Survey of Municipal, Industrial and Large Domestic Septic Tank Systems in North Carolina and a Preliminary Assessment of Their Impact On Groundwater Quality

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Groundwater Section
Division of Environmental Management
Department of Environment, Health & Natural Resources

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This report was prepared by Nathaniel C. Wilson in partial fulfillment of the FY-88 Underground Injection Control (UIC) Program objectives.

Survey of Municipal, Industrial and Large Domestic Septic Tank Systems in North Carolina and a Preliminary Assessment of Their Impact on Groundwater Quality

Nathaniel C. Wilson

Introduction

As a part of North Carolina's Underground Injection Control (UIC) Program, an inventory and assessment of certain septic tank systems in North Carolina was conducted in FY-87 and FY-88. Products of that study include the following: (1) an inventory of all domestic septic tank systems with a design flow greater than 2,000 gallons per day (gpd) and industrial and municipal septic tank systems of any size, and (2) an in-depth study of the environmental impact of five (5) geographically diverse septic tank systems. It is intended that conclusions reached during this study benefit the regulation of septic tank systems in North Carolina.

Septic Tank Inventory

An industrial septic tank system, in the regulatory sense, is one that accepts industrial waste water which is defined as all wastewater resulting from any process of trade, industry, manufacture, or business. Industrial wastewater excludes stormwater and wastewater from restaurants. Domestic septic tank systems accept sewage and domestic wastewater only. Municipal systems are regulated as industrial systems because they accept sewage and other wastewater with a wide variety of contaminents including solvents.

Responsibility for regulation of septic tank systems is delegated to the Department of Environment, Health and Natural Resources (EHNR), Division of Environmental Management (DEM), and Division of Health Services (DHS).

Septic tank systems regulated by DEM were inventoried during FY-87. DEM is responsible for regulating all industrial facilities, publicly owned facilities, and public utilities. Statutory authority is defined under Chapter 130, Section 160 of the General Statutes of North Carolina. Regulations under that authority are contained in North Carolina Administrative Code Title 15, Subchapter 2H, Section .0300.

Large septic tank systems regulated by DHS were inventoried during FY-88. DHS is responsible for all non-industrial facilities, including restaurants, not regulated by DEM. Their statutory authority is defined in Chapter 130A, Article 11 of the General Statutes of North Carolina. Regulations are contained in North Carolina Administrative Code Title 10, Subchapter 10A, Section .1900.

The total of 858 septic tank systems in the DEM inventory is a diverse group of systems ranging from domestic systems to industrial process water systems (ex: seafood processing). The 615 septic tank systems in the DHS inventory consist of schools, restaurants, and large domestic systems. The total of 1,473 large septic tank systems represents only about .1% of the total number of septic tank systems in North Carolina and about 2% of the estimated average daily flow (based on extrapolated 1980 census data).

The following table lists the major types of facilities and their percentage of the total inventoried (see also figure 1):

Table 1:

Types of Facilities

	%	#
Domestic systems including: subdivisions, mobile home parks, campgrounds, child care facilities, rest homes, country clubs, condominiums, and churches	23	336
Miscellaneous municipal, state, and federal systems	3	50
Food processing; seafood, meat and poultry	4	54
Vehicle washes	5	70
Furniture Manufacturers	2	30
Schools	20	298
Restaurants	8	115
Textile Manufacturers	3	40
Laundromats, dry cleaners, and funeral homes	1	18
Miscellaneous commercial and industrial systems including: metal finishing, leather manufacturing, gas stations, stores, and laboratories (many are "domestic" systems with no process water)	31	462
	100	1,473

The miscellaneous commercial and industrial category reflects the wide variety of types of facilities and the number of facilities of which only the name of the facility is known. Further work will include definition of the facilities by types, location by latitude and longitude, and inspection.

Over the years, DEM's responsibilities for permitting septic tank systems has changed, leading to a mixture of domestic, municipal, and industrial permitted facilities. Although many manufacturing plants or commercial establishments may have only been permitted for sewage disposal (no process water), the characteristics of the influent to the septic tank may differ widely from a typical domestic system because of the use of various commercial and organic compounds, including acids, bases, and cleaning solvents. Although DHS currently has no upper size limitation on their regulated systems, most of their permitted systems have flows less than 2,000 gpd. Figure 2 illustrates the geographic distribution of the 1,473 septic tank systems presently inventoried. Generally, the areas which have high concentrations of septic tank systems are located near large municipalities (10,000 or more people), but not all large municipalities have a concentration of septic tank systems. This disparity may be a function of the availability of sewer systems. Approximately 80% of the inventoried systems are non-domestic and would normally be found near metropolitan areas.

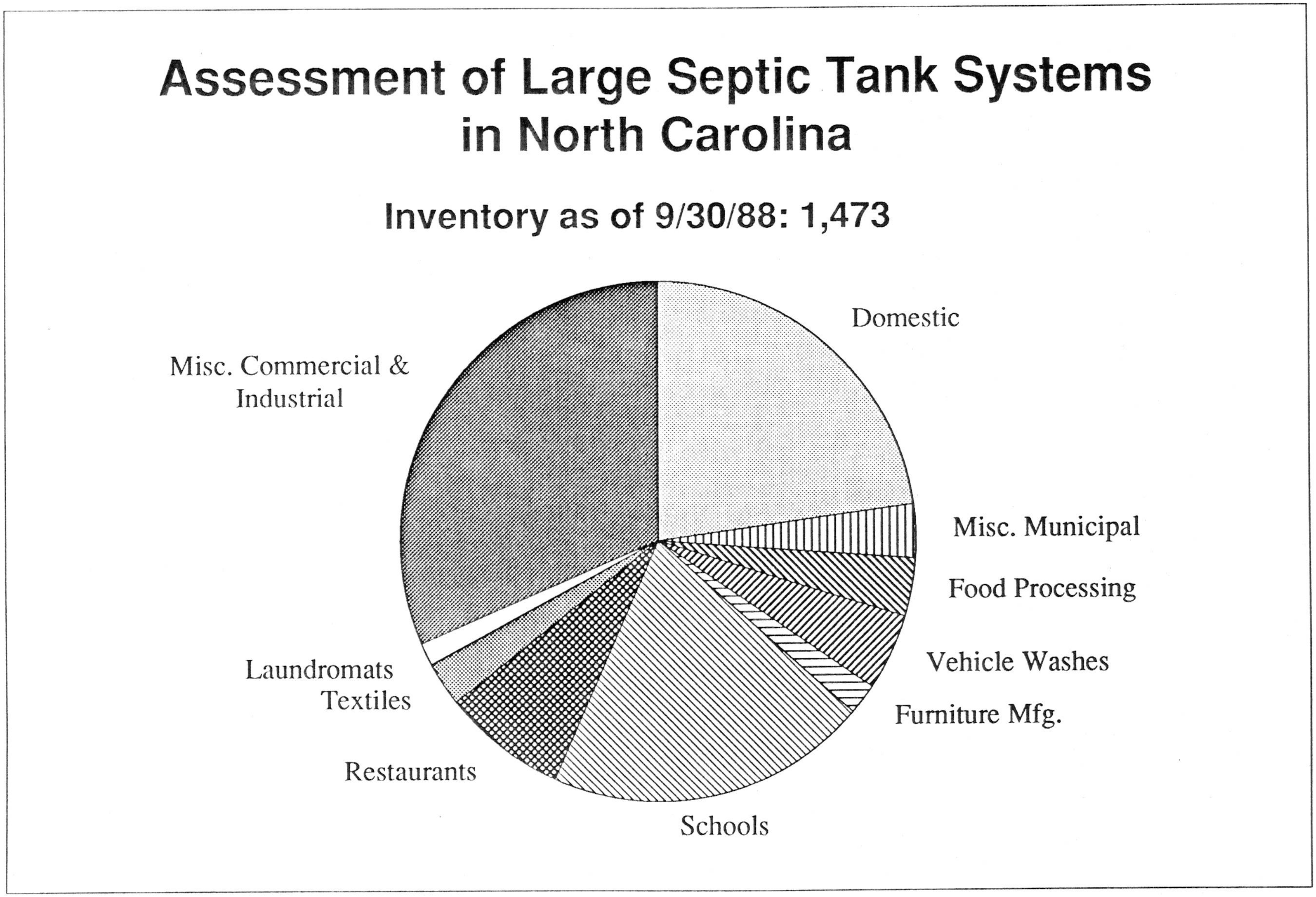
Assessment of Large Septic Tank Systems
in North Carolina
Inventory as of 9/30/88: 1,473
Domestic
Misc. Commercial &
Industrial
Misc. Municipal
Food Processing
Vehicle Washes
Furniture Mfg.
Laundromats
Textiles
Restaurants
Schools

Figure 1

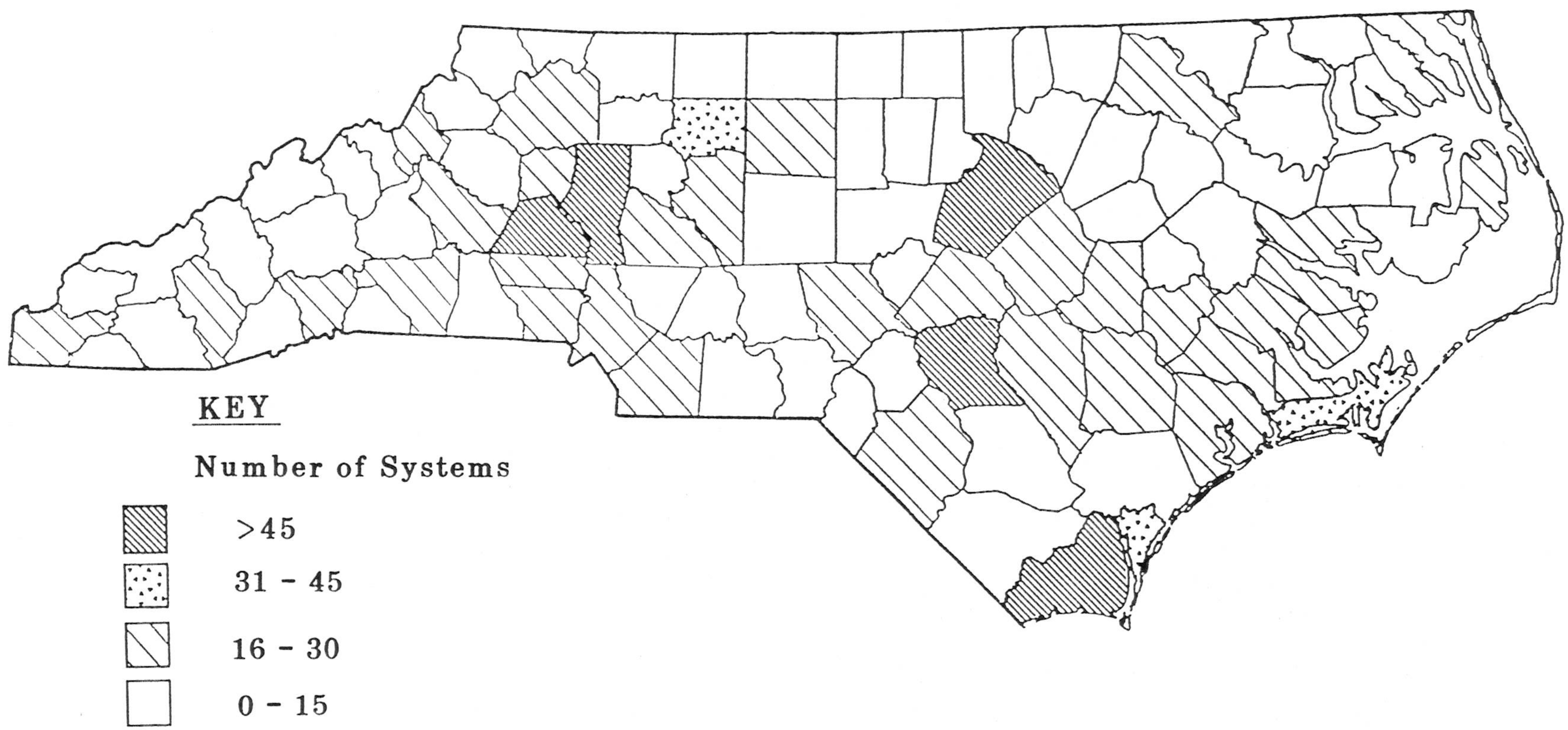

Figure 2
Distribution of Septic Tank Systems

Septic Tank System Assessment

From a group of 795 DEM permitted systems inventoried in FY-87, five facilities were chosen for detailed study of their impact on groundwater. The selection of these facilities was based on their geographic region (see figure 3) the type of waste generated by the facility, system age, and their willingness to cooperate in the research project. The facilities chosen are a good cross-section of the different types of operating facilities inventoried. Table 2 briefly describes the five systems studied.

Table 2: Septic Tank Systems Selected for Detailed Study

Type of Facility	Year Inst.	Design Flow	Type of Disposal	No. of Fields	County	Region
School	1975	6000	trench	1	Henderson	Mountain
School	1985	2250	trench	1	Iredell	Piedmont
Furniture Plant	1961	6250	trench	1	Chatham	Piedmont
Car Wash	1985	1260	low pressure pipe	1	Onslow	Coastal
Funeral Home	1985	500	trench	1	Wayne	Coastal

The field investigation at each of these sites involved basically the same techniques. During the months of August and early September, 1987, a hollow-stem auger rig was used to bore 5-8 wells around the disposal field of each system. Each well (see Figure 4 and Table 3), was drilled to a depth of 5-20 feet below the water table and screened, with one exception, over the lower 5 feet (WAY-5 was screened over the lower 15 feet). Stainless steel casing and screens were used exclusively. Wells were terminated at or above ground level and were locked for protection. Clean sand was poured into the annulus to cover the screened interval of casing. Bentonite pellets were used as grout to fill the annular space above the sandpack. All casing, screens, and auger sections were steam cleaned before use and each five-foot auger section was used at only one well per site.

During the first sampling event, PVC gloves, stainless steel bailers, and nylon cord were used. The bailers were cleaned with distilled water and rinsed twice with methanol, then air dried to avoid contamination. Newly cased wells were bailed 3-5 times their water volume and sampled within 24 hours after bailing. For the second sampling event, approximately six months later, teflon bailers, cotton cord, and de-ionized water were used. This change in technique was made in order to be more efficient (lighter bailers), and to eliminate caprolactam (see analyses) from analytical results. It was thought that caprolactam may have been contributed by the nylon cord used during the first sampling run; however, this theory was not confirmed by laboratory analyses. In general, laboratory results from the second sampling paralleled the first sampling results; however, all of the organic samples in both sampling events were analyzed after the lapse of the maximum 14 day recommended laboratory holding time (EPA). This problem may have limited the detection of volatile organics, especially from the second sampling event. The first sampling run had a range in holding time in the laboratory of 1.5 to 2 months and the second sampling run holding time ranged from 2.5 to 3.5 months. As noted in Kolega et al., 1987, it is not always possible to complete water analyses within the recommended lab holding time which can be a limitation with this type of research project.

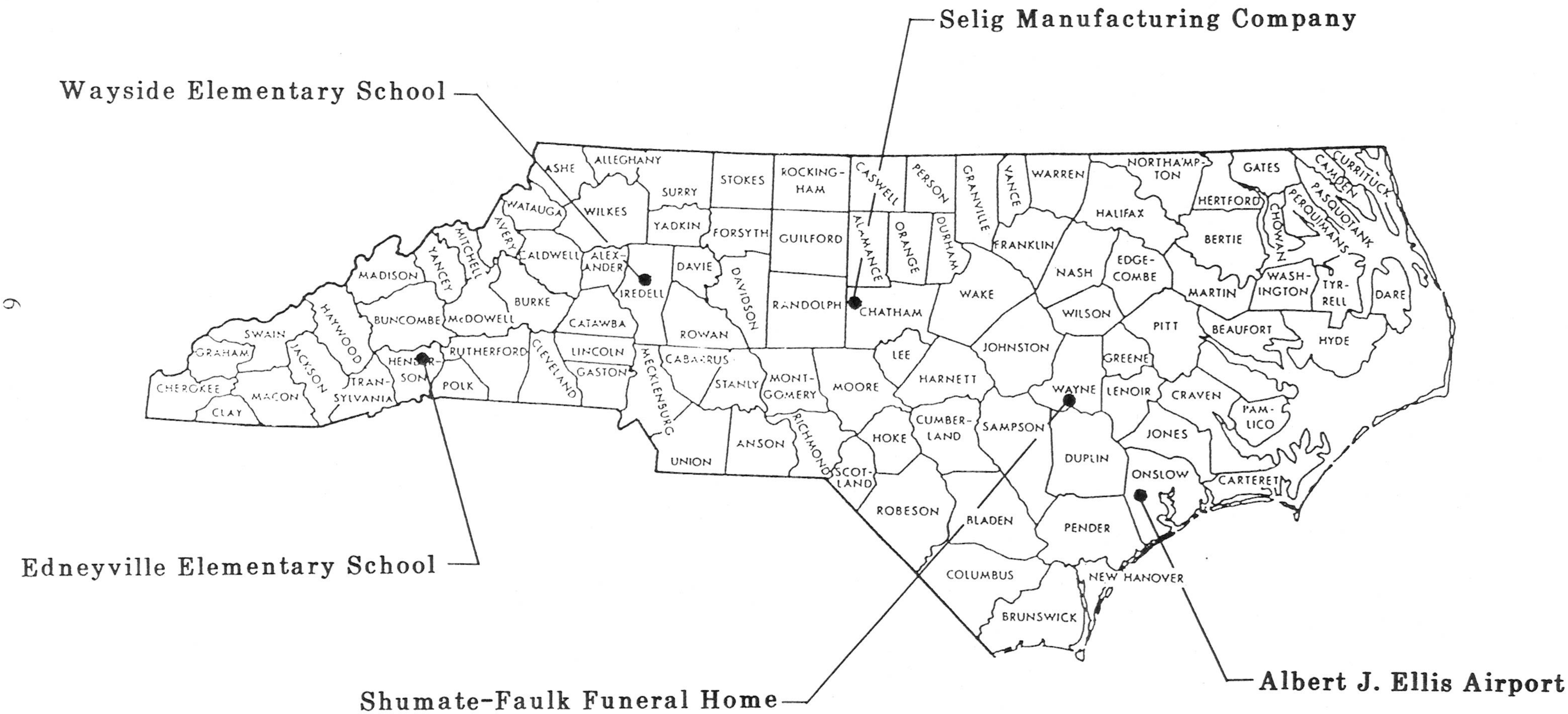

Figure 3
Locations of Five Septic Tank Systems Investigated For Their Impact on Groundwater

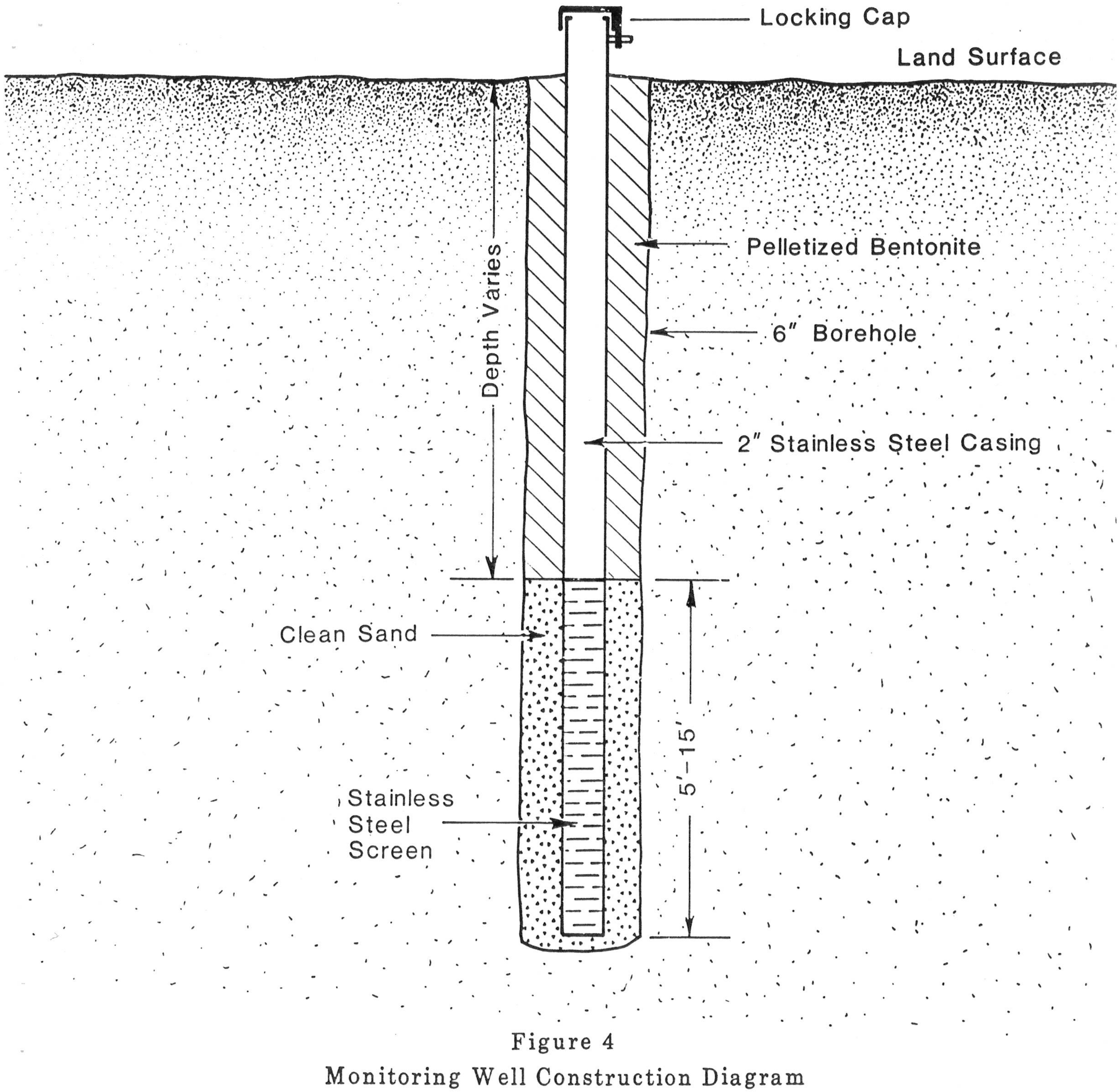

Figure 4
Monitoring Well Construction Diagram

Table 3

Well Construction Data

Well	*Well Depth (ft)	*Mean Water Depth (ft)	*Top of Screen (ft)	Length of Screen (ft)	Sand (ft)	Bentonite (ft)	**Distance (ft)	GW Flow Direction	Direction from Disposal Field
EDN-1	16.00	12.10	11.00	5	7.00	9.00	500	South	Northeast
EDN-2	25.50	18.58	20.50	5	7.00	18.50	6		North
EDN-3	15.90	10.39	10.90	5	7.00	8.90	8		Southwest
EDN-4	20.60	14.75	15.60	5	7.00	13.60	14		South
EDN-5	20.90	11.99	15.90	5	7.00	13.90	40		Southwest
EDN-6	20.70	14.60	15.70	5	7.00	13.70	10		South
EDN-7	20.70	11.04	15.70	5	7.00	13.70	53		South
EDN-8	15.70	9.30	10.70	5	7.00	8.70	104		South
WAY-1	30.60	20.19	25.60	5	16.00	14.60	14	Southwest ?	Northeast
WAY-2	38.60	24.31	33.60	5	18.00	20.60	3		Southeast
WAY-3	30.70	21.52	25.70	5	8.00	22.70	12		Northwest
WAY-4	35.70	23.46	30.70	5	17.00	18.70	47		Southwest
WAY-5	45.50	24.26	30.50	15	21.00	24.50	26		South
SEL-2	21.50	12.20	16.50	5	6.00	15.50	20	Southeast	Northeast
SEL-3	11.33	7.10	6.33	5	7.00	4.33	26		Southwest
SEL-4	15.25	9.34	10.25	5	6.00	9.25	5		Southwest
SEL-5	12.44	3.98	7.44	5	6.40	6.04	7		West
SEL-6	16.00	8.05	11.00	5	6.60	9.40	180		North
SEL-7	23.94	18.00	18.94	5	7.00	16.94	113		Northeast
SHU-1	28.60	25.81	23.60	5	7.00	21.60	53	North	South
SHU-2	29.70	24.70	24.70	5	12.00	17.70	6		West
SHU-3	28.70	24.38	23.70	5	9.00	19.70	42		Northeast
SHU-4	27.95	23.31	22.95	5	11.00	16.95	33		North
SHU-5	29.05	23.68	24.05	5	11.00	18.05	38		North
ALB-1	19.30	3.66	14.30	5	7.00	12.30	109	Southeast	Northeast
ALB-2	14.60	3.15	9.60	5	6.00	8.60	18		Southwest
ALB-3	14.36	3.37	9.36	5	7.00	7.36	77		Northwest
ALB-4	13.93	3.31	8.93	5	7.00	6.93	8		Northwest
ALB-6	9.41	2.80	4.41	5	6.00	3.41	10		Southeast
ALB-7	9.61	3.22	4.61	5	6.00	3.61	8		Southeast

* Measured from Land Surface

** Distance from Edge of Disposal Field to Well

The site descriptions in Appendix A include a detailed listing of analytical results; however several general observations are made here:

The five facilities chosen ranged in age from 2 to 26 years. They were constructed in soils ranging in texture from medium sands to silty clays, with mean depths to the water table, from land surface, (levels from two sampling runs approximately 6 months apart) ranging from 3 to 24 feet. Contamination is higher at (a) the older sites, (b) the sites where the water table is closer to the land surface, and (c) sites where the sand content of the soil is highest.

Aquifer tests (slug tests) conducted at each site reveal a range of soil hydraulic conductivity from >3 feet/day in Wayne County (at the funeral home) to .06 feet/day in Iredell County (at the school). Water table levels were measured before each sampling event and these values were plotted using a computer contouring program. Mounding of the water table beneath the disposal field existed in different degrees at every system. This seemed to indicate, at some sites, along with contamination distribution, which section of the disposal field was operating properly.

(1) Fecal and Total Coliform bacteria counts were very inconsistent. The only facility showing consistently high coliform bacteria contamination was Selig Manufacturing Company. Analytical problems, such as over-dilution or silt/clay rich samples, seemed to exist as values were sometimes reported "<100" or "<1000" organisms/100 ml. Highest bacterial contamination existed at the furniture plant; medium contamination at the two schools and funeral home; and low contamination at the car wash facility, where one would not expect high bacterial contamination.

(2) Mean chloride concentrations show a trend of increasing chloride contamination with increasing age of system and increasing design flow rate. Chloride has long been recognized as an indicator of septic tank system pollution.

(3) Nitrogen contamination was measured by nitrate and ammonia concentrations. Nitrate contamination was highest at Edneyville Elementary School when it exceeded Groundwater Standards (North Carolina Administrative Code Title 15, Subchapter 2L, Section .0200) at four of the eight wells each sampling run. All but one of the sites have nitrate concentrations exceeding ammonia concentrations which translates to an oxidizing environment beneath the disposal field. At Selig Manufacturing Company, mean ammonia concentration exceeds mean nitrate concentration which translates to a reducing environment.

(4) Samples for metals analyses at these sites were not filtered because of possible loss (removal from solution) due to aeration (oxidation) during a filtering process. In general, iron and manganese concentrations exceeded North Carolina Groundwater Standards; however, these may be false concentrations because they include iron and manganese suspended on clay particles. Chloride concentrations did not correlate well with metal concentrations (except slightly with manganese) suggesting that although there may be metal contamination, the noise from possibly false metal ion highs eliminate positive correlation to septic tank pollution. Arsenic was found as a contaminent at the car wash facility, and not found in high concentrations at other sites.

(5) As described above, accurate organic analyses can not be assured because all samples were analyzed after the 14 day recommended laboratory holding time. However, because of the diversity of organic compounds detected and the good correlation to compounds detected in other studies (discussed below) there is no question that trace organic compounds are present in the groundwater beneath most of the sites. In some

cases, depending on the proximity of the drain field to supply wells, and the rate of groundwater flow, these compounds represent a significant health hazard. A table in Appendix B includes the trace organic compounds detected at the septic tank systems in this study, some of the more common sources of those compounds, the wells in which they were detected, and their groundwater quality standard. The groundwater standards are the maximum allowable concentrations as specified in 15 NCAC 2L .0200. Where a standard is not specified, the standard is the naturally occurring concentration as determined by the Director of Environmental Management. Synthetic, man-made, or other substances that do not naturally occur are prohibited. Those standards footnoted as revised standards are contained in revisions to the aforementioned administrative code to become effective August 1, 1989.

Summary

The septic tank system inventory reveals interesting information about their distribution in North Carolina. It has also helped define the different types of facilities that commonly use septic tank systems. These systems are spread throughout the state with high concentrations near major metropolitan areas. These metropolitan areas presumably lack complete municipal sewer systems. Almost 80% of the systems are for industrial, commercial, or municipal facilities. Further inventory work in FY-89 will help define those types of facilities where activities are unknown at this time and add more exact geographical location information (latitude and longitude).

Monitoring wells were constructed at five of the facilities in the inventory. The two samplings of these wells reveals a higher degree of contamination at older sites (ex: Edneyville Elementary School), sites with a small vertical separation between distribution lines and the water table (ex: Albert J. Ellis Airport), and sites in sand-rich soil (ex: Shumate-Faulk Funeral Home). However, all of the facilities indicated groundwater contamination to some degree.

Groundwater quality data from other septic tank systems monitored over the last four years is rather limited. There is a lack of data because many of the systems required to monitor the groundwater beneath their septic tank facilities have either not been constructed as planned or they have simply not sent in their monitoring results. The data that is recorded (from two schools, and several large domestic low pressure piping systems) shows high TOC values, coliform bacteria contamination, and high nitrate concentrations. One school reported high TOC concentrations due to the presence of Methylene Chloride, Toluene, Tetrachloroethylene, and 1,1,2,2 - Tetrachloroethane. Two of these constituents were found in the monitoring of the five facilities in this present study. Many of these results were from samples taken from wells 20-50 feet deep and screened at the lowest 10 foot interval.

There have been several studies in recent years (DeWalle et al., 1985; Kolega et al., 1987; Greer et al., 1987) that have discussed results from studies of contamination due to septic tank systems. In all cases data indicates contamination from trace organic compounds, many of which are found in the analytical data from this study. Their studies included septic tank systems for subdivisions, towns, commercial complexes, and condominiums. Their conclusions were that (1) trace organic compounds are part of the influent to the septic tank in many circumstances, not necessarily associated with industrial facilities, and (2) once in the system, those trace organic compounds will migrate to the groundwater. Canter and Knox, 1985 state that organic contaminents from septic tanks are becoming increasingly important, and that some of these chemicals are carcinogenic, and thus pose a health hazard.

Accurate wasteload and soil properties must be determined for proper system design and installation. Pretreatment of industrial wastes, or separation of waste at an industrial facility into sewage and process waste water may be necessary in some instances. One of the most critical concerns is the minimum vertical separation distance between drainage lines and the water table required by North Carolina State Regulations under DEM (15 NCAC 2H .0219) and DHS (10 NCAC 10A .1942). As can be seen by results of monitoring in this study, contamination is worse at sites where the depth to the water table is less than about 20 feet. However, there are other factors such as age of the system and soil type that directly affect the variation in that figure. The DEM and DHS minimum requirement is one (1) foot of separation with predictive calculations showing no contravention of groundwater quality standards. It is recommended that, in the future, groundwater at more septic tank systems be monitored, older septic tank systems be eliminated or refurbished, and the effect of changing the minimum design requirement for vertical separation to a larger distance be analyzed.

These results and conclusions should be used to help guide future studies and identify any needed changes in septic tank system regulation in North Carolina.

Appendix A

SITE DESCRIPTIONS

Site: Edneyville Elementary School

County: Henderson
System: Conventional Trench
Year Installed: 1975

Region: Mountain
Design Flow: 6000 gpd
Sampling Dates: 8/6/87, 2/11/88

Approximate Vertical Separation: 13.56 feet

Hydraulic Conductivity: .1 feet/day

Site Characteristics: Edneyville Elementary School is located southeast of Edneyville in Henderson County. The school is constructed in moderately hilly topography. Drainage field trenches are dug into a slope with a 5% grade toward the south away from the school. Thick grass covers the entire field. A potential source of contamination to groundwater other than the septic tank system is a heating oil tank located northeast of the drainage field, near the school.

Well Construction: Eight wells were constructed with depths below ground surface ranging from 16 to 25 feet. The distances between the downgradient wells and the drainage field range from 6 to 104 feet. In general the groundwater flow is to the southwest. Mounding of the water table under the northwestern half of the drainage field was evident during both sampling events. Contamination was less pronounced and mounding was non-existent under the southeastern half of the drainfield, suggesting that only the northwestern part was operating properly.

Soils:
0 to 4-20 feet: red-brown to yellow sandy silt, clay.
> 4-20 feet: residual clayey silt, rock textures preserved including altered feldspar and foliations.

Groundwater Chemistry: Contamination is evident from high chloride, total Coliform bacteria, NO3, and TOC concentrations found near and downgradient from, the northwestern part of the drainage field. Many trace organics also were present in the water samples including 1,1 - Dichlorobenzene, benzene, tetrachlorlethene, and methyl napthalene.

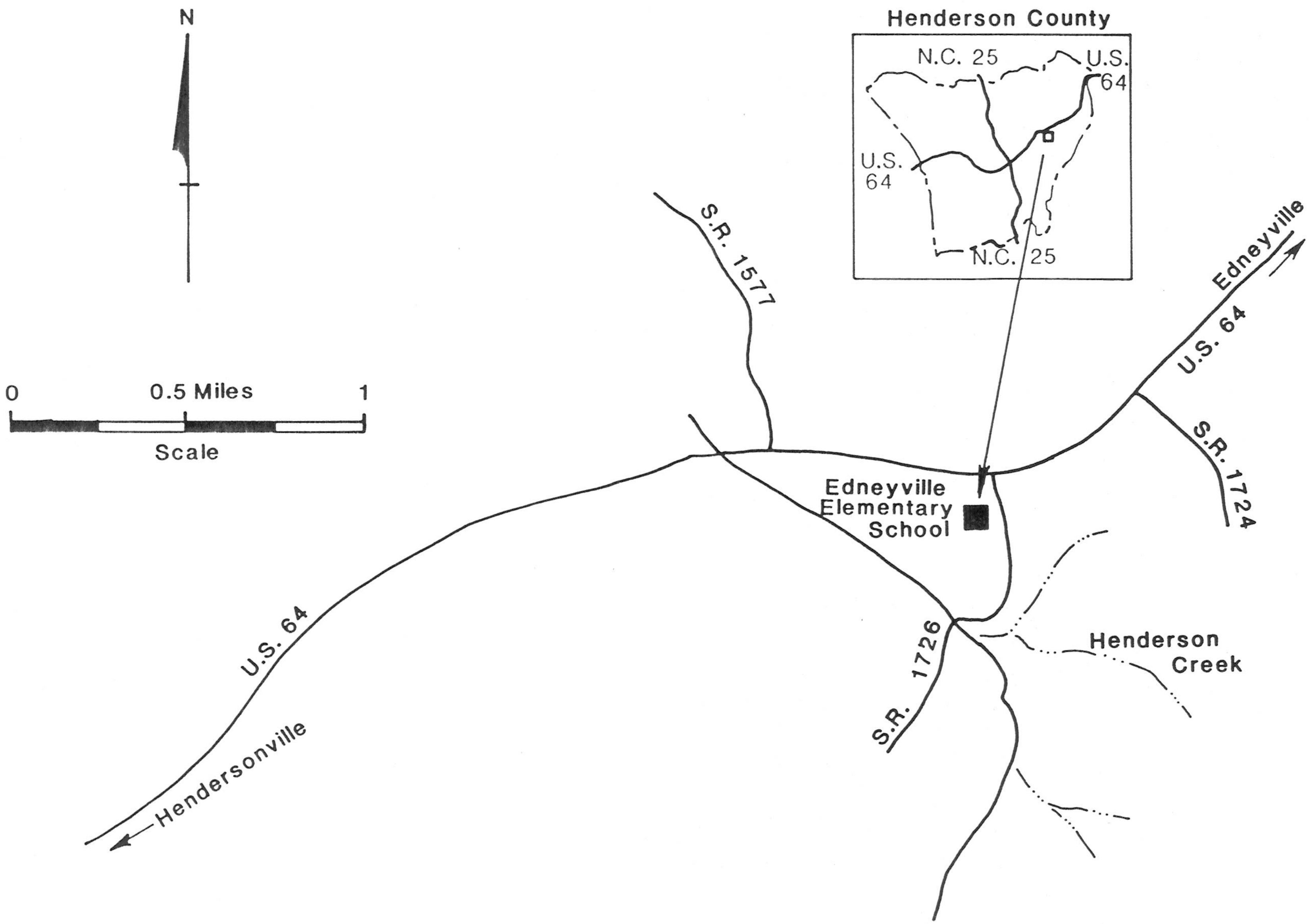

Figure 5
Edneyville Elementary School
Vicinity Map

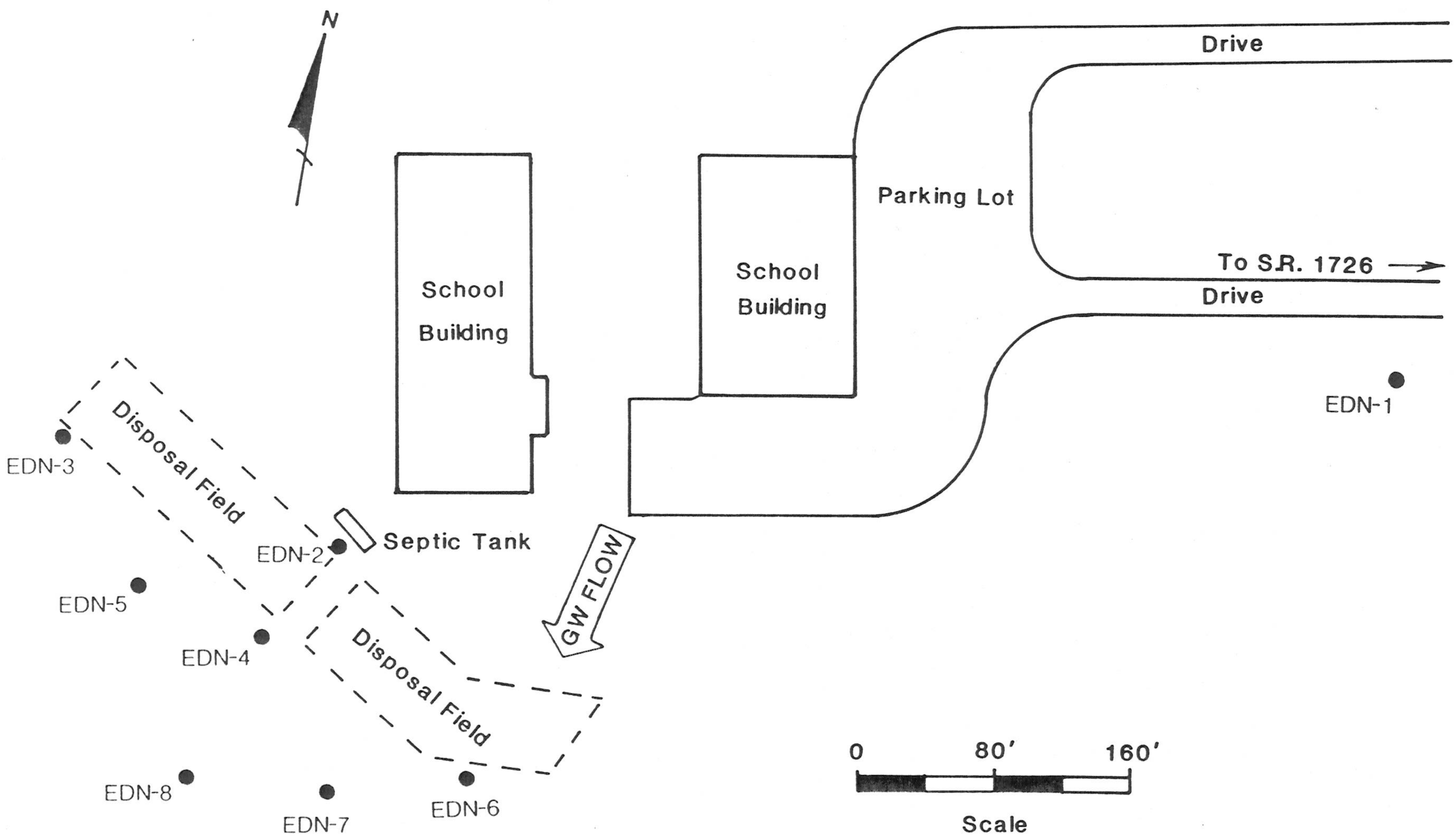

Figure 6
Edneyville Elementary School
Henderson County

Table 4

ANALYTICAL DATA

EDNEYVILLE ELEMENTARY SCHOOL

Concentrations in mg/l

Well	Date	Time	Water Elev. (ft)	Water Depth	Dist. (ft)	Field pH	Field Cond.	Temp.	BOD	Fecal Coliform	Total Coliform	TOC	As	Cl	SO4	NH3	NO3	P	Cu	Fe	Mn	Pb
***EDN-1	870608	10:00	91.73	11.1	500	7.50	40	23.5		<4	<100	<5	<.01	4	8	0.05	1.8	0.45	<.01	0.41	0.4	<.05
EDN-2	870608	13:30	80.76	18.7	6	6.85	220	23		<4*	<100*	8	<.01	13	47	0.07	9.3	0.78	0.016	18	1.6	0.055
EDN-3	870608	10:30	80.41	11.3	8	6.32	210	20		<4	<100	6	<.01	32	8	0.05	15	0.3	0.024	3.9	2.4	<.05
EDN-4	870608	13:00	78.40	15.3	14	6.39	245	23		<4	100*	7	**	23	9	0.06	22	2.4	0.037	170	4.2	0.14
EDN-5	870608	9:00	79.55	12.8	40	5.83	380	18		<4	<4*	<5	<.01	44	6	0.05	40	0.17	<.01	2.6	5	<.05
EDN-6	870608	11:20	77.19	15.3	10	6.67	50	22		<4	<100	11	<.01	4	6	0.04	0.49	0.5	<.01	8.5	1.1	0.07
EDN-7	870608	9:30	77.22	11.6	53	7.00	63	18.5		<4	<100*		<.01	4	6	0.01	0.49	0.23	<.01	7.5	0.8	0.085
EDN-8	870608	10:55	77.23	9.9	104	6.30	250	21		<4	<100*	6	<.01	27	<5	0.03	22	0.83	<.01	15	1.6	0.065
***EDN-1	880211	13:40	89.73	13.1	500	7.80	25	13.5	0.4	<1	<1	<5		3	<5	0.01	0.7	0.05	0.014	6.8	0.31	<.01
EDN-2	880211	11:20	81.00	18.46	6	7.27	100	13.3											<.01	28	0.92	0.033
EDN-3	880211	10:55	82.23	9.48	8	6.85	186	12.3	0.1	<1	50	6		32	10	0.04	18	0.12	<.01	1.6	1.7	<.01
EDN-4	880211	12:05	79.50	14.2	14	6.32	156	13.6	0.6	<1	<1	6		21	<5	0.11	19	0.34	0.054	196	4	0.046
EDN-5	880211	10:30	81.17	11.18	40	5.93	188	12.8	0.6	<1	<1	<5		32	<5	<.01	31	0.06	<.01	4.6	4.6	0.015
EDN-6	880211	10:45	78.59	13.9	10	6.37	37	13.2	0.8	<1	<1	<5		3	<5	0.01	5.2	0.11	0.019	99	0.87	0.056
EDN-7	880211	12:28	78.34	10.48	53	6.88	59	13.7	0.8	<1	1	<5		3	11	0.01	4.6	0.03	<.01	4.8	0.32	<.01
EDN-8	880211	11:50	78.43	8.7	104	6.67	195	13.1	0.4	<1	<1	<5		29	<5	0.03	24	0.4	<.01	19	1.5	0.023

Well	Date	Organics (ug/l)
***EDN-1	870806	benzene .59
EDN-2	870806	benzene 1.3
EDN-3	870806	chloromethylbenzene 11, 2 unidentified peaks
EDN-4	870806	Tetrachloroethene .35, 1,1-Dichloroethane .19, Benzene 1.7, Toluene .36
EDN-5	870806	methyl Napthalene 39
EDN-6	870806	1,1-Dichloroethane .17, benzene 2.8, 1 unidentified peak
EDN-7	870806	Benzene .68
EDN-8	870806	none detected
***EDN-1	880211	none detected
EDN-2	880211	none detected
EDN-3	880211	1-chloro-2-methyl benzene 12, 2 unidentified peaks
EDN-4	880211	1,1-Dichloroethane .33, Tetrachloroethene .11, 2 unidentified peaks
EDN-5	880211	6 unidentified peaks
EDN-6	880211	1,1-Dichloroethane .66, Tetrachloroethene .28, 2 unidentified peaks
EDN-7	880211	none detected
EDN-8	880211	1,1-Dichloroethane .35, 1 unidentified peak

* many non-coliforms present
** interference
***upgradient well

Site: Wayside Elementary School

County: Iredell
System: Conventional Trench
Year Installed: 1985

Region: Piedmont
Design Flow: 2250 gpd
Sampling Dates: 8/13/87, 3/2/88

Approximate Vertical Separation: 20.66 feet

Hydraulic Conductivity: .06 feet/day

Site Characteristics: Wayside Elementary School's disposal field is located in slightly hilly topography between U.S. 70 and the school. There does not appear to be any problem with the integrity of the disposal system. Thick grass covers the entire drainage field area. The septic tank is located on the opposite side of the school from the drainage field and effluent is piped to the front of the building. No other known sources of contamination exist on this site.

Well Construction: Five wells were constructed about the drainage field with depths below ground level ranging from 30 to 45 feet. WAY-5 was screened the last 15 feet of its 45 foot depth. Distances from the downgradient wells to the boundary of the disposal field range from 3 to 47 feet. Water-level measurements indicated that groundwater was mounded slightly, flowing southwest into the soils beneath the drainage field and outwards from the center of the drainage field toward the northwest, southeast, and southwest.

Soils:
0 to 19-24 feet: red-brown to yellow sandy silt, clay
> 19-24 feet: residual red-tan-yellow silty clay, foliations and veining preserved

Groundwater Chemistry: BOD and metal concentrations were the only substantial indicators of groundwater contamination at this septic tank system.

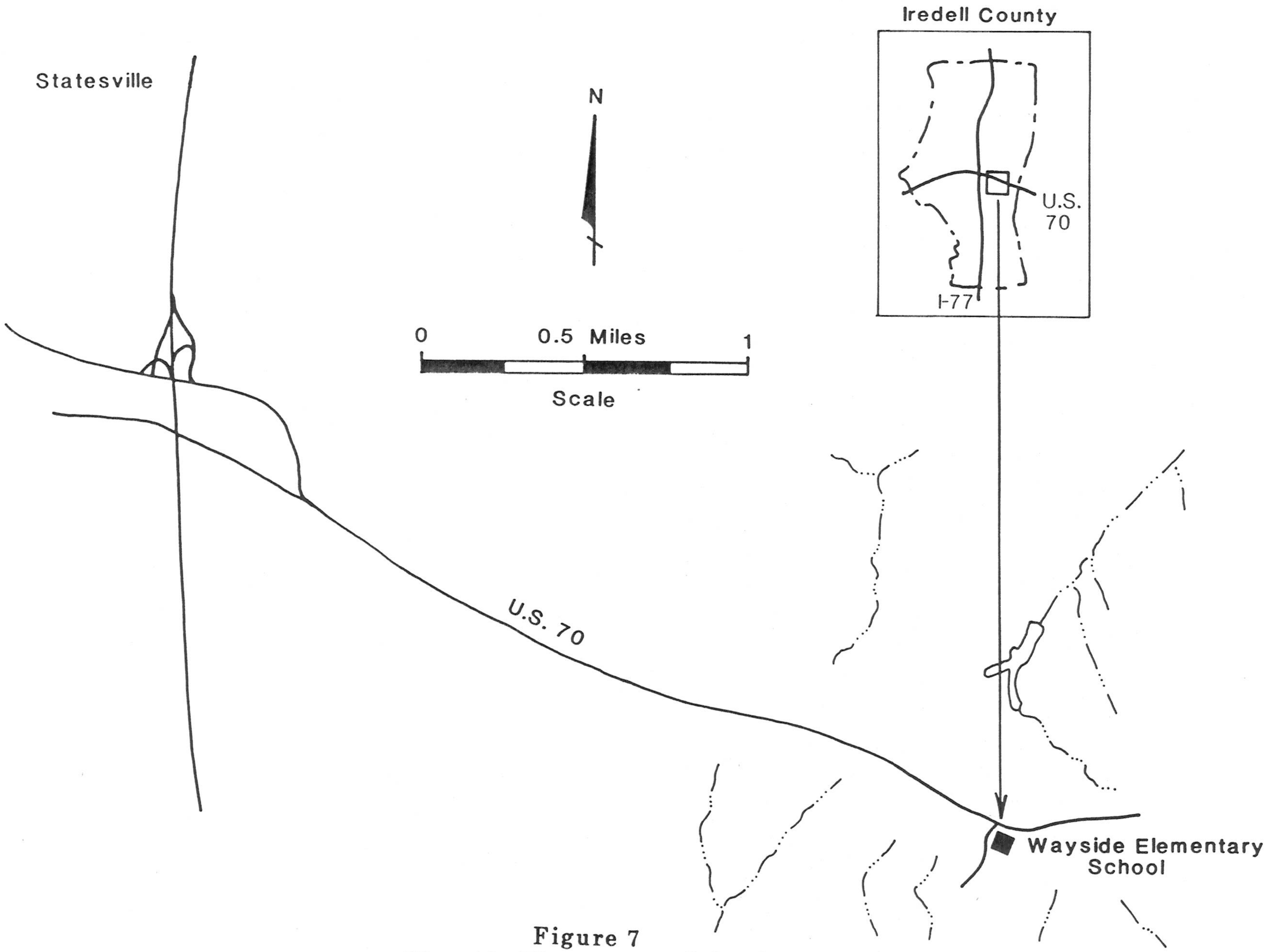

Figure 7
Wayside Elementary School
Vicinity Map

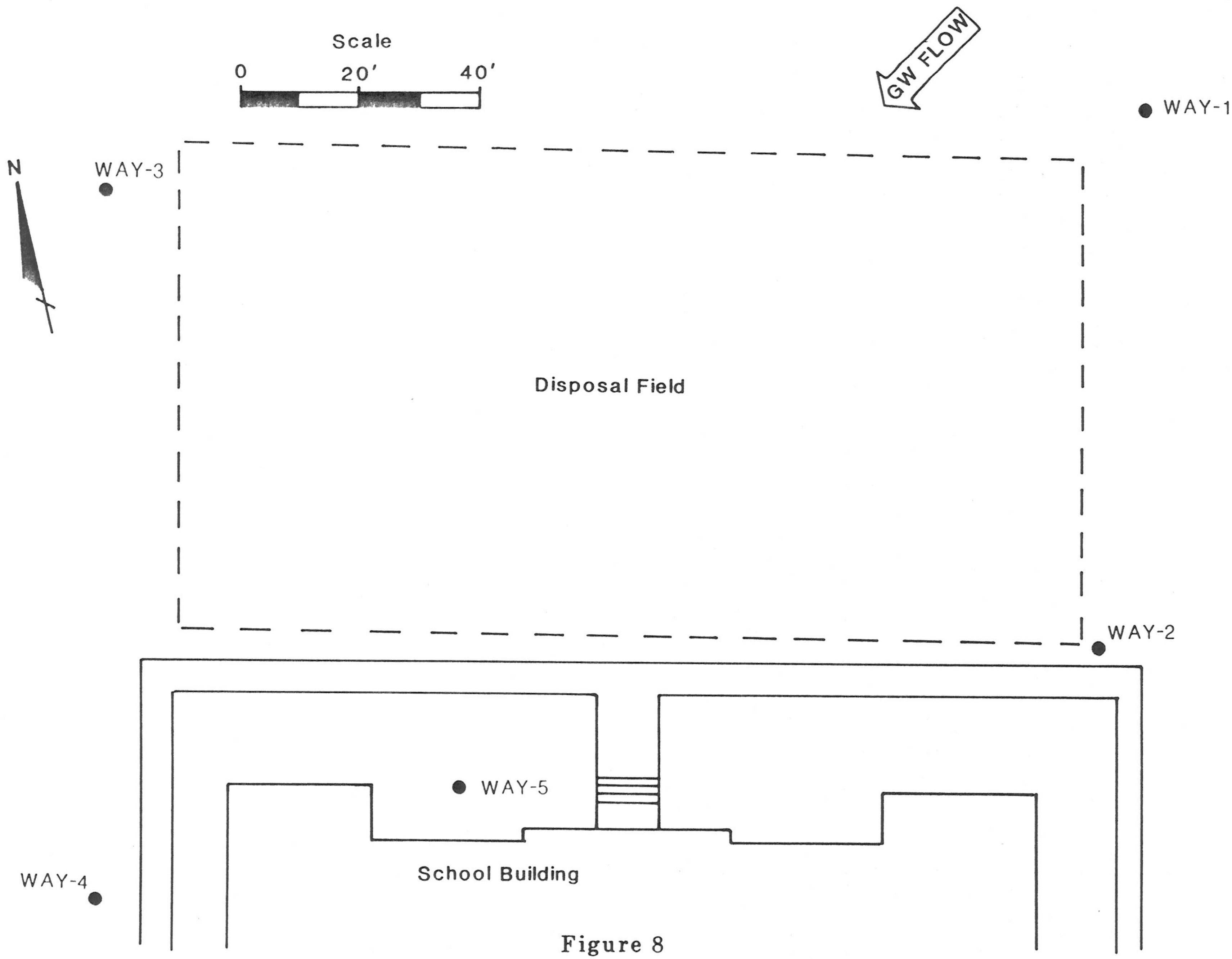

Figure 8
Wayside Elementary School
Iredell County

Table 5

ANALYTICAL DATA

WAYSIDE ELEMENTARY SCHOOL

Concentrations in mg/l

Well	Date	Time	Water Elev. (ft)	Water Depth	Dist. (ft)	Field pH	Field Cond.	Temp.	BOD	Fecal Coliform	Total Coliform	TOC	As	Cl	SO4	NH3	NO3	P	Cu	Fe	Mn	Pb
***WAY-1	870813	13:00	75.04	20.85	14	7.90	22	23	6.4	<1*	<2*	<5	<.01	2	<5	0.02	21	0.02	0.039	8.8	0.22	<.05
WAY-2	870813	13:25	73.45	25.7	3	7.89	20	22	4.4	<2*	<2*	<5	<.01	2	<5	<.01	0.6	0.03	0.025	3.4	0.14	<.05
WAY-3	870813	14:10	74.30	22.3	12	7.62	23	22	3.2	<2*	<2*	<5	<.01	2	<5	0.04	0.88	0.68	0.076	27	0.36	0.05
WAY-4	870813	14:40	74.64	24.35	47	7.62	19	21.5	2.4	<2*	<2*	<5	<.01	1	<5	0.02	0.82	0.28	0.016	0.87	0.075	<.05
WAY-5	870813	15:10	74.72	25.5	26	7.52	18	22	12	<2*	<2*		<.01	1	<5	0.02	0.28	0.1	0.022	6.4	0.21	<.05
***WAY-1	880302	10:40	76.36	19.53	14	7.20	63	15.8	1.1	<1	30*	<5		2	<5	0.06	1.1	0.23	0.023	3	0.09	<.01
WAY-2	880302	10:05	76.23	22.92	3	7.45	40	16.3	1.2	<1	100	6		2	<5	0.02	0.45	0.19	<.01	0.73	0.11	<.01
WAY-3	880302	9:45	75.86	20.74	12	7.30	90	15.9	0.5	<1	<100	<5		2	21	0.02	1.9	0.32	0.022	13	0.26	0.017
WAY-4	880302	10:47	76.43	22.56	47	6.26	32	15.9	1.3	<1	100	<5		2	<5	0.02	1.2	0.54	0.027	10	0.34	0.018
WAY-5	880302	10:33	77.20	23.02	26	7.48	52	15.9	1.6	<1	<100	<5		2	<5	0.03	2.4	0.42	0.022	14	0.29	<.01

Well	Date	Organics (ug/l)
***WAY-1	870813	caprolactam 25, 1 unidentified peak
WAY-2	870813	none detected
WAY-3	870813	1 unidentified peak
WAY-4	870813	caprolactam 18
WAY-5	870813	none detected
***WAY-1	880302	none detected
WAY-2	880302	none detected
WAY-3	880302	none detected
WAY-4	880302	none detected
WAY-5	880302	none detected

* many non-coliforms present
** interference
***upgradient well

Site: Selig Manufacturing Company (furniture manufacturer)

County: Chatham
System: Conventional Trench
Year Installed: 1961

Region: Piedmont
Design Flow: 5250 gpd
Sampling Dates: 8/19/87, 3/23/88

Approximate Vertical Separation: 8.15 feet

Hydraulic Conductivity: .2 feet/day

Site Characteristics: Selig Manufacturing Company lies in a moderately hilly region with its drainage field on a slope dipping slightly to the south. The septic tank has one manhole cover missing (a metal sheet covers the opening) and one manhole cover only partially covering another opening. The eastern distribution box lid has been broken and is covered by a metal sheet. The drainage lines are covered with thick grass. During the construction of SEL-6 a strong odor was evident soon after breaking the ground. The smell was similar to old oil or fuel. No other known sources of contamination are present at the site, however the odor at well SEL-6 is worth further attention.

Well Construction: All seven boreholes were augered to refusal at the saprolite-rock interface. SEL-1 was 13 feet deep but never produced any water and was abandoned. The other boreholes yielded water and were fitted with casing. Depths below the ground surface ranged from 9.5 to 24 feet. Distances from the downgradient wells to the edge of the disposal field range from 5 to 113 feet.

Soils:
0 to 4 feet: red-brown silty clay, sand
> 4 feet: residual red-brown-tan silty clay, micaceous, bed-rock is metagraywacke

Groundwater Chemistry: High concentrations of BOD, TOC, Coliform bacteria, chloride, ammonia, phosphorous, metals, and trace organics identify this site as a highly contaminated area. The trace organic compounds detected at SEL-6 were very different from those detected at the other wells suggesting two sources of contamination; the spill or tank at SEL-6 and the septic tank system drainage area.

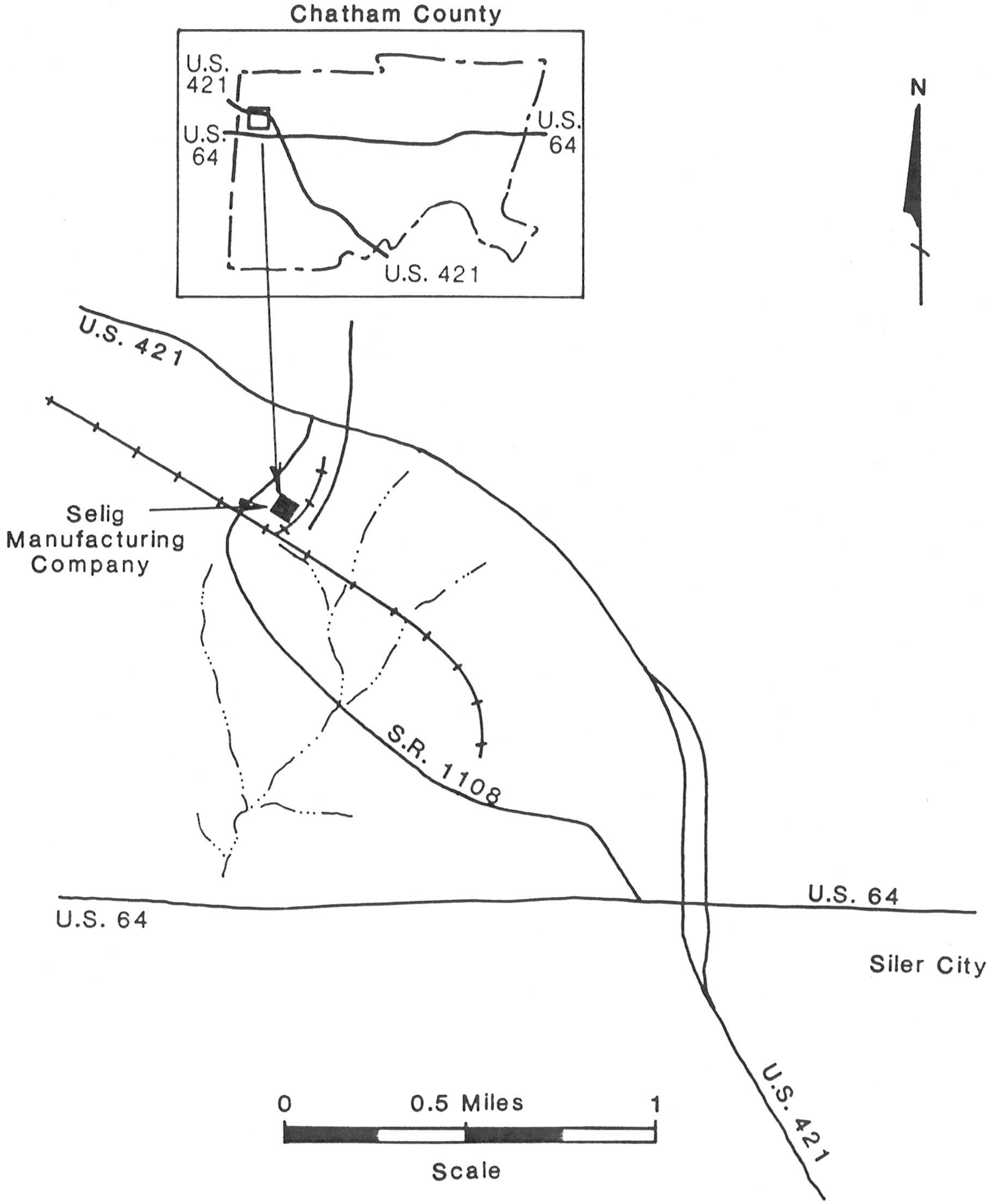

Figure 9
Selig Manufacturing Company
Vicinity Map

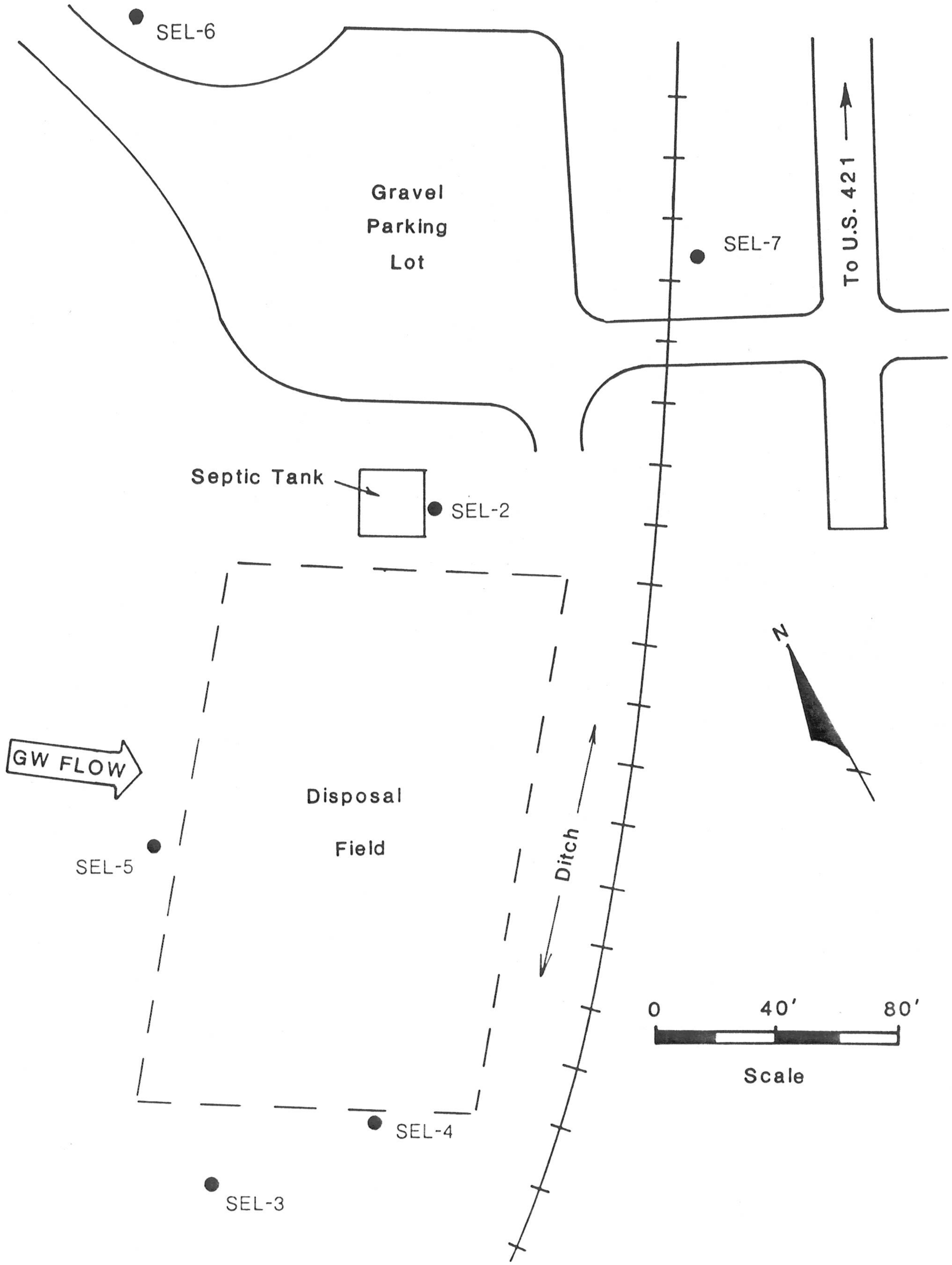

Figure 10
Selig Manufacturing Company
Chatham County

Table 6

ANALYTICAL DATA

SELIG MANUFACTURING COMPANY

Concentrations in mg/l

Well	Date	Time	Water Elev. (ft)	Water Depth	Dist. (ft)	Field pH	Field Cond.	Temp.	BOD	Fecal Coliform	Total Coliform	TOC	As	Cl	SO4	NH3	NO3	P	Cu	Fe	Mn	Pb
SEL-2	870819	9:50	84.56	12.9	20	6.58	280	24	>34	<2	130*	12	<.05	34	20	4.6	0.56	1	0.11	110	4.1	0.05
SEL-3	870819	14:00	83.50	8.73	26	7.35	550	26	>24	<1000	360000	27		25	50	1.6	0.58	1.9	0.35	410	7.4	0.26
SEL-4	870819	11:20	83.08	11.05	5	7.06	495	26	>34	240	1200*	24	<.01	26	53	4.9	2	2.6	0.1	100	3.6	0.075
SEL-5	870819	10:30	89.93	4.84	7	6.90	365	26.5	>33	42000	90000	26	<.01	38	17	18	0.03	0.55	0.076	76	4	<.05
***SEL-6	870819	10:30	88.81	9.5	180	7.35	255	26	42	100	200*	16	<.01	8	13	0.41	0.23	0.98	0.2	29	0.44	<.05
SEL-7	870819	11:30	80.82	18.74	113	7.71	330	25	16	<1000	<1000*	16	**	18	20	0.5	0.78	1.8	0.33	300	7.3	0.18
SEL-2	880323	13:40	85.96	11.5	20	6.11	285	19.7	2.9	160	9000	<5		34	14	8.9	0.43	0.39	<.01	2.6	3	0.012
SEL-3	880323	13:45	86.76	5.47	26	6.99	390	17.9	9.4	<1	2	8		32	81	2.1	2.4	0.55	<.01	4.8	1.7	0.01
SEL-4	880323	13:55	86.51	7.62	5	7.40	360	21.5	14	<1	400	<5		32	27	4.4	1.6	27	<.01	0.4	1.7	<.01
SEL-5	880323	12:55	91.65	3.12	7	6.22	345	18	5.4	4	1600	<5		40	12	18	0.09	0.31	<.01	3.8	3.2	0.1
***SEL-6	880323	12:05	91.72	6.59	180	6.38	40	18.5	1.3	<1	<2*	6		4	6	0.02	<.01	0.23	0.03	17	0.34	0.016
SEL-7	880323	14:00	82.32	17.245	113	6.21	105	20.4	5.1	<1	720	<5		11	<5	0.1	0.83	0.79	<.01	1.9	0.87	<.01

Well	Date	Organics (ug/l)
SEL-2	870819	Chloroform 3.2, Bromodichloromethane .20, Methyl Ethyl Ketone 2.5 Benzene .73, Toluene .30, 2 unidentified peaks
SEL-3	870819	Chloroform 10, Bromodichloromethane 7.5, Ethyl Ether .70, Methyl Ethyl Ketone 4.0, Benzene 1.4, 1 unidentified peak
SEL-4	870819	Chloroform 17, Benzene .85, Bromodichloromethane 1.9, 1 unidentified peak
SEL-5	870819	benzene 1.5, 2 unidentified peaks
***SEL-6	870819	chloroform 6.7, bromodichloromethane 1.5, benzene 2.7, toluene 3.2, ethyl benzene 14, m-xylene 21, o&p-xylene 24, ethyl methyl benzene 18, tetramethylbenzene 28, tetrahydromethylnapthalene 11, methylnapthalene 42, dimethylnapthalene 66, 6 unidentified peaks
SEL-7	870819	Bromodichloromethane 2.2, Benzene 1.1
SEL-2	880323	2 unidentified peaks
SEL-3	880323	none detected
SEL-4	880323	none detected
SEL-5	880323	1,1-dichloroethane .54, 4 unidentified peaks
***SEL-6	880323	benzene .8, toluene 1.4, ethylbenzene 6.7, m-xylene 9.4, o&p-xylene 13, trimethyl benzene 7, methylnapthalene 45, biphenyl 6, dimethyl napthalene 32, tetrahydronapthalene 9, 7 unidentified peaks
SEL-7	880323	1 unidentified peak

* many non-coliforms present

** interference

***upgradient well

Site: Shumate-Faulk Funeral Home

County: Wayne
System: Conventional Trench
Year Installed: 1985

Region: Coastal
Design Flow: 500 gpd
Sampling Dates: 9/10/87, 4/14/88

Approximate Vertical Separation: 24.37 feet

Hydraulic Conductivity: >3 feet/day

Site Characteristics: The Shumate-Faulk Funeral Home is located in a very flat area and is surrounded on the west, south, and east by asphalt covered surfaces. This conventional trench system is fed by effluent from a 1000 gallon septic tank located south of the disposal field in front of the funeral home. Sparse grass covers the drainage lines which all appear to be in good condition. There are no other known sources of groundwater contamination.

Well Construction: Five wells were constructed with depths below land surface ranging from 28 to 30 feet. Distances between the boundary of the drainage field and the downgradient wells range from approximately 6 to 42 feet. Water level measurements taken more than 24 hours after construction indicate slight mounding of the water table with general groundwater flow to the north.

Soils:
0 to 9 feet: red-brown coarse sandy to pebbly clay
> 9 feet: yellow-white fine to coarse sand

Groundwater Chemistry: Very high BOD, TOC, phosphorous, and trace organic compound concentrations indicate contamination at the northern end of the drainfield. Formaldehyde was not detected at any of the wells from either sampling run. Analytical results from the second sampling run appear to be very different from the first sampling run. This might be explained by a deeper water table during the second sampling event or laboratory analytical error.

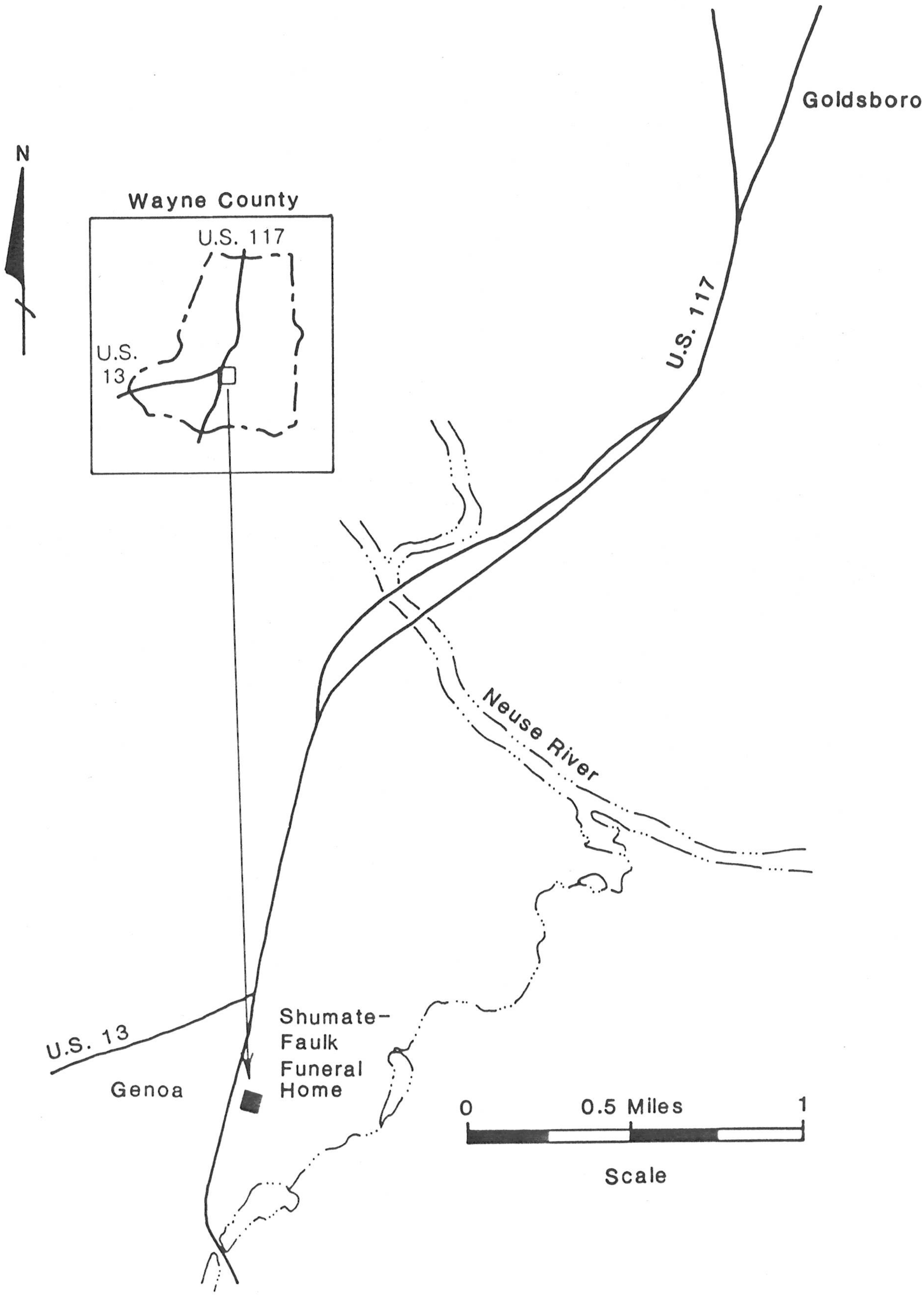

Figure 11
Shumate-Faulk Funeral Home
Vicinity Map

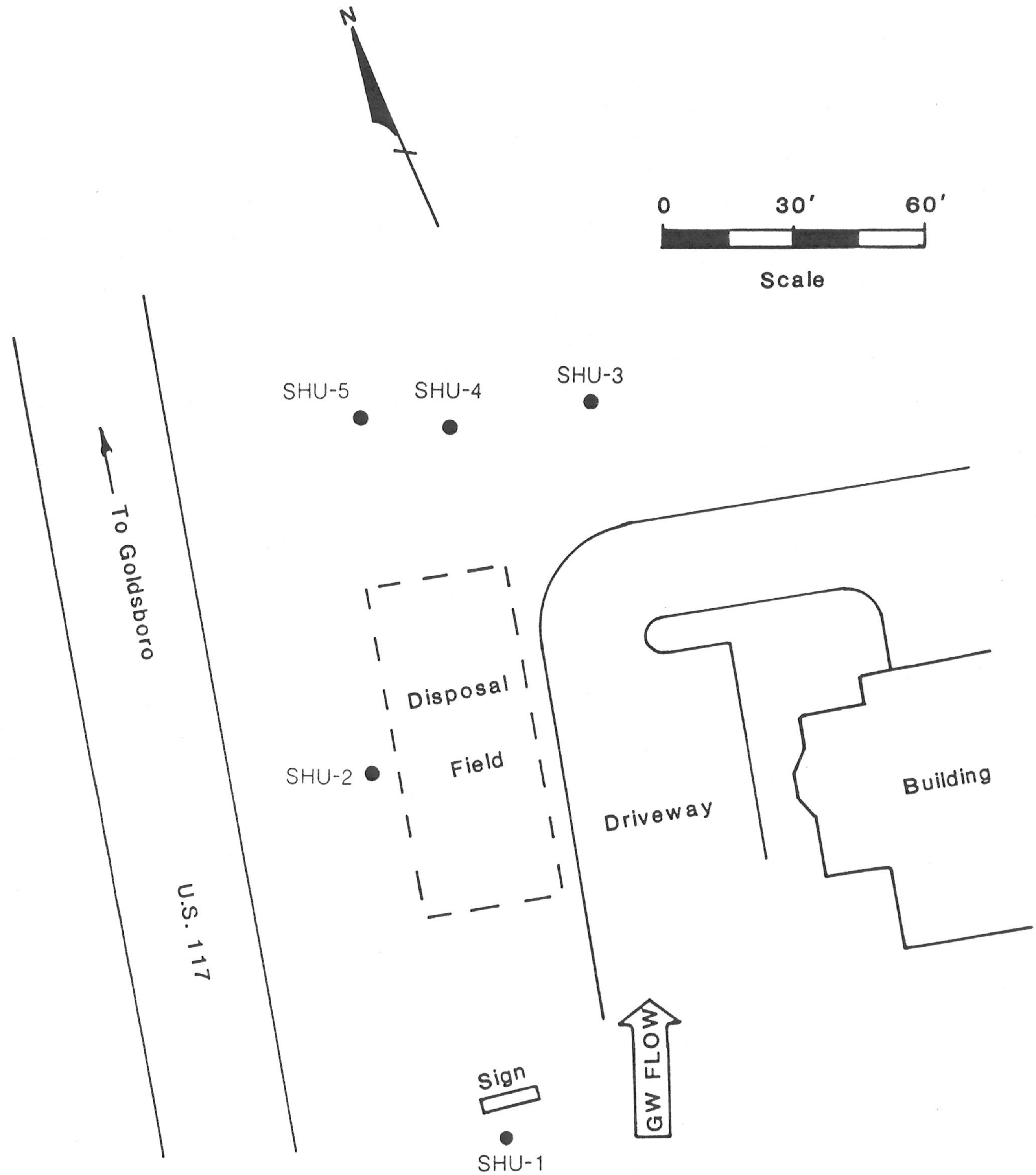

Figure 12
Shumate-Faulk Funeral Home
Wayne County

Table 7

ANALYTICAL DATA

SHUMATE-FAULK FUNERAL HOME

Concentrations in mg/l

Well	Date	Time	Water Elev. (ft)	Water Depth	Dist. (ft)	Field pH	Field Cond.	Temp.	BOD	Fecal Coliform	Total Coliform	TOC	As	Cl	SO4	NH3	NO3	P	Cu	Fe	Mn	Pb
***SHU-1	870910	9:30	76.77	25	53	7.95	50	23	76	500	800	17	0.041	9	5	0.02	0.86	3.1	0.049	100	0.31	0.14
SHU-2	870910	9:50	76.51	23.95	6	7.20	55	23	7.2	<1	800	<5	<.01	8	9	0.02	1	1.3	0.035	16	0.095	<.05
SHU-3	870910	10:10	75.87	23.62	42	7.20	50	22	12	<1	5*	13	<.01	8	8	0.02	1.4	0.81	0.016	0.26	0.045	<.05
SHU-4	870910	10:30	76.66	22.57	33	6.90	35	21.5	>74	<1	<1	35	<.01	6	<5	<.01	0.75	3.6	0.12	0.19	0.03	<.05
SHU-5	870910	10:50	76.61	22.95	38	7.19	35	22	>140	<1	<1*	8	<.01	7	10	14	0.65	7.5	0.091	0.38	0.035	<.05
***SHU-1	880414	16:20	75.16	26.61	53	7.15	48	23.1	<1.0	<1	<1	<5		11	<5	0.02	2.8	1.5	<.01	0.92	<.025	<.01
SHU-2	880414	15:10	75.02	25.44	6	6.53	54	21.5	1.1	<1	<1	<5		10	5	0.04	1.2	1.1	0.011	5.1	<.025	0.027
SHU-3	880414	16:10	74.36	25.135	42	5.59	33	21.2	0.3	<1	<1	<5		9	6	0.01	0.76	0.97	<.01	5.2	<.025	0.018
SHU-4	880414	15:50	75.19	24.045	33	5.65	37	20	0.4	<1	<1*	<5		10	<5	0.01	0.66	2.3	<.01	10	0.045	0.013
SHU-5	880414	15:30	75.15	24.41	38	5.93	40	20.5	1.1	<1	<1*	<5		7	<5	0.01	0.72	6.3	<.01	7.4	<.025	0.016

Well	Date	Organics (ug/l)
***SHU-1	870910	methyl ethyl ketone 12, benzene 1.6, caprolactam 100
SHU-2	870910	benzene .26
SHU-3	870910	benzene 1.6, caprolactam 54, 1 unidentified peak
SHU-4	870910	methyl ethyl ketone 2.9, isopropyl acetate 8.9, benzene .34 toluene .16, caprolactam 35, 3 unidentified peaks
SHU-5	870910	benzene .13, 1 unidentified peak
***SHU-1	880414	none detected
SHU-2	880414	none detected
SHU-3	880414	none detected
SHU-4	880414	1 unidentified peak
SHU-5	880414	none detected

* many non-coliforms present
** interference
***upgradient well

Site: Albert J. Ellis Airport; Rental Car Wash Facilities

County: Onslow
System: Low Pressure Piping
Year Installed: 1985

Region: Coastal
Design Flow: 1260 gpd
Sampling Dates: 9/3/87, 5/4/88

Approximate Vertical Separation: 3.12 feet

Hydraulic Conductivity: 1.1 feet/day

Site Characteristics: The rental car wash facilities consist of three operating car washes and one under construction. Each car wash has a 1000 gallon septic tank, and effluent from each facility is piped into a pump pit located to the north of the disposal field. The effluent is then pumped into the low pressure pipes in the drainage area. The airport is located on a broad flat area with drainage ditches beside all roads and along the runway. The disposal area for the car washes is in fairly good repair except for a broken line on the southwestern corner and slight ponding on the south side. Thick grass covers the entire drainage field. The main septic system for the airport, a few thousand feet to the northeast, has very bad ponding and appears to be draining into ditches nearby. Other possible sources of groundwater contamination are fuel storage tanks about 180 feet to the north and fuel tanks 100 to 200 feet away at each of the car washes to the west.

Well Construction: Six wells were constructed about the drainage area with depths below ground surface ranging from 9.5 to 19 feet. Distances between the boundary of the drainage field and the downgradient wells range from 8 to 109 feet. Water level measurements taken 24 hours after construction indicate groundwater flow was southward, but mounding beneath the site has created flow to the southeast and southwest.

Soils:
0 to 9 feet: tan to dark brown, silty sand to silty coarse sand, pebbles, very dense.
> 9 feet: gray to white, clay and fine sand layers.

Groundwater Chemistry: Arsenic, chloride, nitrate, sulfate, phosphorous, BOD, TOC, and Coliform bacteria concentrations are higher in wells near the south side of the drainage field.

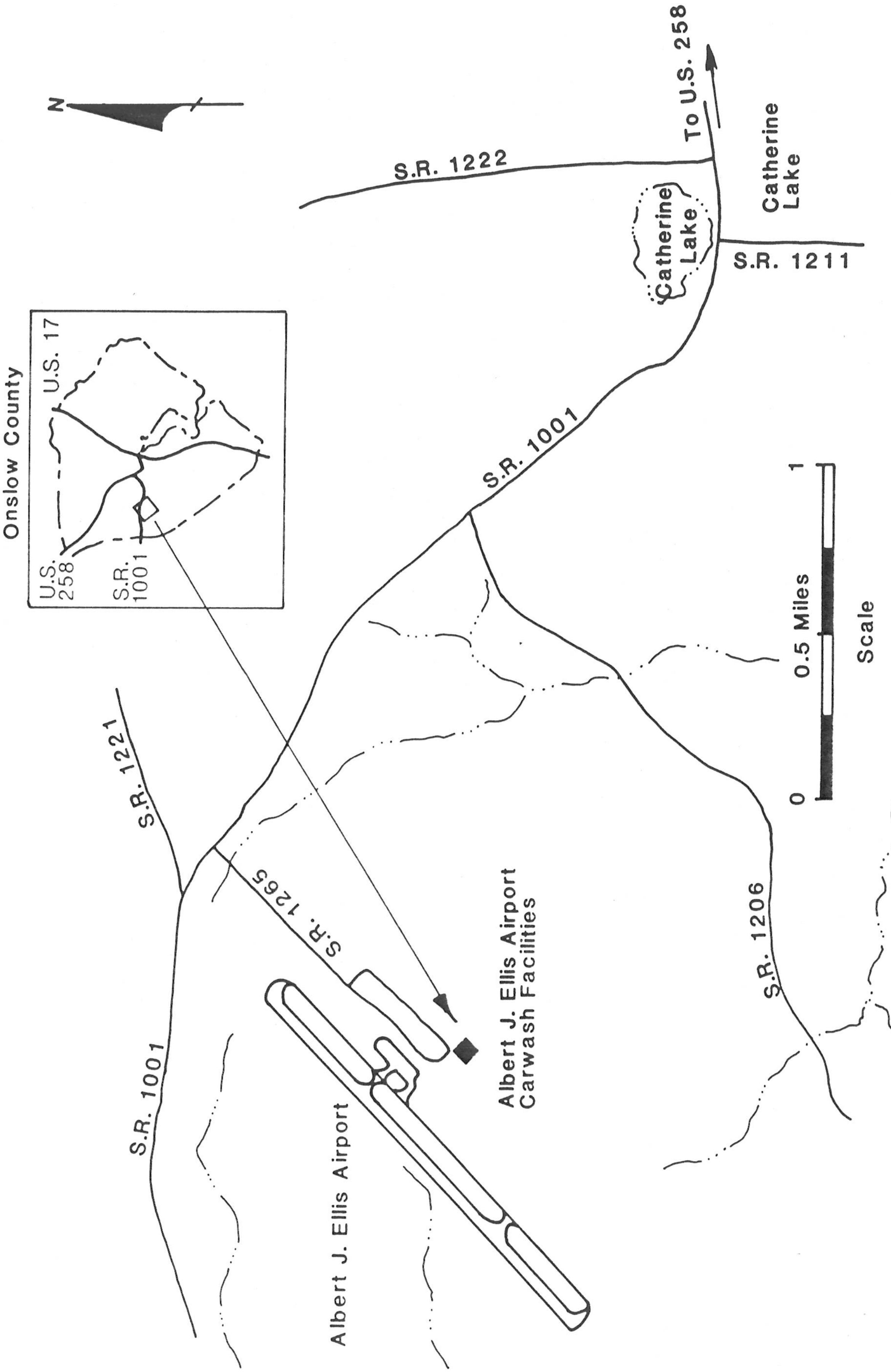

Figure 13
Albert J. Ellis Airport
Vicinity Map

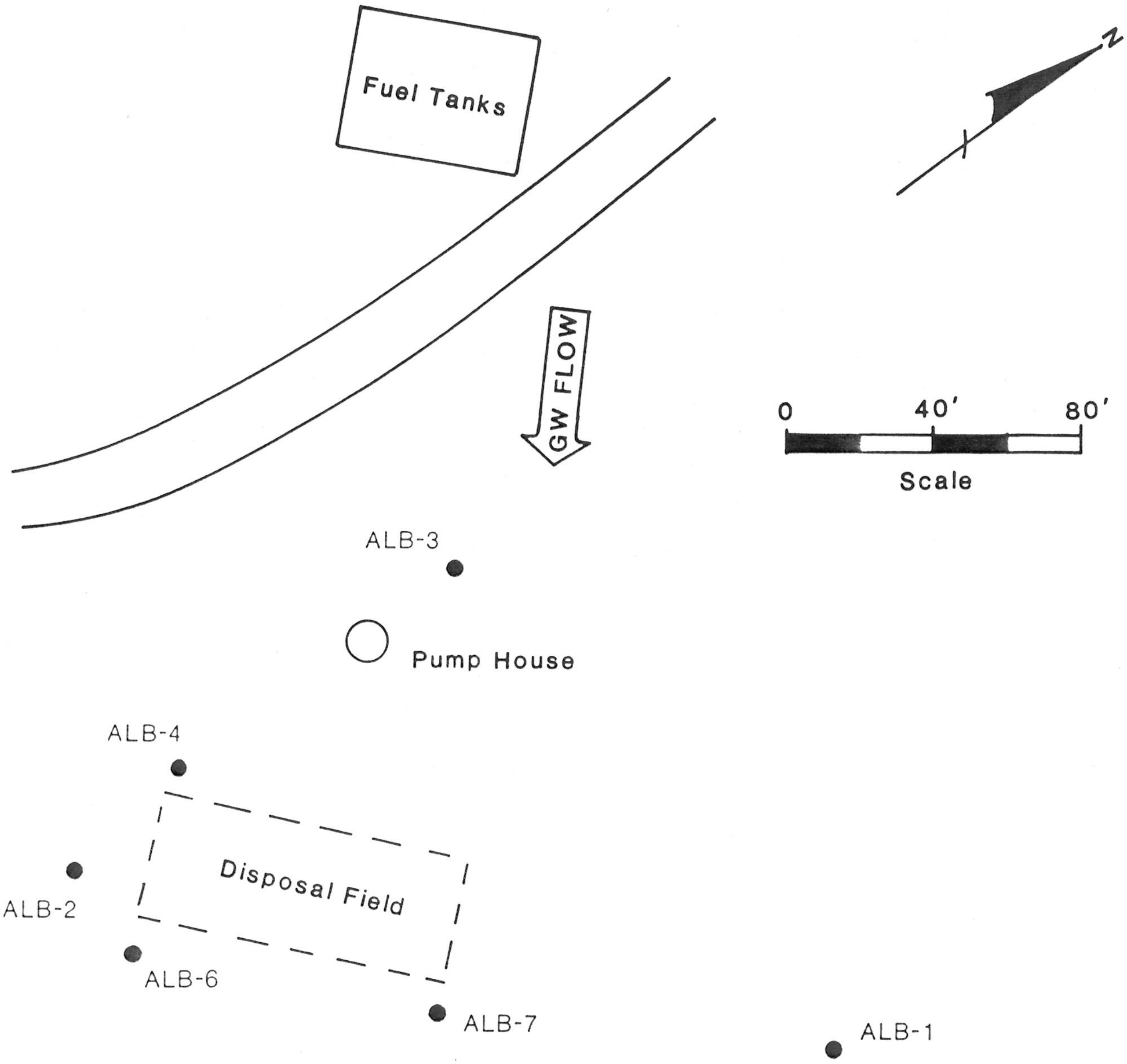

Figure 14
Albert J. Ellis Airport
Onslow County

Table 8

ANALYTICAL DATA

ALBERT J. ELLIS AIRPORT

Concentrations in mg/l

Well	Date	Time	Water Elev. (ft)	Water Depth	Dist. (ft)	Field pH	Field Cond.	Temp.	BOD	Fecal Coliform	Total Coliform	TOC	As	Cl	SO4	NH3	NO3	P	Cu	Fe	Mn	Pb
ALB-1	870903	9:20	96.13	3.77	109	6.95	45	23	45	<1	20	7	0.025	6	<5	0.02	<.01	0.05	<.01	4.7	0.04	<.05
ALB-2	870903	10:40	96.32	3.1	18	6.85	30	24.5	16	<1	<10*	<5	0.011	6	<5	0.01	<.01	0.06	<.01	2	<.025	<.05
***ALB-3	870903	9:50	96.61	3.22	77	6.87	35	24.5	3	<1	<10*	5	0.012	6	7	0.03	<.1	0.2	<.01	1.7	<.025	<.05
ALB-4	870903	10:15	96.53	3.21	8	6.79	45	24.5	>74	<1	<10	17	0.016	5	6	0.02	<.01	0.04	<.01	2	<.025	<.05
ALB-6	870903	10:25	96.29	2.91	10	6.85	250	26	26	<1	170*	45	0.02	22	55	<.01	0.57	1.2	0.012	7.8	0.04	<.05
ALB-7	870903	9:40	96.61	3.31	8	6.85	95	25	8.8	<1	<10*	64	0.073	11	8	<.01	0.04	1.7	0.021	18	0.065	0.08
ALB-1	880504	15:10	96.36	3.545	109	5.79	45	24.5	2.4	<1	<1	7	0.02	8	<5	0.02	0.01	0.04	0.011	4.1	0.028	<.01
ALB-2	880504	16:15	96.23	3.19	18	6.36	70	22.2	<.1	<1	<1	<5	<.01	10	16	0.02	0.02	0.05	<.01	1.2	<.025	0.011
***ALB-3	880504	15:35	96.32	3.515	77	5.94	35	23.8	0.6	<1	<1	11	<10	7	<5	0.02	<.01	0.54	<.01	0.87	<.025	<.01
ALB-4	880504	16:05	96.33	3.41	8	6.72	90	23	<.1	<1	<1	6	<.01	12	15	0.02	<.01	0.24	<.01	3.8	<.025	0.013
ALB-6	880504	15:50	96.51	2.685	10	7.22	310	24	3.4	<1	<1	17	<.01	28	50	0.01	0.07	0.59	<.01	3.9	<.025	0.029
ALB-7	880504	16:30	96.80	3.12	8	5.91	155	22.8	<2.0	<1	<1	80	<.01	19	32	0.01	0.13	3.6	<.01	1.1	<.025	<.01

Well	Date	Organics (ug/l)
ALB-1	870903	caprolactam 45
ALB-2	870903	none detected
***ALB-3	870903	none detected
ALB-4	870903	1 unidentified peak
ALB-6	870903	none detected
ALB-7	870903	none detected
ALB-1	880504	none detected
ALB-2	880504	none detected
***ALB-3	880504	none detected
ALB-4	880504	none detected
ALB-6	880504	none detected
ALB-7	880504	none detected

* many non-coliforms present
** interference
***upgradient well

Appendix B

Trace Organic Compounds Detected at Septic Tank System Sites

Groundwater Standard ug/l	Name	Uses**	Wells
0.7*	Benzene	detergents, styrene monomer, nylon, paint and varnish cutter, plasticizers, insecticides, phenol, solvent	EDN - 1, 2,4,6,7 SEL - 2,3,4,5,6,7 SHU - 1,2,3,4,5
	Chloromethylbenzene Chlorotoluene	solvents, intermediates, dyes	EDN - 3
	Methyl Napthalene	organic synthesis, insecticides	EDN - 5 SEL - 6
	1,1 - Dichloroethane Ethylidene chloride	extraction solvent, fumigant	EDN - 4,6,8 SEL - 5
0.7*	Tetrachloroethane Perchloroethylene	dry cleaning solvent, drying agent, vapor-degreasing solvent	EDN - 4,6
1000*	Toluene	benzene; phenol, and caprolactam; solvent for paints, most oils, coatings, and gums; aviation gasoline; detergents; other chemicals (dyes, perfumes)	EDN - 4 SEL - 2,6 SHU - 4
	Bromodichloromethane Dichlorobromomethane	organic synthesis	SEL - 2,3,4,6,7
0.19*	Chloroform	fluorocarbon refridgerants, fluorocarbon plastics, solvent, insecticides, fumigant	SEL - 2,3,4,6
	Ethyl Ether	organic synthesis, extractant, industrial solvent	SEL - 3
170*	Methyl Ethyl Ketone MEK	solvent, paint removers, cements and adhesives, organic synthesis, cleaning fluids, printing	SEL - 2,3 SHU - 1,4
	Caprolactam Hexahydro-Azepinone	manufacture of synthetic fibers (esp. Nylon 6), plastics, film, coatings, synthetic leather, bristles, plasticizers, and paint vehicles	WAY - 1,4 ALB - 1 SHU - 1,3,4
	Isopropyl acetate	solvent for nitrocellulose, resin gums; paints, lacquers, and printing inks; organic synthesis; perfumery	SHU - 4
29*	ethyl benzene	intermediate in production of styrene; solvent	SEL - 6
400*	meta - xylene	solvent; intermediate for dyes and organic synthesis, esp. isophthalic acid; insecticides, aviation fuel	SEL - 6

Appendix B (cont.)

Trace Organic Compounds Detected at Septic Tank System Sites

Groundwater Standard ug/l	Name	Uses**	Wells
400*	ortho/para - xylene	vitamin and pharmaceutical synthesis; insecticides; motor fuels; dyes; polyester resins & fibers	SEL - 6
	ethyl methyl benzene cumene	manufacture of phenol, acetone, acetophenone, 2-methyl styrene	SEL - 6
	tetramethyl benzene isodurene, durene	organic synthesis; plasticizers; polymers; fibers	SEL - 6
	tetrahydronapthalene	chemical intermediate; solvent for greases, fats, oils, waxes; subs. for turpentine	SEL - 6
	biphenyl diphenyl	organic synthesis; heat-transfer agent; dyeing assistant for polyesters; plasticizer for cellulogics, vinyl resins, and chloroinated rubbers	SEL - 6
	trimethyl benzene 1,2,3 - trimethyl benzene	combustible, occurs in some petroleums	SEL - 6
	tetrahydromethylnapthalene		SEL - 6
	dimethyl napthalene		SEL - 6

* Revised Groundwater Standard -- 15 NCAC 2L Revisions Effective August 1, 1989
** Source: The Condensed Chemical Dictionary (tenth ed.), 1981

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NCAC Title 10, Subchapter 10A, Section .1900

NCAC Title 15, Subchapter 2H, Section .0200

NCAC Title 15, Subchapter 2L, Section .0200