BARNSTABLE COUNTY DEPARTMENT OF HEALTH AND ENVIRONMENT DATABASE MANAGEMENT PROGRAM FOR INNOVATIVE/ALTERNATIVE ON-SITE SEWAGE TREATMENT SYSTEMS

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Abstract

Barnstable County Department of Health and Environment serves the fifteen towns comprising Cape Cod. Cape Cod has experienced rapid development over the last 30 years, but wastewater treatment infrastructure was not developed concurrently, and approximately 85 % of our sewage is disposed of in conventional on-site septic systems. Wastewater from septic systems is increasingly causing nitrogen impacts in many of our coastal embayments. In response to concerns about coastal water quality, towns on Cape Cod are requiring the installation of innovative/alternative (I/A) on-site treatment systems under certain circumstances and approximately 1000 of these systems have been installed countywide. Ensuring that these systems are properly maintained and that effluent meets water quality limits is extremely labor intensive for local health departments which typically have small staffs and diverse duties. To maximize efficiency of I/A system tracking, Barnstable County Department of Health and Environment has partnered with local Health Departments to develop a customized database that uses web-based reporting. Wastewater operators report maintenance and water quality monitoring results directly to the database via the internet, creating virtually paperless reporting. The database has multiple capabilities including tracking of inspection and sampling visits, whether the system has an active O&M contract, whether effluent meets specified limits (which can be customized for each system), ability to download effluent water quality data sets, ability to notify us when system inspection or sampling does not occur, and ability to track correspondence and other actions undertaken to effect compliance. The database was chosen for its reasonable cost, ease of use, and because of its ability to be customized to our diverse needs, which include highly variable sampling and inspection requirements for individual systems. Benefits of the database include real time information on systems, increased compliance with regulatory requirements, and ability to collect large data sets of effluent water quality information which allows us to better assess the performance of technologies in residential settings

Introduction

Barnstable County, Massachusetts, is comprised of the 15 towns on Cape Cod. Cape Cod has experienced a rapid increase in population over the past 50 years, with nearly a 20% growth rate during the last decade (US Census, 2000). Increased residential development and associated commercial, industrial and tourism-related land use has transformed much of the land area from rural to suburban or urban density.

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development. Only four of the fifteen towns in Barnstable County have small sewered areas with wastewater treated at municipal plants. Eighty five percent (85%) of all buildings on Cape Cod rely exclusively on on-site septic systems for wastewater treatment and disposal. It is estimated that 1 billion gallons per year of minimally treated wastewater is disposed of via septic systems on Cape Cod.

Cape Cod is a peninsula comprised of glacial outwash plains and hilly moraines. It is underlain by coarse, highly permeable, sandy soils and a Sole Source Aquifer (US EPA 1982) which serves as the drinking water source for Cape Cod's entire population. The aquifer is recharged solely from rain and ultimately drains to surrounding marine waters and embayments (Strahler, 1966).

Due to Cape Cod's highly permeable soils, septic systems have been an affordable, low maintenance wastewater disposal option. Traditional septic systems as used in Massachusetts are designed to disperse wastewater, but do not remove soluble contaminants such as nitrogen, which passes readily into the soil beneath the soil absorption system and then into groundwater and drinking water supplies. Because Cape Cod's groundwater eventually discharges to marine waters and coastal embayments, these waters are being negatively impacted by nitrogen from septic systems.

Over the last 10 years, there has been a growing awareness that our embayments need to be protected from the effects of excess nitrogen loading. Because the largest source of nitrogen entering the embayments comes from septic systems, it is clear that wastewater infrastructure will be needed to remediate nitrogen. Towns are in various stages of initiating or formulating Comprehensive Wastewater Management Plans (CWMP) to address these concerns.

Before most towns began the CWMP process, and as the nitrogen problem was recognized over the last decade, many towns began requiring the installation of advanced on-site wastewater treatment technologies (commonly called Innovative/Alternative or I/A systems) capable of nitrogen reduction. I/A systems have also been required in remedial situations when older septic systems cannot be upgraded in compliance with current regulations. The 15 towns on Cape Cod have permitted approximately 1100 I/A on-site systems. The majority of these have been installed at single family homes, with a limited number at condominiums, motels, restaurants, congregate living facilities, and commercial buildings. According to state regulations, local health departments have regulatory authority over all sewage treatment systems with design flows less than 10,000 gpd; design flows over 10,000 gpd are regulated by the Massachusetts Department of Environmental Protection (MA DEP) under Groundwater Discharge Permits.

The MA DEP requires that all I/A systems must have an operation and maintenance contract with a licensed wastewater operator. Systems must be inspected at least annually; those which are installed for nitrogen reduction must generally be inspected quarterly, to include effluent sampling. In addition, local health departments frequently impose additional monitoring requirements, including sampling for parameters not required by MA DEP. Operators are required to report results of maintenance visits and water quality data to the local health department and to MA DEP. Local health departments have regulatory responsibility for ensuring that systems meet maintenance and monitoring requirements. Tracking and enforcing

these requirements presents a significant management burden for local health departments. Barnstable County Department of Health and Environment (BCDHE) provides regional public health and environmental health services to the 15 towns on Cape Cod, including technical assistance with I/A systems. The Department is recognized as the regional leader in the area of innovative/alternative sewage treatment technology, and has sustained research and educational efforts in this area since 1994. In 1999, BCDHE established the Massachusetts Alternative Septic System Test Center, which serves as a state and national testing and demonstration site for various advanced sewage treatment technologies.

Creation and Use of the Web-based Database

In 2001, BCDHE undertook early efforts to assist towns to better track and enforce compliance with maintenance and monitoring requirements for I/A systems. The department began by establishing a Microsoft Access database of all I/A systems installed in the county. The database was updated routinely by visiting local health departments to gather information on new systems installed and to obtain maintenance reports and water quality monitoring data for all systems being operated. Updating the database involved significant department staff time visiting the town health departments, collecting paper records, and manually entering data into the database. Because managing the database for the towns was so labor intensive, little time was left over for compliance efforts. Barnstable County Department of Health and Environment recognized a need to find a more efficient way to manage data, so that staff efforts could be redirected to assist towns in ensuring that systems are operated in a way that maximizes treatment efficiency and otherwise comply with maintenance and monitoring requirements.

To this end, in 2005 BCDHE contracted with Carmody Data Systems, Inc. (CDS) for use of their web-based database. The Carmody Data Systems database was chosen for several reasons. First, the database is highly flexible and has been extensively customized to meet the unique needs of Barnstable County. The database is easy to use for both BCDHE staff and for the system operators who report to the database using the internet. Lastly, the cost for using the database is relatively inexpensive, which allowed BCDHE to be able to pursue this project with limited start up funding. Barnstable County financially supports use of the database and staff to run the program; there is no cost to local towns to participate.

To initiate the program, BCDHE requested local Boards of Health to pass a regulation requiring system operators to report results of all maintenance and monitoring activities directly to the database. The database was customized so that, when an operator logs in and finds the system he wishes to report on, only questions specific to that system and it's technology type appear. After the operator completes the report, it can be printed and the database was customized so that all reports print out on a form identical to the one required by MA DEP. However, use of the database has largely eliminated the need for paper reporting. Our goal was to make this easy and efficient for operators to use. Operators received training in use of the database directly from BCDHE and from CDS staff. On-line tutorials which demonstrate common database procedures are also available. In addition, whenever operators encountered difficulty, they were encouraged to contact BCDHE directly and department staff worked with the operator and CDS to resolve problems quickly. Operator response to use of the database has been almost uniformly positive.

The database has been customized to provide many valuable features. These features allow

BCDHE to track highly variable maintenance schedules and water quality monitoring requirements, and are discussed in more detail below. Some of the most important features of the database are:

- Service Schedule Summary tracks maintenance and sampling events as well as status of system O&M Contract, for individual systems.
- Service Schedule Summary provides alerts that inspections or sampling are needed or when these events are missed.
- Database tracks effluent testing results and provides alerts when effluent does not meet limits.
- Database automatically creates a system service history for each system. System history includes information on all maintenance events, sampling results, and compliance actions.
- Database tracks all compliance actions (enforcement letters, phone calls, hearings, etc.)
- Database provides real time information on individual systems.
- Data on system performance is readily available to local jurisdictions.
- Database is searchable by numerous parameters, including by town, technology type, MA DEP approval level, operator, and individual system results.
- Data transfer capabilities to Excel and GIS.

One of the main features of the database is the Service Schedule Summary, which appears on the database home page. This summary tracks when each system is due for maintenance, sampling, and O&M contract renewal (Figure 1). It shows both systems due for activity within the next 30 days, and systems that are 30, 60 and 90 days or more overdue. The system works as discussed below.

Each system is set up in the database with an individual permit. This permit lists system address and owner information. Each component (beyond those of a standard septic system) of the system is listed, and custom maintenance and sampling schedules can be set for each component. For example, a system might have a septic tank with an effluent filter that needs annual maintenance, an aerobic treatment component that requires quarterly inspection, a pump which needs semi-annual maintenance, a UV treatment unit that requires monthly sampling, and a pressure-distribution leach field that needs quarterly inspection. Each of these components, and their service schedule, are set up individually in the system permit, and the database will track all of these individual schedules. If a component is not inspected according to schedule, a notification appears in the overdue area of the Service Schedule Summary, alerting us that the system is in need of follow-up.

A second important feature of the database is the ability to track whether systems are sampled when required, and whether effluent quality meets required limits. Sampling parameters, associated water quality limits, and customized sampling schedules are also set up in the system permit. For example, a treatment unit designed for nitrogen reduction might need quarterly sampling for pH, BOD, Total Suspended Solids (TSS), and Total Nitrogen (TN). Water quality limits are typically pH 6-9; CBOD< 30 mg/L; TSS<30 mg/L and TN< 19mg/L. The permit for this system would be set up to indicate quarterly sampling with water quality limits specified for each parameter. When the operator logs into the database to file the sample report, the water

Message Center

Message	Maintenance Verification	Sample Reports	Non-Compliance
102	172	85	97

Service Schedules Summary

(System Components, Flags, Reports, Sampling and Renewals)

Click here for help on how to read the Service Schedule Summary below.
Service events are updated once every day at 2:00 AM EST

Description	Total	Notice (60 days)	Due	30	60	90+
Advantex	11	2				2
Aerobic (Norweco Singulair Bio-Kinetic)	73	13		30		12
Amphidrome	11	2	1	1		1
Anoxic Filter	2					1
Bioclere	152	45	1	20		27
Bioren Living Filter	1	1				
CERES III	1			1		
Clivus	8				1	2
FAST	601	213	7	83		78
FAST - Modular	8	3		1		
JET	2	1				1
Orenco Trickling Filter	6					5
Post Equalization Tank	1					1
Pre-Equalization	3			1		2
Pressure Dose	42	4				5
Puraflo Peat Biofilter	4					3
RSF	89	24		9		9
RUCK System	55	4		2		26
Sample Report (Effluent)	781	160	2	42	2	184
Sample Report (Influent & Effluent)	91	20	5	8	1	16
Septitech	25	11		4		3
UV Disinfection	44	4		3		4
Waterloo Biofilter	9	1		1		2
Maintenance A	11					11
Maintenance Contract	239	9	2	2	3	41
Operational Permit	97	9	3	2	1	30
TOTALS	2367	526	21	208	8	447

Figure 1. BCDHE Database Homepage, Showing Service Schedules Summary and Message Boards

quality parameters specified in the system permit automatically appear on the report form. After filing the report, if the water quality parameters are exceeded (within certain tolerances), a notice is automatically generated to a message board on the database home page notifying us of this violation.

A third major feature of the database is Message Boards which also appear on the BCDHE home page. There are several types of message board. The first, as discussed above, is a message board where notices of water quality violations are automatically posted when the operator completes a sample report. The second type of message board, called Maintenance Verification, also contains messages automatically generated when the operator files a maintenance report. There are two mandatory questions at the end of this report, relating to whether the operator performed a complete inspection of all required components, and whether the system is need of any type of repair or corrective action. If the operator indicates he was unable to inspect all components, or that the system is need corrective action, a message is automatically generated on this message board alerting us that this system needs follow-up. The third type of message board receives messages directly from the operators. When operators are in logged into the database, a button is visible which enables them to send a message to us. This has been a very useful feature, as operators frequently report change in ownership, expired O&M contracts, and system problems and repairs to us. Messages can be left on the message board for a long as needed. The message board serves as a convenient place to keep track of non-compliant systems while they are being brought into compliance.

All maintenance and inspection reports that are filed are saved in the database and become part of the individual system history. Messages saved from the Message Boards also become part of system history. For each system, BCDHE can log into system history and see a concise listing of all inspections, water sample reports, water quality violations, and maintenance messages. This allows quick assessment of system performance: how a system has performed over time, and if it has had recurring maintenance problems or water quality violations. There are also links in the system history to each maintenance and sample report, if these need to be viewed in greater detail.

As an integral part of the I/A program, BCDHE performs follow-up and compliance enforcement efforts for our local towns, including compliance for expired O&M contract, failure to inspect or sample, and effluent quality violations. The database has also been customized to track individual system compliance history. Each time BCDHE staff undertakes a compliance action (phone call to owner or local health department, letter to owner or operator, etc.) a record is created in the database. Documents, such as notices of non-compliance, can also be uploaded and stored in the database. All compliance efforts are documented thoroughly, so that, if an owner has to be brought before a local Board of Health for hearing, a complete system history and documentation of all compliance efforts can be produced.

One of the most valuable features of the database is the ability to easily search for and retrieve information. Data can be searched by multiple parameters, including town, technology type, MA DEP approval level, date range, or any combination of the above. It can also be queried to find systems based on type of non-compliance; for example, cancelled contract, system not inspected, sampling not performed or exceeds effluent limits.

A major focus of the program is data analysis to determine how systems are performing. Use of the database allows BCDHE to obtain large data sets representing multiple years of sampling. Water quality data is easily downloadable in Excel. This allows examination of how individual systems are performing over the long term. Figure 2 shows an example of data for one single family residential system, downloaded to Excel and used to create a chart showing system performance for effluent nitrogen. Note that total nitrogen values are highly variable on different sampling dates; data sets show that this is a common occurrence at single family on-site I/A systems.

More importantly, aggregate data sets can be used to assess how particular technology types are performing under conditions of actual use. For example, Massachusetts grants "Provisional" approval to a number of technologies that are attempting to demonstrate a reliable level of nitrogen reduction. The state allows a limited number of each type of technology type to be installed with the expectation of 50% reduction in nitrogen and a total nitrogen limit of 19 mg/L in effluent. Due to local concerns with nitrogen, a significant number of these systems have been installed on Cape Cod. To date, however, performance of these systems has been highly variable, and performance data has received little analysis.

Data collected in the database was recently used to examine whether Provisionally approved systems installed at single family homes do, in fact, generally meet a total nitrogen effluent limit of 19 mg/L. Start-up data was eliminated from the analysis. The resulting data set represents 391 individual effluent samples taken from 62 systems of 5 different technology types (Figure 3). Total nitrogen in all samples averaged 18.4 mg/L with a median value of 15.3 mg/L. While these values suggest that system performance meets the 19 mg/L requirement, it is important to note that the data shows that 67% percent of all samples met the 19 mg/L TN limit, but 33% did not. This is graphically demonstrated by constructing a histogram showing data frequency distribution (Figure 4). The horizontal axis of the histogram shows the interval of observations involved (in this case, 5mg/L intervals; i.e. TN= 0-5 mg/L, 5.1-10 mg/L, 10.1-15 mg/L, etc), and the vertical axis gives the number of observations that fall in each interval. The height of each bar is equal to the proportion of samples which fall into that interval. The greatest number of

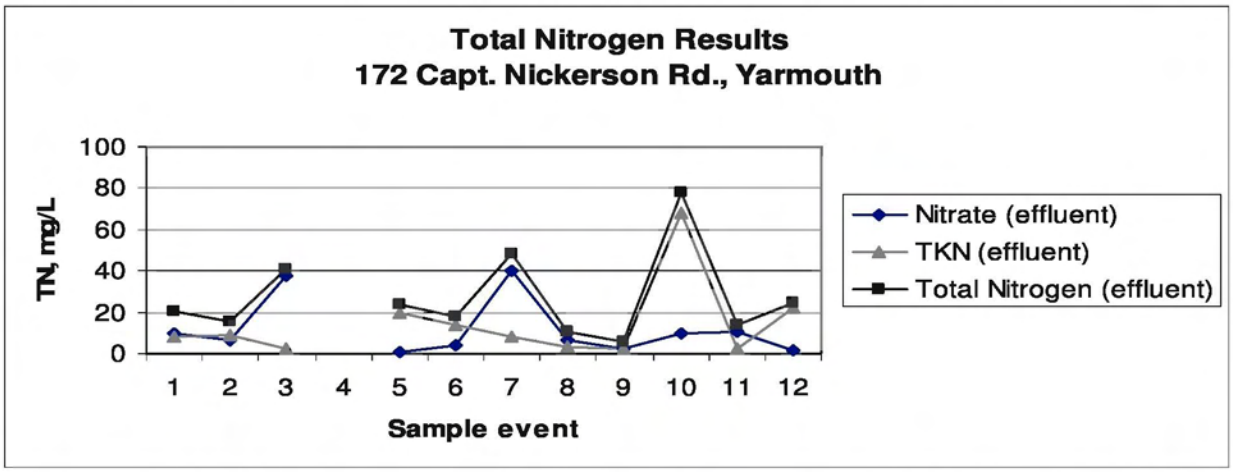


Figure 2. Effluent Nitrogen at a Single Family Residential I/A System Sampled Over Time, Showing High Variability of Total Nitrogen Results on Different Sampling Events.

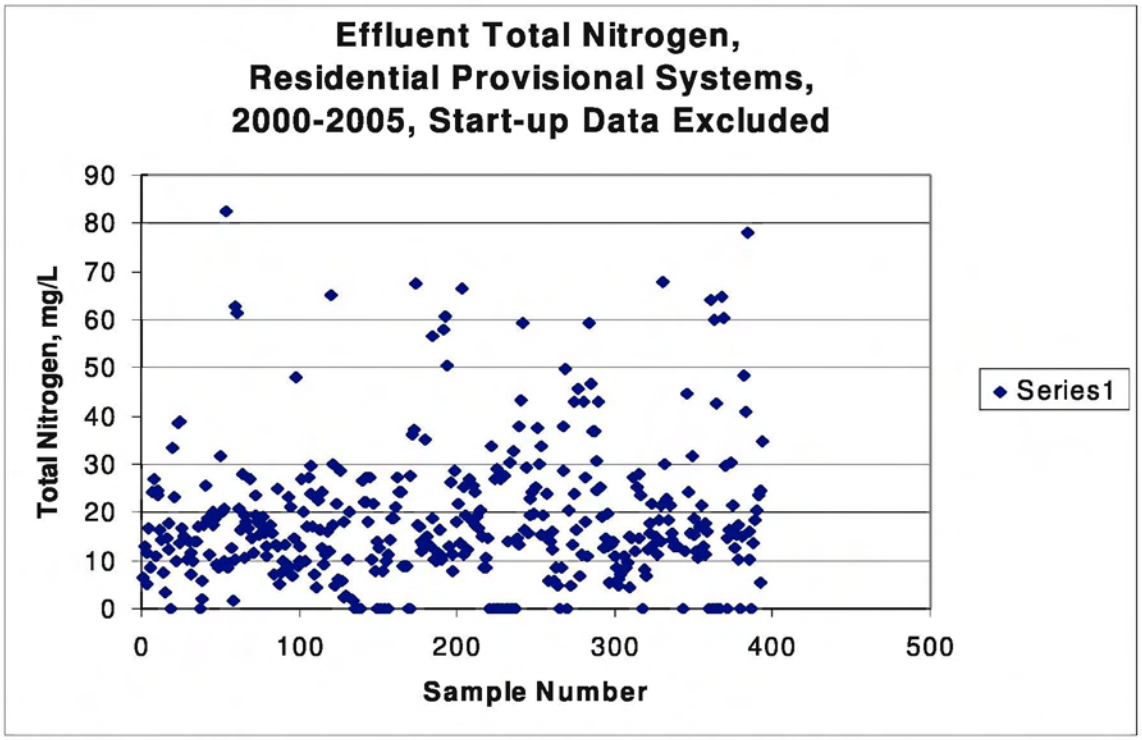
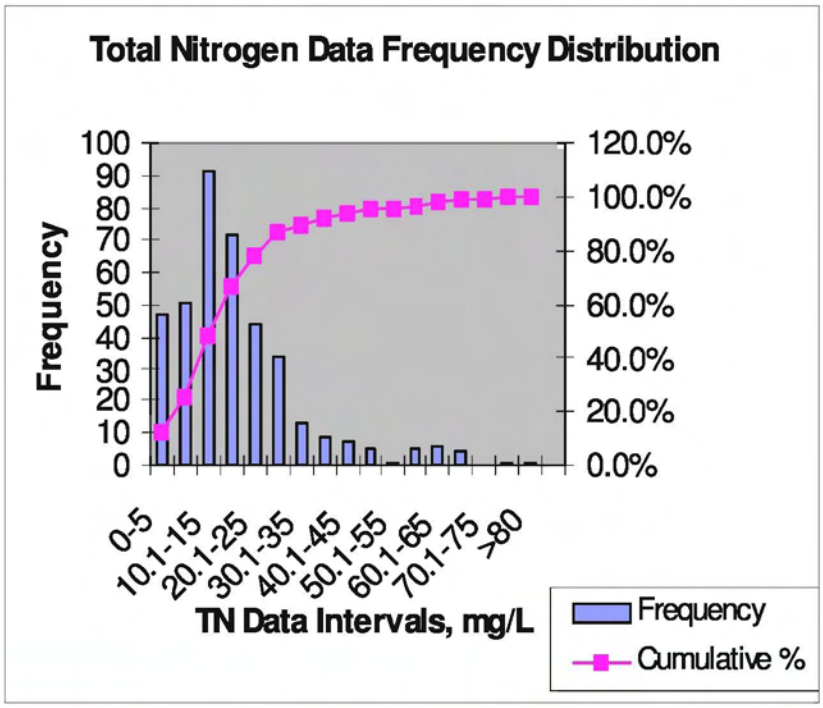


Figure 3. Effluent Total Nitrogen from 391 Samples Taken from 62 Residential I/A On-site systems of 5 Technology Types. Effluent from These Systems Should Meet a 19 mg/L Limit.



TN mg/L	*Frequency*	*Cumulative %*
0-5	47	12.1%
5.1-10	51	25.1%
10.1-15	91	48.5%
15.1-20	72	66.9%
20.1-25	44	78.2%
25.1-30	33	86.7%
30.1-35	13	90.0%
35.1-40	9	92.3%
40.1-45	7	94.1%
45.1-50	5	95.4%
50.1-55	1	95.6%
55.1-60	5	96.9%
60.1-65	6	98.5%
65.1-70	4	99.5%
70.1-75	0	99.5%
75.1-80	1	99.7%
>80	1	100.0%

Figure 4. Histogram Showing Data Frequency Distribution for Total Effluent Nitrogen Using Data Shown in Figure 3. Note that 67% of All Samples Meet TN < 20 mg/L Total Effluent Nitrogen, But 33% show TN > 20 mg/L.

samples, 91, fell into the 10.1-15 mg/L range, followed by 72 in the 15.1-20 mg/L range, as shown in the cumulative frequency table associated with the histogram. As shown in Figure 3, a significant number of samples (129) were above 20 mg/L.

The data set used represents individual samples from multiple systems, which posed the question whether the samples that did not meet the 19 mg/L limit represented a small number of systems that consistently performed poorly, or whether these data points represented a large number of systems each of which perform poorly occasionally. This is an important question, because if the former is true, it is likely that a good operator could work with the non-performing systems to adjust them as needed to bring them into compliance. On the other hand, if the data represents a large number of systems each of which performs inconsistently some of the time, this is a much harder problem to address and raises serious questions about how effective these systems are for reducing nitrogen under the highly variable sewage flows regimes found at single family homes. The data set was examined and 6 installations that consistently performed poorly were identified. When this data was removed from the analysis, it was found that total nitrogen in effluent averaged 17.7 mg/L with a median value of 15.3 mg/L. 70% of all samples met the 19 mg/L limit while 30% did not. This is not significantly different from the previous data set, suggesting

Conclusion

Barnstable County Department of Health and Environment has been using the CDS database for just over one year. Much of the past year was spent working to get the database customized to meet program goals. Within the last six months, efforts to work with non-compliant systems have been initiated. When the compliance program began, 335 out of the 1100 total systems were missing maintenance and/or sampling reports; this number has now been reduced to 170 systems missing reports. Initially, 60 systems were out of compliance for lack of an O&M contract. Of these 60, 20 now have O&M contracts, 30 additional systems have new contracts pending, and 10 have been found to be resistant to complying and have been referred to local Boards of Health for hearings and other legal procedures. As these systems come into compliance with the requirement for O&M contracts, compliance with maintenance and inspection reporting will increase. Over the coming months, systems that are not meeting effluent limits will be worked with intensively, to investigate what is needed to bring these systems into compliance.

Use of the CDS database will continue to benefit local towns as well as I/A system operators and owners. Local health departments can log into the database and obtain real time information on performance. By partnering with Barnstable County, towns have gained increased oversight of their I/A systems, and compliance is being enhanced. Operators have reduced repetitive paperwork by having only to report results to the database, and not produce multiple paper copies. Increased oversight of systems and on-going enforcement efforts have resulted in a closer working relationship between operators and BCDHE, which has already resulted in better communication and in the long term should enhance system performance. System owners, many of whom have been ignorant of the most basic requirements associated with owning an I/A system, are receiving educational outreach and it is hoped that as systems are better maintained and operated, system performance will improve. This should lead to increased system longevity and possibly fewer sampling requirements in the future, which may result in lower homeowner costs to operate their systems.

Most importantly, use of the CDS database will continue to play an important part in regional wastewater efforts. As system performance data is accumulated, it will allow greater insight into questions about which technologies perform most consistently, especially for nitrogen reduction. Information gathered in the database will lend a clearer understanding of the level of maintenance and oversight needed for each technology type to maximize system performance while minimizing operating costs. This will allow BCDHE to develop guidance, based on performance data, as to the role individual or small cluster I/A systems may appropriately play in wastewater planning related to protecting our coastal waters. These questions are not unique to Cape Cod, as many other coastal areas are grappling with wastewater planning decisions needed to protect coastal waters from nitrogen-related degradation. For Barnstable County, using a web-based database to track I/A on-site systems has proven to be an efficient way to improve regulatory oversight and enhance I/A system performance.

References

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