

Condition Assessment Survey of Onsite Sewage Disposal Systems (OSDS) in Hawaii

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Abstract

This study investigated the existing conditions of onsite sewage disposal systems (OSDS) such as cesspools, septic tanks and aerobic treatment units in the State of Hawaii. Failing OSDSs may contaminate groundwater supplies, streams and nearshore ocean waters thereby endangering public health and the environment. Currently, in Hawaii, once OSDSs are operational, there is no governmental inspection/management program to monitor on-going performance or system condition. Previous work has recommended implementing an “Operating Permits” type OSDS management model. The main goal of this study was to help determine if the current situation (no management program) is acceptable or if there is a need to implement a new OSDS management program.

The area of study covered for the condition assessment and survey of OSDSs in Hawaii included the islands of Kauai, Oahu, Molokai, Maui and Hawaii Island. Various sites were evaluated, including schools, parks, beaches, businesses and private residences. A typical inspection consisted of: (1) Owner/Resident Interview (2) Site Assessment (3) System Inspection (4) Effluent Sample Collection (5) Recommendations to Owner Regarding System (when necessary). The characteristics measured for effluent samples were Total Nitrogen (TN), Total Phosphorus (TP), Total Suspended Solids (TSS), and 5-Day Biochemical Oxygen Demand (BOD₅).

Sixty-eight percent of all OSDSs inspected throughout the State of Hawaii were determined to be in satisfactory condition. Conversely, sixteen percent of the inspected OSDS were deficient and in need of immediate repairs or maintenance to address problems. The remaining sixteen percent represented the fraction of OSDS that were found to have problems that may potentially lead to a future system failure. These statistics imply that nearly one out of every three systems is not functioning satisfactorily. In addition, 80% of the participants surveyed indicated that they have never pumped their septic system, meaning that basic preventative maintenance is not being performed on the vast majority of OSDS systems. The islands of Oahu and Kauai had a significant number of failures by surfacing and overflow likely due to lower-

permeability soils whereas Big Island had no similar failures likely due to highly-permeable soils. However, these high-permeability soils translate into shorter travel times for effluent to reach drinking water aquifers. OSDSs in SWAP capture zone B (close proximity to drinking water supplies) had higher average concentrations of TSS, BOD₅, and Total P than other facilities in this study. ATUs sampled in this study were not performing much better than septic tanks and not performing as well as expected. This means that the ATUs are not being maintained adequately and that the existing management program (owners required to have an active maintenance contract) is not working. Statewide, about 70% of effluent samples collected had values of Total N and Total P greater than typical literature values and 40% of the samples had values of TSS and BOD₅ greater than typical ranges in the technical literature. Taken together, the findings from this study strongly suggest the need for the implementation of a proactive, life cycle OSDS management program for the State of Hawaii.

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1 Introduction

1.1 Purpose

Nationwide, Onsite Sewage Disposal Systems (OSDSs) including cesspools, septic tanks, and aerobic treatment units are utilized in approximately 25% of all existing households and 33% of new developments (USEPA, 2003b). In Hawaii, once OSDSs are operational, there is no governmental inspection/management program to monitor on-going performance or system condition. Failure or poor operation of OSDSs, especially in the vicinity of drinking water supplies, could have serious effects on public health. A previous study recommended the “Operating Permits Model” as the most applicable method for the implementation of an OSDS management program for the State (Ogata & Babcock, 2009). The focus of the recommended model would involve the Hawaii Department of Health (DOH) issuing renewable permits for OSDSs and requiring inspections every two years by licensed professionals for permit renewal in order to protect public health and natural resources. A successful program would help to ensure a high level of quality for recreational waters and drinking water supplies. The following report contains information regarding the current status of OSDSs and offers insight into the need for implementation of a management program in the State of Hawaii.

The purpose of this study was to examine the existing condition of OSDSs throughout the state of Hawaii by conducting on-site inspections and to educate OSDS owners. A comprehensive inventory of the sample population included an assessment of each system and a water quality analysis of effluent from all sites where samples could be obtained. Best Management Practices (BMPs) developed in the previous studies (Ogata and Babcock, 2009 and WRRC and Engineering Solutions, 2008) were explained to OSDS users encountered during the course of this project. The baseline data gathered and described herein will aid regulators, service providers, homeowners, and legislators in first deciding if a new management program is warranted and then, if needed, during the course of program implementation.

1.2 Context

Material and information contained within this document represents the perspective of an environmental engineering graduate student at the University of Hawaii at Manoa. The facts gathered throughout the course of this study include: testimonial data from participants, interviews from some service providers (septic pumpers, engineers, and water purveyors), and first hand observation from the author. The material presented does not directly reflect the views of all service providers, the University of Hawaii, or any regulatory agency mentioned throughout this paper.

1.3 Scope

Centralized wastewater treatment plants and public sewers will not be discussed in detail in this report. These systems involve the conveyance of raw wastewater from individual homes through a network of pipes and pump stations to a wastewater plant for treatment and disposal.

Decentralized wastewater treatment systems are defined as individual onsite or clustered wastewater systems used to collect, treat and disperse wastewater from individual homes, businesses, and small communities. These include cesspools, septic tanks, and aerobic treatment units as well as disposal units such as seepage pits, absorption beds/fields, and evapotranspiration mounds. In addition to meeting public health and water quality goals, the implementation of management practices also provides a greater range of options for cost-effectively meeting wastewater requirements, and protects investments in homes and businesses (USEPA,2003b). An OSDS is sometimes looked upon as temporary solution that will eventually be replaced by a public centralized sewer system. However, it is important to note that these systems usually become permanent when a cost analysis reveals that it would not be economically feasible to extend sewer service to remote and less densely populated rural areas.

This study sought to inventory the status of OSDSs on all of the main Hawaiian Islands.

1.4 Areas of Study

The following section provides a brief description of the various areas around Hawaii that have been examined during this study. Several decentralized wastewater systems were examined on the islands of: Kauai, Oahu, Molokai, Maui, and Hawaii Island (Big Island). Each island, although very different, has many similarities to the other islands. One such similarity is the presence of a windward and leeward side. The windward side is commonly found on the eastern side of an island. The leeward side is located on the western side. The prevailing wind pattern in the tropics north of the equator has a direction blowing from the northeast. This phenomenon is known as trade winds or trades. Because of cloud formation from this type of wind on the windward side of all islands, the precipitation rate is significantly higher than its leeward counterpart. Precipitation rate plays an important role when properly siting and designing an OSDS. In addition to precipitation and wind, the solar radiation, temperature, and humidity vary significantly over relatively short distances on all islands. Both windward and leeward areas of all islands were included in this study.

Another key aspect that must be considered is the location of the Hawaiian Islands. The nearest land mass is nearly 2,500 miles away. Because of its isolation, the majority of goods and commodities are imported. However, precious resources such as water are provided locally. Thus, great importance must be placed on protection of the potable drinking water supplies throughout the state. The figure below identifies the areas on each island that were included in this study.

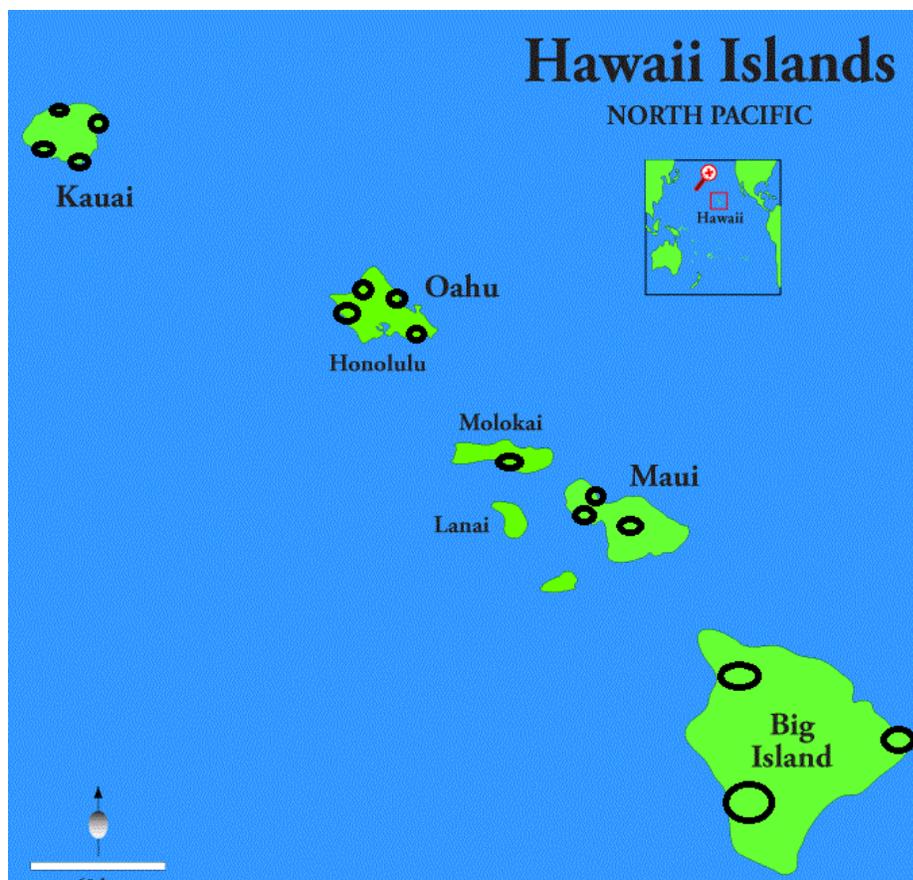


Figure 1-1: Map of Study Area (Circled in Black)

This investigative study was primarily focused on the impacts that OSDS have on environmentally sensitive areas. In particular, the highest priority systems were those near well-heads located within the Source Water Assessment and Protection (SWAP) capture zone B (CZ-B). Capture zones are defined as the surface and subsurface area surrounding a well that supplies a public water system. The CZ-B area is delineated by a theoretical boundary that includes the 2-year time of travel. This implies that a water particle will take two years from the time it enters the surface or sub-surface area to reach the well inlet. Potential contamination sources (such as OSDSs) in CZ-Bs are of major concern to public health professionals.

1.5 Regulating Authorities

At the federal level, the U.S. Environmental Protection Agency (EPA) is assigned the task to monitor and provide guidelines for proper planning, design, construction,

inspection and maintenance of OSDSs. However, in the State of Hawaii, the EPA has relinquished the authority to the State Department of Health (DOH). The DOH-Environmental Management Division, Wastewater Branch provides framework guidelines and enforces all wastewater rules and regulations in the State of Hawaii. However, the EPA continues to provide assistance and remains committed to elevating and maintaining the standard of onsite wastewater management practices (WRRC & Engineering Solutions, 2008).

Currently, an OSDS operating permit program does not exist in Hawaii. However, there are rules and regulations in place for siting, designing and constructing new OSDSs. Hawaii Administrative Rules Title 11, Chapter 55 “National Pollutant Discharge Elimination System Permitting” regulates the permitting of wastewater treatment facilities. The following regulations and requirements apply to OSDSs in the State of Hawaii:

1. Selection of appropriate wastewater treatment and disposal systems is outlined in the regulations. Effluent standards do not exist at the present time for cesspools and septic tanks. However, National Sanitation Foundation (NSF) Class A certification is required for all aerobic treatment units (ATUs). Class A effluent contains less than 30 mg/L of BOD₅ and TSS on a 30-day average. Innovative and alternative technologies are allowed pending testing and monitoring on a case-by-case basis.
2. Hawaii rules require that new OSDS plans be reviewed and approved by the DOH prior to construction. Following construction, written authorization for use must also be acquired from the DOH. According to the Administrative Rules, the design of the OSDS shall be done by a Hawaii licensed professional engineer (PE). The system must also be installed by a licensed contractor.
3. Periodic inspections following construction are not mandatory. DOH requires an operation and maintenance manual and owner certification that they will follow the manual. In addition, the engineer-of-record

must submit a final inspection report, certifying the OSDS was constructed in accordance with the approved plans. Once completed, the DOH will issue a written approval to use the OSDS.

4. With the exception of ATUs, state law does not require recordkeeping and monitoring of management and maintenance programs for OSDS. ATUs require ongoing maintenance contracts.
5. Any innovative technologies proposed and conditionally approved by DOH require testing and certification by NSF International or third party certification and testing, using NSF and DOH approved testing protocol.

1.6 EPA Programs

Hawaii could benefit in several different areas of environmental quality and monitoring already established in the state with the implementation of a management program for OSDS throughout the state. Listed below is a description and summary of programs that have already been mandated or implemented by the government (USEPA, 2003b).

Watershed Management

OSDS management plans could be incorporated into a comprehensive watershed approach at all levels of the government. Monitoring onsite systems at the watershed level has many benefits. This approach will facilitate the identification of both existing and anticipated sources of pollutants. With the appropriate type of information, governmental agencies can take the correct steps to restore an identified resource. Both long- and short-term wastewater management plans and activities can be integrated into a comprehensive plan that may include analyses and steps taken that address the impacts of other contributing sources of pollutants such as animal waste, wildlife, or agriculture. The watershed method encourages the synchronization of management entities and promotes coordinated actions across jurisdictions. As a result, resources can be utilized more efficiently and inconsistent policies or requirements can be avoided. An additional benefit is the opportunity for data sharing amongst all stakeholders.

National Pollutant Discharge Elimination System (NPDES)

The National Pollutant Discharge Elimination System (NPDES) was established by Congress in 1972 under the Clean Water Act (CWA). This program is a permitting system that prohibits the discharge of pollutants from a point source to water of the United States unless that particular discharge is authorized by a NPDES permit. It includes discharges to ground water with a direct hydrologic connection to surface waters. The permit establishes necessary technology-based and water quality-based terms, limitations, and conditions on the discharge to safeguard public health and the environment.

Water Quality Management

Onsite wastewater treatment systems can be major contributors of pathogens and nutrients. There are an estimated 5,400 bodies of water that are reportedly impaired by pathogens throughout the nation. An additional 4,700 are impaired by excessive nutrient levels. The most common solution to mitigate this type of problem has been to replace onsite systems with a centralized wastewater treatment and collection system. However, this decision may not be economically feasible for many communities throughout Hawaii.

When implemented correctly, a decentralized approach with a high level of management would be capable of meeting Hawaii's water quality goals. The EPA requires a Total Maximum Daily Load (TMDL) determination when the total loading of pollutants to a water body results in a violation of water quality standards. Because of this, systems that may be contributing a large load of pollutants will be subject to the NPDES permitting program.

Source Water Assessment and Protection (SWAP)

The Source Water Assessment and Protection (SWAP) program delineates the areas serving as sources of drinking water. Potential threats are identified and steps to implement protection efforts are taken. States are obligated to fulfill this requirement on all public water systems. An assessment for water systems includes an inventory of onsite and clustered systems located in delineated source water protection areas and

identifies some of them as priority pollution threats. The information gathered allows officials to decide upon the type of management model that is best tailored for that location.

Coastal Zone Management Act/Coastal Zone Act Reauthorization Amendments of 1990 (CZMA/CZARA)

As a requirement administered jointly by the EPA and the National Oceanic and Atmospheric Administration (NOAA), 29 states with approved Coastal Zone Management Programs must establish and implement Coastal Nonpoint Pollution Control Programs. The programs must include management for both new and existing OSDSs. New systems need to be designed, installed, and operated properly and be located at safe distances from sensitive resources, including wetlands and floodplains. The operation of OSDSs requires maintenance to prevent surface water discharge and reduction of loadings to groundwater, as well as inspection at regular time intervals and repair or replacement of faulty systems. Currently, the EPA considers Hawaii's program deficient for not having a life cycle inspection/management program for OSDSs.

1.7 Stakeholders

There are several stakeholders that are either directly or indirectly involved with OSDS management. The following section will discuss the stakeholders affected by this issue and identify the interdependence that ties all involved parties together. The reason why this is important is that in order for a successful OSDS management program to be implemented, cooperation amongst all involved will be vital.

Homeowners

A properly functioning OSDS can often be taken for granted. It is because of this fact that many such systems are neglected until failure occurs. Ultimately, it is the responsibility of the homeowner to properly maintain their OSDS. As mentioned many times throughout this report, the best means to achieve this is controlling what is disposed into the system and most importantly periodic pumping (best management practices, BMPs). The use of screens for sink drains is an effective way to intercept undesirable food waste and solids from entering the wastewater stream. Preventative

maintenance will save the homeowner money for costly repairs that could have otherwise have been avoided.

Surrounding Community

In addition to homeowners, neighboring residents also have a vested interest in maintaining a well-functioning OSDS. Failing systems such as overflowing cesspools and septic tanks pose an imminent threat to the well-being and safety of those who are within close proximity. In addition to infectious waterborne diseases, unpleasant and potentially corrosive odors may also cause a nuisance. Undesirable odors may negatively affect surrounding property values.

Tourism

The number one industry in Hawaii is tourism. Each year millions of visitors visit the islands to enjoy beautiful beaches and tropical landscapes. As a result, essentially all businesses and residents depend on tourism for a healthy Hawaiian economy. Various activities like swimming and surfing in the ocean utilize natural resources, so the preservation and protection of these resources are vital to tourists and residents alike.

This issue was clearly exemplified with the infamous sewage spill that occurred in March of 2006. The entire island chain was blanketed by heavy rains for several weeks leading up to the incident. As a result, the sewer pumping system in Waikiki was running at very high capacity and a pressurized pipe in a pump station in Waikiki failed. In an attempt to avoid the back-up of raw sewage into hotels, condos, and other neighborhood businesses, the City and County of Honolulu decided to make a difficult decision. Millions of gallons of untreated raw sewage were discharged into the Ala Wai canal. This body of water led directly to the ocean. Consequently, several beaches including Waikiki had become contaminated and were closed. In addition to the threat of public health and safety, many businesses suffered tremendously.

Housing Market

As mentioned earlier, the value of a property and those surrounding it may be reduced if it is determined that an OSDS is failing. This dilemma also directly translates

to others that are involved. In particular, realtors and lenders have much to lose. In Hawaii, the common practice when selling a house is for full disclosure and buyer beware. This means that the seller must fully disclose any known deficiencies with the property, including a failing OSDS, but the buyer must beware.

A key factor to consider is that in many instances, a system may be failing or have the potential to fail but may not be apparent to the person selling it. Therefore, a prospective buyer would want a licensed wastewater professional to inspect the system prior to entering a purchase agreement. This key factor has many in the industry cautiously apprehensive when representing a client that involves a deficient onsite system. Some cities in the U.S. already have a point-of-sale inspection that is required for all houses that are served by an OSDS. This means that a thorough inspection of the OSDS must be completed any time there is a change in ownership.

Banks and other lenders should also have a vested interest on the proper functioning of an OSDS. Before any loans or mortgages are approved, it is important to know if there are any problems or household repairs that may cost the owner a significant amount of money in the future. Failure to do so may put these financial institutions in a bind. For example, costly repairs for a faulty wastewater system can add a financial strain that may result in a default of monthly payments by the homeowner. Another situation that may occur is that the owner may give up and further neglect the system, which would consequently reduce the overall value of the property. In extreme cases, the housing unit may be viewed as unlivable and potentially be condemned.

Regulatory Agencies

Occasionally, the general public may have negative feelings toward regulatory entities for fear of potential fines and penalties that may be accrued in the event that an OSDS is deficient or in violation of some sort. However, these agencies play a vital role in protecting the health of the general public and the environment. Both state and federal agencies have been cautiously monitoring the activities that pertain to decentralized wastewater treatment and its impact on natural resources. One such

undertaking involving OSDSs is the decommissioning of large capacity cesspools (LCCs).

2 Literature Review

The literature reviewed herein includes the research and monitoring methods related to wastewater that are pertinent to the specific issues Hawaii's wastewater systems will encounter.

2.1 Environmental Impacts

Pollution originating from septic tanks and other OSDSs is a direct result of human activity. Excessive nutrient loading originating from surface runoff and subsurface disposal of residential sewage poses a serious concern. Nutrient fluxes to coastal waters elevate the threat of eutrophication. In addition, elevated coliform bacteria levels indicate the possible presence of human pathogens. As with other types of non-point pollution, it is typically quite difficult to positively identify the pollution as of wastewater origin and/or to identify the source of wastewater effluent. In many cases, adequate resources are not available to address this problem.

The foundation of a healthy ocean ecosystem is a thriving coral reef. A recent report by the U.S. Geological Survey revealed that there is an outbreak of white coral disease along Kauai's north shore that is spreading rapidly. A new strain of cyanobacteria is smothering and killing otherwise healthy coral reefs at a few inches per week. Possible causes of this devastating coral disease include overfishing, pollution, sewage spills and anything that adversely affects water quality (Associated Press, 2012, B-1). It cannot be assumed that there is a direct correlation of this problem to OSDS contamination. However, properly maintaining wastewater systems will help to minimize any potential impact in this sensitive ecosystem.

Septic systems are the second leading cause of ground water contamination (leading cause is leaking underground storage tanks) in the USA. Ingestion of sewage-contaminated drinking water may lead to disease outbreaks and other adverse health

effects. The bacteria, protozoa, and viruses found in domestic wastewater can cause numerous diseases, including gastrointestinal illness, cholera, hepatitis A, and Typhoid (USEPA, 2001). Disease outbreaks can occur when untreated or partially treated effluent is discharged into the soil and migrates downward to the receiving aquifer and then to nearby drinking wells.

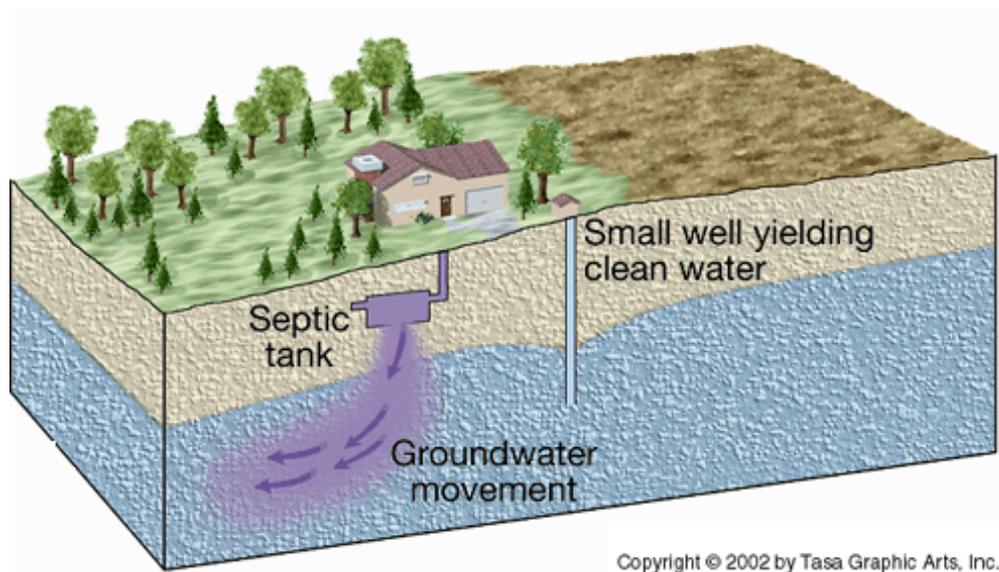


Figure 2-1: Contamination of Groundwater from Septic Systems

2.2 Nitrate and Nitrite

Nitrate and nitrite are compounds that are commonly present in many products that we use daily. They can be found in fertilizers, pesticides, and food preservatives. Sodium and potassium nitrates are used as fumigants in canisters, which are placed underground in rodent dens and holes. These canisters are ignited to explode and release toxic gases that kill rodents (USEPA, 1991). Nitrate (NO_3^-) and Nitrite (NO_2^-) are also naturally-occurring compounds that are a metabolic product of microbial digestion of wastes containing nitrogen, such as human/animal feces (USEPA, 2006). Sodium nitrite is a food additive that is used as a preservative (U.S. Agency for Toxic Substances and Disease Registry, 2001; World Health Organization, 2006). Leaching

into aquifers from OSDSs is a known source of nitrate/nitrite contamination. These compounds are highly mobile and have a high potential of migrating to groundwater following surface application (fertilizers) or subsurface application (OSDS dispersal). This is due to high solubility in water and weak retention by soil (USEPA, 1991; World Health Organization, 2006).

Likely pathways for children to encounter nitrates or nitrites include the ingestion of contaminated drinking water, most commonly of concern for private wells (U.S. Agency for Toxic Substances and Disease Registry, 2001); and foods containing preservatives, particularly cured meats such as hot dogs and lunch meats (World Health Organization, 2006; Laitinen, 1993; Reinik, 2005). Exposure to nitrates and nitrites at elevated levels has adverse health effects on infants. The Maximum Contaminant Levels (MCLs) for Nitrate and Nitrite are 10 mg-N/L and 1 mg-N/L respectively. The health effect of most concern to the U.S. EPA for children is Methemoglobinemia (USEPA, 1991).

Blue Baby Syndrome

Methemoglobinemia, also known as blue baby syndrome, is a condition seen most frequent in infants exposed to elevated levels of nitrate/nitrite in drinking water. The exposure can be due to ingesting baby formula mixed with contaminated water (Knobeloch et al, 2000). However, a diagnosis that links the condition to a contaminated well requires thorough investigation and water quality testing of the well in question to determine whether nitrates/nitrites were ingested via other pathways.

The link between nitrate-contaminated well water and blue baby syndrome was first discovered by Hunter Comly in the early 1940's. At the time, he was an Iowa City physician who treated two infants for symptoms of cyanosis (Comly, 1945). He found that both infants became ill after they were fed formulas that were diluted with water from shallow wells. Nitrate-nitrogen (nitrate-N) concentrations in the related wells were 90 and 150 mg/L. Since then, significant efforts have been made to reduce infant exposure to nitrate contaminated water through education and protection efforts.

Although public wells are monitored and must adhere to the U.S. EPA MCLs, private wells are unregulated and often unchecked. The Wisconsin Department of

Health and Family services in Madison, Wisconsin has recently investigated two cases of blue baby syndrome (Knobeloch et al, 2000):

Case 1: In June 1998, public health nurses in Columbia County, Wisconsin, saw a 6-month-old male that had been brought to a clinic in the Village of Cambria for immunizations. Skin around his mouth and nose was unusually gray. According to his parents, the infant's skin color had been "gray" and he had been "crabbier than normal" for a couple of weeks. Healthcare providers at the clinic suspected that the culprit was nitrate/nitrite contamination of drinking water. It was later determined that the infant had consumed formula that consisted of powdered concentrate that was diluted with water from the family's well. The family had recently moved into a new home that was served by a private well. A water sample from the drinking well was collected the following day. Laboratory tests later confirmed that the nitrate-N concentration was 22.9 mg/L, more than double the acceptable limit. When examined by the physician 12 days after being placed on bottled water, the gray color, irritability and vomiting had subsided.

Case 2: During April 1999, a 3-week-old white female was brought into an emergency room in Grant County, Wisconsin. Upon arrival, the child's skin was pale, cyanotic, and mottled. She was also very fussy and irritable. According to her parents, the child started to show signs of illness the day before. The infant had turned completely blue and was also having difficulty breathing. She became ill 1-2 days after her parents ran out of bottled water that was used to prepare her formula and began using water from the farm well as a substitute. Water samples that were collected 2 days after the child was hospitalized indicated elevated levels of nitrate-N with a concentration of 27.4 mg/L, more than double the acceptable limit. It was later determined that potential sources of nitrate were barnyard runoff, septic tank effluent, and agricultural fertilizers.

The infants in the cases described above made complete recoveries once the problem was addressed. The rapid improvement of the infants' conditions observed after they were switched from tap water to bottle water supports the diagnosis of Blue Baby Syndrome. It is not known whether any long term effects persisted.

2.3 On-site Wastewater System Technologies

OSDSs can be categorized as: (1) Conventional Systems or (2) Advanced Systems. Conventional systems are more common and have no moving parts or electrical components. The most common types of conventional systems are cesspools and septic tanks. Advanced systems, which are more complex and require more maintenance, have moving parts such as pumps, blowers, switches, sensors, and electrical mechanisms. An example of an alternative system is an Aerobic Treatment Unit (ATU). ATU's provide a better quality of effluent because they provide primary sedimentation treatment and secondary biological treatment and may also include effluent disinfection with chlorine. The sophisticated nature of this technology may also create unforeseen problems for the user if proper care and maintenance is not practiced.

A typical conventional OSDS is comprised of either one or two parts: for a cesspool there is only a disposal unit; no treatment is provided. For a septic tank system, the first component is a treatment unit (septic tank), and the second a disposal unit (see Figure 2-2). The purpose of a septic tank is to receive and clarify raw wastewater from a house or dwelling. Heavy settleable solids and floatables like fat, oil, and grease, plastics and hair are retained in the tank and must be pumped out periodically while the effluent is sent to the disposal unit (leaching pit or drainfield).

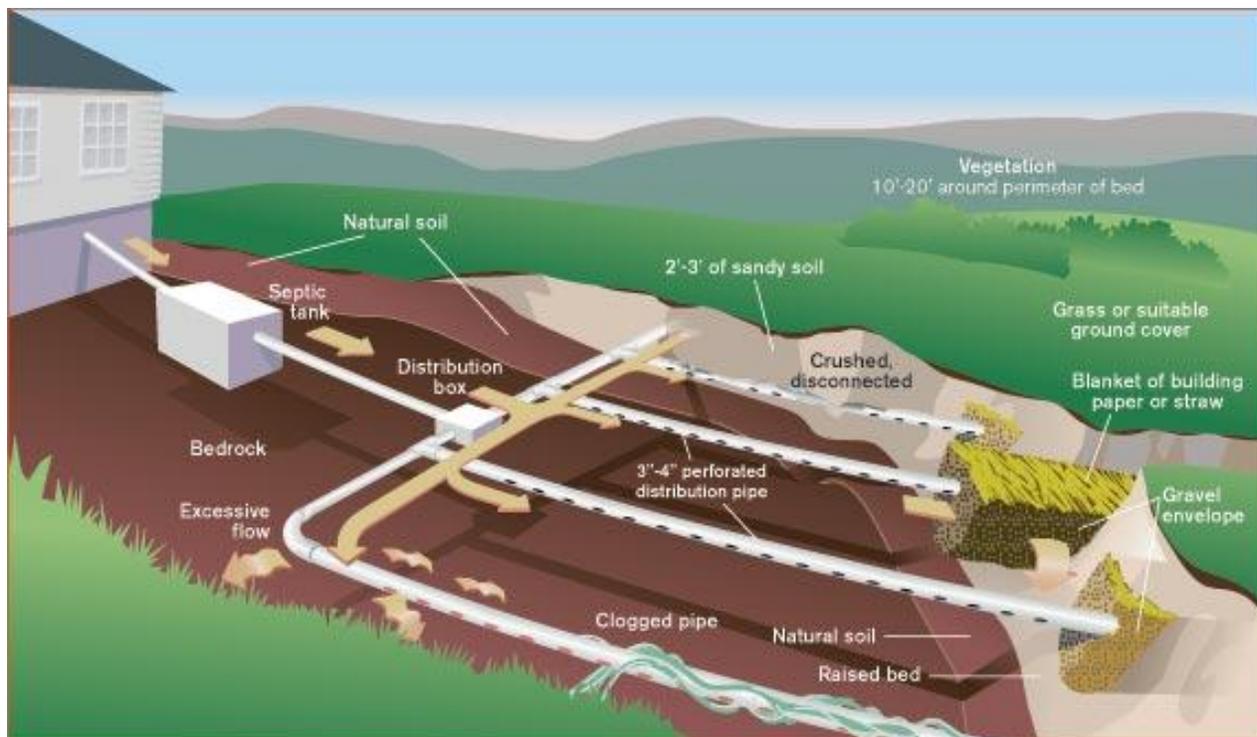


Figure 2-2: Cross-Section of a Typical OSDS

Cesspools

The cesspool is the most common type of OSDS in the State of Hawaii. Although new developments (other than Hawaii Island) are prohibited from using this disposal method, older homes are still allowed to use these if construction was completed prior to 1992. Those houses built before 1992 were exempt from mandatory upgrades. Hawaii has an estimated 170,000 cesspools in use. In 2005, the EPA placed a ban on the use of large capacity cesspools (LCC's) which have mostly been upgraded. LCC's are defined as any cesspool serving 20 or more persons per day.

A cesspool is a pit or hole in the ground that is typically lined with perforated stone or terraced brick or concrete blocks. Household plumbing is connected to the cesspool and raw wastewater is allowed to enter. Once in the cesspool, solids are allowed to settle and the effluent exits through the sides. The continuous use over time

contributes to both an accumulation of sludge and the formation of a biological growth called bio-mat. Sludge must periodically be removed from the cesspool via pumping. Although some sludge is consumed by microbial action, the continuous influx of wastewater eventually outpaces this naturally occurring phenomenon. The environment in the cesspool is anaerobic (no dissolved oxygen) and hence any biodegradation action will produce foul odors including hydrogen sulfide (rotten egg smell). Bio-mat can be removed from the walls either physically (washing with a hose) or through chemical treatment. The latter is often the preferred method because it is much easier. Removal of bio-mat will allow effluent to exit easier with less obstruction (Ogata & Babcock,2009).

It is the homeowner's responsibility to properly operate and maintain their cesspool. Because of the age of most cesspools and the possibility that many were constructed using sub-standard methods, these types of OSDS should be constantly monitored and caution should be taken when approaching such structures. Indications and symptoms of a failing cesspool include:

1. Ponding of water or abnormally lush/burnt vegetation over cesspool. This may be due in part to overflowing from an overloaded or clogged cesspool. Lush vegetation may be attributed to high levels of nutrients accelerating growth. Burnt vegetation may be caused by toxic chemicals within the wastewater.
2. Ground subsidence over cesspool. Caution must be taken as this is a sign of potential cave-in.
3. Sewage back-up or presence of odors. This may be attributed to excessive flow entering the system or a clog in the piping or cesspool itself.

Septic Tanks

In Hawaii, over 4,500 homes are served by septic tanks. They are often also referred to as conventional OSDSs. This treatment method is becoming more abundant as outdated and malfunctioning cesspools need to be replaced. Septic tanks function by receiving raw wastewater discharged directly from a home. Once in the tank, effluent is clarified in two compartments separated by a baffle wall and a submerged connection pipe resulting in removal of both sludge (settleables) and scum (floatables) in the first chamber and fairly clarified effluent exiting the second. The environment in

the septic tank is anaerobic (no dissolved oxygen) and hence any biodegradation action will produce foul odors including hydrogen sulfide (rotten egg smell). Some treatment will occur if the tank is sized to accommodate the amount of water generated by the facility which it serves. A typical tank is water-tight and constructed of plastic, fiberglass, or concrete.

The maintenance required for a septic tank is minimal (periodic pumping). However, failure to do so could result in costly repairs that could have otherwise been avoided. Proper maintenance of septic tanks may also aid in extending the life of the downstream disposal unit (seepage pit, absorption trenches/bed). Controlling the materials that enter the septic tank is the most effective way for a homeowner to care for their septic system. In addition to household hazardous waste, other items such as diapers, condoms, feminine hygiene products, and coffee grounds should not be disposed of in sinks or toilets. Kitchen sink grinders can add an enormous amount of solid waste to the system (contributing to sludge build-up) and are not recommended. The use of drain screens to intercept solids materials is also highly recommended.

Table 2.1: Suggested Pumping Intervals (1,000 gallon tank with 4 occupants)

Tank Size (Gallons)	Household Size (number of people)								
	1	2	3	4	5	6	7	8	9+
	Duration (in years) Between Pumping and/or Inspections								
500	5.8	2.6	1.5	1.0	0.7	0.4	0.3	0.2	0.1
750	9.1	4.2	2.6	1.8	1.3	1.0	0.7	0.6	0.4
900	11.0	5.2	3.3	2.3	1.7	1.3	1.0	0.8	0.7
1000	12.4	5.9	3.7	2.6	2.0	1.5	1.2	1.0	0.8
1250	15.6	7.5	4.8	3.4	2.6	2.0	1.7	1.4	1.2
1500	18.9	9.1	5.9	4.2	3.3	2.6	2.1	1.8	1.5
1750	22.1	10.7	6.9	5.0	3.9	3.1	2.6	2.2	1.9
2000	25.4	12.4	8.1	5.9	4.5	3.7	3.1	2.6	2.2
2250	28.6	14.0	9.1	6.7	5.2	4.2	3.5	3.0	2.6
2500	31.9	15.6	10.2	7.5	5.9	4.8	4.0	3.5	3.0

Source: Septic tank pumping table from EPA Septic Systems website

Periodic pumping is an important way that homeowners can perform routine maintenance. The advisable pumping interval is determined by both tank size and facility water use. Simply put, a smaller tank size with high water use translates to more frequent pumping. Table 2.1 shows the EPA recommended pumping interval. For example, a home or dwelling with a 1,000 gallon tank and 4 occupants should have the septic tank pumped every 2.6 years.

With regard to sludge and scum levels, it has been advised by a professional that “if the combined amount of sludge & scum accumulated is 25% or more of the total depth of the tank, then the septic system must be pumped immediately” (Balberde, 2012). Failure to pump as recommended may cause backups into the dwelling, or allow solids to overflow the tank and clog the downstream drainfield or cause overflows (surface ponding).

Aerobic Treatment Units (ATUs)

ATUs are the least common type of OSDS in Hawaii. It is estimated that there are a few hundred ATUs in Hawaii. This advanced technology provides the highest quality effluent prior to disposal. ATUs are commonly implemented in environmentally sensitive areas where conventional septic systems are not able to meet the required treatment criteria. New homes located within close proximity to drinking water wells are often required to install ATUs. As older septic tanks and cesspools fail to meet treatment standards in Hawaii, the number of ATU units will continually increase.

Unlike cesspools and septic tanks, ATUs employ aeration to promote aerobic microbial degradation of sewage. Air is bubbled through wastewater via a blower or mixer. Aerobic microorganisms uptake oxygen and simultaneously biodegrade the organic materials and nutrients in the sewage. Aerobic biodegradation does not produce foul odors and instead smells “musty” or “earthy”. The input of oxygen also allows microbes and sewage to be thoroughly mixed. While ATUs provide a higher level of wastewater treatment, these devices also require much more maintenance. Seemingly minor malfunctions can significantly inhibit treatment performance (e.g. malfunction of aeration system could result in poorer quality effluent than a septic tank).

There are several things that need to be done in order to maintain an ATU. New ATUs are required by DOH rules to have a two year service contract with a licensed service provider. However, there was little evidence to confirm that this mandate is being followed. Several interviewed homeowners were unaware of this requirement. Several tips regarding proper care and maintenance are:

1. Maintain a service contract with a licensed professional service provider.
2. Be familiar with the ATU and how it works, sounds, smells, and looks like when it is properly functioning. This will allow for recognition of when it is malfunctioning.
3. Routinely verify that pumps and blowers are operating (sound/heat) and that air bubbles can be observed in the tank.
4. Maintain all ATU records and drawings.
5. Be familiar with any ATU alarms and what they signify.
6. Avoid using kitchen sink grinders and conserve water.

Disposal System

As mentioned earlier, OSDS are most often comprised of two units, the treatment unit and the disposal unit. The first unit can either be a septic tank or an ATU. Cesspools are not considered treatment units, they are disposal units. Thus, in cesspool-equipped installations, there is only one unit. The effluent from a septic tank can be considered partially treated effluent and that from an ATU is generally considered fully treated. Either way some form of disposal unit is required.

In the case of a cesspool, there is no treatment in the tank and the main function is dispersal of untreated wastewater. There will be some limited biodegradation in the biomat that forms on the walls of the cesspool and may be some additional treatment in the soil pores adjacent to the system. In the case of a septic tank, the purpose of the disposal unit is to provide for biodegradation and dispersal of the partially treated wastewater using a purposely designed soil absorption unit that naturally performs physical and biological treatment. Soil absorption units are usually either parallel gravel-filled trenches or beds of gravel. Straining and filtration occurs as effluent percolates out of perforated pipes in the absorption unit, through the gravel, and through

the adjacent soil towards the water table. Individual soil particles provide a surface on which a biomat will form and biochemical processes can occur. As wastewater migrates through the biomat and into and through the soil, organic compounds are used as a source of food by microbes. Eventually, these microbes convert organic matter into carbon dioxide and water. The equation below illustrates the process being described:



Septic systems with properly designed downstream absorption systems that are sited properly and functioning well promote wastewater treatment that prevents contamination of groundwater or surface water. In the case of an ATU, the effluent is considered fully treated and disposal can be via a seepage pit which is often the same design as a cesspool or it could be a pit filled or partially filled with rocks or gravel. In sensitive locations where no subsurface disposal is desired/allowed, soil evapotranspiration (ET) systems can be used. Soil ET units are designed to biodegrade residual organics, uptake residual nutrients, and evaporate all water. These disposal units are most appropriate following ATUs but are occasionally employed after septic tanks.

With the vast majority of the Hawaii's drinking water originating from subsurface aquifers, it is vital that concerted action be taken to protect this precious resource. Preventing sewage contaminants (from OSDSs) entering the drinking water distribution system is a critical component of public health protection and any OSDS management plan.

2.4 Wastewater Characterization

The determination of wastewater characteristics can be a difficult task. However, this issue must clearly be considered when siting and designing a new OSDS. Characterizing wastewater quantity and composition provides critical information that aids in the development of the framework for establishing and monitoring performance requirements. Parameters such as daily volumes, flow rates, and associated pollutant

load are all key factors for effective treatment system design. Flow types are grouped into two categories: (1) residential/domestic (2) non-residential. The determination of flow type will provide insight into the quality of wastewater that is to be received by the wastewater system. Residential/domestic type flows originate from dwellings including single-family households, condominiums, apartment houses, multifamily households, cottages and resort residences. Schools, restaurants, and industrial facilities fall into the category of non-residential (USEPA, 2002).

Throughout this study several OSDS effluent samples were collected and analyzed. The significance of this was to estimate the concentrations exiting these systems to be used by others in modeling efforts such as SWAP and other fate and transport modeling and risk assessments. Concentrations of Total Nitrogen (TN), Total Phosphorus (TP), Total Suspended Solids (TSS), and 5-day Biochemical Oxygen Demand (BOD₅) were measured.

2.5 Proposed Management Model

In a recent publication, the U.S. EPA has proposed several possible frameworks to raise the level of performance of onsite and clustered wastewater treatment systems (USEPA, 2003b). Implementation of the proposed Management Guidelines can help communities provide a wide array of options for cost-effectively meeting wastewater needs that will also help meet water quality and public health goals. If successful, it will also protect consumer investments in home and business ownership.

There are five proposed models that increase in complexity from the basic “Homeowner Awareness Model” to the most complex “Responsible Management Entity (RME) Ownership Model” (USEPA, 2003b). An earlier study recommended the most appropriate model for the State of Hawaii is a modified version of the EPA’s “Operating Permit Model” (Ogata & Babcock, 2009). The modification that was recommended was the creation of a licensing program for certified professionals that must be used for semi-annual inspections and system maintenance as part of operating permit renewal. The operating permits could be renewed on a periodic basis or revoked if performance criteria are not met. The Operating Permits Model takes into account these factors:

1. Environmental Sensitivity- It is a key element to the protection of both groundwater and surface water resources.
2. System Complexity- ATU's are more complex than cesspools and septic tanks due to their mechanical and electrical components. Also, large capacity systems receiving high strength wastewater are of greater concern.
3. Socioeconomic Factors- Implementing a Responsible Management Entity (RME) may not be feasible.
4. DOH Experience- DOH currently requires and issues permits for wastewater treatment plants (WWTP). They also require wastewater operators to be licensed and oversee the process of training and certifying the operators.

3 Methods

The following section explains the methodologies used to gather information for this study.

3.1 Communication Approaches

Throughout the course of this investigation, several different types of communication methods were utilized. The objectives for this part of the study were: 1) to contact the homeowners of OSDSs on all islands with emphasis on those in CZ-B; 2) to describe to the homeowners background information regarding OSDSs in Hawaii and how they may negatively impact our natural resources via contamination of near-shore coastal waters, streams, rivers, lakes, and potable groundwater supplies; 3) to provide tips and suggestions to the homeowner or resident for proper care and maintenance of their OSDS; and 4) to receive consent to inspect and assess the OSDS.

The following paragraphs explain a variety of different communication approaches that were used during this investigative study. Each method was unique and served as a vital tool in reaching out to the diverse population of the state of Hawaii. The first approach and most commonly used, was the cold call or cold visit. The next type of method was to send out mailing packets that contained information regarding this study. Also included in these mailing packets were contact information and instructions for participation. The third technique that was used was to make presentations at community and homeowner association meetings.

Cold Calls

Often the most difficult task when trying to establish communication is getting the correct contact information for the owner or resident of the property utilizing an OSDS. In many instances, the residences were not owner occupied and instead served as rental units. Another problem that arose was that public databases are infrequently updated and don't always provide complete or correct information (such as address, owner name, or contact information). Taking all of this into consideration, it was decided that a cold call or cold visit would be used to initiate communication in many instances.

A cold call is a phone call in which the person receiving the call does not have prior knowledge that he or she will be receiving that call. In most cases, the person being contacted by a cold call is a prospective customer/client and the caller is trying to sell something. The persons of interest in this study were those who owned a house or lived in a house that was served by an OSDS. In addition to the use of cold calls, cold visits were also utilized. This process is very similar to a cold call. The only difference is that instead of a phone call, an unannounced in-person on-site visit was conducted. In general, most people do not appreciate cold calls or cold visits and many even feel it is an invasion of privacy and are highly skeptical of the cold caller's intentions and assertions. In short, cold calls and cold visits are a difficult (but necessary) way to initiate an OSDS inspection.

This method of communication proved very difficult to implement for this investigative study. Although there were some people who were receptive, the majority

of the people surveyed using this technique were very skeptical and often very hesitant in disclosing information. A few cooperative participants understood the urgency and importance for maintenance of OSDSs, but indicated they felt that it was not in their best interest to participate for fear that penalties and/or fines would be issued to them if their system was not working properly. Even though they were told that this was merely a study and that the data would not be used against them, they remained understandably skeptical. It is important that the results of this study are not used to penalize individual owners of OSDSs that participated in the study in any future management program.

Mailing Packets

Informational packets were compiled and mailed to members of the community thought to have onsite systems serving their properties. In particular, the sites of interest were those that were located within the 2-year time of travel capture zones for several wellheads (CZ-B). The goal was to establish communication in an effort to build rapport and trust with members of the community. The importance of this approach was due in part to the fact that this was a voluntary study. A list containing potential sites was generated using the GIS (Geographic Information Systems) database from SWAP efforts. The results for the mailing campaign responses will be discussed later in the results and discussion section. Included in these packets were three main components (copies included in Appendix A):

1. An official letter signed and addressed from the University of Hawaii Department of Civil and Environmental Engineering. The letter explains the purpose, objectives, and participating parties involved in this academic study.
2. Informational sheets that explain what an OSDS is and steps a homeowner can take to properly operate and maintain their system. Cesspools, septic tanks and aerobic treatment units (ATUs) were the only types of OSDS technologies that were covered.
3. An Evaluation Request Form. This form asked for key information such as: participants name, site address, contact information, system type (i.e.

Cesspool, Septic Tank, or ATU), and the time that would best accommodate them for a site-visit. The goal for this portion of the packet was to reiterate to residents that this was a free service provided by the University of Hawaii and that it would not penalize people for participating regardless of the inspection outcome.

Community Meetings

There were several obstacles and problems that occurred during the process of establishing communication. This study was ultimately a technical survey that involved a combination of the science, engineering, and social science disciplines. Although much preparation was done prior to inspections, cold calls and unexpected visits were commonly met with public skepticism. However, this situation proved to be less of an issue with the use of community meetings.

Community or Homeowners Association meetings were looked upon as viable alternatives to cold calls and unannounced site visits where possible and feasible. These types of meetings were conducted on the islands of Molokai and Maui. The initial reaction among a majority of attending residents was very positive. These people were both inquisitive and involved once a brief introduction regarding the relevance to the environment and potable water supplies was presented. Correlating potential impacts that OSDSs have on valuable natural resources raises the public awareness and ultimately increases the urgency for preventative action. Meetings provided a forum for an open dialogue amongst stakeholders involved. Of course only a few of the invited residents actually attended and it is likely that these self-selected groups were that portion of the community with some interest and open-mindedness about the issues involved, such that they volunteered to attend.

3.2 Inspection Procedure

Owner/Resident Interview

At the beginning of each OSDS inspection, the owner or current resident was interviewed for the purpose of gathering critical information. This interview served two

purposes. The first goal was to gather as much relevant information regarding the system as possible. This included system location, tank pumping history, and any other issues that may have occurred during operation of the OSDS. The second goal was to inform the users of proper methods to maintain their OSDS. It was found that the most efficient way to conduct thorough inspections involved pre-planning prior to the site visit. When possible, a pre-interview was used which allowed coordination of an appropriate day and time for the inspection to take place. Although this approach is not required, doing so can significantly reduce the length of the site visit and inspection. The information collected during the interview portion of the inspection procedure included:

1. Name of Resident
2. Is the resident an owner or renter?
3. Address of site to be inspected
4. Contact information (phone number, e-mail, and mailing address)
5. System information (type of system, location, and condition if known)
6. Frequency of sludge and scum removal, i.e. pumping
7. Date and Time that would best accommodate the resident for an inspection

DOH-Wastewater Branch Cesspool Cards

The key to successful OSDS management is dependent upon many factors, and all components involved are equally important. However, the foundation of a new program such as this can benefit greatly from a well-organized structure. Creating a comprehensive inventory of existing OSDSs in the State is a critical starting point. Presently, information from existing OSDSs is readily available at the Department of Health Wastewater Branch in the form of cesspool cards. Facts that are included on this reference tool include:

- Identification info such as owner's name, site address and TMK (Tax Map Key).
- System's distance from building, boundary, stream or well.
- Depth to water table and total capacity.
- Date of installation, type of material used for construction, and names of contractor and inspector.

Site Visits

Site visits were conducted with varying levels of thoroughness. Not all residents were willing to divulge all critical information. In addition, some system assessments could not be completed because of site-specific conditions, most notably that the owner/resident did not know the location of the OSDS. Another issue that played a role in the thoroughness of each OSDS assessment was the number of inspectors. Some site visits were conducted by a single inspector, while others used two or more. Although it is possible to conduct an OSDS assessment with a single inspector, the presence of two is more efficient. Based on the experiences from this study, the most effective scenario is for one person to serve as a data collector (picture taking & note taking) while the second person is assigned the labor portion (opening tank covers, taking measurements, collecting samples). For safety reasons, it should be noted that all visits were done in relatively favorable weather (no rain, strong winds, or other adverse conditions). Inspections sought to observe sludge and scum levels, structural integrity, odors, and condition of the inlet and outlet tees. This was not always possible.

Condition Assessment Scoring System

The operating condition of an OSDS may not always be assessed due to inaccessibility (unknown location, lack of adequate inspection ports, etc.). Because the pipes within a soil absorption disposal unit are out of sight below the ground surface, symptoms of potential problems may not be observed prior to failure. Determination of the operating condition may also vary from season to season. For example, an OSDS may function properly during summer months when precipitation is low. However, tropical rain storms during winter months can saturate soil absorption systems that may result in poor drainage and clogged leachfields. All OSDS assessments were made based on observations and measurements completed at the time of the visit and water quality results for samples collected during the visit. A scoring system was created to rate the condition of each system. A score from 0 to 4 was assigned to each OSDS in order to place each system into one of 5 categories as described in Table 3.1.

Table 3.1: OSDS Assessment Scoring Criteria

<u>OSDS Assessment Scoring</u>	
<i>Score</i>	<i>Description</i>
0	Condition cannot be determined (i.e. no permission from owner, could not schedule an appointment, could not access system to do a thorough analysis).
1	System working properly at time of visit. No deficiencies were observed.
2	Excessive sludge or scum that <u>may</u> cause problems in the future.
3	System working at current time, but may fail soon.
4	System failing & remedial action or damage control should be taken.

Types of Failures

Two common questions from homeowners are: “What are some indicators of a failing system?”, and “Are all failures the same?” A failing system may not always have obvious indicators that it is malfunctioning. An example of this is excessive sludge and/or scum that accumulate over time. These factors may only be evident when assessing the interior of the tank. There are several signs that can be observed either visually or by smell. Described below are some signs of a failing system (Ogata & Babcock, 2009):

1. Back-up of sewage into a structure or building
2. Discharge of effluent onto ground surface or into any stream or water body
3. Excessive foul odors present
4. Connection of an OSDS to storm drain
5. Any structural deterioration or failure
6. Liquid level in septic tank or treatment system above outlet invert
7. Maximum groundwater table above base of distribution field
8. Improper operation of mechanical or electrical system components
9. Burnt vegetation above drainfield
10. Excessive sludge or scum

3.3 Inspection Tools

This section provides a brief description of the types of tools or instruments used in this study. Tools included the following:

- Traveling Case- A plastic storage chest with wheels that was used to transport inspection tools
- Camera- For documentation purposes
- Note Book- For note taking and documentation purposes
- Informational Sheets- To provide the public with educational information regarding operation and maintenance procedures for OSDSs
- Pliers- Used to remove the covers of observation ports
- Allen Wrench- To remove manhole covers on plastic and fiberglass septic tanks
- Flashlight- to assist inspection of interiors of OSDSs
- Gloves- To provide protection from chemicals, bacteria, pathogens and other potentially harmful substances
- Plastic Bags- For waste such as used gloves and other disposable inspection equipment
- Cleaning Supplies- Disinfecting wipes, anti-bacterial soap, paper towels, simple green, and bleach to decontaminate and clean inspection tools.
- Effluent Sampling Supplies- Sample bottles, cooler with ice, tape, and a funnel to collect and store samples for transportation to laboratory for analysis
- Sludge Judge- For measurement of sludge, scum, and clear water depths in the water column within tanks. Discussed in further detail below.

- Sewer Camera- A device used to record images of sewer piping and inner portions of OSDS that may not be otherwise visible from the ground surface. Discussed in further detail below.

Sludge Judge

The sludge judge sampler consists of several clear plastic tubes each 5 feet in length with 1 foot incremental markings. The combined length required is determined by the total distance from ground surface to bottom of the tank. For example, a distance of 8 feet from the ground to bottom of the tank will require two 5 foot sections for a total sludge judge length of 10 feet. The particular model used during the course of this study had a maximum length of 15 feet.



Figure 3-1: Sludge and Scum Measurements Taken with Sludge Judge

Measurements are made by slowly lowering the sludge judge to the bottom of the tank allowing fluid to fill the tube. The instrument is lowered slowly to avoid disturbing or breaking up the scum layer and the sludge blanket. A check valve is equipped on the

entry point (bottom) of the apparatus. Once filled, a quick tug will seat the valve and seal the sample in the tube. Lifting the sludge judge vertically will reveal a water column 'snap shot' of the contents within a tank. The sludge, scum, and clear water depths can all be determined as a direct result of this procedure. The contents are allowed to drain out by touching the check valve stem to any hard surface. Because of the potentially harmful nature of the contents, care must be taken when using and cleaning this device.

Sewer Camera

The use of a sewer camera was recommended by a plumber. A sewer camera is comprised of a camera, reel, and monitor all in one. This device is used to inspect plumbing lines. It allows the user to view a real-time color image inside of a pipe to determine its condition. This technology will help reveal obstructions, broken joints, and intrusions such as tree roots. A transmitter is also built into the camera head. This device emits a frequency that is used by a detector device to trace and locate plumbing lines that are buried beneath the ground surface.

4 Results and Discussion

This section explains and summarizes the data and findings from this study. Both effluent characteristics and OSDS conditions are discussed.

4.1 Participation Rates

Participation was divided into three categories: visited, contacted, and inspected. A property for which no form of communication was made was classified as 'Visited'; no one was home. Those properties in which contact was established but no OSDS assessment could be made were classified as 'Contacted'. Sites for which an assessment of the OSDS was successfully made were classified as 'Inspected'. Table 4.1 presents an island-by-island tally of participation rates for each category. It can be observed that a total of 443 OSDS properties were included in the study. The breakdown by island was 31% Kauai, 28% Oahu, 17% Maui, 17% Big Island, and 6% Molokai. For the inspected category, there was an overall 48% (213 of 443)

participation rate throughout the State of Hawaii. Similarly, the overall rate for contacted properties was 23% (104 of 443); this represents the percentage of homes which either refused to allow an inspection and/or where the OSDS could not be located on the property. The overall participation rate for properties contacted or inspected was 72% (317 of 443) and therefore at approximately 28% of OSDS properties, no one was home at the time of the visit.

Table 4.1: Participation Rates for Each Island

	Visited	Contacted	Inspected	
Kauai	45	31	63	139
Oahu	21	44	59	124
Molokai	15	5	7	27
Maui	34	13	29	76
Big Island	11	11	55	77
<i>Totals</i>	126	104	213	443

4.2 Mailing Campaign

The island of Kauai was chosen as the first location in the attempt to contact homeowners via mailing packets. Because not all mailing addresses were provided with the GIS information, addresses for property tax bills were sought. This information was gathered using a database commonly used by realtors throughout the state of Hawaii.

In an effort to expand the number of responses from that of Kauai, the island of Maui was selected as the second location to conduct a mailing campaign. With the help of a local land management company, packets were mailed out to members of a particular community who were served by OSDSs. These packets were included with their monthly irrigation or water bills. This approach was chosen in an effort to

associate this project with established members of the community. Below is comparative description of the results from Kauai and Maui:

Table 4.2: Comparison of Mailing Campaign Between Kauai and Maui

Mailing Campaign Results	
<i>Kauai</i>	<i>Maui</i>
<ul style="list-style-type: none"> • 86 total sites on generated list (81 were mailed, 5 had no address to mail too) 	<ul style="list-style-type: none"> • 300 Total packets mailed out.
<ul style="list-style-type: none"> • 14 sites had incorrect owner information because of a recent change in ownership. The list was then updated to the current owner. The dates of which there was a change in ownership ranged from September 2000 to November 2010. 	<ul style="list-style-type: none"> • Informational packets were included with water bills.
<ul style="list-style-type: none"> • 2 people responded via phone call and said that they were not interested and did not want anyone associated with this study to come to their property. 	<ul style="list-style-type: none"> • 1 response from a consultant representing the homeowners association called on behalf of several residents with concerns of this program being mandatory. It was reconfirmed that participation was not mandatory.
<ul style="list-style-type: none"> • 4 people responded positively and requested and evaluation of their OSDS. 	<ul style="list-style-type: none"> • 4 people responded positively and requested an evaluation of their OSDS.
<ul style="list-style-type: none"> • A success of 4.9 % (4 of 81) was achieved using this method. 	<ul style="list-style-type: none"> • A success rate of 1.3 % (4 of 300) was achieved using this method

It can be concluded that mailing campaigns are not very successful (less than 5% success rate). Receiving unexpected mail from strangers can cause uneasy feelings for almost everyone. In addition, most people are very skeptical when you offer them a good or service that is free of charge to them. This was the type of feedback

that was given by homeowners and residents when asked their opinion of the mailing packets that were sent to them. Common questions included:

1. “What will happen to me as a homeowner if it is determined that my system is failing?”
2. “How much will it cost me in terms of penalties, fees, or fines?”
3. “Who do I call to have the problem fixed and how much will they charge me?”
4. “How does my system work, and what do I do to maintain it?”

4.3 Pumping Intervals

It is known that an important component of OSDS maintenance is periodic pumping of accumulated solids from the tank. Both the bottom (sludge) and the top (scum) need to be removed and appropriately disposed at a sewage treatment facility. Although naturally occurring bacteria decompose some of the organic material, over time solids do accumulate and if not removed will eventually reduce available volume in the tank, reduce retention time and thereby settling efficiency and solids removal leading to solids carry-over or clogging and overflow/back-up.

Table 4.4 and Figure 4.1 show the findings from the study regarding self-reporting of OSDS pumping. Twenty-eight percent of owners/occupants interviewed said they “have never had their OSDS pumped ever.” In addition, 52% of the owners/residents did not know when or even if their OSDS had ever been pumped. The count denoted as ‘Contracted’ were those sites that have a service contract with a septic pumper for periodic inspection and/or pumping. All thirty of the ‘Contracted’ sites were public facilities (schools, parks, public housing, etc.). The “unknown” responses are essentially the same as “never” and together represent 80% of the OSDSs statewide in this study. This probably means that only about 20% of OSDSs are being maintained at all since pumping is the main form of maintenance for cesspools and septic tanks. This could either mean that most OSDSs are operated such that they do not require pumping or that many OSDSs can be expected to fail in the future when

finally overwhelmed by solids accumulation. The data could also indicate that only about 20% of OSDSs require regular pumping do to overloading or failure of disposal units due to poor soils.

Table 4.3: Pumping Frequencies reported for septic tanks in Hawaii

Hawaii Statewide Septic Pumping Survey		
<i><u>Pumping Interval</u></i>	<i><u>Count</u></i>	<i><u>Percentage</u></i>
Never	81	28.1%
Unknown	150	52.1%
Once or Twice	11	3.8%
Once <u>or</u> More Per Year	16	5.6%
Contracted	30	10.4%
Total:	288	

An island-by-island breakdown of the septic pumping survey is located in Appendix C. On the island of Oahu, 9 of the 10 OSDSs that had to pump once or more per year were located in Waialua. No residential sites on the Big Island have reported ever having to pump. The two Big Island sites that required pumping were restaurants that had failing systems.

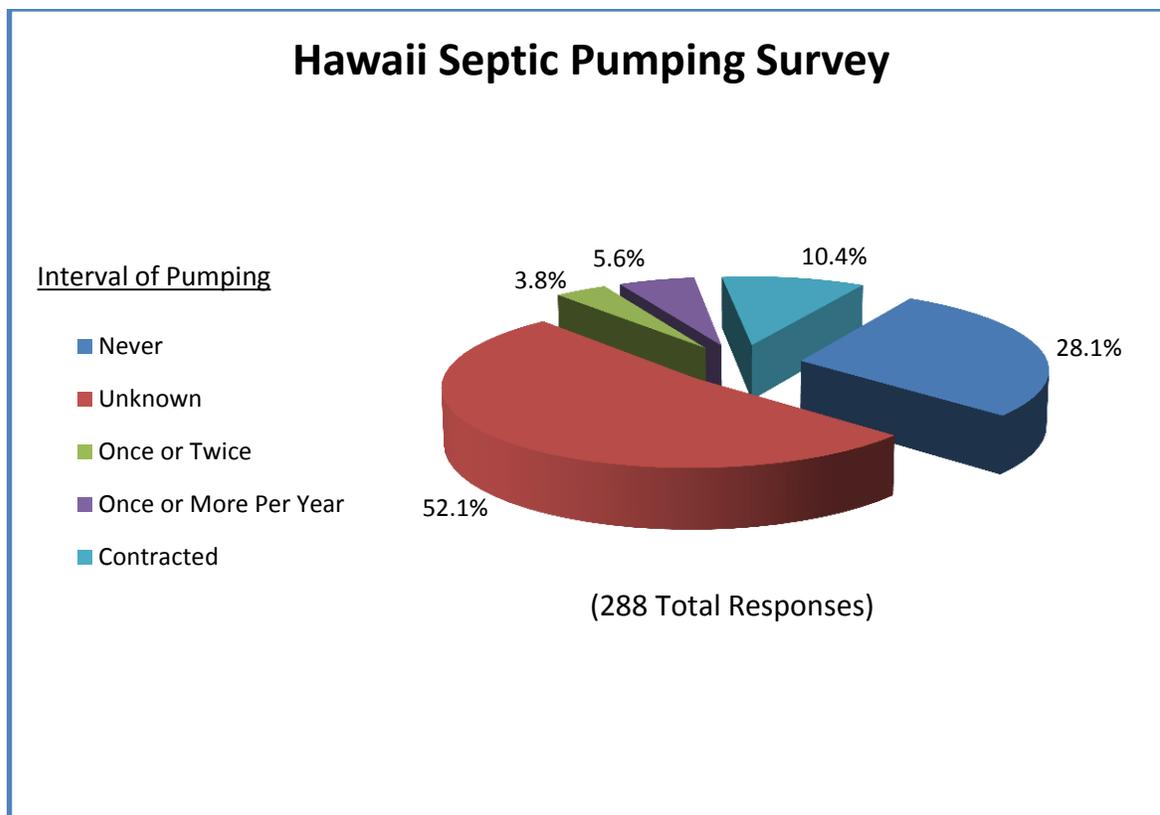


Figure 4-1: OSDS Pumping Frequencies in Hawaii

4.4 Condition Assessment

After each successful inspection which included an interview, an OSDS inspection, and often effluent sample analysis, a condition assessment score was assigned. Table 4.5 shows the findings for OSDS condition. The total number of OSDSs that could be assigned a score was 181. This is less than the total inspected (213) because for 32 of the inspected units, it was not possible to physically access the OSDS but a site visit and interview were successfully conducted. Overall, the data show that approximately 68% of all OSDSs thoroughly inspected can be classified as “Pass” and appear to be in good working order. Conversely, nearly 16% can be classified as “Fail” and are in need of immediate attention. Also, another 16% are considered borderline condition (score 2 and 3) and need to be maintained in order to prevent future failure. Combining the non-passing OSDS scores, it is apparent that 32% of the OSDSs for which a complete assessment could be conducted are not doing well. If these data are representative of OSDSs statewide, then it indicates that nearly

one third of all OSDSs in Hawaii are functioning in a manner which could have adverse impacts on human health and the environment. Implementing an active management program should make it possible to greatly reduce this percentage.

Table 4.4: OSDS Condition Assessment Scores

		Assessment Score					
		1	2	3	4	0	
		Pass	Sludge/Scum	Potential Fail	Fail	Couldn't Access	
Kauai	37 (64%)	3 (5%)	7 (12%)	11 (19%)	58	5	
Oahu	33 (59%)	3 (5%)	12 (21%)	8 (14%)	56	3	
Molokai	4 (67%)	1 (17%)	0 (0%)	1 (17%)	6	1	
Maui	12 (71%)	1 (6%)	1 (6%)	3 (18%)	17	12	
Big Island	37 (84%)	1 (2%)	0 (0%)	6 (14%)	44	11	
Totals	123 (68%)	9 (5%)	20 (11%)	29 (16%)	181	32	213 inspected

Note: Listed below is a description of the 32 sites that could not be accessed

- 4 - Sites that had portable toilets but was previously served by OSDS
- 12 - An attempt was made but the location could not be determined
- 8 - OSDS that were located but the covers for access could not be removed because of obstructions
- 8 - Sites were presumed to be OSDS but further investigation revealed that it was served by centralized sewer

The percentage of passing scores was fairly similar for each island at 59 to 71 percent, except for Big Island where the passing percentage was much higher (84%) which is assumed to be due to highly porous soils known to exist there. With the exception of sites that were classified as Couldn't Access, OSDSs which did not receive a score (assigned a '0') were not included in Table 4.5. *Couldn't Access* represented those properties in which permission was given and an attempt to inspect was made, however, unforeseen obstacles or obstructions didn't allow for access to the system in question. For example, many older cesspools are often buried several feet below the surface. Although an approximate location was determined, complete access for a system inspection was not possible. The systems which could not be scored were further classified as shown in Table 4.6. A classification of *No Permission* was assigned when contact was made with the homeowner but refusal or no permission was granted

when asked to inspect the OSDS in question. *No Contact* was assigned to sites that were visited, but where we were unable to communicate with the homeowner or resident. *Couldn't Schedule* categorizes the amount of respondents that were willing to participate, but could not find the time to schedule a site assessment. Overall, 262 out of 443 OSDSs in this study (59%) were not able to be scored which also shows the need for the implementation of a mandatory management program.

Table 4.5: Island-by-Island Breakdown of Sites Unable to Score

	<u>Sites Unable to Score</u>		
	<u>0</u> No Permission	<u>0</u> No Contact	<u>0</u> Couldn't Schedule
Kauai	22	45	9
Oahu	16	21	28
Molokai	2	15	3
Maui	8	33	6
Big Island	8	10	4

4.5 Effluent Analysis

A total of 213 OSDSs were assessed in this study and effluent samples were gathered from 72 systems (34%). Samples were obtained from systems with a variety of uses including: residential, public restrooms, and commercial sites. 58 of the samples were from septic tanks and 14 were from aerobic treatment units. Each unit was sampled once at the conclusion of a site visit. Septic tank samples were collected from the outlet-T preceding the distribution box. ATU samples were collected from the aeration chamber. Each sample was preserved on ice and taken back to the University of Hawaii Environmental Engineering laboratory for analysis. Appendix B contains all of the water quality data collected in this study.

Figures 4.2 – 4.5 present the average concentrations of Total N, Total P, BOD₅, and TSS for septic tank effluent. Error bars denote standard deviations. Each chart shows a comparison between residential sites, public facilities (parks, schools, etc.), Capture Zone B sites, and those sites in close proximity to coastal areas. Please note that the categories are not all independent, so some sites are represented more than

once in these figures (i.e. some of the residential sites are also Zone B, some of the public facilities are also coastal, etc.). The values in Figures 4.2-4.5 can be used in SWAP modeling efforts and other water quality fate and transport model and risk assessments.

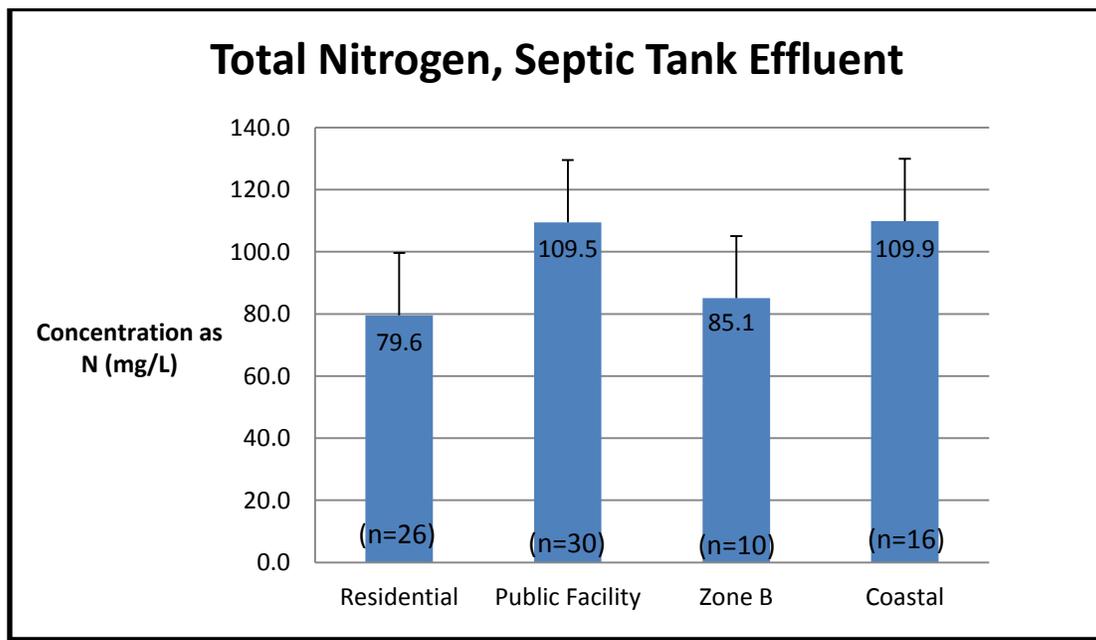


Figure 4-2: Septic Tank Total N Effluent Concentrations

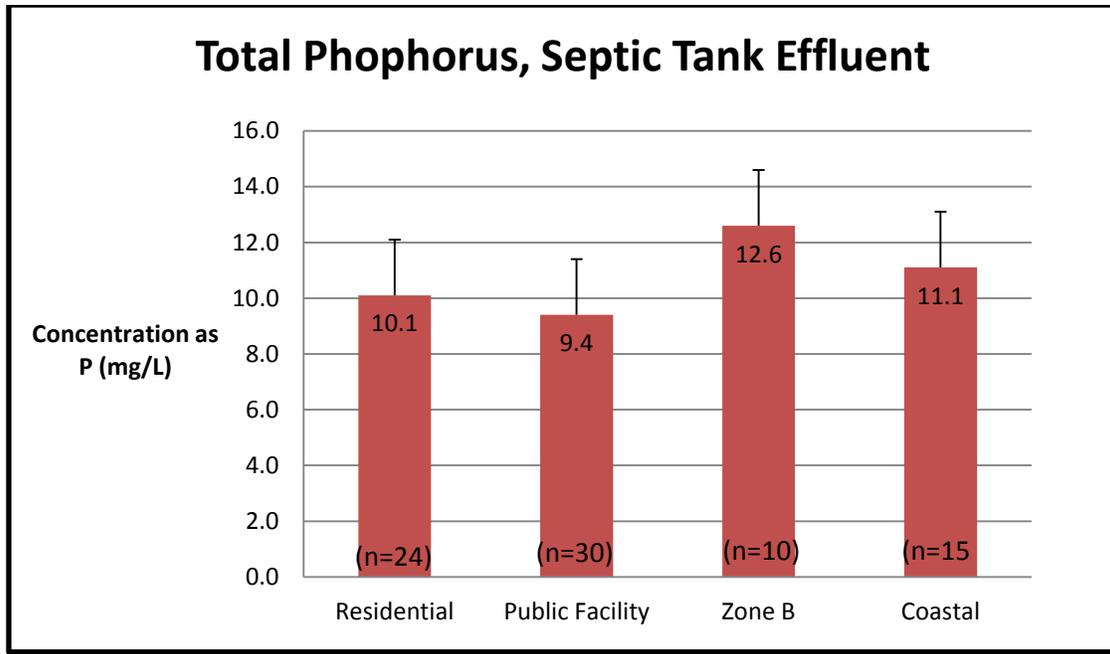


Figure 4-3: Septic Tank Total P Effluent Concentrations

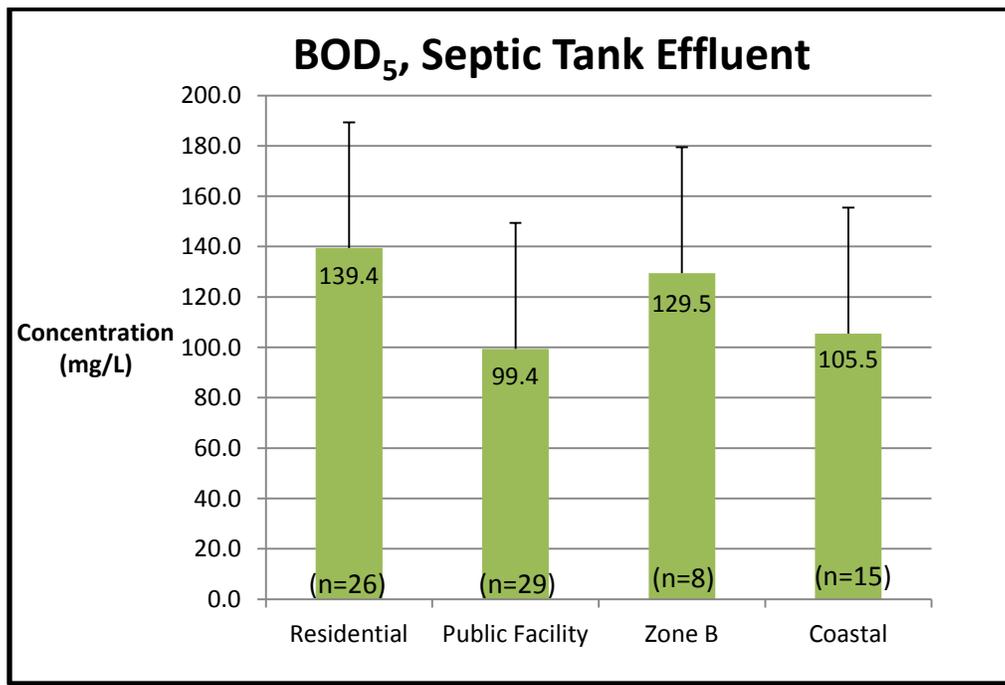


Figure 4-4: Septic Tank Effluent BOD₅ Concentrations

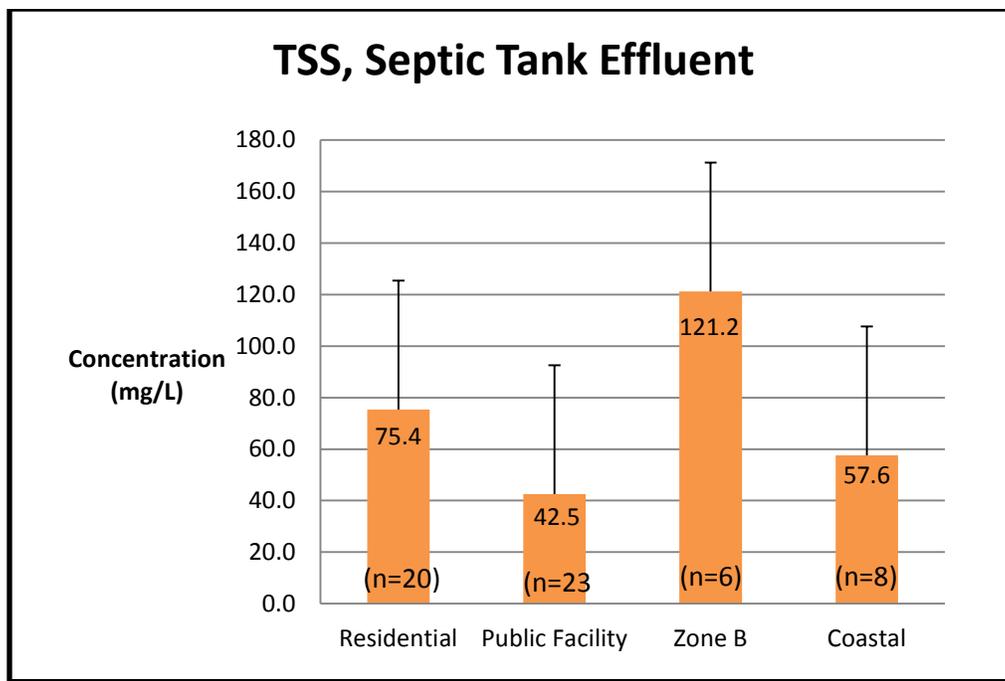


Figure 4-5: Septic Tank Effluent TSS Concentrations

The septic tank effluent concentrations measured in this study were compared to values published by the EPA (2002b) in Table 4.7. The measured value numbers in Table 4.7 represent the percentage of samples that fall within the expected concentration range and the percentage that exceed the typical concentration value. The remaining measured values either were above or below the typical range and/or the typical concentration value. All of the concentration data are included in Appendix B.

Table 4.6: Comparison of Measured Values to Expected Values

Septic Tank Effluent Characteristics				
Component	Concentration Range	Typical Concentration	% That Fall Within Range	% Exceeding Typical Conc.
TSS (mg/L)	36 - 85 mg/L	60 mg/L	40% (19)	43% (20)
BOD ₅ (mg/L)	118 - 189 mg/L	120 mg/L	25% (14)	40% (23)
Total N (mg/L)	29.5 - 63.4 mg/L	60 mg/L	19% (11)	74% (43)
Total P (mg/L)	8.1 - 8.2 mg/L	8.1 mg/L	2% (1)	69% (38)
	Expected Values from EPA		*Actual Measured Values*	

Source: EPA Onsite Wastewater Treatment System Manual, 2002, EPA/625/R-00/08

Figure 4.6 shows a comparison of average effluent water quality for samples collected from septic tanks and ATUs in this study. The comparison shows that the average concentrations were similar for septic tanks and ATUs for all constituents except TSS for which the septic tank value was more than twice as large as the ATU value. In general, ATUs are capable of achieving effluent BOD₅ and TSS concentrations of less than 30 mg/L as a running average if operated and maintained properly. These findings suggest that, on average, ATUs in this study were not performing much better than septic tanks and not performing as well as expected. This means that the ATUs are not being maintained adequately (some of the ATUs did not have operating aeration devices). And, even though there were only 14 ATUs sampled, this finding suggests that the existing management program (owners required to have an active maintenance contract) is not working.

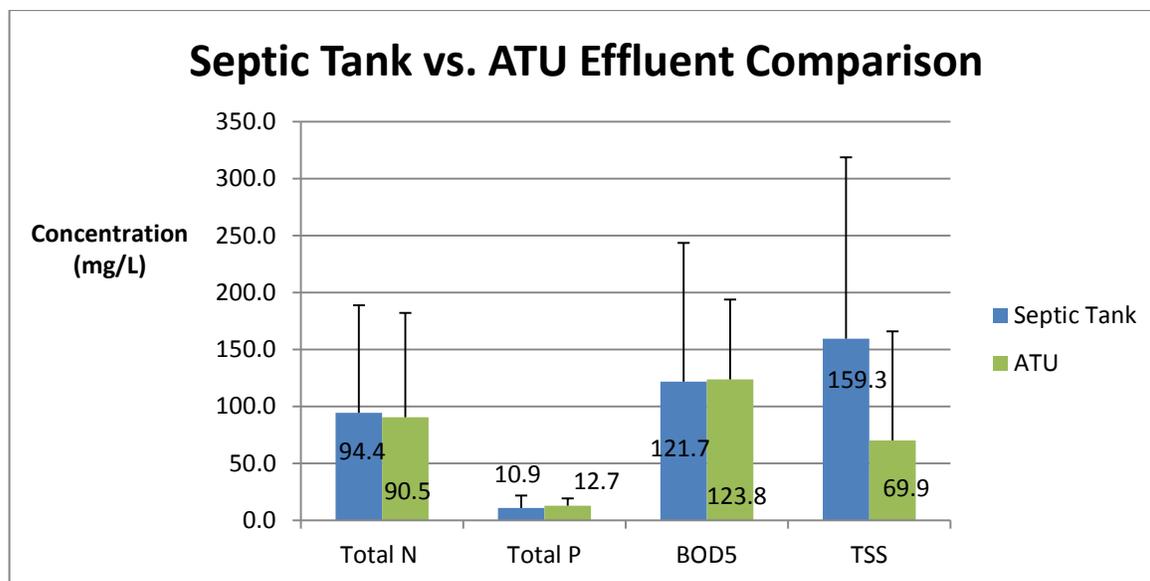


Figure 4-6: Comparison of Septic Tank and ATU Effluent Quality

5 Conclusions

The results of this study lead to the following conclusions:

- Attempts were made to inspect and assess 443 OSDSs in the State of Hawaii and meaningful inspections were successfully completed for 213 systems (48%). Most of the successful inspections were conducted on septic tanks (115) with a few cesspools (58) and ATUs (20). This represents a small sample of the total estimated numbers of OSDSs in Hawaii: 0.03% of the 170,000 cesspools, 2.5% of the 4,500 septic tanks, and 8% of the 250 ATUs. Despite the small sample size, because of spacial distribution and a random response rate, it is assumed that the findings are representative of the current status quo for OSDSs in the State of Hawaii.
- Nearly all homeowners were initially hesitant to participate in the assessment study for fear of penalties if their system was not up to par, but were often more willing once they were informed of potential adverse impacts to them (back-ups, surface ponding) and to natural resources such as their own drinking water. Owners were mostly interested to learn about how their OSDSs work, how to maintain them, and indications of problems/failures. Increased knowledge could lead to better maintenance and fewer failures and acceptance of a management program.
- The use of direct mailing informational packets to OSDS owners may be a good method to educate the public, but was not found to be effective when attempting optional participation in an inspection/assessment program. Just two percent (8 of 381) of all

informational packets mailed out resulted in a request for an OSDS assessment from the homeowner/resident.

- The use of cold calls/visits to OSDS properties were somewhat more successful than direct mailing (144 of 371, 39%) for completing assessments, however, this method is time consuming, tricky and generally just very difficult to accomplish. There are logistical issues of travel time between locations, finding OSDS properties in remote/rural areas, dogs on properties preventing initial contact, and the amount of time required at each location to complete a thorough assessment. There are the major challenges of finding a time when property owners are on site and trying to convince highly skeptical/fearful or even confrontational homeowners to participate.
- Fifty-two percent (150 of 288) of OSDS owners did not know if their OSDS had ever been pumped. Twenty-eight percent (81 of 288) of those surveyed indicated that their OSDS had never been pumped. Combining these groups indicates that 80% of OSDSs are not receiving basic preventative maintenance to remove accumulated solids and scum which will likely lead to future failures. Practicing only reactive maintenance of OSDSs after failure occurs and risks to public health and the environment are realized seems to be the norm for Hawaii presently and is the antithesis of a management program.
- Sixty-eight percent (123 of 181) of OSDSs that received a thorough assessment were rated as passing. Sixteen percent (29 of 184) were rated as failing and another 16% were found to have problems that may soon lead to failure. The good news is that 2/3 of the systems are okay at present, however, the bad news is that nearly 1/3 are in a condition that places the public health and the environment at unnecessary risk.
- The islands of Oahu and Kauai have a significant number of OSDS failures most likely attributable to lower-permeability clay soils.

Surfacing and overflows are the most common types of failures on these islands.

- The Big Island did not have any OSDSs in which surfacing or overflowing was a problem most likely due to highly permeable soils. However, the potential threat for these systems is that the travel time to underlying aquifers may be rapid leading to aquifer contamination in general and drinking water well contamination specifically in CZ-Bs.
- When compared to residential, public facilities and coastal areas, effluent samples from OSDSs within SWAP capture zone B had higher average concentrations of TSS, BOD₅, and Total P. This is troubling information because public health could be affected and indicates the need for better management of these systems statewide. Public facilities had a significantly higher average concentration of Total N when compared to other categories. This may be attributed to less dilution from plumbing fixtures like washing machines, showers, and numerous sink basins that are commonly found in residential units.
- ATUs in this study were not performing much better than septic tanks and not performing as well as expected to produce effluent with less than 30 mg/L BOD₅ and TSS. This means that the ATUs are not being maintained adequately and suggests that the existing management program (owners required to have an active maintenance contract) is not working.
- About 70% of the effluent samples collected had measured values that exceeded the typical concentrations of Total N and Total P reported in USEPA literature. About 40% of the effluent samples collected had measured values that exceeded the typical concentrations of TSS and BOD₅ reported in USEPA literature.
- A statewide life cycle OSDS management program is needed to address the present OSDS failures and the likely future increase in

failures of the remaining systems that are being neglected. The previously recommended “operating permits” model with certification of inspectors and maintenance providers would be a big improvement over the current situation and would help to protect public health and the environment.

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Appendix A – Mailout Packet to Homeowners

December 5, 2012

RE: Onsite Sewage Disposal System (OSDS) Survey

Dear <Homeowner>:

The University of Hawaii Civil and Environmental Engineering Department is currently conducting a research project to assess and evaluate onsite sewage disposal systems (OSDS) in your neighborhood. The most common types of systems include: cesspools, septic tanks, and aerobic treatment units (ATU).

Through this assessment program, you will have the opportunity to have your onsite sewage disposal system inspected and evaluated by University of Hawaii Environmental Engineering graduate student Michael Cummings. At the time of the in-person visit, you will also be provided with educational pamphlets and recommendations for proper OSDS maintenance. The site visit should only require 30 to 40 minutes of your time.

Worldwide, drinking water wells contaminated by sewage effluent pose health risks such as waterborne disease, which can be fatal. Untreated wastewater traveling through the ground may eventually find its way to our fresh water drinking source. One of the primary goals of the assessment program is to promote safe, properly maintained OSDS throughout the state of Hawaii.

To schedule your 30 to 40 minute OSDS assessment, contact Michael Cummings immediately, to set up an appointment (mjnc@hawaii.edu). The appointment will be arranged so you or your representative can be present at the time of the OSDS assessment.

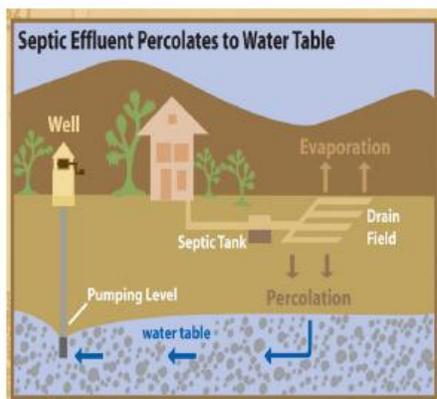
Property of Interest:

<Site Address>

Sincerely,

Michael Cummings
Research Assistant
U.H. Manoa - Civil and Environmental Engineering Department
Phone# 808-652-3594
E-mail: mjnc@hawaii.edu

FREE Septic System Assessment



A Research Project Conducted by UH Manoa

The University of Hawaii Civil and Environmental Engineering Department is currently conducting a research project to assess and evaluate onsite sewage disposal systems (OSDS) in your neighborhood. The most common types of systems include: cesspools, septic tanks, and aerobic treatment units (ATU).

Worldwide, drinking water wells contaminated by sewage effluent pose health risks such as waterborne disease. Inadequately treated wastewater that seeps through the ground may eventually find its way to our fresh water-drinking source. One of the primary goals of the assessment program is to facilitate safe, properly maintained OSDS throughout the state of Hawaii in order to protect our drinking water. To schedule your **FREE** OSDS assessment, contact Graduate Research Assistant Michael Cummings.



Disclaimer: Information acquired from the OSDS assessment is intended to be used for research purposes only.

Email: mjnc@hawaii.edu

Phone: 808-652-3594

OSDS Evaluation Request Form

Instructions:

- 1) If you are interested in scheduling a free OSDS evaluation please fill out the required information.
- 2) Fax this form to 808-956-5014 or
- 3) Scan and e-mail this form to mjnc@hawaii.edu

Name: _____

Address: _____ <Site Address> _____

Contact Phone (with preferred time of day to call): _____

E-mail: _____

System Type (i.e. cesspool, septic tank, etc.): _____

Please list the dates or time of day that would best accommodate you or your representative (i.e. weekends, weekdays after 4 p.m.):

*** To contact directly call Michael Cummings at 808-652-3594 or send an e-mail to: mjnc@hawaii.edu**

*** Information gathered during this study will be used for educational purposes only.**

Appendix B – Water Quality Data

Total Nitrogen	
Range (mg/L)	# of Samples
0 - 29	4
30 - 59	10
60 - 89	17
90 - 119	13
120 - 149	6
150 - 179	4
180 - over	4

Septic Tank Effluent: Total N, mg/L (N=58)					
0.0	52.0	67.0	84.0	116.0	151.0
19.0	52.0	71.0	91.0	117.0	155.0
22.0	54.5	71.5	93.0	118.0	155.0
22.0	55.0	72.0	100.0	119.0	165.0
37.0	60.0	73.5	100.0	121.0	201.0
40.0	64.0	76.0	104.0	121.0	218.0
42.0	64.5	78.0	106.0	131.5	220.0
43.0	65.0	78.0	106.0	135.0	273.0
46.0	65.0	79.0	109.0	138.0	
46.0	66.0	83.0	112.0	149.0	

Total Phosphorus	
Range (mg/L)	# of Samples
0 - 3.9	3
4.0 - 7.9	11
8.0 - 11.9	21
12.0 - 15.9	13
16.0 - 19.9	4
20.0 - over	3

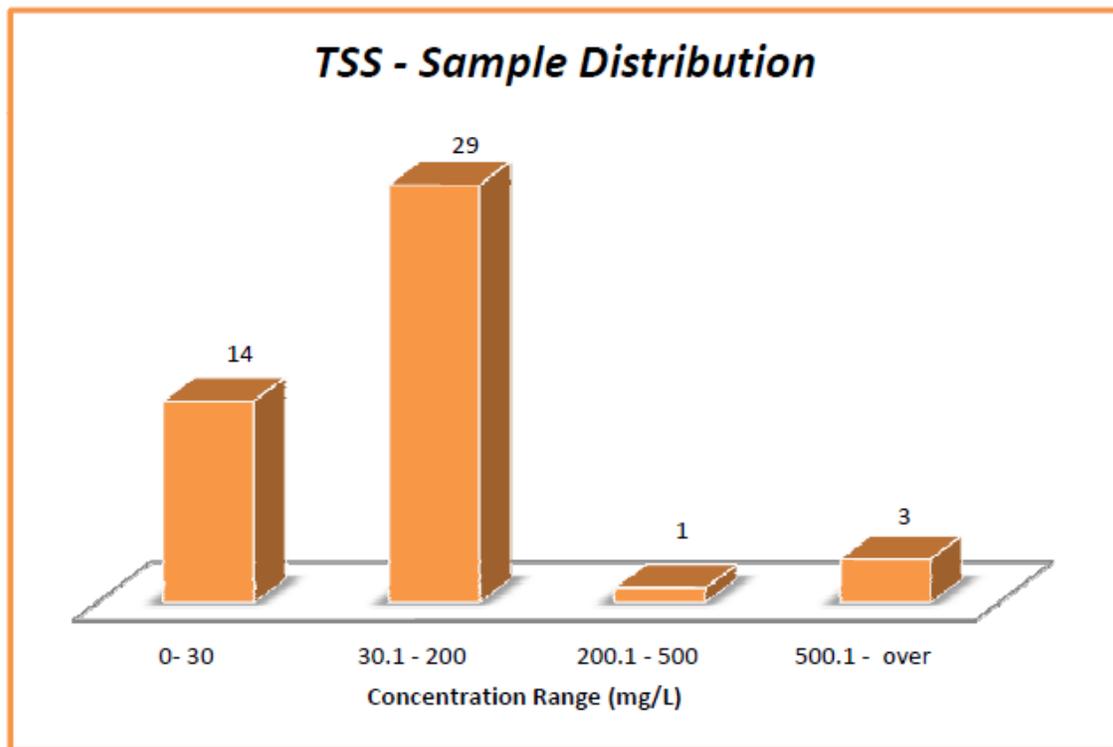
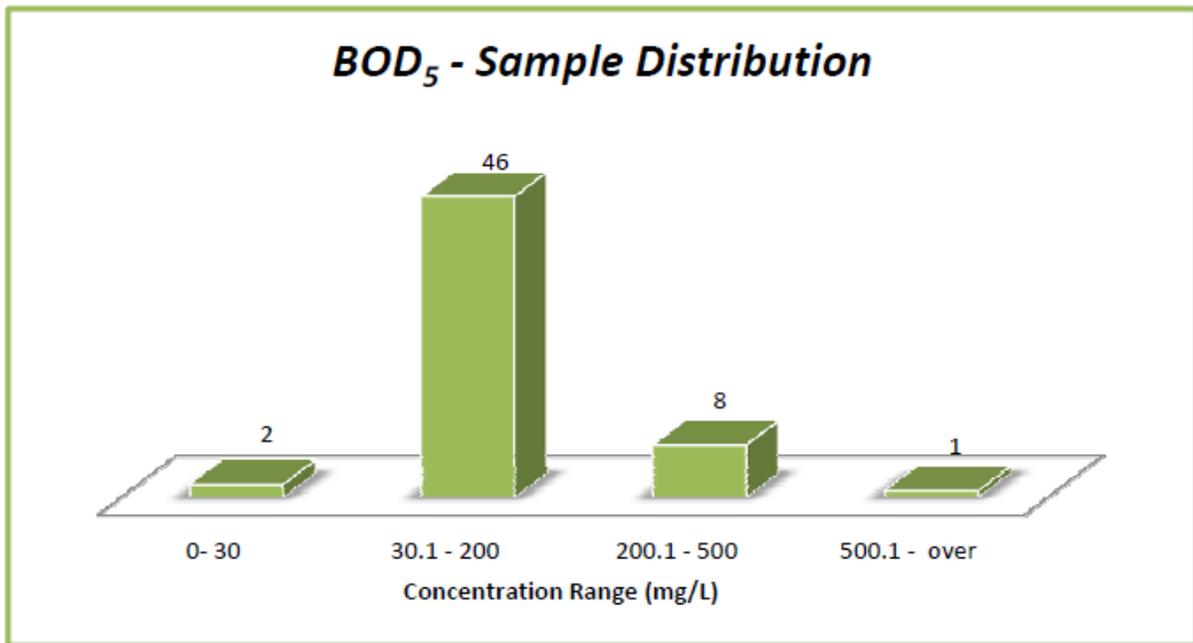
Septic Tank Effluent: Total P, mg/L (N=55)					
1.4	7.2	9.0	11.6	12.8	19.2
2.8	7.3	9.0	11.7	13.0	19.6
2.9	7.3	9.0	11.7	13.1	20.4
4.4	7.8	10.0	11.7	13.4	20.6
5.2	8.0	10.2	11.9	13.6	25.3
5.8	8.1	10.3	12.0	14.0	
6.0	8.4	10.5	12.2	14.2	
6.8	8.5	10.6	12.3	15.6	
7.0	8.6	10.7	12.3	17.8	
7.0	8.7	11.2	12.6	18.4	

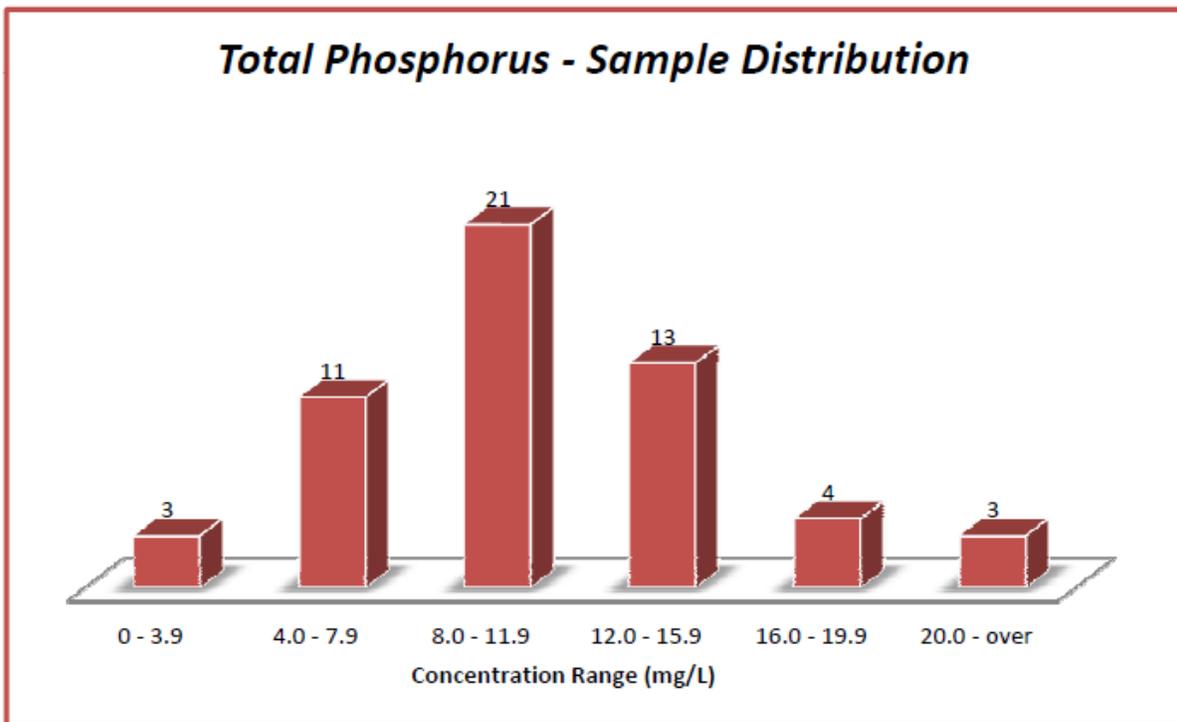
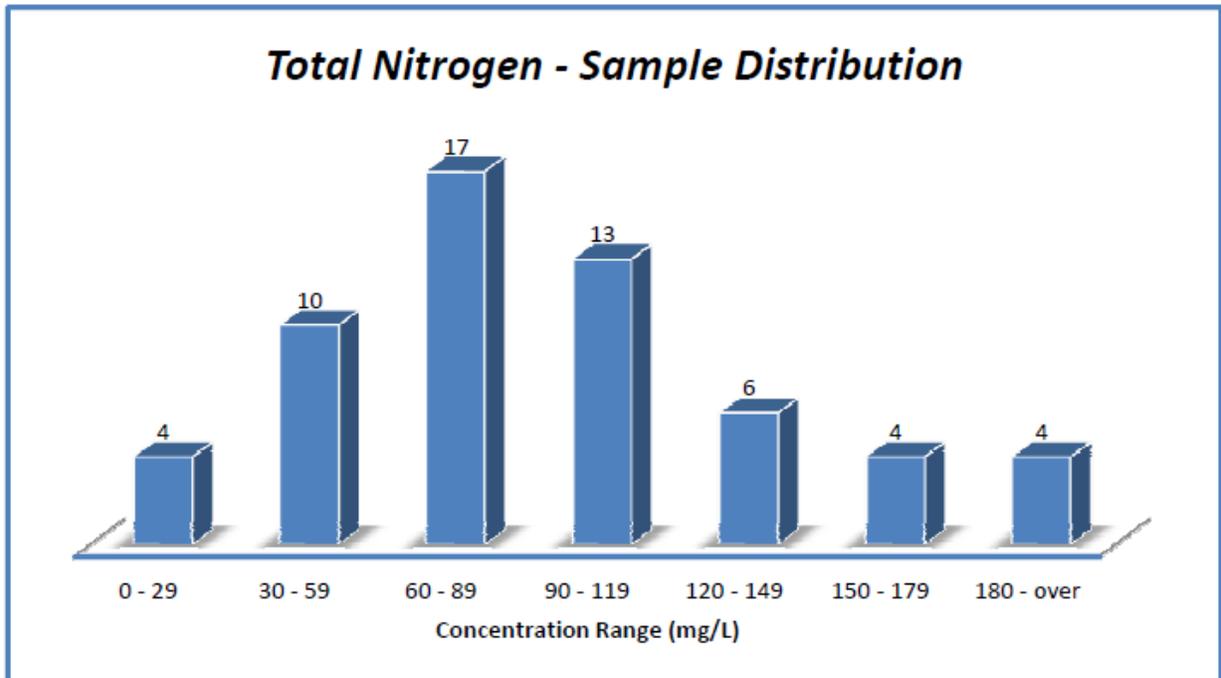
BOD₅	
Range (mg/L)	# of Samples
0- 30	2
30.1 - 200	46
200.1 - 500	8
500.1 - over	1

Septic Tank Effluent: BOD₅, mg/L (N=57)					
22.8	59.7	79.8	105	144	219
29	60.9	80.4	107.7	152.4	219.9
35	62.7	82.8	111.9	154.2	221.1
36	64	87.6	114	158.1	223
36.6	65.1	89.1	122.4	159	228.6
37	66	95	125	159	389.4
41.7	66.6	95.1	128	164.7	543.3
42.6	69.3	96.6	138.6	182	
52.2	72	99.6	140.1	210.3	
56.1	75	100.8	141	217.5	

TSS	
Range (mg/L)	# of Samples
0- 30	14
30.1 - 200	29
200.1 - 500	1
500.1 - over	3

Septic Tank Effluent: TSS, mg/L (N=47)					
3.8	17.4	36.0	49.1	76.2	146.0
6.7	17.4	40.4	50.0	82.8	148.1
6.9	22.0	42.0	56.7	84.0	186.7
7.4	25.8	42.0	60.7	92.5	290.0
9.8	28.9	42.6	62.9	105.3	502.0
10.0	29.2	45.0	64.3	108.0	1015.0
11.1	32.0	45.8	72.0	120.0	3300.0
11.9	34.8	46.0	72.5	130.0	





Appendix C – Septic Tank Pumping Statistics

Hawaii Statewide Septic Pumping Survey		
<i>Pumping Interval</i>	<i>Count</i>	<i>Percentage</i>
Never	81	27.3%
Unknown	150	50.5%
Once	7	2.4%
Twice	4	1.3%
Often	8	2.7%
Monthly	3	1.0%
Quarterly	3	1.0%
Anually	2	0.7%
Contracted	30	10.1%
Total:	288	

Hawaii Statewide Septic Pumping Survey		
<i>Pumping Interval</i>	<i>Count</i>	<i>Percentage</i>
Never	81	28.1%
Unknown	150	52.1%
Once or Twice	11	3.8%
Once <u>or</u> More Per Year	16	5.6%
Contracted	30	10.4%
Total:	288	

Area Breakdown

<i>Pumping Interval</i>	<i>Kauai</i>	<i>Oahu</i>	<i>Molokai</i>	<i>Maui</i>	<i>Big Island</i>
Never	21	22	8	12	18
Unknown	64	41	3	20	22
Once or Twice	5	3	1	2	0
Once <u>or</u> More Per Year	4	10 ^a	0	0	2 ^b
Contracted	0	8	0	0	22

Notes:

^a On the island of Oahu 9 of 10 subjects who had to pump once or more per year resided in Waialua.

^b No residential sites on the Big Island have reported ever having to pump. The two sites that required pumping were resteraunts that had failing systems.

Appendix D – Inspection Photos



Fig. 1 and 2, Storage tanks for potable water supplies on the Big Island and Moloka`i respectively.



Fig. 3 and 4, Both pictures are public restroom facilities served by OSDS that are located in Hanalei, Kauai.



Fig. 5, OSDS located within close proximity to a campsite at Anini on the island of Kauai



Fig. 6 and 7, Manhole covers being removed in order to conduct a system assessment.



Fig. 8 and 9, Workers from a Big Island septic pumping company perform routine maintenance by cleaning effluent screens.



Fig. 10, Inspection ports provide an access point for OSDS assessments in which manhole covers cannot be located.



Fig. 11, Inspection tool kit used for conducting OSDS assessments.



Fig. 12 and 13, Septic tank inlet and outlet compartments respectively. Both pictures are from the same system.



Fig. 14 and 15, Sludge and scum test being conducted on a septic tank.



Fig. 16, Estimated scum level of approximately 10 inches. No presence of sludge for this water sample.



Fig. 17 Estimated sludge level of approximately 15 inches. No presence of scum for this water sample



Fig. 18, A failing ATU unit that has no signs of operation. Air compressor was cold and wiring was corroded.



Fig. 19 and 20, Both pictures are failing ATU systems with root intrusion from outside plants.



Fig. 20, An exposed cover of a failing cesspool creates a hazardous situation.



Fig. 21, The burnt outline of a cesspool cover. Possibly caused by overflow due to excessive water usage and a high water table.



Fig. 22, A recently repaired cesspool cover that had previously collapsed.



Fig. 23 and 24, A cesspool in Waialua, Oahu overflowing with raw sewage.



Fig. 25 and 26, A septic tank cover is damaged. This allows storm run-off and sediment to enter and overload the system.



Fig. 27, A septic tank with feminine hygiene products that could potentially compromise the OSDS.



Fig. 28, High water markings from a septic tank with two housing units served by one OSDS.



Fig. 29, High water markings from a septic tank. This indicates that an overflow has happened in the past.



Fig. 30, A drainfield with abnormally lush vegetation . This OSDS is located adjacent to a river. A high water table may have contributed to this situation.



Fig. 31, A damaged sewer line leading to an OSDS that caused plumbing to back up. The septic tank was working properly once this problem was addressed.