REMOTELY MONITORED AND E-CONNECTED ADVANCED ON-SITE WASTEWATER TREATMENT NETWORK*

Christina M. Edvardsson and Tomas G. Edvardsson
MicroSepTec, Inc.
23112 Alcalde Dr., Suite C, Laguna Hills, CA 92653

ABSTRACT

Today most on-site systems fail due to lack of monitoring and maintenance. For instance, the septic tank, which is the most common on-site system, requires periodic checking of the bottom sludge layer and the top scum layer, so that the homeowner knows when it is time to pump it out. Otherwise, the scum and sludge layers may become too thick and eventually overflow into the leach field, which may clog both the leach lines and the soil. If the soil gets clogged, the bacteria contaminated water may surface and cause ponding. Clogging of the leach lines may cause the wastewater to back up into the house. One of the reasons for the lack of monitoring is that the layers have to be manually checked, which requires working with wastewater and risking bacteria and virus contamination. Some homeowners may not even know where the septic tank is buried.

MicroSepTec has developed the first intelligent wastewater treatment system called the EnviroServer. The EnviroServer itself can be described as a hybrid fixed film-suspended growth extended aeration system with a two-stage biological process to optimize denitrification and on-site destruction of sludge. It produces tertiary quality water that is normally reused for subsurface irrigation. Typical test data for residential installations are below 10 mg/l of $CBOD_5$, below 10 mg/l of TSS, below 10 mg/l of TKN and nitrates, and non-detectable fecal coliform. The EnviroServer is NSF certified and has undergone third-part evaluations. The system is controlled and monitored by an onboard computer. The computer connects via a telephone line to MicroSepTec's service database computer. If one of the EnviroServers goes into alarm, the onboard computer will call up the service computer and report the alarm. The service computer will then email and call the assigned Service Technician for this unit. The Service Technician can then access the service computer via the Internet and check the status, current and historical alarms, and service reports for that unit. This will tell him what is wrong before he actually goes out and service it. It will also indicate the urgency, which may allow him time to schedule the service visit instead of responding to an emergency.

The service computer can also be accessed by Regulators via Internet, which allows them to check the status of the systems in their area without leaving the office. Each county is assigned its own password. If effluent water samples have been taken, the lab result is reported in the service database. This monitoring network system has been in operation for almost one year with very successful performance. Detailed results and operating experience will be presented.

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INTRODUCTION

Approximately 25% of U.S. households are using an on-site wastewater treatment system. More than half of these systems are more than 30 years old, and homeowners indicates that at least 10% of all systems are not working at all (Rubin et al, 2000). Most of these failures or non-working systems are caused by lack of maintenance or poorly designed systems. During a survey performed in the Stinson Beach District, the following causes for failures were recorded (Crites, 1998):

- Clogged leachfield 44%
- Poor leachfield design 26%
- Inadequate septic tank maintenance 15%
- High groundwater/poor drainage 10%
- Undersized septic tank 5%

Of course, a clogged leachfield is normally the result of not maintaining the septic tank.

There are also a large amount of on-site systems where the homeowner does not know that his system has failed. It used to be that as long as the water disappeared in the ground, the system was working fine. This is obviously not true, if the water is not adequately treated before it “disappears in the ground”, it may contaminate the groundwater.

MicroSepTec has addressed these problems by developing the first intelligent on-site wastewater treatment system, which not only senses if a component goes out, but also automatically sends a technician to take care of the problem.

DESIGN OF TREATMENT UNIT

The EnviroServer system consists of one fiberglass tank installed below ground and two enclosures installed above ground, typically on the outside wall of the house, which hold the air compressors and on-site controller. Figure 1 shows a schematic of the unit. The tank contains five compartments, which can be accessed through four different man-ways that extends up to ground level. All the equipment inside the tank is made so it can easily be replaced or serviced through the four man-ways.

The Enviroserver unit itself operates continuously and on demand. The influent feed from the residence is by gravity flow similar to an activated sludge plant. Residential wastewater enters the first compartment where primary clarification takes place. The primary clarified wastewater along with the floatables including grease then overflows to the first aerated compartment where it undergoes aerobic digestion. Biological $CBOD_5$ (Carbonaceous Biochemical Oxygen Demand) removal and nitrification takes place in this and the subsequent aerated compartment. To promote $CBOD_5$ removal and nitrification both compartments contain moving media for attached biofilm growth. Biologically treated wastewater underflows into the fourth compartment reactor where final clarification takes place.

Excess biomass including biomass sloughed off the fixed film support is wasted using a thermal process that converts biological solids to a small residual consisting of carbon and inert ash. Periodically, a small submersible pump is activated to return settled biomass from the secondary clarifier to the primary clarifier. Settled biomass from the primary clarifier is periodically pumped from the bottom of the compartment to the thermal processor where the solids are retained by a stainless steel sieve and the water is drained back to the primary clarifier. After a set number of pump cycles the control system initiates the thermal decomposition of the retained solids, which includes drying, gasification, and oxidation at controlled temperatures. The exhaust gas is forced back into the water in the first compartment, which further scrubs the gases to remove any remaining particulates, gas products, and potential odor before it is vented together with the air in the tank through the normal vent at the roof of the house. The controlled temperatures in combination with forced air results in minimum emissions. The end product is an

inert residual of carbon and ash that is flushed back into the tank the next time the primary clarifier sludge pump is turned on. Recirculation of settled biomass from the secondary clarifier to the primary clarifier in combination with periodic thermal processing also helps maintain low effluent TSS (Total Suspended Solids) concentrations.

Enhanced nitrogen removal also becomes possible when the aerobically treated and nitrified wastewater from compartment two and three is recycled from compartment four to compartment one if a carbon source is readily available and the first compartment is free of dissolved oxygen, e.g. anoxic. The NO_3-N in the aerobically treated wastewater serves as the terminal electron acceptor and the raw wastewater influent entering the first compartment serves as the necessary carbon source for the denitrification reactions. Anoxic conditions are normally maintained throughout the day because the pre-react zone in compartment one is not aerated and because incoming raw wastewater quickly depletes any available oxygen despite the periodic influx of dissolved oxygen that is introduced into the pre-react zone during recycle pumping, assuming the recycle ratio is in balance with the incoming wastewater. The clarified and treated wastewater next flows from the fourth compartment through a chlorination unit into the chlorination contact and effluent storage tank. The chlorination contact tank is designed for a hydraulic residence time of 90 minutes for complete coliform destruction.

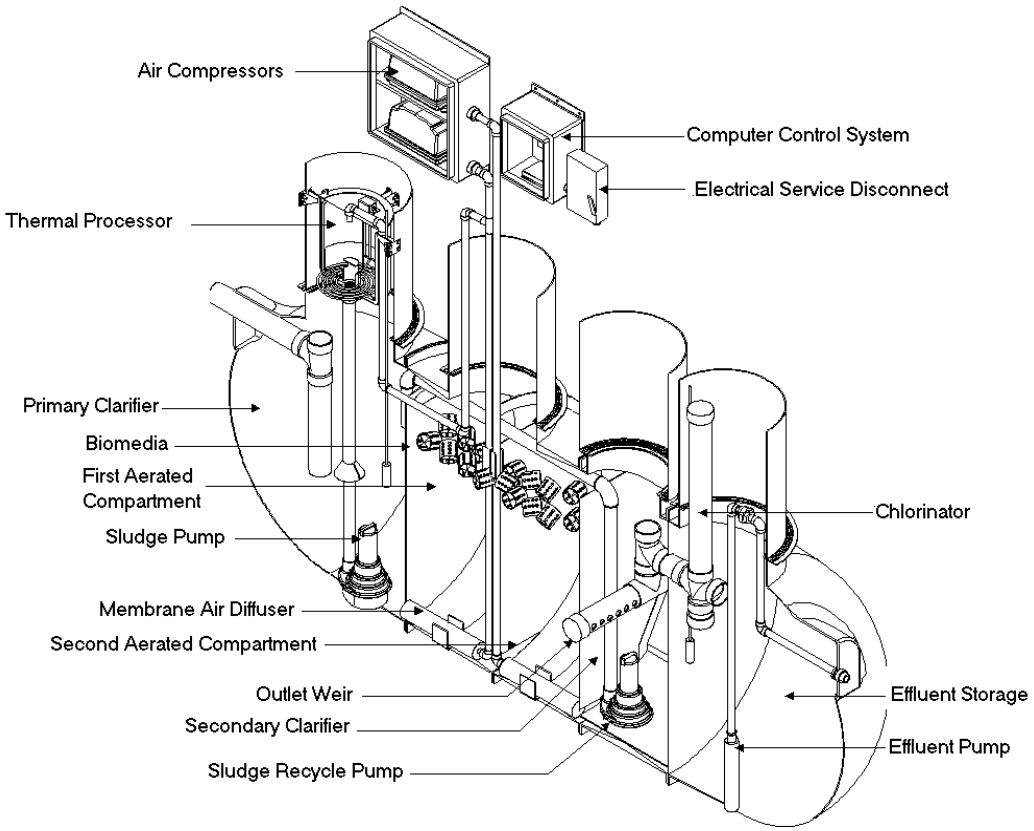


Figure 1. Schematic of EnviroServer advanced wastewater treatment system.

DESIGN OF CONTROLLER AND MANAGEMENT SYSTEM

The EnviroServer System is controlled and monitored by an on-site custom computer control system. The computer is capable of detecting failures of electrical and mechanical components critical to the treatment processes. The alarms are:

- ✓ High tank level, which is activated by a mechanical float switch located in the last compartment.
- ✓ Recirculation pump failure, which is sensed by a pressure switch located on the recirculation pipe.
- ✓ Air compressor failure, which is sensed by a pressure switch located on the air line inside the enclosure.
- ✓ Sludge pump failure, which is generated by using the thermocouple and heater inside the thermal processor. The controller turns on the heater for a few seconds, and then monitors the temperature decrease when the sludge pump is turned on. If the decline is too slow, it will generate an alarm.
- ✓ Incomplete thermal decomposition cycle, which is generated if the thermal processor does not reach the required temperature stages within the allowed time frame.
- ✓ Thermocouple failure is activated if the temperature does not rise significantly within the first five minutes that the heater is on.
- ✓ Burn over temperature alarm is generated if the temperature exceeds a predetermined value.
- ✓ Disinfection failure, which is sensed by using an ORP probe (Oxidation Reduction Potential). The ORP measures the millivolt in the water, which can be correlated to mg/l of chlorine residual.

All the EnviroServer controllers connects to a central monitoring computer..

The main purpose of connecting all treatment units to a central monitoring station was to give the customers a "flush-and-forget" system, and still ensure that the system was being properly maintained. Specific goals were:

- ➢ Provide a mechanism in which the EnviroServer can call the main monitoring system in case of malfunctioning. The main system will in turn alert a service representative.
- ➢ Allow Service Personnel to quickly set parameter values, poll status information, or review historical records from the units already deployed without physically having to visit the units.
- ➢ Allow County Health Officials to monitor the status of the units in their jurisdiction
- ➢ Allow customers to monitor the systems they own to make sure they operate within the specification and provide feedback
- ➢ Provide reports on all parameter variations during the lifetime of the tank
- ➢ Provide MicroSepTec Management with reports regarding the system maintenance costs, overall system performance and reliability (number of service calls)

The function of the management system is illustrated in Figure 2.

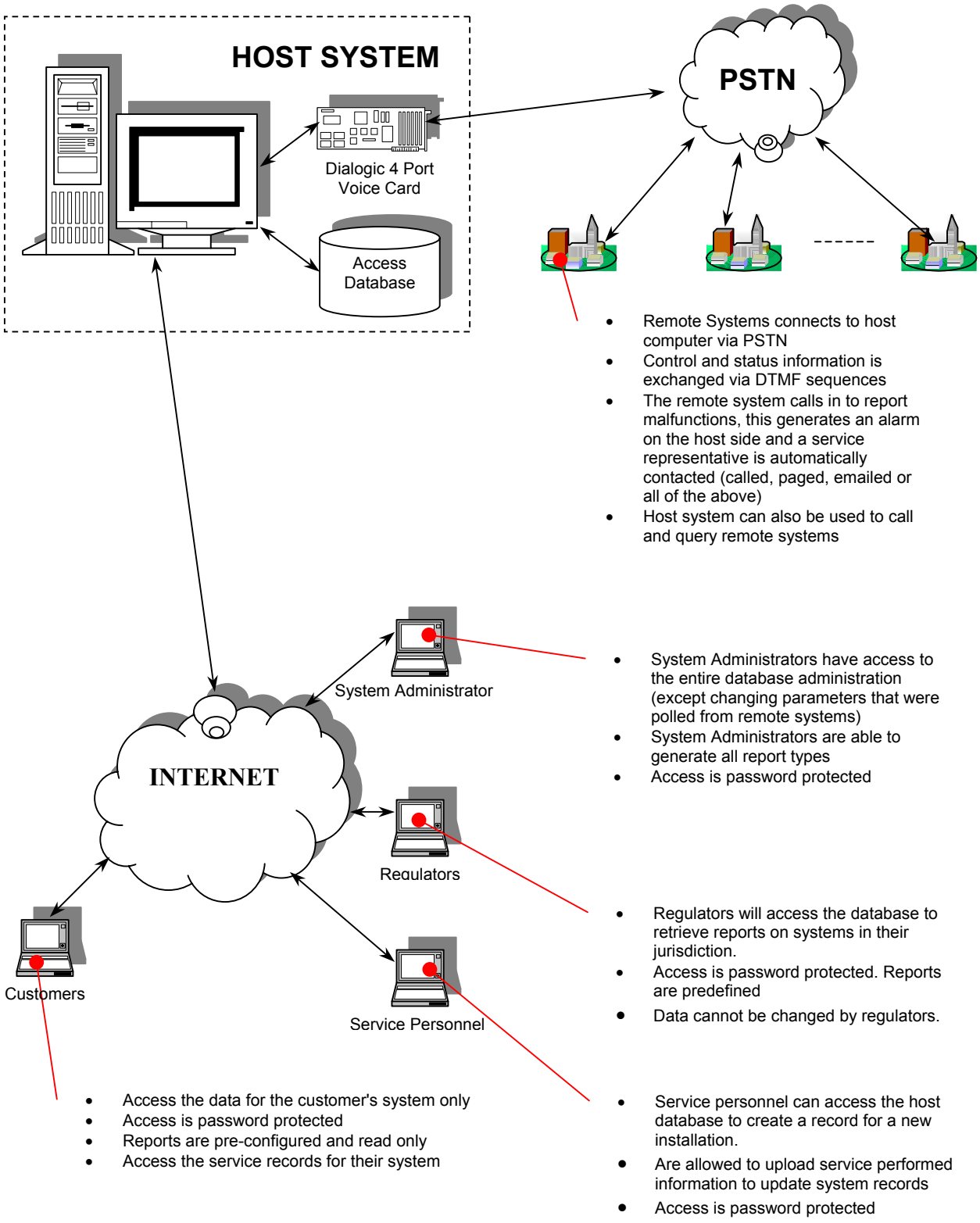


Figure 2. Illustration of the systems functionality and access.

SYSTEM OPERATION

So how does all this work in real life? If a pump stops working, and the system goes into alarm, the on-site controller will call the central monitoring system and report the alarm. If the telephone line is in use, the controller will try again after a predetermined time. The controller will keep trying until it has reached the central station and reported the alarm. At the same time, it will also download current status of the unit when it went in to alarm. The central monitoring computer will record the alarm and the current status, and save it in a database. The computer will then call/page and email the assigned Service Technician for this EnviroServer unit. If the Service Technician receives the alarm as an email, it will tell him which unit went into alarm, at what date and time, and finally what the alarm is. The Service Technician can then via Internet access the database on the central monitoring computer to check status of the unit when it went into alarm and historical records. This will tell him what needs to be done and how urgent it is. It will also tell him which spare parts to bring. If the Service Technician is notified of the alarm by his cellular telephone or a pager, voice synthesis will read out the alarm, the system number and time and date when the alarm took place.

CENTRAL MONITORING DATABASE

The database in the central monitoring computer contains the following records for each unit:

- Alarm Records - List of alarms
- Thermal Decomposition Records
- Performance/Water Test Data- List of certified lab results
- Service/Maintenance/Repair Records - List of service records
- Customer and System Record - List of customers

The current status will show which components are running, the temperature and time remaining if the unit is going through a thermal decomposition cycle, and the actual ORP (Oxidation Reduction Potential) reading. The ORP reading has been correlated to an approximate chlorine residual (mg/l) in the effluent, which will tell if the disinfection is complete or non-complete. Figure 3 shows a snapshot of the current status at the Ventura Demonstration Project.

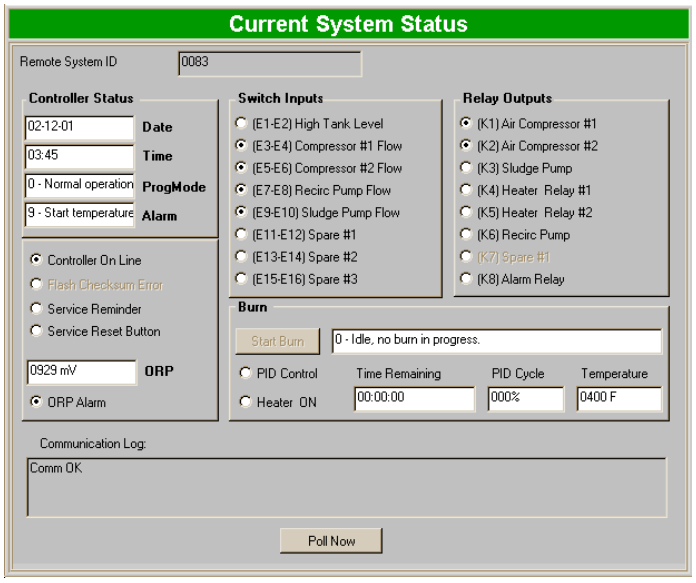
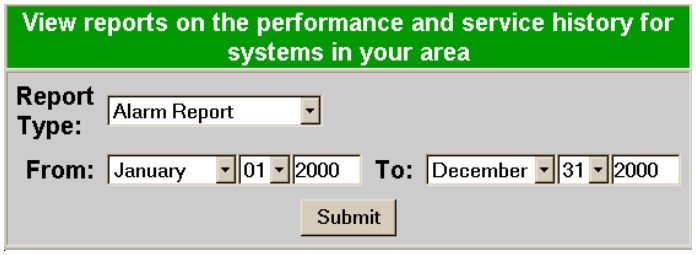


Figure 3. Current status of the EnviroServer 600 installed at the Ventura Sanitation District.

The current status at Ventura shows that everything is normal. The ORP reading is at 929 mg/l, which corresponds to approximately 5 mg/l of free chlorine. The chlorine level needs to be between 1 and 5 mg/l to ensure complete disinfection, measured as non-detectable fecal coliform. The status also shows that the temperature in the thermal processor is 400°F, and it is waiting for it to come down so it can start the sludge pump
The Alarm Report shows all the alarms between selected dates, so the Service Technician can check the history of alarms for each unit. A snapshot is shown in Figure 4. This particular unit is installed on an office complex, which already had two septic tanks installed. The main reason that they needed an advanced treatment unit was that they had high nitrate levels in the groundwater. The old septic tanks are currently used as dosing tanks in front of the EnviroServer. The problem that temporarily caused the EnviroServer to go into high level on August 24 and 28 was that the dosing pumps were pumping in 80 gpm and the effluent pump only pumped out 10 gpm. This has been taken care of by controlling the dosing pumps with two timers, which doses in small quantities at a time
The burn over temperature alarm shown on August 12 is very common when a unit first starts up and there is no sludge to destruct, but no action is needed unless it continues. If the thermal processor goes into "burn over-temperature alarm", it will automatically shut the thermal decomposition cycle off and reset the alarm. If this is a repeating alarm, the Service Technician needs to inspect the unit and possibly change the heating coil.



Alarm Report

Date	Time	SystemID	Alarm Type	Alarm Status	Alarm Description
8/12/00	00:36	0111	12	0	Burn over temperature 1 alarm
8/24/00	10:07	0111	4	0	Tank high level alarm
8/28/00	10:52	0111	4	0	Tank high level alarm

Figure 4. Alarm reports from EnviroServer 1200 installed in San Joaquin County in California.

EXPERIENCE AND CURRENT STATUS OF THE CENTRAL MONITORING SYSTEM

Currently (January, 2001), there are 25 EnviroServers, located in the US (east and west coast), Canada, Mexico, and Bahamas controlled and monitored by the MicroSepTec Central Monitoring System. It is expected that another 300 units will be added to the system within the next year. The first system was hooked up to the central monitoring station in December of 1999. The experience so far has been very successful.

In the beginning of using the system, there were several erroneous alarms caused by sensors not being installed correctly or as in the case described in the previous section the add-on equipment not functioning satisfactorily. During the entire operating time of the system, there has only been one equipment failure where the air compressor needed to be replaced. This specific unit is located in Arizona, and when the air compressor failed, the pressure switch triggered the controller, which called the central monitoring station and reported the alarm and alerted the assigned Service Technician in Arizona. The air compressor was replaced within 48 hours without the customer having to do anything. The compressor itself was still under warranty from the original manufacturer.

The only sensor in the treatment system that measures the water quality is the ORP probe, which measures chlorine residual. In general, on-line probes and analyzers that measure other components in the water such as nitrates, ammonia, suspended solids, etc, are too expensive and require too much maintenance for an on-site system. The way the EnviroServer "measures" the water quality is to sense that all the equipment is working properly. If the current status report is showing "normal operation", the effluent water quality is typically less than 10 mg/l of $CBOD_5$ (Carbonaceous Biochemical Oxygen Demand), less than 10 mg/l of TSS (Total Suspended Solids), and less than 10 mg/l of nitrate-nitrogen and TKN (Total Kjeldahl Nitrogen). For sensitive areas or when the effluent is used for surface irrigation, the air compressor alarm and/or the ORP alarm can be set to automatically shut-off the effluent pump. This will prevent discharge of water that is not completely treated and/or disinfected. Again, the central monitoring system will alert the Service Technician to take care of the problem.

The function of the monitoring system itself is currently being upgraded to take full advantage of its capabilities. The most important change is the add-on of a communication alarm and run-time monitoring of electrical equipment (pumps and heaters) to allow for preventive maintenance. Each unit will be set up to call in each week. The central monitoring station will send an alarm and alert the assigned Service Technician to check the communication if a unit does not call in when it is expected to.

CONCLUSION

The only way of reducing the number of on-site systems failing each year is to start implementing Central Management Systems for all on-site wastewater treatment units, including the septic tank with leachfield system. Some states are already requiring service and maintenance programs for advanced systems, but it needs to be extended to also include the passive systems, such as septic tanks since they are the largest polluters of our waters if not maintained properly. It is important to take the service and maintenance of the wastewater treatment unit away from the customer and put into a central program.

MicroSepTec decided to start doing just that and give the customer a "flush-and forget" treatment unit. The Central Monitoring Program has been in operation since December of 1999 with very successful results.

REFERENCES

Crites, R, and Tchobanoglous, G, "Small and Decentralized Wastewater Management Systems", McGraw-Hill, 1998

Rubin, A.R., Hogye, S., and Hudson, J, "Development of EPA Guidelines for Management of Onsite/Decentralized Wastewater Systems", NOWRA 9th Annual Conference, Grand Rapids, Michigan, Oct. 31-Nov. 1, 2000