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Department of Environment and Natural Resources
Division of Environmental Health

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Performance of Chamber Systems Compared to Conventional Gravel Septic Tank Systems in North Carolina

INTRODUCTION

Recent legislation in North Carolina provides for the designation of approved Innovative on-site wastewater systems as accepted systems. The legislation was supported by Innovative product manufacturers because of a perceived stigma attached to Innovative designation of their product, and real permitting differences for Innovative products compared to conventional gravel systems, which were required by the state. Additional funds came from a grant awarded to the On-Site Section from the EPA 319 Non-Point Source Pollution Program. This effort demonstrated a partnership of private and public entities in the effort to evaluate these products and protect the public. The legislation requires that the manufacturer of a system must submit evidence that the system has been in general use in the state for 5 years. In addition, the manufacturer shall provide the Commission for Health Services with information sufficient to enable the Commission to fully evaluate the performance of the system in this State for at least the five-year period immediately preceding the petition. Rule was subsequently developed which established the requirements for what constituted "sufficient information" for the Commission to make their evaluation. For trench systems, the Rule requires "the field evaluation of at least 250 randomly selected innovative systems compared with 250 comparably-aged randomly selected conventional systems, with at least 100 of each type of surveyed system currently in use and in operation for at least five years. Systems surveyed shall be distributed throughout the three physiographic regions of the state in approximate proportion to their relative usage in the three regions. The survey shall determine comparative system failure rates, with field evaluations completed during a typical wet-weather season (February through early April), with matched innovative and conventional systems sampled during similar time periods in each region" (NCDEHNR. 2006).

Infiltrator, Inc., which manufactures a chamber system, and Ring, Inc., which manufactures a polystyrene aggregate system, subsequently applied for accepted system designation. A special provision within the law allowed either company to be granted accepted system status provided the comparative survey required in the Rule was completed within 2 years of accepted system designation. Results of the survey needed to show that there was no greater than a 5% difference in the failure rate of the innovative product compared to conventional gravel systems in order for the product to retain accepted system designation.

In addition to Infiltrator, three other chamber manufactures chose to participate in the survey, PSA, Inc., manufacturer of the Bio-diffuser chamber, Cultec, Inc., manufacturer of the Contractor Model chamber, and Hancor, Inc., manufacturer of the Envirochamber.

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Background

The chamber systems surveyed in this study were the standard design and had an average open bottom width (in) about 29 inches. The polystyrene aggregate systems surveyed were the EZ1203. The North Carolina approval for the both the standard chamber and the EZ1203, allows for a 25% reduction in trench length compared to a conventional gravel trench system. Other trench requirements for chambers are the same as for conventional systems. Trenches are dug with a 3-foot width, and placed on 9-foot centers, if multiple trenches are required.

Methods and Materials

The Rule required that a survey be conducted, which was to be able to detect if the failure rate, for the standard chamber or EZ1203 systems, was 5 or more percentage points higher than the failure rate for conventional systems. Further, if the comparison showed a difference of at least 5 percentage points (e.g. 9% failure rate for innovative system A and a 4% failure rate for conventional gravel systems), there should only be a 5% chance that the difference between the two samples would occur by chance. This is the "95% confidence level". If a statistically significant higher failure rate was not detected in the innovative group, than the conclusion would be that the innovative system performs the same as or better than conventional systems. This is a "one sided" test of the difference between proportions.

Preliminary analysis by Dr. Paul Beuscher with the State Center for Health Statistics revealed that, a sample size of 300 was needed for each type of system surveyed, in order to conclude with a 95% confidence that a measured failure rate for an innovative system that is 5 percentage points higher than the failure rate for conventional systems is not due to chance. The calculation of required sample size assumed that the samples have an 80% "power" to detect a **true** difference of 5 percentage points. This sample size estimate also assumed an overall septic tank failure rate (across all system types for 5-9 year old systems) in the range of 5%. It was determined that a sample size of 300 for each system would result in valid analysis, regardless of the total number of systems (population) from which the sample was chosen. It was recommended though that the sample selected might need to be slightly larger to allow for sites at which failure status could not be determined, such as inaccessible sites.

It was determined that systems from each of the three physiographic regions must be included in the survey in order for the results to be valid, since soils vary by region of the state. Two counties were chosen in each of North Carolina's physiographic regions (Mountains, Piedmont, and Coast Plain) for the purpose of conducting the required comparison of system performance. The six counties surveyed were selected on the basis of being representative of the region and the fact that they had a good system of record keeping for septic tank system permits. Further, counties were chosen that were known to have large numbers of each system type, so that it would be likely that a statistically valid sample could be drawn from the records for each system type. Since the total sample size for each system type was required to be at least 300 and there were 6 counties chosen, at least 50 systems were selected from each county for the survey. The

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Counties chosen were Alamance (Piedmont), Buncombe (Mountain), Henderson (Mountain), Lincoln (Piedmont), Onslow (Coast) and Wilson (Coast).

A retired employee formerly with the NC Division of Environmental Health, whose primary responsibilities before retirement involved restaurants, was retained to draw a random sample of the required size from each county. This person was chosen because he was familiar with Health Department records, but had not been involved with the permitting of chamber or EZ1203 systems, in order to avoid a possible source of bias in the sample selection. The available records for each type of system were assigned a number. Records were than drawn on the basis of a random number generator until the required number of systems to be inspected was achieved.

A team of third party inspectors, *unaffiliated* with the NC On-Site Wastewater Section or the product manufacturers, was hired to visit each system for which a record was randomly drawn. The inspectors were Environmental Health students from Western Carolina University under the supervision of Dr. Burton Ogle from WCU. The students were trained to inspect septic tank systems by a former employee of the NC Wastewater Discharge Elimination program now with Western Carolina, whose primary responsibility had been the identification of failed septic tank systems in need of remediation. Systems were surveyed from March through April of 2005, in an effort to inspect systems during a time when the most failures are normally recorded and control seasonal effects on failure rate. Each system was inspected by two members of the survey team. Only houses, which were known to be occupied, were inspected.

The following questions were answered with a yes or no by the survey for each system inspected:

1.) Is sewage ponded on the surface?
2.) Does pressure to the soil surface with a shoe result in sewage coming to the surface?
3.) Is there straight pipe?
4.) Is there evidence of past failure
5.) Is there evidence of a repair?

In addition, an attempt was made to interview the occupants at each survey site in person or by phone. Answers to the following questions were obtained during the interview:

1.) Has your tank been pumped for other than routine maintenance?
2.) Are you having any of the following problems with your system today: surfacing on the ground; wet over system; odors; back up into the house; other?
3.) Have you had problems with the system in the past: surfacing on the ground; wet over system; odors; back up into the house; other?
4.) How was the problem solved?
5.) Has system been repaired or replaced?

A yes for one or more of the above questions answered by the survey or the occupant was considered to be a system failure. More information was collected, but was not used to determine system failure.

Literature about septic system management and homeowner tips provided by the 319 grant was distributed to each household. Optical brightener tests were conducted to see if the "wetness" was sewage related. This turned out to be positive in most cases.

Results and Discussion

A total of 912 systems were inspected, 303 chamber systems, 306 EZ systems and 303 gravel systems. Interviews were completed with 370 of the occupants. The survey sample contained 290 sites from the Coastal Region, 317 sites from the Piedmont region and 305 sites from the Mountain region. The survey sample had the following age distribution: 307 systems were 2 to 4 years old, 377 systems were 5 to 7 years old, and 228 systems were 8 to 12 years old. No systems older than 12 years were included in the survey because neither the chamber nor EZ1203 were approved in the state at that time.

The following survey results were obtained.

Table 2. System failure rate for conventional gravel, chamber systems, and EZ1203 systems.

System Type	Systems OK	Systems Failed	Total	Percent Failure
Gravel	281	22	303	7.3
Chamber	277	26	303	8.5
EZ1203	277	29	306	9.5
Total	835	77	912	8.4

The statewide failure rate was 7.3 % for conventional gravel systems, 8.5% for chamber systems and 9.5% for the EZ1203 systems. The difference in failure rate between the conventional and chamber systems was 1.2%. The difference in failure rate between the conventional and EZ1203 systems was 2.2%. The purpose of this survey was to determine if there was a 5% difference in the failure rate of chamber systems compared to conventional gravel systems. Statistical analysis was performed controlling for both physiographic region and age of system. At a 95% confidence level, the null hypothesis of no difference in failure rate could not be rejected for the chamber or EZ1203 system compared to the gravel system, based on the data collected. In laymen's terms, we would say that the chamber and EZ1203 performed the same as gravel when compared on a statewide basis.

Dominant soil texture, upon which LTAR is assigned for system design, varies by physiographic region of the state. In the Coastal region, the two dominant soil groups are sands and fine loams. The most limiting factor to the performance of septic tank systems is often depth to the seasonal high water table. In the Piedmont region, the two most dominant soil groups are fine loams and clays. Soil depth and slowly permeable soils are often the most limiting factors to system performance. In the Mountain region, coarse loams and fine loams are the dominant texture groups. Shallow soil depth and steep slopes are often the most limiting factors to system performance. To see if there was a difference in performance by region given the identified dominant site differences, the data was further analyzed by physiographic region of the state (Coastal Plain, Piedmont or Mountains). An insufficient numbers of sites were surveyed to statistically compare the performance of each system type by region. The data was therefore grouped by region without regard for system type to make the regional comparison. The results are given in Table 3.

Table 3. System failure rate by physiographic region disregarding differences in system type.

Physiographic Region	Systems OK	Systems Failed	Total	Percent Failure

Coast	256	34	290	11.7
Piedmont	286	31	317	9.8
Mountain	293	12	305	3.9
All Regions	835	77	912	8.4

The failure rate for all systems combined was highest in the Coast at 11.7, and lowest in the Mountains 3.9%. In the Piedmont area the failure rate was similar to the Coast at 9.8%. The difference in failure rate when the mountains region is compared to both the Piedmont and Coast region was statistically significant at the 95% level. The significant effect of region might be explained in as follows. Most systems in the mountains are long and narrower. This factor in conjunction with slope ranging in excess of 25% promotes efficient movement of sewage away from the drain field, e.g. low linear loading rates, and better system performance.

The data was also analyzed to see if there was a difference in system failure rate as systems aged. System performance is summarized in the Table 4 below for three age groups: 1.) 2 to 4 years old, 2) 5 to 7 years old, and 3.) 8 years to 12 years old.

Table 4. System failure rate by age group disregarding differences in system type.

System Age	Systems OK	Systems Failed	Total	Percent Failure
2 to 4 years	283	24	307	11.8
5 to 7 years	351	26	377	7.4
8 to 12 years	201	27	228	13.4
All Ages	835	77	912	8.4

When data for all system types was aggregated within an age group and the aggregated data compared by system age,, the failure rate was higher for the 2 to 4 year old systems (11.8%) compared to the 5 to 7 year old systems (7.4%), and higher for the 8 to 12 year old systems (13.4%) compared to the 5 to 7 year systems (7.4%). The differences between the age groups, while controlling for system type and physiographic region, were statistically significant at the 95% level. It is relatively easy to understand why the oldest systems would have a failure rate higher than the middle-aged systems, because clogging of the trench can be expected to increase as more sewage is disposed in the trenches over time. It is harder to provide an explanation for why the youngest systems had a statistically higher failure rate than the middle-aged systems. One possibility may be the following. We have seen smaller lot sizes in recent years with larger houses, as developers try to maximize density and profit. Because of the increased housing density, there is often more site disturbance in the designated septic system area, due to contractors who deliver materials such as bricks and lumber to the site. Further, there is more impervious surface per lot, as the ratio of roof and driveway to open space on the lot gets smaller, which tends to make the remaining open space wetter. Both site disturbance and wetter site conditions would result in poorer system performance. We have no factual information from the survey to support this hypothetical explanation, though.

Finally, it is interesting to note that the average failure rate state-wide is 8.4% for systems with an age up to 12 years old. There is much speculation about the failure rate of ground absorption septic tank systems, with little or no substantive information to support the speculation. Perhaps a side benefit of this survey will be a defensible failure rate upon which to base future discussions.

Summary

The purpose of this survey was to determine if there was a 5% difference in the failure rate of chamber and EZ1203 systems compared to gravel. Based on the data collected, the null hypothesis of no difference in failure rate could not be rejected for the chamber compared to gravel. In laymen's terms, we would say that the chamber and EZ1203 systems performed the same as gravel.

References

NCDENR. 1977. Laws and Rules for Sewage Treatment and Disposal Systems. Department of Environment and Natural Resources, Division of Environmental Health, On-Site Wastewater Section, 1642 Mail Service Center, Raleigh NC 27699-1642
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