications of the United States Geological Survey and from reports and files of the North Carolina Department of Natural Resources and Community Development. Data on community and private water supplies were obtained from the county health departments and the North Carolina Division of Health Services. Housing information was found in the 1970 U.S. Census and from each county's tax assessor and register of deeds offices.
LOCATION OF THE STUDY REGION

The four counties analyzed are located in the Appalachian mountain region of western North Carolina (Figure 1). Haywood, the easternmost county, is southwest of the Asheville Metropolitan area. Haywood and Graham Counties are adjacent to the Great Smoky Mountains National Park and to the Tennessee state line. Macon County is adjacent to Georgia, about 130 miles northeast of Atlanta, and the southern part of Jackson County abuts on South Carolina. Portions of Graham, Macon and Jackson counties are in the Nantahala National Forest and portions of Haywood County are in the Pisgah National Forest. Approximately one-half of the Cherokee Indian Reservation is in the northwestern part of Jackson County.

NATURAL FACTORS

Geology

The underlying geology of the region influences topography, soil properties, patterns of settlement, and the quality and availability of water. Most of the rocks beneath the study region were formed during the formation of the Appalachian mountain chain over 550 million years ago. Nearly all rocks present are metamorphic, having been converted into their current form by the intense pressure and heat which accompanied the building of the Appalachian Mountains (1). From the standpoint of rock composition, the mountains are the most complex region of North Carolina (2). Gneiss, mica-schist, quartzite, granite, slate and diorite are the most common minerals. Flood plain deposits along the region's streams and rivers include clays, sands and gravels. The floodplain deposits in the mountains contain more very fine sand, silt and clay, compared to those in the piedmont (3).

Bedrock in the region is broken up by innumerable fractures, joints and intrusions. A layer of saprolite or broken up, poorly weathered rock, lies between the bedrock and soil zones. Saprolite thickness is usually
Figure 1

Location of Study Area in the Appalachian Region of Western North Carolina
between 25 to 75 feet, although it may be absent in some places and over 100 feet in others (4). Saprolite is generally thickest in valleys and draws, where the underlying bedrock is also characterized by a greater number of fractures.

Topography

The topographical variability of the western North Carolina mountains is its most striking feature. Elevation differences of over 4,500 feet occur in each of the counties studied, with peaks rising over 6,000 feet above sea level along the Jackson-Haywood County line. The landscape is characterized by high mountain ranges, high plateaus, rolling foothills, narrow valleys, flood plains, bottom lands, and an occasional old terrace adjacent to a river. Graham County contains the most rugged terrain, with about 90% of the land over 30% in slope.

Climate

The climate of the region is quite comfortable, with beautiful springs and autumns, pleasant days and cool nights in summer, and several severe but short-lived cold spells during winter. Rainfall varies greatly within the region and within each county. An average of 90 inches per year falls near Coweeta in Macon County and in the Great Smoky Mountains National Park. Only in the Pacific Northwest are rainfall rates consistently higher. Precipitation averages about 70 inches per year along most of the mountain ridges, 50 inches around Sylva in Jackson County, and 40 inches near Canton in Haywood County. Precipitation measured at the Cullowhee weather station in Jackson County averages 40 inches less annually than at the Coweeta station in Macon, only 27 miles away. Snowfall is frequent, especially on the higher mountain slopes, but rarely is the accumulation extensive or sustained.

Soils

Geology, topography, climate and time interact with vegetation and land use to create the soils that exist in the region today. Most soils in the mountains are younger and less developed than those elsewhere in the state.
The soils on steep uplands are constantly being eroded and renewed by weathering of the underlying rock. Flood plain and bottom land soils are continually renewed with new material washed down from the uplands. The high plateaus and gently rolling uplands have the oldest and best developed soils in the region.

Vegetation, slope, rainfall and temperature influence the fertility and organic matter content of the evolving soil profile. Excessive rainfall helps leach minerals out of the mountain soils, particularly in the upper elevations. Dense deciduous forest cover provides an annual input of organic material. The cool mountain temperatures make decomposition slower in the higher elevations than in the valleys, which somewhat compensates for the leaching effect. However, the forests recycle nutrients very efficiently, so little organic materials become incorporated into the soils.

Water Resources

Surface Waters

High rainfall, steep slopes, thin soils and erosion resistant rocks have interacted to create a well developed drainage network of rivers and streams throughout the region. The eastern continental divide crosses through the study area, with all of Graham and Haywood and most of Jackson and Macon Counties draining westward by tributaries to the Tennessee River. The southern edge of Macon and Jackson Counties drains south by tributaries to the Savannah River (Figure 1).

Graham County is drained predominantly by the Cheoah River, which flows into the Little Tennessee below Lake Fontana. Haywood County is drained almost entirely by the Pigeon River, which flows northward across the state line and enters the French Broad River near Newport, Tennessee. Most of Jackson County is drained by the Tuckaseigee River, which enters the Little Tennessee River in Lake Fontana, about 20 miles below the Jackson County line. The southern part of Jackson County around Cashiers drains into South Carolina towards the Savannah River via the Horsepasture, White-water and Chattooga Rivers. Macon County is drained primarily by the
Little Tennessee. The Nantahala drains the western portion of the county, draining northward into Swain County above the famous Nantahala Gorge. The southeastern part of the county drains southward into the Chattooga River.

Nearly all of the streams in each of the study area counties originate within that county.

These surface waterways comprise one of the most treasured resources of the mountains. Over 1,100 miles of North Carolina's 4,000 miles of trout streams are within the four study counties. The Nantahala and Chattooga are the most popular recreational rivers in the state and indeed rank among the most popular rivers in the nation. The streams draining the Great Smoky Mountains National Park, such as the Cataloochee, are of interest to the international scientific community as representative of the stream ecosystems present in the pre-settlement Eastern Deciduous Forest Biome. Reservoirs on the Tuckaseigee, Pigeon, Nantahala, Little Tennessee and Cheoah are important components of the flood control, power generation and recreational programs of the Tennessee Valley Authority. The lesser known streams and reservoirs are locally important for water supply, recreation and industry.

Ground Water

Groundwater is located in saturated zones within the saprolite and bedrock fractures beneath the land surface. Groundwater is a major source of drinking water in the region, through dug and drilled wells, and where it surfaces, through springs. Ground water reserves are not as extensive in the mountains as they are in the coastal plain, but a sufficient water yield for domestic purposes can be obtained beneath most areas (1). The average water yield from wells varies greatly, but correlates positively with the depth of saprolite and the extent of bedrock fractures (4).

The elevation of the water table also varies greatly. It generally follows the land surface elevation, but is closer to the surface in valleys and draws than on mountain tops. The numerous springs in the mountains attest to the close proximity of the ground water table to the surface throughout the region.
Ground water directly affects and is affected by on-site wastewater treatment systems. High water tables severely limit the ability of septic systems to function properly. Due to thin soils, highly fractured bedrock zones, high water tables and occasional areas where soil permeability is rapid, the potential for ground water contamination from on-site wastewater disposal in the region is great.

**ON-SITE WASTEWATER TREATMENT SYSTEM UTILIZATION**

**Extent of Utilization in 1970**

The majority of homes in the study region depend on on-site wastewater disposal systems. The 1970 Census of Housing includes the most comprehensive data that is currently available (5). Data for each study county, the four-county total, and the state are presented in Table 1. For the purposes of this discussion, "on-site" systems are defined to include everything under the "Wastewater Treatment" category in Table 1 except public sewers.

Haywood County has the highest and Graham County has the lowest amounts with respect to:

- the total number of homes
- total number of homes with on-site systems
- the total number of homes with public sewer systems
- the relative percentage of homes with public systems

Macon and Jackson have intermediate numbers of homes served by public on-site sewer systems.

The relative percentage of homes with on-site wastewater disposal systems for each study county on a township basis is shown in Appendix A. The majority of townships in each county are served entirely by on-site disposal systems. The mean density of houses with on-site systems on a county and township basis is presented in Appendix B. A summary of the data is presented in Table 2. Haywood County has the greatest average concentration of on-site systems, and Graham has the lowest. The densest areas of on-site system utilization occur around the major population.
Table 1
Housing, Water Supply and Wastewater Treatment Inventory, 1970*

<table>
<thead>
<tr>
<th>Housing</th>
<th>County</th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>4-County Total</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Housing Units</td>
<td></td>
<td>2,528</td>
<td>15,030</td>
<td>7,254</td>
<td>8,446</td>
<td>33,258</td>
<td>1,641,194</td>
</tr>
<tr>
<td>Vacant -- Year Round, %**</td>
<td>Units</td>
<td>572</td>
<td>1,802</td>
<td>1,198</td>
<td>3,249</td>
<td>6,821</td>
<td>131,630</td>
</tr>
<tr>
<td>Year Round Housing Units</td>
<td></td>
<td>2,266</td>
<td>14,418</td>
<td>6,663</td>
<td>6,386</td>
<td>29,733</td>
<td>1,619,548</td>
</tr>
<tr>
<td>Mobile Home) Units</td>
<td>or Trailer ) %++</td>
<td>193</td>
<td>836</td>
<td>746</td>
<td>423</td>
<td>2,198</td>
<td>77,382</td>
</tr>
<tr>
<td>Water Supply</td>
<td>Public System or) Units</td>
<td>634</td>
<td>7,780</td>
<td>1,679</td>
<td>1,572</td>
<td>11,665</td>
<td>881,365</td>
</tr>
<tr>
<td>Private Company ) %++</td>
<td></td>
<td>28%</td>
<td>54%</td>
<td>25%</td>
<td>25%</td>
<td>39%</td>
<td>54%</td>
</tr>
<tr>
<td>Individual Well) Units</td>
<td>) %++</td>
<td>186</td>
<td>4,058</td>
<td>2,032</td>
<td>2,993</td>
<td>9,269</td>
<td>659,159</td>
</tr>
<tr>
<td>Springs, Other) Units</td>
<td>) %++</td>
<td>1,432</td>
<td>2,575</td>
<td>2,944</td>
<td>1,823</td>
<td>8,774</td>
<td>78,755</td>
</tr>
<tr>
<td>Wastewater Treatment</td>
<td>Public Sewer) Units</td>
<td>324</td>
<td>5,250</td>
<td>958</td>
<td>1,054</td>
<td>7,586</td>
<td>733,848</td>
</tr>
<tr>
<td>Septic System or) Units</td>
<td>Seepool ) %++</td>
<td>1,060</td>
<td>7,854</td>
<td>4,139</td>
<td>4,153</td>
<td>17,206</td>
<td>867,512</td>
</tr>
<tr>
<td>No Flush Toilet) Units</td>
<td>) %++</td>
<td>413</td>
<td>1,297</td>
<td>1,193</td>
<td>1,094</td>
<td>3,997</td>
<td>189,772</td>
</tr>
<tr>
<td>Other### Units</td>
<td>) %++</td>
<td>455</td>
<td>12</td>
<td>365</td>
<td>87</td>
<td>919</td>
<td>8,087</td>
</tr>
</tbody>
</table>


+ Includes second homes, seasonal homes, migratory workers' homes, weekend homes, vacant homes, etc.

** Percentage is with respect to all housing units.

*** "Other" may represent "straight-piping," or running wastes directly to creek.
### Table 2: Density of On-site Wastewater System Utilization*

<table>
<thead>
<tr>
<th>County</th>
<th>Homes Using On-site Wastewater Treatment Systems Per Square Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graham</td>
<td>6.5</td>
</tr>
<tr>
<td>Macon</td>
<td>10.6</td>
</tr>
<tr>
<td>Jackson</td>
<td>11.6</td>
</tr>
<tr>
<td>Haywood</td>
<td>16.7</td>
</tr>
</tbody>
</table>

**Townships with Highest On-site system density**

<table>
<thead>
<tr>
<th>County</th>
<th>Township</th>
<th>Homes Using On-site Wastewater Treatment Systems Per Square Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackson</td>
<td>Sylva</td>
<td>80.2</td>
</tr>
<tr>
<td>Haywood</td>
<td>Clyde</td>
<td>56.1</td>
</tr>
<tr>
<td>Haywood</td>
<td>Pigeon</td>
<td>47.5</td>
</tr>
<tr>
<td>Macon</td>
<td>Franklin</td>
<td>43.4</td>
</tr>
<tr>
<td>Haywood</td>
<td>Waynesville</td>
<td>41.0</td>
</tr>
<tr>
<td>Jackson</td>
<td>Webster</td>
<td>40.2</td>
</tr>
<tr>
<td>Jackson</td>
<td>Dillsboro</td>
<td>30.8</td>
</tr>
</tbody>
</table>

**Regional Averages:**
- **4-County Total:** 12.0
- **Triangle J region 6-County Total:** 18.3

---

*Source: 1970 Census of Housing and Planimetry of Township areas.*

*Derived from Triangle J Council of Government Individual Wastewater Project Task A Report (6).*
centers, despite the fact that these areas are also served by public sewers.

A density comparison with the six-county "Triangle J" region in the vicinity of Raleigh, one of the most densely populated parts of North Carolina, is also presented in Table 2. The mean density of on-site wastewater systems in the study area is about two-thirds of the mean concentration in the Triangle J region.

Given the large amount of land in public ownership in the mountains, the density of on-site homes is comparatively high. Haywood County, the most densely populated county in the western North Carolina study area, had an on-site home density in 1970 nearly equivalent to that of Orange County in the Triangle J region.

Types of Systems

On-site wastewater systems used in the region include septic tank systems, privies, straight-pipes and no system at all. The stereotype of the mountain home with an outhouse perched over a gushing stream has all but faded into history. The extent of various on-site system usage according to the 1970 Census is shown in Table 3.

There is considerable geographical variability in the types of wastewater systems utilized in the region. The relative number of homes in each township in the study area counties which have no flush toilets (i.e., which utilize a privy or do not have any wastewater treatment system) as of 1970 are shown in Appendix C. There still are many areas where people do not have plumbing connections to a sewage disposal system: in five townships over 45% of the homes had no flush toilets.

The use of privies in the study area is about as common as it is state-wide. About 1,000, or 3%, of the homes in the study area straight-pipe their raw sewage to the nearest stream. The proportion of homes straight-piping in the study area is over five times higher than the rate state-wide. The four study counties accounted for about 12% of the homes estimated to be straight-piping throughout the state.

There is a great variability between and within counties in the extent of straight-piping. The distribution of straight-piping by township is
<table>
<thead>
<tr>
<th></th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>4-County Total</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Year-round Houses</strong></td>
<td>2,266</td>
<td>14,418</td>
<td>6,663</td>
<td>6,386</td>
<td>29,733</td>
<td>1,619,548</td>
</tr>
<tr>
<td>Public Sewer (%)</td>
<td>324</td>
<td>5,250</td>
<td>958</td>
<td>1,054</td>
<td>7,586</td>
<td>733,848</td>
</tr>
<tr>
<td>(14%)</td>
<td>(36%)</td>
<td>(14%)</td>
<td>(17%)</td>
<td>(26%)</td>
<td></td>
<td>(45%)</td>
</tr>
<tr>
<td>Septic System (%)</td>
<td>1,060</td>
<td>7,854</td>
<td>4,139</td>
<td>4,153</td>
<td>17,206</td>
<td>687,572</td>
</tr>
<tr>
<td>(47%)</td>
<td>(54%)</td>
<td>(62%)</td>
<td>(65%)</td>
<td>(58%)</td>
<td></td>
<td>(42%)</td>
</tr>
<tr>
<td>Privy or no toilet** (%)</td>
<td>419</td>
<td>1,223</td>
<td>1,199</td>
<td>1,092</td>
<td>3,933</td>
<td>190,009</td>
</tr>
<tr>
<td>(19%)</td>
<td>(9%)</td>
<td>(18%)</td>
<td>(17%)</td>
<td>(13%)</td>
<td></td>
<td>(12%)</td>
</tr>
<tr>
<td>Straight-pipe*** (%)</td>
<td>463</td>
<td>91</td>
<td>367</td>
<td>87</td>
<td>1,008</td>
<td>8,119</td>
</tr>
<tr>
<td>(20%)</td>
<td>(1%)</td>
<td>(6%)</td>
<td>(1%)</td>
<td>(3%)</td>
<td></td>
<td>(1%)</td>
</tr>
</tbody>
</table>

*Source: 1970 Census of Housing (5).

**Computed from the number of homes without flush toilets.

***Computed from the number of homes without public sewage or septic systems, minus the privy or no-toilet estimate.
shown in Appendix D. Macon County has the lowest and Graham County the
highest percentage of homes straight-piping. Straight-piping occurs
throughout Graham County, while in Haywood County straight-piping occurs
primarily in the northwestern part of the county, into streams drained
by the Pigeon River below the Champion Paper Company's discharge. Straight-
piping occurs in many portions of Jackson County, with the greatest con-
centrations in Cashiers, Caney Fork, Barker's Creek, Greens Creek, and
Savannah townships.

Septic tank systems are the most commonly used on-site wastewater treat-
ment systems in the region. There is great variability in the characteristics of
the septic tank systems in use. Old systems common in the region include:

- the system of straight-piping directly from the septic
tank to an embankment or creek
- the pit system, where a pit is dug directly after the
  septic tank or at the end of a drain-line with the
capacity to hold one or two truck loads of gravel
- the dynamite system, where tank and pit are blasted into
  rock (this method was frequently used in the Highlands-
  Cashiers area)

Since the Ground Absorption Sewage Disposal System Act of 1973 has
been enforced, the standards of septic system design and construction have
become more uniform, regionally and state-wide. Single compartment septic
tanks are used in all of the study counties, with a sanitary tee at the
outflow end of the tank. Distribution boxes are also standard in each
county. Haywood and Jackson require water leveling of the distribution
box while a sanitarian is present.

From the distribution box, water flows by gravity through standard
four-inch septic-system pipe into beds or trenches. Haywood and Macon
Counties approve beds very infrequently as a last resort for a repair.
Relatively more bed systems are installed in Graham and Jackson Counties.
Step-downs are not commonly used in the region. Pits are now not regularly
permitted but are still sometimes recommended for separated washing machine
drain-lines in Jackson County.

Trends in Utilization

An accurate estimate of housing growth in the region and of the
increased usage of on-site wastewater treatment systems will not be possible until the 1980 Census results are released. Based on the records of the numbers of new septic systems installed and estimates of the increase in the number of homes served by public sewer systems since 1970, approximately 90% of the new homes built in the study region from 1970 to 1980 utilize on-site wastewater treatment systems. If this estimate is correct, nearly 80% of the homes in the study region now depend on on-site wastewater treatment systems.

The increase in the number of homes in each county served by septic systems from 1970 to 1978 is shown in Tables 4 and 5. The mean annual growth rate of on-site systems in the four study area counties of 5.8% is slightly higher than the rate for the state as a whole. The per-capita rate of new septic system installations, however, was 75% higher in the study region than the rate of growth statewide. Of the four counties, Macon had the greatest number of new systems installed as well as the highest mean annual and per-capita growth rate.

The distribution of new residential construction using septic systems within each county is shown in Appendix E. In each county, most of the new homes are being built where there already are concentrations of homes, but there are also significant amounts of construction taking place county-wide.

In Table 6 some characteristics of new homes using septic systems in the study region are summarized, based on an analysis of building permits and health department completion permits for recent years. Mobile homes make up a significant portion of the new homes in each study area county and account for nearly half of the new homes in Haywood County. Many of the new individual homes in the region are being constructed in subdivisions. The percentage is greatest in Haywood County.

The distribution of subdivision lots registered from 1975 to 1979 in each county is shown in Appendix F and summarized in Table 7. Subdivision registration has decreased in all counties since 1977. Of the four study area counties, Haywood County has had by far the greatest number of lots registered. Consistently more lots are registered each year than are being developed. Based on a rough calculation, in 1978 there were three times more subdivision lots registered than there were lots developed.
### Table 4

Septic System Approvals, 1970 - 1978*

<table>
<thead>
<tr>
<th>Year</th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>4-county Total</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>3</td>
<td>294</td>
<td>18</td>
<td>10</td>
<td>325</td>
<td>37,918</td>
</tr>
<tr>
<td>1971</td>
<td>24</td>
<td>366</td>
<td>27</td>
<td>112</td>
<td>529</td>
<td>43,468</td>
</tr>
<tr>
<td>1972</td>
<td>13</td>
<td>490</td>
<td>21</td>
<td>295</td>
<td>819</td>
<td>52,549</td>
</tr>
<tr>
<td>1973</td>
<td>15</td>
<td>533</td>
<td>94</td>
<td>491</td>
<td>1,133</td>
<td>57,705</td>
</tr>
<tr>
<td>1974</td>
<td>155</td>
<td>504</td>
<td>679</td>
<td>602</td>
<td>1,940</td>
<td>54,484</td>
</tr>
<tr>
<td>1975</td>
<td>112</td>
<td>467</td>
<td>542</td>
<td>581</td>
<td>1,702</td>
<td>43,813</td>
</tr>
<tr>
<td>1976</td>
<td>223</td>
<td>413</td>
<td>563</td>
<td>1,277</td>
<td>2,476</td>
<td>50,323</td>
</tr>
<tr>
<td>1977</td>
<td>272</td>
<td>614</td>
<td>394</td>
<td>973</td>
<td>2,253</td>
<td>48,680</td>
</tr>
<tr>
<td>1978</td>
<td>254</td>
<td>606</td>
<td>432</td>
<td>647</td>
<td>1,939</td>
<td>51,087</td>
</tr>
<tr>
<td></td>
<td><strong>Total, 1970-1978</strong></td>
<td><strong>1,071</strong></td>
<td><strong>4,287</strong></td>
<td><strong>2,770</strong></td>
<td><strong>4,988</strong></td>
<td><strong>13,116</strong></td>
</tr>
</tbody>
</table>

*Source: Division of Health Services, Sanitation Branch Records.*
Table 5
Estimated Growth of Homes Using Septic Systems

<table>
<thead>
<tr>
<th></th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>Total 4-county</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>All housing units*</td>
<td>2,528</td>
<td>15,030</td>
<td>7,254</td>
<td>8,446</td>
<td>33,258</td>
<td>1,641,194</td>
</tr>
<tr>
<td>Homes with on-site</td>
<td>2,165</td>
<td>9,555</td>
<td>6,210</td>
<td>7,052</td>
<td>24,982</td>
<td>897,538</td>
</tr>
<tr>
<td>wastewater disposal, 1970**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New septic system</td>
<td>1,071</td>
<td>4,287</td>
<td>2,770</td>
<td>4,988</td>
<td>13,116</td>
<td>440,027</td>
</tr>
<tr>
<td>installations, 1970-1978***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated number of</td>
<td>3,236</td>
<td>13,842</td>
<td>8,980</td>
<td>12,040</td>
<td>38,098</td>
<td>1,337,565</td>
</tr>
<tr>
<td>homes with on-site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wastewater disposal, 1979+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean annual growth rate, %++</td>
<td>5.5%</td>
<td>5.0%</td>
<td>5.0%</td>
<td>7.9%</td>
<td>5.8%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Population, 1978+++</td>
<td>6,726</td>
<td>44,673</td>
<td>25,853</td>
<td>19,219</td>
<td>96,471</td>
<td>5,678,621</td>
</tr>
<tr>
<td>Per capita growth rate*</td>
<td>0.16%</td>
<td>0.10%</td>
<td>0.11%</td>
<td>0.26%</td>
<td>0.14%</td>
<td>0.08</td>
</tr>
</tbody>
</table>

*: U. S. Census of Housing

**: Extrapolated from U. S. Census of Housing

***: Division of Health Services, Sanitarian Branch Records

+: Row 2 plus Row 3 (a rough estimate)

++: Row 3 divided by Row 2, multiplied by 100, divided by 9 years

+++: Estimate for July 1, 1978, by Office of State Planning, North Carolina Department of Administration

\*: Row 3 divided by Row 6
<table>
<thead>
<tr>
<th>Characteristics of New Homes Using Septic Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
</tr>
<tr>
<td>Mobile Homes, %*</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Individual Homes, %*</td>
</tr>
<tr>
<td>Individual Homes in Subdivisions, %**</td>
</tr>
<tr>
<td><strong>Water Supply</strong></td>
</tr>
<tr>
<td>Public System, %+</td>
</tr>
<tr>
<td>Well, %+</td>
</tr>
<tr>
<td>Spring, %+</td>
</tr>
<tr>
<td><strong>Water Supply of Existing Homes Using Septic Systems, 1970++</strong></td>
</tr>
<tr>
<td>Public System, %</td>
</tr>
<tr>
<td>Well, %</td>
</tr>
<tr>
<td>Spring, %</td>
</tr>
</tbody>
</table>


++ extrapolated from 1970 Census of Housing.

NA - data not available.
Table 7

Subdivision Lots Registered from 1975 to 1979*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Graham</td>
<td>1</td>
<td>46</td>
<td>519</td>
<td>62</td>
<td>103</td>
<td>731</td>
</tr>
<tr>
<td>Haywood</td>
<td>709</td>
<td>1,126</td>
<td>708</td>
<td>541</td>
<td>592</td>
<td>3,676</td>
</tr>
<tr>
<td>Jackson</td>
<td>254</td>
<td>246</td>
<td>604</td>
<td>350</td>
<td>285</td>
<td>1,739</td>
</tr>
<tr>
<td>Macon</td>
<td>302</td>
<td>539</td>
<td>387</td>
<td>371</td>
<td>350</td>
<td>1,949</td>
</tr>
<tr>
<td>Total</td>
<td>1,266</td>
<td>1,957</td>
<td>2,218</td>
<td>1,324</td>
<td>1,330</td>
<td>8,095</td>
</tr>
</tbody>
</table>

*Information obtained from Register of Deeds office in each county courthouse.
Table 6 also shows the trend in the types of water supply systems serving homes on septic systems. An increasing percentage of homes is using public water systems and private well systems. Springs are still used, however, in many of the new homes constructed in Graham, Haywood, and Jackson counties.

PROBLEMS WITH SEPTIC SYSTEMS

A summary of the problems encountered with septic systems in the four study area counties is presented in Table 8. Based on interviews with county sanitarians, it is roughly estimated that 2,500 homes (6%) in the study area have failing systems, due to site, installation and maintenance problems. Major site problems identified were excessive slope, high water table or shallow depth of soil to bedrock, poor site drainage and insufficient lot size. Leveling of the distribution box was the most frequently cited installation problem. Lack of regular septic tank pumping and excessive use of water were the major maintenance problems identified. Problems occur most frequently in subdivisions and second home developments, especially in densely populated areas developed prior to enforcement of the current septic system regulations.

The rugged mountain terrain is a major factor limiting the amount of land in the region that is suitable for effective long-term septic system operation. The suitability of land in each county for conventional septic systems, based on the Soil Conservation Service's soil association maps is shown in Appendix G. The amount of land in each capability class is summarized in Table 9. From 69% to 93% of the land in the four study area counties has severe limitations for conventional septic systems. The most severe limitations occur in Graham County, where approximately 90% of the land has slopes greater than 30% (7). In comparison, between 30% and 50% of the land within the six-county Triangle J region is unsuitable for conventional septic systems (6).

CONSEQUENCES OF SEPTIC SYSTEM INADEQUACIES

Water Supply Contamination

Contamination of drinking water supplies within the region is associated
**Table 8**

**Septic System Problems***:

<table>
<thead>
<tr>
<th>Counties</th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Site ratings for septic systems in county:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>suitable lots</td>
<td>None</td>
<td>Few</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>provisionally suitable lots</td>
<td>All</td>
<td>Most</td>
<td>All</td>
<td>Most</td>
</tr>
<tr>
<td>unsuitable lots</td>
<td>10%</td>
<td></td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td><strong>2. Estimated rate of septic system failure in county</strong></td>
<td>15-20%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>3. Amount of health department staff time spent on rehabilitation of failing systems, as compared to installing new systems</strong></td>
<td>10%</td>
<td>10-15%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>4. Site problems in county:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>excessive slope</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>high water table</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>poor site drainage</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>insufficient lot size</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>tight soils</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>shallow depth to bedrock</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>cut &amp; fill</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>5. Installation problems:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>septic tank leveling</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>distribution box leveling</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>absorption lines</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>6. Maintenance problems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>infrequent pumping</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>excessive use of water</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>7. Special problems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>subdivisions</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>mobile home parks</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>second home development</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Information derived from interviews with sanitarians in each of the study area counties.*
Table 9

SOIL SUITABILITY FOR SEPTIC SYSTEMS*

<table>
<thead>
<tr>
<th>Soil Suitability Class</th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
</tr>
</thead>
<tbody>
<tr>
<td>(% of County Land within Suitability Class)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slight to Moderate</td>
<td>2.2</td>
<td>3.0</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Moderate to Severe, due to Slope</td>
<td>4.7</td>
<td>14.1</td>
<td>17.2</td>
<td>10.7</td>
</tr>
<tr>
<td>Moderate to Severe, due to Slope and Rock</td>
<td>-</td>
<td>1.9</td>
<td>11.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Severe, due to Slope</td>
<td>54.3</td>
<td>41.4</td>
<td>35.0</td>
<td>43.7</td>
</tr>
<tr>
<td>Severe, due to Slope and Rock</td>
<td>38.0</td>
<td>37.6</td>
<td>32.0</td>
<td>37.4</td>
</tr>
<tr>
<td>Severe, due to Flooding</td>
<td>-</td>
<td>.8</td>
<td>.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Severe, due to Flooding and High Water Table</td>
<td>.8</td>
<td>1.1</td>
<td>1.2</td>
<td>1.8</td>
</tr>
</tbody>
</table>

*Source: Soil Interpretations of General Soil Maps for each county, prepared by the US Soil Conservation Service, obtained from District offices in Waynesville, Sylva, Franklin and Robbinsville.
with inadequate on-site sewage disposal and inadequately protected, or otherwise unsatisfactory, surface water, well, and spring facilities. A current estimate of the number of homes using each major type of water supply system in the four study area counties is shown in Table 10.

Individual Water Supplies

Individual water systems are depended upon by over 60% of the homes in the region, varying from 44% of the homes in Haywood County to 82% of the homes in Graham County. Statewide, individual systems are used in 46% of the homes, according to the 1970 Census of Housing. The distribution of homes using individual water supply systems within each county in 1970 is depicted in Appendix H. In most townships within the study area, 81% to 100% of the homes depend on individual water supply systems.

The major types of individual water supplies in the study area are drilled wells, bored wells or dug wells, and springs. Wells account for about 54% of the individual water systems in the study area. The variation between study area counties, however, is considerable (see Table 10). Wells account for only 10% of the individual water supplies in Graham County and 70% of those in Macon County. While in the past nearly all wells in the region were dug by hand, drilled wells now account for nearly 90% of the wells currently in use.

Springs are used much more frequently in the region than elsewhere in North Carolina -- the rate of spring utilization is about six times higher in the study area than it is statewide. The distribution of spring usage within each county is shown in Appendix I. The distribution of individual well usage can be approximated by comparing the figures in Appendix I with those which depict the distribution of all individual water systems in Appendix H. Both springs and wells predominate in a number of townships in all but Graham County, where springs are uniformly the most frequently utilized individual drinking-water systems.

Very little information is available on the degree to which individual water supply systems are contaminated in the region. Information on the extent to which contamination problems are caused by inadequate septic
## Table 10

Water Supply Systems, 1980*

<table>
<thead>
<tr>
<th>Type of System and Source</th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>4-County Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Homes</td>
<td>3,950</td>
<td>19,650</td>
<td>10,050</td>
<td>13,350</td>
<td>47,000</td>
</tr>
<tr>
<td>Individual Systems</td>
<td>3,250</td>
<td>8,650</td>
<td>7,550</td>
<td>9,850</td>
<td>29,300</td>
</tr>
<tr>
<td>Wells</td>
<td>350</td>
<td>5,250</td>
<td>3,250</td>
<td>6,900</td>
<td>15,750</td>
</tr>
<tr>
<td>Springs</td>
<td>2,900</td>
<td>3,400</td>
<td>4,300</td>
<td>2,950</td>
<td>13,550</td>
</tr>
<tr>
<td>Public Systems</td>
<td>700</td>
<td>11,000</td>
<td>2,500</td>
<td>3,500</td>
<td>17,700</td>
</tr>
<tr>
<td>Surface-A-I*</td>
<td>350</td>
<td>5,400</td>
<td>1,200</td>
<td>-</td>
<td>6,950</td>
</tr>
<tr>
<td>Surface-A-II**</td>
<td>320</td>
<td>5,350</td>
<td>220</td>
<td>2,850</td>
<td>8,740</td>
</tr>
<tr>
<td>Wells</td>
<td>30</td>
<td>150</td>
<td>930</td>
<td>520</td>
<td>1,630</td>
</tr>
<tr>
<td>Springs</td>
<td>-</td>
<td>100</td>
<td>150</td>
<td>130</td>
<td>380</td>
</tr>
</tbody>
</table>

*Sources: Estimates derived from 1970 Census of Housing, septic tank completion permits, building permits, and records from area wastewater treatment plants and public water systems.

**Surface-A-I: Surface water source draining an uninhabited watershed and requiring minimal treatment.

**Surface-A-II: Surface water source draining an inhabited watershed, requiring treatment.
systems, and on related health problems is also limited. There are indications, however, that hazardous conditions exist which are at least partly attributable to on-site sewage treatment problems.

Cases of giardiasis, shigellosis, hepatitis, salmonellosis, amebiosis and typhoid were reported from the study area counties between 1974 and 1978 (8). These are all diseases which occurred nationally during the 1970's in water-related disease out-breaks reported to the Center for Disease Control (9).

Results from all samples of individual drinking water supplies taken by each county health department since 1976 were tabulated to estimate the extent and distribution to water supply contamination in the study area. A private water system investigation will be made by the county health department upon request, which includes the analysis of the water for bacterial and sometimes for chemical contaminants. While this cannot be assumed to provide a systematic sampling of all water systems in a county, it is the only relevant data available and gives at least a rough indication of the nature of contamination problems. Results are summarized in Table 11.

The most striking finding is the relatively high percentage of springs which appear to be contaminated in the study area. The small variation between counties in the percentage of spring samples positive for coliforms (68% to 78%) suggests that spring contamination is a significant problem regionwide. Data from Haywood and Macon counties also indicate that a substantial portion of the dug wells analyzed are contaminated. Due to the frequency of spring utilization within the region, spring contamination is considered to be the most significant potential public health problem.

The distribution of positive water samples taken from springs and wells within each county is shown in Appendix J. In general, most problems appear to be occurring near the more densely populated parts of each county. Spring contamination occurred most frequently in Cheoah and Stecoah townships in Graham County; Waynesville, Ivy Hills, and Beaverdam townships in Haywood County; Sylva, Dillsboro, and Cullowhee townships in Jackson County; and Millsboroal and Highlands townships in Macon County. Well contamination occurred most frequently in Cheoah Township in Graham County; Waynesville and Pigeon townships in Haywood County; Qualla, Sylva and Cashiers townships
<table>
<thead>
<tr>
<th>Type of System</th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Wells</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samples Analyzed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
<td>894</td>
<td>379</td>
<td>491</td>
<td>1,825</td>
</tr>
<tr>
<td>Positive for Coliform, Number</td>
<td>12</td>
<td>267</td>
<td>79</td>
<td>130</td>
<td>488</td>
</tr>
<tr>
<td>Positive for Coliform, %</td>
<td>20%</td>
<td>30%</td>
<td>21%</td>
<td>26%</td>
<td>27%</td>
</tr>
<tr>
<td>Drilled Wells</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samples Analyzed</td>
<td>**</td>
<td>757</td>
<td>**</td>
<td>407</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>172</td>
<td></td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Positive for Coliform, Number</td>
<td></td>
<td>23%</td>
<td></td>
<td>17%</td>
<td></td>
</tr>
<tr>
<td>Dug Wells</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samples Analyzed</td>
<td>**</td>
<td>137</td>
<td>**</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>95</td>
<td></td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Positive for Coliform, Number</td>
<td></td>
<td>69%</td>
<td></td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>All Springs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samples Analyzed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>96</td>
<td>367</td>
<td>239</td>
<td>194</td>
<td>894</td>
</tr>
<tr>
<td>Positive for Coliform, Number</td>
<td>75</td>
<td>278</td>
<td>162</td>
<td>138</td>
<td>653</td>
</tr>
<tr>
<td>Positive for Coliform, %</td>
<td>78%</td>
<td>76%</td>
<td>68%</td>
<td>71%</td>
<td>73%</td>
</tr>
</tbody>
</table>

*Data from records at each county's health department.

** Data for drilled and dug wells not distinguished in the records for these counties.
in Jackson County; and Franklin Township in Macon County.

Public Water Supplies

Community and non-community public water supplies have problems due to inadequate protection from sewage, as well as to poor design and construction, and to irregular inspection and maintenance. "Public water supplies", as defined by the Safe Drinking Water Act of 1974, include all supplies which serve 15 or more connections or 25 or more people at least 60 days of the year (10). A public water supply is designated a "community" system if it serves year-round residents. Otherwise, the supply is considered to be a "non-community" system.

The location and detailed information on each public water system in the study area are presented in Appendix K. An estimate of the number of homes served by various types of public water supplies appears in Table 10. A majority of the homes on public water systems in the study area depend on surface water sources, highlighting one of the major demands placed on the region's water resources. Wells and spring sources are tapped by all of the small public systems but serve only 30% of the homes connected to public systems in the region. All major municipal water systems depend on surface water sources. Cherokee and Sylva also have wells to supplement their surface supplies, and Jackson county's new water system depends entirely on wells.

The general condition of the public water systems in each county is summarized in Table 12. Approximately 57% of the systems in the region are in good condition and 16% are in poor condition. Water supplies in Macon County are in the best condition, with Graham having the highest percentage -- 33% -- and Haywood having the greatest number -- 4 -- of poor systems. Robbinsville's current surface water supply system is the worst public system in the study area that serves a substantial number of people. With the exception of Robbinsville's system, the public supplies dependent on springs are in the poorest condition. Three of the five worst spring systems occur in Macon County. A substantial number of well systems are also in fair or poor condition. Well systems are the most commonly used public water
Table 12
Condition Assessment of Public Water Supply Systems*

<table>
<thead>
<tr>
<th></th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>Four-County Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Water Systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Public Systems</td>
<td>6</td>
<td>20</td>
<td>21</td>
<td>27</td>
<td>74</td>
</tr>
<tr>
<td>Condition:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>3</td>
<td>10</td>
<td>10</td>
<td>19</td>
<td>42</td>
</tr>
<tr>
<td>Fair</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Surface Source Systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Fair</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Poor</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Spring Source Systems</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Condition:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Fair</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Poor</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Well Source Systems</td>
<td>3</td>
<td>13</td>
<td>16**</td>
<td>19</td>
<td>51</td>
</tr>
<tr>
<td>Condition:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>15</td>
<td>29</td>
</tr>
<tr>
<td>Fair</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Poor</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

*Assessment derived by evaluating records on each water system at the Division of Health Services regional office in Black Mountain, N.C. Details on each system appear in Appendix K.

** A number of public well systems in Jackson County were not included because sufficient information on their condition was not available.
supplies in trailer parks, subdivisions, and second homes and seasonal developments.

A summary of the problems and the approval status of public water systems in each county is shown in Table 13. The most common water system problems are:

- poor water quality
- an inadequate quantity of water
- poorly built, old, and outmoded systems
- poorly selected or inadequately protected well and spring sites
- poor maintenance

About one-third of the water systems have violated the coliform or monitoring standards under the North Carolina Safe Drinking Water Act. Less than half of the water systems in the region have had their designs, plans, and specifications approved by the Division of Health Services.

Contamination levels measured in many of the streams which are utilized as surface supply-sources is a major area of concern in the region. The largest number of homes served by public water systems in the region depend on surface-source systems (see Table 10). Inadequate septic systems upstream of the water supply intakes could cause a potential health problem. While sources drawing on streams classified 'A-II' provide extensive treatment before water is distributed for public utilization, the potential for problems exists if the treatment process temporarily breaks down, or if certain pathogens and other hazardous substances are not removed by conventional treatment methods. In Table 14 are summarized six months of monitoring data from the major surface water-supply-sources in the study area. Three of the eight major surface-source systems in the region depend on water which frequently exceeds state raw water standards for A-II supplies.

Stream Water Quality Degradation

High quality water is the basis for many people of their attraction to
Table 13
Problems, Standard Violations, and Approval Status of Public Water Supply Systems

<table>
<thead>
<tr>
<th>Problems</th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>4-county total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old, Outmoded System</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Poorly Built System</td>
<td>1</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Poor Well Site</td>
<td>1</td>
<td></td>
<td>3</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Watershed Inadequately Protected</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Site Not Adequately Protected</td>
<td></td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>No One Responsible for System</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Quantity of Supply Limited</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Quality of Water Frequently Poor</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Distribution System Limitations</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Poor Maintenance</td>
<td></td>
<td>4</td>
<td>5</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Taste and Odor Problems</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Iron and Manganese</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Standards Violations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coliform Standard Exceeded</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>Turbidity Standards Exceeded</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Monitoring Requirement not met</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td><strong>Approval Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>6</td>
<td>13</td>
<td>17</td>
<td>39</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>13</td>
<td>19</td>
<td>10</td>
<td>45</td>
</tr>
</tbody>
</table>

*Based on data from files at Division of Health Services Regional office in Black Mountain, N.C. Details on each system appear in Appendix K.

**Violations of North Carolina Safe Drinking Water Act, as of June, 1980

***Indicates whether plans and specifications for the system have been approved by the Division of Health Services.
Table 14

Major Municipal Water Supplies
Influent Water Monitoring Data+

<table>
<thead>
<tr>
<th>Water System</th>
<th>Percentage of samples with fecal coliform levels greater than 2000 per 100 milliliters</th>
<th>Percentage of Months &amp; Violation of Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>July '79</td>
<td>August '79</td>
</tr>
<tr>
<td>Waynesville</td>
<td>10%</td>
<td>6%</td>
</tr>
<tr>
<td>Maggie Valley</td>
<td>19%</td>
<td>*29%</td>
</tr>
<tr>
<td>Canton, Mountain</td>
<td>19%</td>
<td>3%</td>
</tr>
<tr>
<td>Canton, Pendland St.</td>
<td>*55%</td>
<td>*39%</td>
</tr>
<tr>
<td>Western Carolina</td>
<td>*26%</td>
<td>*45%</td>
</tr>
<tr>
<td>University</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Franklin</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Highlands</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Fontana</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Source: Files in the Division of Health Services Regional office in Black Mountain, N.C.

*Indicates a violation of A-II water supply stream fecal coliform standard—20% or more samples taken in the month had fecal coliform levels in excess of 2000 colonies per 100 milliliters.
the western North Carolina Mountains. Many opportunities are provided in the region to fish, boat, swim, and tube in pristine rivers, creeks and reservoirs, and to hike, picnic, and sightsee along the banks of mountain waterways. Any degradation of water quality affects nearly everyone living or visiting here.

The Department of Natural Resources and Community Development has developed a stream classification system based on the desired use of a body of water, that has been applied to waterways throughout the state. The basic classifications are:

Class A-I: Suitable as a drinking water supply source after treatment by disinfection only.
Class A-II: Suitable as a drinking water supply source after extensive treatment only.
Class B: Suitable for bathing, boating, wading, and other forms of recreation involving water contact
Class C: Suitable for fish and wildlife propagation and recreation not involving extensive water contact
Trout Water: Suitable for trout fishing and managed by the North Carolina Inland Fisheries Division

For each stream classification, standards are established for certain water quality parameters which must be met to assure that the intended use is not impaired. Maps depicting the classifications of streams in the study area counties are presented in Appendix L.

Water quality data collected by the Department of Natural Resources and Community Development, the United States Geological Survey, and by point source pollution discharges were analyzed to determine the degree of water quality degradation in the study area and to identify instances where degradation may be attributed to inadequate septic systems. Excessive bacterial levels occur in many of the region's streams, which could be due to inadequate on-site wastewater treatment.

Many factors can cause degradation of water quality. Point source discharges from major municipal and industrial wastewater treatment plants often cause the most serious zones of degradation. The Pigeon River in Haywood County at one time was considered to be one of the most severely

30
degraded rivers in the nation, due to industrial wastewater discharges. Non-point source pollution originates from diffuse areas throughout the region and is associated with the way man uses the land. Sedimentation and nutrient runoff from construction sites and agricultural lands are the most significant non-point source pollution problems in North Carolina (11). For the purposes of this investigation, inadequate septic systems are also considered to be non-point sources of pollution.

A number of parameters are commonly used as measures of water quality, such as the concentrations in the water of dissolved oxygen, suspended solids, nitrates, phosphates, alkalinity, metals and fecal coliforms. Fecal coliform is the most frequently measured parameter that could be an indicator of non-point source contamination from inadequate septic systems. Without further investigation, however, it is not possible to conclusively identify the source of coliform contamination, since coliform bacteria can live in the intestines of many other warm-blooded animals, in addition to man. Such detailed studies have not been made within the study region.

The location and detailed information on water-quality monitoring stations and point-source wastewater dischargers in each study area county are included in Appendix M. A summary of the information collected on stream degradation and excessive coliform levels due to non-point sources is presented in Table 15. About three-fourths of the water-quality monitoring stations in the region indicate some type of water quality degradation. In all but Jackson County, non-point sources are responsible for degraded conditions at most of the monitoring stations in the study area.

Fecal coliform data are collected at many of the monitoring stations and by point source dischargers upstream and downstream from their discharges, as part of the compliance monitoring required by the state. The location of 29 monitoring stations and 38 wastewater discharge facilities that have collected fecal coliform data were upstream of major municipal and industrial point source dischargers. Water samples from about 80% of these sites frequently showed fecal coliform levels that far exceeded the "recreational use" stream standard of the 200 colonies per 100 milliliters.
Table 15

Water Quality Monitoring Stations and Wastewater Treatment Facilities: Summary of information on stream degradation and excessive coliform levels due to non-point sources.

<table>
<thead>
<tr>
<th>Water Quality Monitoring Stations</th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Stations</td>
<td>15</td>
<td>19</td>
<td>17</td>
<td>26</td>
<td>77</td>
</tr>
<tr>
<td>Stations showing water quality degradation, total</td>
<td>9</td>
<td>14</td>
<td>14</td>
<td>21</td>
<td>58</td>
</tr>
<tr>
<td>-Due to point sources only</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>-Due to non-point sources only</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>13</td>
<td>29</td>
</tr>
<tr>
<td>-Due to both point and non-point sources</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Stations where non-point source coliform levels were sampled</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td>Stations showing excessive non-point source coliform levels</td>
<td>100%</td>
<td>89%</td>
<td>100%</td>
<td>80%</td>
<td>90%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wastewater Discharge Facilities **</th>
<th>Total</th>
<th>8</th>
<th>35</th>
<th>21</th>
<th>37</th>
<th>101</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities where non-point source coliform levels were sampled</td>
<td>3</td>
<td>15</td>
<td>8</td>
<td>12</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Stations showing excessive non-point source coliform levels</td>
<td>67%</td>
<td>93%</td>
<td>50%</td>
<td>67%</td>
<td>74%</td>
<td></td>
</tr>
</tbody>
</table>

* Determined from analysis of data from United States Geological Survey and the Department of Natural Resources and Community Development. Detailed information on each station is presented in Appendix M.

** Determined from analysis of data at Department of Natural Resources and Community Development regional office in Asheville, N.C. Detailed information on each station is presented in Appendix M.
ALTERNATIVES FOR REDUCING ON-SITE WASTEWATER MANAGEMENT PROBLEMS

There is an array of alternatives which can be used to reduce problems with on-site wastewater management in western North Carolina. Some programs could be applied region-wide, while others are applicable only in a particular area.

Improvement and Expansion of Conventional Wastewater Treatment Facilities

In the past, connection to a sewer line was considered the ultimate solution to an area's septic system problems. Conventional wastewater treatment consists of a collector system and a wastewater treatment plant which discharges treated water to a stream or river. Problems with infiltration and inflow of ground water and storm water into collector systems is a major problem faced by many of the existing municipal and community sewer systems in the region. Wastewater flow to many treatment plants exceeds their capacity, resulting in the direct discharge of untreated or partially treated wastes. Some treatment plants in small communities are inadequately maintained, which often results in a poor quality effluent.

The extent of public sewage service and the problems at existing wastewater treatment facilities in the study area are summarized in Tables 16 and 17, respectively. Municipal facilities and facilities serving schools, rest homes, and children's homes have substantial problems with excessive wastewater loading and poor effluent quality. Excess loading problems occur at the municipal treatment plants serving Robbinsville, Clyde, Dillsboro, Jackson County, and Highlands. Before these plants could be used to treat wastewater from additional homes, the sewer lines serving the homes already on the systems need to be repaired, and, in most cases, the treatment plant capacity must be expanded.

Many steps must be taken before communities can improve or expand their central wastewater treatment facilities. These steps are mandated by the federal Clean Water Act, most recently amended in 1977 (Public Law 95-217). Section 201 of the Act sets forth the planning procedures to be followed before the actual construction and repair of public wastewater treatment works
<table>
<thead>
<tr>
<th>County</th>
<th>Subunit</th>
<th>Number of Homes on Public Sewage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graham</td>
<td>Robbinsville</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Fontana Village</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>Tapoca</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>720 TOTAL</td>
</tr>
<tr>
<td>Haywood</td>
<td>Clyde</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Canton</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>Hazelwood</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Waynesville</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td>Birchwood Estates</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Ghost Town</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Green Valley</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Maggie Valley Country Club</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Royal Oaks</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6400 TOTAL</td>
</tr>
<tr>
<td>Jackson</td>
<td>Dillsboro</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Sylva</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>Western Carolina University</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Cherokee</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Jackson County</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Sapphire Valley</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Jay Vee Apartments</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1180 TOTAL</td>
</tr>
<tr>
<td>Macon</td>
<td>Franklin</td>
<td>1100</td>
</tr>
<tr>
<td></td>
<td>Highlands</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Highlands Mountain Club</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1300 TOTAL</td>
</tr>
<tr>
<td>4 - county</td>
<td>TOTAL, 1980</td>
<td>9600</td>
</tr>
<tr>
<td>4 - county</td>
<td>TOTAL, 1970</td>
<td>7586</td>
</tr>
<tr>
<td>mean annual</td>
<td>growth rate, 1970 - 1980</td>
<td>+2.7%</td>
</tr>
</tbody>
</table>

*Sources: These data are of an approximate nature only, derived in many instances from rough estimates made by town clerks, or by back calculating from measured wastewater flows.*
Table 17
Wastewater Discharge Facilities:
Summary of Problem*

<table>
<thead>
<tr>
<th></th>
<th>Graham</th>
<th>Haywood</th>
<th>Jackson</th>
<th>Macon</th>
<th>4-County Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Facilities</td>
<td>8</td>
<td>35</td>
<td>21</td>
<td>37</td>
<td>101</td>
</tr>
<tr>
<td>Municipal Facilities, total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problems with excessive</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>wastewater loading</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Problems with poor</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>effluent quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Facilities, total**</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Problems with excessive</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>wastewater loading</td>
<td>15</td>
<td>19</td>
<td>5</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>Problems with poor</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>effluent quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community Facilities, total***</td>
<td>4</td>
<td>19</td>
<td>5</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>Problems with excessive</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>wastewater loading</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Problems with poor</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>effluent quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schools, rest homes</td>
<td>1</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>Children's homes, total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problems with excessive</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wastewater loading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problems with poor</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>effluent quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Derived from files at Department of Natural Resources and Community Development regional office in Asheville, N. C. Detailed information on each facility is presented in Appendix M.

**Includes paper company, oil companies, rubber manufacturer, water treatment plants, mines, sand and gravel companies, textile company, and laundromats.

***Includes subdivisions, mobile home parks, motels, rest areas, camps, restaurants, industri with domestic wastes only, and churches.
can begin. Step 1 of the facility planning process involves the delineation of a planning area, preparation, submission, review, and approval of a facilities plan. Steps 2 and 3 involve the actual design and construction, respectively, of treatment facilities. Substantial amounts of federal and state monies have been available in the past for communities to undertake planning and construction phases. In North Carolina, the program is administered by the Department of Natural Resources and Community Development, following the regulations of the U. S. Environmental Protection Agency.

The portions of the study area for which facilities plans are being prepared are shown in Appendix M. Regional Step 1 plans are in preparation in Haywood and Jackson Counties, and planning for predominantly municipal areas is under way in the vicinity of Robbinsville, Cherokee, Cashiers, Franklin, and Highlands. In Table 18 is shown the amount of funds allocated for wastewater treatment facilities by the Environmental Protection Agency in the study area between October, 1976, and July, 1980. Significantly less federal funds, on a per-capita basis have been spent in the study area than in the state as a whole. This same pattern was found to be true for each of the 17 westernmost counties in North Carolina (12).

Some reasons why there has not been more participation in the facilities planning and construction program can be hypothesized. The Step 1 planning phase has been under way for years in many of the communities in the study area. This is partially attributable to the time it has taken to analyze infiltration and inflow problems within the existing sewer systems, which are extensive. An "I and I" study must be completed and approved before the Step 1 plan in its entirety can be certified. Substantial delays have been the rule during nearly every portion of the planning process -- the consulting firms, the state and federal agencies have all taken a considerable amount of time to complete their respective tasks. The towns and counties ultimately responsible for carrying out this process generally do not have the personnel or technical resources necessary to assure that planning is rapidly completed. Because these communities have not completed the Step 1 planning phase, they are not yet eligible to apply for the more substantial Step 2 and 3 grants for design and construction.
Table 18

Environmental Protection Agency Support for Wastewater Treatment Facility Planning and Construction, 1976 to 1980

<table>
<thead>
<tr>
<th>County</th>
<th>Population*</th>
<th>EPA Wastewater Construction Grant Funds Allocated, Oct., 1976 - July, 1980 (Thousands of Dollars)**</th>
<th>Funds per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graham</td>
<td>6,726</td>
<td>29</td>
<td>4.3</td>
</tr>
<tr>
<td>Haywood</td>
<td>44,673</td>
<td>114</td>
<td>2.6</td>
</tr>
<tr>
<td>Jackson</td>
<td>25,853</td>
<td>29</td>
<td>1.1</td>
</tr>
<tr>
<td>Macon</td>
<td>19,219</td>
<td>463</td>
<td>24.1</td>
</tr>
<tr>
<td>4-County Total</td>
<td>96,471</td>
<td>635</td>
<td>6.6</td>
</tr>
<tr>
<td>State Total</td>
<td>5,678,621</td>
<td>253,022</td>
<td>44.6</td>
</tr>
</tbody>
</table>

*Projected by Office of State Planning of the North Carolina Department of administration for July 1, 1978

Financial Assistance Programs for Improving
On-Site Wastewater Management

Most financial assistance efforts for improving wastewater management focus on support for centralized facilities in urban and urbanizing areas. While assistance is potentially available from an array of agencies, most funding for improving sewage treatment must be funneled through the same 201 planning process described above.

The 1977 amendments to the Clean Water Act included some provisions that could greatly improve on-site wastewater treatment problems within the study area. A three-year, special-grant program was initiated that is designed to encourage the use of "innovative and alternative" wastewater treatment systems, especially in rural areas. This program makes public assistance available for wastewater treatment, including septic systems, at private homes, as long as a public management program is simultaneously developed. The primary objective of this program is to provide more appropriate, less costly alternatives to conventional wastewater collection and treatment facilities in order to more economically serve communities that have been by-passed by previous federal and state funding programs. Approximately $4.5 million of North Carolina's total annual federal grant for wastewater construction projects must be allotted to this program -- 4% of the total ($3.3 million annually) must go to fund "alternative" systems in communities having populations below 3,500, and 2% ($1.2 million annually) must go to fund "innovative" systems. Although this program has been under way for almost two years, it has yet to be applied to meet problems anywhere in western North Carolina. As of September, 1980, of the $4.5 million that has thus far been allocated, none of these funds has been used to support projects in the study area counties or in any of the 17 westernmost North Carolina counties (12). Funding under this special program is scheduled to be terminated on September 30, 1981.

Financial assistance to install and improve individual septic systems may also be available to eligible home-owners through the 502 and 504 home improvement and repair programs administered by the Farmers Home Administration. Eligible applicants must be owner-applicants and meet certain
income restrictions. Primarily, loan funds are available, but grant funds may also be available for eligible households where a senior citizen 62 or more years of age resides. The funds available for loans under these programs have not normally been fully utilized in the study region. It is likely that many eligible home-owners are not aware of the program. Furthermore, people in the region are often reluctant to become encumbered by a loan. District program managers have also been reluctant to approve loan or grant applications from people who own more than five acres of land, even though they otherwise meet income eligibility criteria.

All financial assistance programs for wastewater treatment and disposal are in jeopardy under the current federal administration. It may be successfully argued, however, that some of the rural needs, such as those of the western North Carolina study area, can be met more economically than the more complex problems in and around urban centers. Whether this is demonstrated and the extent to which public funds for needed improvements will continue to be available remains to be established.

Appropriate Alternatives for On-site Wastewater Disposal in Western North Carolina

There has been considerable interest in developing alternative technologies for on-site wastewater disposal during the past decade. This is due, in part, to the rapid growth of homes constructed using septic systems, and the rapid decline in the number of sites where conventional systems can be adequately installed.

There has been little change in the basic design and installation of septic tank systems in over fifty years. Even today, the majority of public health officials agree that the best alternative for wastewater disposal in rural areas is a properly located, designed, installed and maintained "conventional septic system." This has been recently substantiated by studies of the U. S. General Accounting Office and the Environmental Protection Agency (13, 14).

There is much disagreement about what is meant by "conventional" and "alternative" on-site treatment systems. A standard septic tank system is considered an "alternative" to a central collection and treatment system by
the Environmental Protection Agency. The public health sanitarian generally views an alternative as a system which is much more sophisticated than the customary septic-tank system.

In this report, "alternative" is intended to apply to any technology or management program which differs from the standard procedures presently used on a regular basis within the four mountain-area-study counties. A substantial amount of work on alternative on-site wastewater treatment systems has been undertaken by the Individual Wastewater Project of the Triangle J Council of Governments in Research Triangle Park, North Carolina (15). While their work focused on applications appropriate to the piedmont, many of these systems could be adapted for use in the mountains.

**Modifications to Make "Conventional" Systems Work Better**

1. Water Conservation

Water conservation is the simplest, yet often the most neglected, method of improving and maintaining any on-site wastewater treatment system. Except during infrequent periods of severe drought, an abundant drinking water supply is generally available to individuals and communities throughout western North Carolina. People often forget that the vast majority of water used in homes passes through to the sewer or septic system. Graham County sanitarians cited excessive use of water as the most serious maintenance problem, reducing the effectiveness of septic tank systems county-wide. Haywood County sanitarians said that the problem is particularly a problem in older homes where the original septic system was not designed for accepting automatic washing machine wastewaters.

Adopting water-conserving habits is often an inexpensive and effective way to reduce excessive use of water. Wasteful habits include using the toilet to flush away a cigarette butt, leaving the sink spigot on while shaving or tooth-brushing, taking frequent lengthy showers, and running the washing machine or dishwasher with only half a load.

A variety of inexpensive water conserving devices is available which can greatly aid people's efforts to conserve water in the home. Sanitarians interviewed from the four study area counties indicated that they are
currently aware of very little use of water-conserving devices in the region. Toilet dams are one of the most effective devices which typically reduce wastewater production by about two gallons per flush. Flow-restricting shower heads and spigots are also simple to install and have a rapid pay-back period as a result of the energy savings from reduced hot-water use. The North Carolina Building Code has recently been amended, requiring water-conserving toilets and shower heads to be installed in new homes.

2. Septic Tank Pumping

Infrequent septic-tank pumping was identified as the most significant septic system maintenance problem by sanitarians in Haywood, Jackson, and Macon Counties. It was pointed out in Jackson County that most people do not have their tanks pumped until they are experiencing problems. Pumping every three to five years is recommended. The sludge level within the tank should be checked annually and the tank pumped out before the sludge level exceeds one-third of the tank's liquid capacity.

3. Two-Compartment Septic Tanks

Two-compartment septic tanks were at one time required in North Carolina, but since the requirement was dropped, there has been little use within the study area. Restoring this requirement is a recommendation of the Individual Wastewater Project of the Triangle J Council of Governments (15). Representatives from 25 of the 29 western North Carolina counties in the Environmental Health Section of the Western North Carolina Public Health Association almost unanimously voted to recommend restoring the two-compartment requirement at a special meeting on December 10, 1980.

4. Distribution Box Alternatives

Distribution boxes, commonly installed in the region whenever two or more lateral drainlines are used, cause more difficulty than any other component of a conventional septic system. The distribution box, particularly on sloping terrain, must be installed perfectly level to provide equal distribution of flow to all lateral lines. Sanitarians in each of the four study counties observed that this is the biggest problem faced by septic system installers. Specifications for serial distribution systems on sloping
lands, utilizing earthen-dam step-downs or drop-boxes, are included in the U. S. Public Health Service Manual of Septic Tank Practice (16). These systems have not been applied frequently within the study area. The principle objection to serial distribution is that each upper trench must become filled and, essentially, must fail before there will be overflow into the next trench below.

An alternating drainfield system is a promising alternative which has yet to be tried in the study area. Two full-sized or partial-sized drainfields and a manually-operated diversion valve are installed. By turning the valve on a regular basis, such as annually, effluent distribution is assured and the previously used drainfield has the opportunity to rest. The success of this system is dependent on cooperation by the homeowner in turning the valve at the appropriate intervals.

5. Trenches or Beds

Beds are commonly used by Graham and Jackson Counties, while Haywood and Macon Counties use primarily trenches in their drainfields. Trenches have been demonstrated to be preferable, providing up to five times more sidewall area than do beds for identical bottom areas (14). Effluent absorption and treatment, especially on shallow soils, is much greater on the sidewalls of trenches, in comparison to the trench or bed bottom interface.

On steeply sloping land, it is necessary to cut benches along the contours to allow a backhoe to install a bed or trench system. Some counties permit terraces to be constructed for drainfields on slopes exceeding 30 percent. This exposes bedrock, which is a poor recipient of wastewater, and can lead to seepage of effluent out from the vertical bench cuts.

6. Drainfield Drainage

Excessive surface and subsurface water-flow into the drainfield area is a major cause of system failure in the mountains. Surface-water diversions and subsurface drains around the drainfield can often prevent excess water-loading problems from occurring. Drainfields constructed within flood plains or in low areas where the water table is high are not likely to provide effective, long-lasting on-site wastewater treatment.
Applications of New Technologies

1. The Low Pressure Pipe (LPP) Septic System

The LPP system was initially developed for use on flat, sandy soils subject to a high water table on the coast of North Carolina (17). The system has also been refined and extensively applied and tested in the piedmont, and design guidelines are available (18, 19). Three LPP systems have recently been installed as repairs in Haywood County. Two of these were installed with support from the National Demonstration Water Project (20).

The LPP system involves distributing wastewater through the drainfield under pressure instead of by gravity as in a conventional septic system. Pressure is normally provided by a pump located in a pump tank adjacent to the septic tank. The drainfield also differs significantly from a conventional system's drainfield. Wastewater is distributed through 1¾-inch PVC pipe placed in narrow trenches that are dug with a small ditching machine. The trenches are shallow and holes in the pipe are sized and spaced so that wastewater will be spread out uniformly throughout the drainfield. Some of the basic differences between the LPP system and a conventional septic system are outlined in Table 19.

The LPP System, although still undergoing tests, could be applicable to many problem sites in the mountains, such as where the depth of soil to bedrock or a seasonally high water table is shallow. Special design modifications would be necessary for applications on steep mountain sites. A promising option particularly suited to the region would be to provide the pressure for distribution in the drainfield with a siphon. The siphon would be constructed in a separate tank adjacent to the septic tank, upslope of the drainfield.

2. The Mound System

Mound systems are being used with increasing frequency in the coastal region of North Carolina and elsewhere in the nation. The Mound system involves distribution of sewage in an artificially constructed drainfield, typically consisting of a mound of imported sand and soil mixed together which presumably will accept and treat wastewater better than the naturally available soil at the site.
<table>
<thead>
<tr>
<th></th>
<th>Conventional System</th>
<th>Low-Pressure Pipe System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-treatment</strong></td>
<td>Septic tank</td>
<td>Septic tank</td>
</tr>
<tr>
<td><strong>Dosing</strong></td>
<td>Distribution box or drop boxes</td>
<td>Dosing tank with pump or siphon</td>
</tr>
<tr>
<td><strong>Supply line</strong></td>
<td>4-inch solid pipe to D-box, 4-inch pipe from D-box to drainlines, solid for at least 2 feet</td>
<td>2-inch PVC pipe from dosing tank to drainfield</td>
</tr>
<tr>
<td><strong>Drainfield:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trenches</strong></td>
<td>2 to 3 feet wide and 2 to 3 feet deep, 3-foot centers, built with backhoe</td>
<td>4 to 6 inches wide and 10 to 18 inches deep, 4 to 5 foot centers, built with ditcher</td>
</tr>
<tr>
<td><strong>Gravel</strong></td>
<td>1-to 2-inch gravel, 12 to 18 inches deep</td>
<td>Pea gravel or ½-inch gravel, 6 to 12 inches deep</td>
</tr>
<tr>
<td><strong>Pipe</strong></td>
<td>4-inch black tile, with 3 rows of ½-inch holes, 4 inches apart</td>
<td>1½-inch PVC, holes 3 to 5 feet apart, 3/32 to ½-inch diameter, drilled following design specifications of each system</td>
</tr>
</tbody>
</table>
Mound systems have been installed at new homesites in two parts of the study region. A mound was constructed in Haywood County at a site which was poorly drained and had a high water table. Installation costs were excessive, due to the time required to find and transport suitable fill material, to prepare the drainfield, and to provide adequate drainage and diversion of springs around and beneath the mound. A pump tank, pump and 1½-inch PVC laterals are used in the system, similar to what is used for the pump-dosed LPP system described above.

Modified Mound systems have been installed to serve homes in a development near Highlands in Macon County. The main problem in this area is the presence of rock and water at or near the ground surface. The systems were designed for use on cut and fill sites, although a substantial amount of additional fill material had to be imported to the site. Distribution of sewage to these mounds is through a conventional, gravity-fed drainfield. Operational information is not yet available.

Due to excessive slopes, high water tables, the frequency of springs, and the limited availability of suitable fill materials, the applicability of the mound system alternative to problem sites in the mountains is limited.

3. Composting Toilets

Although there has been a great deal of interest expressed in utilizing "waterless" toilets in the study region, only one unit is currently in operation. Composting toilets may be applicable in summer homes or in existing homes which currently do not have any treatment system. The National Center for Appropriate Technology published a guide for prospective owner-builders of compost toilets (21), and the California Office of Appropriate Technology and the Environmental Protection Agency are in the process of publishing the results of a one-year study of the public health acceptability and performance reliability of 30 waterless toilets being used in California homes (22). Solar-assisted composting privies have been successfully used in the White Mountains of New Hampshire (23, 24) and could be a favorable alternative to the pit privy.

The county health department sanitarians interviewed are dubious about the potential applicability of composting toilets in the North Carolina
mountains. They questioned the safety of such systems and pointed out that
the other home wastewater -- "gray water" -- must still be safely treated.
In areas where water supply is limited and the soil's suitability for a
septic system is poor, a properly constructed and maintained composting
toilet may be a viable alternative.

4. Gray Water Treatment

Gray water includes all non-toilet wastewaters from the home. Research-
ers have found that it may be easier to treat gray water than combined waste-
water, but that it is just as essential that adequate treatment of gray water
be provided to protect public health (25).

In the four study area counties, it is common for portions of the home's
gray water to be treated separately from the main septic system, or not to
be treated at all. The laundry wastewater is most typically discharged into
a separate system -- a distribution box, followed by a pit or small drain-
field, is often recommended.

Research is not currently available that can be used as a basis for de-
signing adequate gray water treatment systems for the mountain region. One
experimental gray water system has recently been installed in a Jackson Coun-
ty home by the Center for Improving Mountain Living. The system incorporates
a small holding tank, a siphon, and distribution through the growing beds of
an attached solar greenhouse. Performance data is not yet available.

Separate gray water treatment systems are not likely to be used exten-
sively in the mountain region, but should be considered whenever the main
home treatment system is not large enough to handle all of the home's waste-
water flow. They are also essential wherever composting toilets are in-
stalled.

Adoption of Improved Management Programs

Currently, the responsibility for maintaining on-site wastewater dis-
posal systems rests primarily with the homeowner. Sanitarians have the au-
thority to require homeowners to repair malfunctioning systems. This au-
thority is generally used only in response to complaints, although on some
occasions house-to-house surveys have been made to locate and correct
instances of failing or non-existant septic systems. A county-wide survey is now under way in Graham County, aimed at eliminating all straight-pipe discharges. This effort was initiated by the Graham County Health Board because a substantial part of the county is drained by the river which will soon be used as the principal water supply source for Robbinsville.

Inadequate maintenance is one of the biggest reasons cited by county sanitarians why septic systems within the study area fail, as discussed previously. Pumping the septic tank at the proper time and conserving water-use habits are often all the maintenance procedures necessary for a conventional septic system. It is much more difficult to restore a failing system than it is to prevent one from initially failing.

Effective use of many alternative on-site wastewater disposal systems is dependent on regular maintenance:

- the diversion valve in a dual drainfield system must be turned periodically
- the pump in a low-pressure or mound system must be frequently checked and repaired when necessary
- low-pressure distribution drainfield lines should be flushed out with a hose annually
- composting toilets must be emptied

If proper maintenance is assured, systems could be designed more effectively to meet the specific needs of an area. For instance, cluster systems serving two or more homes could become practical for use in subdivisions.

There has been a growing interest in public and private septic system maintenance programs nationwide. The U.S. Government Accounting Office reported that millions of dollars could be saved by encouraging the permanent use of properly designed and maintained septic systems as alternatives to community sewers in many areas (13). The Environmental Protection Agency has published a report describing management alternatives and case studies of ongoing management programs throughout the country (26). Hancor published a report on maintenance by private industry of on-site wastewater treatment systems (27).

The Individual Wastewater Project of the Triangle J Council of Governments evaluated management options that would be feasible in North Carolina (28).
As a consequence of newly enacted state legislation, all local governmental units in North Carolina authorized to provide community sewers and wastewater treatment are now authorized to provide on-site operation and maintenance services. This applies to cities, counties, county water and sewer districts, sanitary districts, metropolitan water districts, metropolitan sewerage districts and water and sewer authorities. No local governmental units in the state, however, have yet adopted on-site management programs. Within the study area, Jackson and Haywood counties are the most likely candidates for initiating the development of county-wide programs because they are already involved in regional wastewater management planning.

Standards for local health departments in North Carolina call for the development and implementation of a survey schedule for locating, identifying and correcting malfunctioning individual sewage systems (29). This standard, if implemented, would insure at least a minimum level of septic system maintenance. None of the counties within the study area are currently carrying out such a program, and only two counties throughout the state could be identified that have active survey programs. Sanitarians interviewed in the study area indicated that they are interested in such an effort but do not have the manpower necessary to effectively carry one out and still complete their other mandated responsibilities. The survey programs under way in Guilford and Robeson counties will be briefly described.

The Guilford County Health Department completed a county-wide community survey about 15 years ago, at which time all straight-pipe discharges were eliminated. An additional staff person was added to the department's environmental health section to carry out this survey. Since that time, different sections of the county are resurveyed each year, and malfunctioning systems are identified and needed repairs are specified. Each year, approximately 1,000 systems are checked and about 200 systems subsequently repaired. Approximately one person-day per week is allocated to this program. Guilford County health officials report that the survey program is well accepted and feel it is a vitally important component of the county's efforts to protect the public's health (30).

Robeson County began implementing a home environmental health survey program in 1980 during a slack period in new home construction. The objective
is to survey every home in the county within a two-year period and evaluate each home's water supply and sewage disposal system, its solid waste handling practices, and the home's rodent and safety problems, and to make recommendations to the home owner. Each of the 10 members of the environmental health section staff spends approximately a half-day per week on the survey. About 23,000 homes were surveyed during the first program year (31).

FUTURE OUTLOOK

Most homes in the western North Carolina mountains currently depend on on-site wastewater treatment systems, and a growing proportion of the new homes being constructed will continue to require on-site systems. As the most suitable building sites have already been utilized, septic system problems in the region can only be expected to increase. The long-term quality of our drinking water and recreational streams will be greatly influenced by our present and future on-site sewage system design, installation and management practices.
REFERENCES


LIST OF APPENDICES

A. Percentage of Homes with On-site Wastewater Disposal Systems, by Township
B. Densities of Homes with On-site Wastewater Disposal Systems
C. Percentage of Homes Without a Flush Toilet, by Township
D. Percentage of Homes Straight-piping, by Township
E. New Residential Construction Using Septic Systems, by Township
F. Registered Subdivision Lots, 1975 to 1979, by Township
G. Soil Limitations for Septic Tanks
H. Percentage of Homes with Individual Water Supply Systems, by Township
I. Percentage of Homes with Individual Springs, by Township
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APPENDIX A

PERCENTAGE OF HOMES WITH ON-SITE WASTEWATER DISPOSAL SYSTEMS, BY TOWNSHIP
Percentage of Homes with On-Site Waste Water Disposal Systems

- 40-59
- 60-79
- 80-99
- 100

Source: 1970 Census of Housing
MACON COUNTY, TOWNSHIPS

Percentage of Homes with On-Site Waste Water Disposal Systems

- 40-59
- 60-79
- 80-99
- 100

Source: 1970 Census of Housing
## Appendix B

Density of Homes with On-site Wastewater Disposal Systems

<table>
<thead>
<tr>
<th>County</th>
<th>Township</th>
<th>Area, Sq. Miles*</th>
<th>On-site Homes**</th>
<th>On-site Homes Per Square Mile</th>
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</thead>
<tbody>
<tr>
<td>Graham</td>
<td>Yellow Creek</td>
<td>71</td>
<td>185</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Cheoah</td>
<td>159</td>
<td>1,452</td>
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<tr>
<td></td>
<td>Stecoah</td>
<td>66</td>
<td>291</td>
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<tr>
<td></td>
<td>Total</td>
<td>296</td>
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<td>Haywood</td>
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<td>2,247</td>
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<td></td>
<td>Cataloochee</td>
<td>111</td>
<td>21</td>
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<tr>
<td></td>
<td>Cecil</td>
<td>58</td>
<td>130</td>
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<td></td>
<td>Clyde</td>
<td>13</td>
<td>720</td>
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<tr>
<td></td>
<td>Crabtree</td>
<td>34</td>
<td>327</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td>East Fork</td>
<td>45</td>
<td>488</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>Fines Creek</td>
<td>62</td>
<td>231</td>
<td>3.7</td>
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<tr>
<td></td>
<td>Iron Duff</td>
<td>11</td>
<td>215</td>
<td>20.1</td>
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<tr>
<td></td>
<td>Ivy Hill</td>
<td>43</td>
<td>680</td>
<td>15.9</td>
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<td></td>
<td>Jonathan's Creek</td>
<td>28</td>
<td>302</td>
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<tr>
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<td>Pigeon</td>
<td>24</td>
<td>1,119</td>
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<td></td>
<td>Waynesville</td>
<td>64</td>
<td>2,634</td>
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<td>White, Oak</td>
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<td>548</td>
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<tr>
<td>Jackson</td>
<td>Barker's Creek</td>
<td>25</td>
<td>250</td>
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<tr>
<td></td>
<td>Canada</td>
<td>64</td>
<td>114</td>
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<tr>
<td></td>
<td>Caney Fork</td>
<td>44</td>
<td>141</td>
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<td>Cashiers</td>
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<td>Cullowhee</td>
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<td>728</td>
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<td>Hamburg</td>
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<td>Qualla</td>
<td>64</td>
<td>882</td>
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<td></td>
<td>River</td>
<td>22</td>
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<td></td>
<td>Savannah</td>
<td>23</td>
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<td>Scotts Creek</td>
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<td></td>
<td>Sylva</td>
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<td>Webster</td>
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<td>Total</td>
<td>491</td>
<td>5,697</td>
<td>11.6</td>
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### Appendix B (Cont.)

**Density of Homes with On-site wastewater Disposal Systems**

<table>
<thead>
<tr>
<th>County</th>
<th>Township</th>
<th>Area, Sq. Miles*</th>
<th>On-site Homes**</th>
<th>On-site Homes Per Square Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macon</td>
<td>Burningtown</td>
<td>33</td>
<td>233</td>
<td>7.0</td>
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<tr>
<td></td>
<td>Cartoogechaye</td>
<td>87</td>
<td>431</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>Cowee</td>
<td>42</td>
<td>422</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>Ellijay</td>
<td>22</td>
<td>388</td>
<td>18.0</td>
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<tr>
<td></td>
<td>Flats</td>
<td>12</td>
<td>167</td>
<td>14.2</td>
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<tr>
<td></td>
<td>Franklin</td>
<td>41</td>
<td>1,783</td>
<td>43.4</td>
</tr>
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<td></td>
<td>Highlands</td>
<td>56</td>
<td>561</td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>Millshoal</td>
<td>26</td>
<td>346</td>
<td>13.1</td>
</tr>
<tr>
<td></td>
<td>Nantahala</td>
<td>83</td>
<td>342</td>
<td>4.1</td>
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<tr>
<td></td>
<td>Smiths Bridge</td>
<td>68</td>
<td>485</td>
<td>7.2</td>
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<tr>
<td></td>
<td>Sugar Fork</td>
<td>34</td>
<td>174</td>
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</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>504</td>
<td>5,332</td>
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<tr>
<td></td>
<td>4-County Total</td>
<td>1,839</td>
<td>22,116</td>
<td>12.0</td>
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</table>

*Area derived by planimetry

**Number of on-site homes taken from Census of Housing data files, provided by the North Carolina State Data Center, Chapel Hill.
APPENDIX C

PERCENTAGE OF HOMES WITHOUT A FLUSH TOILET, BY TOWNSHIP
Percentage of Homes Without a Flush Toilet

- 0-15
- 16-30
- 31-45
- Over 45

Source: 1970 Census of Housing
JACKSON COUNTY, TOWNSHIPS

Percentage of Homes Without a Flush Toilet

0-15
16-30
31-45
Over 45

Source: 1970 Census of Housing
APPENDIX D

PERCENTAGE OF HOMES STRAIGHT-PIPING,
BY TOWNSHIP
HAYWOOD COUNTY, TOWNSHIPS

Percentage of Homes Straight-Piping

- 0-2
- 3-10
- 11-20
- Over 20

Source: Derived from 1970 Census of Housing 71
JACKSON COUNTY, TOWNSHIPS

Percentage of Homes
Straight-Piping

0-2
3-10
11-20
Over 20

Source: Derived from 1970 Census of Housing
APPENDIX E

NEW RESIDENTIAL CONSTRUCTION USING SEPTIC SYSTEMS, BY TOWNSHIP
GRAHAM COUNTY, TOWNSHIPS


Number of New Homes Using Septic Systems

- 0-50
- 51-100
- 101-150
- Over 150

Source: Graham County Health Department Completion Files
HAYWOOD COUNTY, TOWNSHIPS


Number of New Homes Using Septic Systems:

- 0-30
- 31-80
- 81-110
- Over 110

Source: Haywood County Health Department Completion Files

Source: Jackson County Health Department Completion Files
MACON COUNTY, TOWNSHIPS


Number of New Homes Using Septic Systems

- 20-40
- 41-60
- 61-80
- 81-110

Source: Macon County Health Department Completion Files
APPENDIX F

REGISTERED SUBDIVISION LOTS,
1975 TO 1979, BY TOWNSHIP
HAYWOOD COUNTY, TOWNSHIPS

Registered Subdivision Lots, 1975-1979

0-100
101-200
201-400
401-600
Over 600

Source: Plat maps in Haywood County Register of Deeds Office
Registered Subdivision Lots, 1975-1979

0-100
101-200
201-400
401-600

Source: Plat maps in Jackson County Register of Deeds Office
SOIL LIMITATIONS FOR SEPTIC SYSTEMS

MACON COUNTY
APPENDIX H

PERCENTAGE OF HOMES WITH INDIVIDUAL WATER SUPPLY SYSTEMS, BY TOWNSHIP
Source: 1970 Census of Housing

GRAHAM COUNTY, TOWNSHIPS

Water Supply Systems
Percentage of Homes with Individual
HAYWOOD COUNTY, TOWNSHIPS

Percentage of Homes with Individual Water Supply Systems

20-40

41-60

61-80

81-100

Source: 1970 Census of Housing
Percentage of Homes with Individual Water Supply Systems:

- 20-40
- 41-60
- 61-80
- 81-100

Source: 1970 Census of Housing
APPENDIX I

PERCENTAGE OF HOMES WITH INDIVIDUAL SPRINGS, BY TOWNSHIP
Source: 1970 Census of Housing

Individual Springs with Percentage of Homes

Graham County, Townships
Percentage of Homes with Individual Springs

- 0-25
- 26-50
- 51-75
- 76-100

Source: 1970 Census of Housing
JACKSON COUNTY, TOWNSHIPS

Percentage of Homes with Individual Springs

0-25
26-50
56-75
76-100

Source: 1970 Census of Housing
Source: 1970 Census of Housing
APPENDIX J

PRIVATE DRINKING WATER SUPPLY TESTS: NUMBER
OF WATER SAMPLES FROM SPRINGS AND WELLS
TESTING POSITIVE FOR COLIFORM BACTERIA
JACKSON COUNTY, TOWNSHIPS
Springs

Number of Water Samples Testing Positive for Coliform Bacteria

- 2-5
- 6-10
- 11-20
- Over 20

Source: Jackson County Health Department Files
Number of Water Samples Testing Positive for Coliform Bacteria

- 0-10
- 11-20
- 21-30
- Over 30

Source: Haywood County Health Department Files

Number of Water Samples Testing Positive for Coliform Bacteria

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Source: Jackson County Health Department Files
APPENDIX K

PUBLIC DRINKING WATER SYSTEMS
### Public Water Supplies - Graham County

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<th>Location</th>
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<th>Condition</th>
<th>Problems+</th>
<th>Violations++</th>
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Source: Division of Health Services, Sanitation Branch, Regional Office, Black Mountain, NC

Notes:

*Source of water supply: Surface-A-I: Surface water source draining an uninhabited watershed requiring minimal treatment
Surface-AII & B: Surface water source draining an inhabited watershed requiring treatment, and considered safe for bathing

**Treatment: Total: Generally means a treatment plant that provides for coagulation, sedimentation, filtration and disinfection
Chl: chlorination only provided for disinfection

†Problems: DS: Distribution system limitations
OS: Old, outmoded system
PB: Poorly built system
W: Watershed inadequately protected
QN: Quantity of supply limited
QT: Quality of water frequently poor
NR: No one responsible for system
PWS: Poor well site
TO: Taste and odor problems
PH: Poor maintenance

‡Violations: C: Coliform standard exceeded
T: Turbidity standard exceeded
CS: Coliform standards for source waters exceeded
M: Monitoring requirements not met
### Public Water Supplies - Haywood County

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## Public Water Supplies - Haywood County (Con't)

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<th>Treatment**</th>
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<th>Violations++</th>
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Source: Division of Health Services, Sanitation Branch, Regional Office, Black Mountain, NC.

Notes:

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PB: Poorly built system
W: Watershed inadequately protected
QM: Quantity of supply limited
PM: Poor maintenance
QT: Quality of water frequently poor
NR: No one responsible for system
MAP: Not adequately protected
PIS: Poor well site
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Source: Division of Health Services, Sanitation Branch, Regional Office, Black Mountain, NC

Notes:
- **Treatment: Total: Generally means a treatment plant that provides for coagulation, sedimentation, filtration and disinfection. FP: filtration only. Chl: chlorination only required for disinfection. Ozone: ozonation provided for disinfection.
- ++Violations: C: Coliform standard exceeded. M: Monitoring requirements not met.
<table>
<thead>
<tr>
<th>Map Code</th>
<th>Location</th>
<th>Source*</th>
<th>Treatment**</th>
<th>Connections</th>
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### Public Water Supplies - Macon County (Cont.)

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<th>Condition</th>
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Source: Division of Health Services, Sanitation Branch, Regional Office, Black Mountain, NC

Notes:

*Source of water supply: Surface-AI: Surface water source draining an uninhabited watershed requiring minimal treatment
Surface-AII: Surface water source draining an inhabited watershed requiring treatment

**Treatment: Total: Generally means a treatment plant that provides for coagulation, sedimentation, filtration and disinfection
Chl: chlorination only provided for disinfection
KP: Alkali added to reduce corrosion

+Problems: OS: Old, Outmoded system
PB: Poorly built system
QN: Quantity of supply limited
QT: Quality of water frequently poor
NR: No one responsible for system
NAP: Not adequately protected
PWS: Poor well site

+Violations: C: Coliform standard exceeded
CS: Coliform standards for source waters exceeded
M: Monitoring requirements not met
APPENDIX L

STREAM CLASSIFICATIONS
APPENDIX M

WASTEWATER DISCHARGE FACILITIES, PLANNING AREAS, AND WATER QUALITY MONITORING STATIONS
### Wastewater Discharge Facilities: Graham County

<table>
<thead>
<tr>
<th>Map Code</th>
<th>Discharge Facility: Name; Type of Ownership</th>
<th>Receiving Stream Name; Classification</th>
<th>Type of Waste</th>
<th>Type of Treatment Plant</th>
<th>Design Capacity (MCD)</th>
<th>Actual Flow (MCD)*</th>
<th>Problems</th>
<th>Upstream Coliform</th>
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<tr>
<td>1</td>
<td>Town of Robbinsville-MU</td>
<td>Cheoah River C-TW</td>
<td>D</td>
<td>EA</td>
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<td>.23</td>
<td>FWL, PEQ</td>
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<td>2</td>
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<td>Little Tenn, River</td>
<td>D</td>
<td>EA</td>
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<td>.3</td>
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<td>Fontana Village Resort</td>
<td>Gold Creek C-TW</td>
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<td>Little Tenn, River</td>
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<td>Farley Branch</td>
<td>D</td>
<td>ST-SF</td>
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<td>Veach-Wilson Oil Co.-PV</td>
<td>Tulula Creek A-II-TW</td>
<td>I</td>
<td>GWS</td>
<td>.004</td>
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**Notes:**

- **Map Code:** Unique identifier for each location.
- **Discharge Facility:** Name and type of ownership (PV: Private, PC: School, MU: Municipal).
- **Receiving Stream:** Name and classification (C-TW: Trout Water, A-II-TW: Turbid Water).
- **Type of Waste:** D: Domestic, I: Industrial.
- **Type of Treatment Plant:** EA: Extended Aeration, ST: Septic Tank, SF: Sand Filter, OWS: Oil - Water Separator, L: Lagoon.
- **Problems:** FWL: Excessive wastewater loading, PEQ: Poor effluent quality.
- **Actual Flow:** Indicates average measured flow or flow during a monitoring day.
- **Upstream Coliform:** Presence or absence of coliform bacteria.

**Type of Ownership:** PV: Private, PC: School, MU: Municipal

**Stream Classification:** C-TW: Trout Water

**Type of Waste:** D: Domestic, I: Industrial
### Water Quality Monitoring Stations: Graham County

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<th>Map Code</th>
<th>Station Number</th>
<th>Station Name</th>
<th>Stream Sampled</th>
<th>Location of Station</th>
<th>Period Sampled</th>
<th>Frequency Sampled</th>
<th>Problem Causes</th>
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<td>C-TW</td>
<td>In Lake Cheoah, below Fontana Dam &amp; Fontana Village discharge</td>
<td>6/68-11/74</td>
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<td>6/68-11/74</td>
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<td>Cheoah River</td>
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<td>Long Creek</td>
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<td>Above sewage outfalls in Robbinsville</td>
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**Notes:**
- Problem Causes: PS: Pollution Source, NPS: NPS Problems
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<th>Receiving Stream Classification</th>
<th>Type of Waste</th>
<th>Type of Treatment Plant</th>
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<th>Actual Flow (MGD)*</th>
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### Wastewater Discharge Facilities: Haywood County (Cont.)

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<th>Receiving Stream</th>
<th>Type of Waste</th>
<th>Type of Treatment Plant</th>
<th>Design Capacity (MGD)</th>
<th>Actual Flow (MGD)*</th>
<th>Problems</th>
<th>Upstream Coliform Problems</th>
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**Notes:**

- **Type of Ownership:** PV: Private, PF: Federal, PC: School, Mu: Municipal, PS: State
- **Stream Classification:** TW: Trout Water
- **Type of Waste:** D: Domestic, I: Industrial, IC: Industrial Cooling Water
- **Type of Treatment Plant:** EA: Extended Aeration, TF: Trickling Filter, CS: Contact Stabilization, GWS: Gravel - Water separator, ST: Septic Tank, SF: Sand Filter, OWS: Oil - Water Separator
- **Problems:** EWL: Excessive wastewater loading, PEQ: Poor effluent quality
- **Actual Flow:** Indicates average measured flow or flow during a monitoring day
- **Connecting to Waynesville sewer line**
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<th>Map Code</th>
<th>Station Number</th>
<th>Name</th>
<th>Classification</th>
<th>Location of Station</th>
<th>Period Sampled</th>
<th>Frequency Sampled</th>
<th>Problem Causes</th>
<th>Excessive NPS Coliform Problems</th>
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<td>A</td>
<td>040305011</td>
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<td>A-II-TW</td>
<td>Above waste discharges from Canton</td>
<td>5/68-5/75</td>
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<td>NPS</td>
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<td>NPS</td>
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<td>FR0044</td>
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<td>Below waste discharge from Canton/Champion</td>
<td>5/68-12/74</td>
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<td>FR0045</td>
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<td>Below Canton &amp; above Waynesville discharges</td>
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Notes:
# Wastewater Discharge Facilities: Jackson County

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<th>Type of Waste</th>
<th>Type of Treatment Plant</th>
<th>Design Capacity (MGD)</th>
<th>Actual Flow (MGD)*</th>
<th>Problems</th>
<th>Upstream Coliform Problems</th>
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</table>

**Notes:**

- **Type of Ownership:**
  - PV: Private
  - PF: Federal
  - PC: School
  - MU: Municipal
  - C: County

- **Type of Waste:**
  - D: Domestic
  - I: Industrial

**Stream Classification:**
- TW: Trout Water

**Type of Treatment Plant:**
- AS: Activated Sludge
- EA: Extended Aeration
- TF: Trickling Filter
- CS: Contact Stabilization
- JA: Jet Aeration
- ST: Septic Tank
- SF: Sand Filter
- OWS: Oil - Water Separator
- L: Lagoon
- RC: Recirculation System

**Problems:**
- ENL: Excessive wastewater loading
- PEQ: Poor effluent quality

*Actual Flow: Indicates average measured flow or flow during a monitoring day.
### Water Quality Monitoring Stations: Jackson County

<table>
<thead>
<tr>
<th>Map Code</th>
<th>Station Number</th>
<th>Stream Sampled</th>
<th>Name</th>
<th>Classification</th>
<th>Location of Station</th>
<th>Period Sampled</th>
<th>Frequency Sampled</th>
<th>Problem Causes</th>
<th>Excessive NPS Coliform Problems</th>
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<tr>
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Notes:

Type of Ownership: PV: Private  
PF: Federal  
PC: School  
MU: Municipal  
C: County  

Stream Classification: TW: Trout Water  

Type of Waste: D: Domestic  
I: Industrial  

Type of Treatment Plant: SB: Settling Basin  
TF: Trickling Filter  
CS: Contact Stabilization  
ST: Septic Tank  
SF: Sand Filter  
JA: Jet Aeration  
L: Lagoon  
DSC: Dredge Spoils Screening  

Problems: EWL: Excessive wastewater loading  
PEQ: Poor effluent quality  

*Actual Flow: Indicates average measured flow or flow during a monitoring day
## Water Quality Monitoring Stations: Macon County

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<td>C</td>
<td>Below Franklin discharge</td>
<td>11/73-5/75</td>
<td>N</td>
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<td>Classification</td>
<td>Location of Station</td>
<td>Period Sampled</td>
<td>Frequency Sampled</td>
<td>Problem Causes</td>
<td>Excessive NPS Coliform Problems</td>
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<td>LT0011</td>
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<td>7/68-4/75</td>
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<td>S</td>
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<td>7/68-4/75</td>
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<td>B-TW</td>
<td>In headwaters</td>
<td>11/73-present</td>
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<td>At Macon-Jackson</td>
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Notes:

Frequency Sampled:
- M: Monthly
- Q: Quarterly
- SA: Semi-annually
- A: Annually