Tennessee Valley Marina and Campground Wastewater Characterization Screening Study

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Project Team
Melissa R. Matassa,
Charles L. McEntyre,
James T. Watson

Executive Summary

The objectives of the marina and campground wastewater characterization study were to examine the makeup of holding tank deodorizers and additives and to characterize the wastewater from the pump-out systems to determine if these additives were likely to adversely affect onsite/decentralized wastewater treatment system (DWS) performance. The review of holding tank additives and deodorizers revealed that the most common active ingredients were formaldehyde, ammonium chloride compounds, sodium nitrate, quaternary ammonium compounds and bacteria cultures.

Eleven marinas and three campgrounds across the Tennessee Valley were chosen to partner with TVA for the wastewater characterization aspect of the study, which took place in the summer of 2003. A one-time sampling event was conducted at each facility, with sampling taking place, as accessible, in the holding tank, in the septic tank influent (first chamber of the septic tank) and in the septic tank effluent (from the final chamber of the septic tank). The samples were analyzed for a variety of parameters including toxicity, bacteria, nutrients, biological and chemical oxygen demands, and oil and grease.

Laboratory results showed that for most of these parameters the pump-out wastewater was highly concentrated in comparison to traditional residential wastewater. Of the samples collected in the final chamber of the septic tank, concentrations more than twice as strong as typical residential wastewater effluents were found in 50% of the BOD_5 samples, 58% of the COD and total phosphorus samples, and 67% of the TKN and ammonia-nitrogen samples. These results validated a concern that DWS drainfields at marinas and campgrounds may be dosed with wastewater that is too strong to treat effectively. However, without an evaluation of the completely treated effluent quality below the drainfield, it is difficult to determine the effect of this wastewater on local water quality. A further study is proposed to examine the completely treated effluent exiting such heavily dosed drainfields to ensure that future DWS designs for marina and campground systems adequately treat wastewaters to prevent impacts to water quality in and around their watersheds.

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1 Introduction

1.1 Investigation Objectives

The goals of the marina/campground wastewater characterization study were two-fold: to determine what types of active ingredients are in boat and recreational vehicle (RV) sewage holding tank additives and deodorizers; and to characterize this wastewater to determine if these additives are likely to adversely affect onsite/decentralized wastewater treatment system (DWS) performance. Although several studies have been performed concerning domestic and industrial wastewater, relatively little is known about the wastewater that is pumped out of holding tanks in boats and RVs. This study focuses on sites that send their sewage pump-out waste to DWS, not to large Publicly Owned Treatment Works (POTWs). Treating pump-out wastes in POTWs is not normally a problem because pump-out wastes only comprise a small percentage of a POTWs total flow. The large volume of 'other' wastewaters in a POTW dilutes the pump-out waste before treatment and discharge. This mixing with large volumes of lower strength wastewaters is not present in most DWS, so additives and high-strength pump-out wastes have a much greater potential impact. However, many POTWs are now establishing restrictions on accepting pump-out wastes because of concerns about potential impacts on POTW performance.

1.2 Study Funding and Overview

The marina and campground wastewater characterization study was funded by TVA's Public Power Institute (PPI), with in-kind support provided by Resource Stewardship (RS). Project implementation was led by Environmental Engineering Services – East (EESE).

Initial project development was jointly established by PPI, RS and EESE. Expected deliverables included a consistent sampling plan, lab results from sampling at 12-15 locations, and a final report. This report discusses study objectives, analyzes all results, and determines whether toxics persist in the DWS, and if so, quantifies their relative toxicity through Microtox values. Marina and campground facilities were selected jointly by RS & EESE, with EESE leading the sampling events and final report preparation.

1.3 Project Background

In 2001, EESE was asked to provide recommendations for a marina in western Tennessee for which components of the onsite system had periodically failed. The marina wanted to expand but couldn't under existing onsite regulations. Essentially all of the available land with soils suitable for septic systems had already been used to handle the existing wastewater load. To determine what options were available to address site limitations, the raw wastewater and septic tank effluent were sampled to ascertain their relative toxicity. The results indicated that the wastes were toxic, as measured by the Microtox procedure. This procedure exposes luminescent organisms to aqueous samples, measuring the increase or decrease in light output by the organisms to determine relative toxicity. This information was used to design a treatment and management system that would protect the existing drainfields and allow them to accept additional flow while allowing limited expansion of the marina facilities. However, funding for these improvements has not yet been secured.

Final wastewater quality depends largely on the level of treatment provided through the DWS. Different design approaches will be reflected in the effluent quality. Since DWS design approach is often directed or even mandated by the applicable state regulations, a summary of those regulations are presented here. The various states in the TVA's service region (Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee and Virginia) address the design of DWS for pump-out waste in different ways. Mississippi and Tennessee explicitly regulate physical sizing/design parameters, while the others address marina and campground wastewater in terms of assumed flow. A summary of each state's regulations for designing onsite wastewater systems is presented in Table 1.

Along with the flow rates and other sizing standards, complete DWS design can not be completed until site characteristics, including soil attributes and water table level, are taken into account. The standards below do not stand alone, but rather are interpreted in a framework based on the proposed drainfield location.

Table 1: Summary of Design Standards for DWS in the TVA Service Area

State	Residential Wastewater	Marina Wastewater	Campground Wastewater
Alabama (AL Dept. of Health 1992)	300 gpd (1-2 bedrooms), additional 150 gpd per bedroom over two bedrooms	10 gpd per slip without bathhouse; 30 gpd per slip with bathhouse	50 gpd per RV/trailer space
Georgia (GA Dept. of Human Resources 2003)	150 gpd per bedroom	30 gpd per slip	50 gpd per vehicle
Kentucky	Established on a county level	Established on a county level	Established on a county level
Mississippi (MS State Dept. of Health 1997, 2000)	Design based on septic tank volume capacity. Minimum 750 gallons (up to 2 bedrooms and 4 occupants), with additional capacity based on bedrooms and occupants	Septic tank is sized at daily flow 2x residential size for same daily flow	Septic tank is sized at daily flow 2x residential size for same daily flow
North Carolina (NC Dept. of Environment, Health and Natural Resources 1990)	240 gpd minimum, additional 120 gpd per bedroom over two bedrooms	10 gpd per slip without bathhouse; 30 gpd per slip with bathhouse	120 gpd per parking space
Tennessee (TN Dept.of Environment and Conservation 1993, 2001)	Up to 2 bedrooms (750 gallon septic tank capacity); 3 bedrooms (900 gal); 4 bedrooms (1000 gal), additional 250 gal for each additional bedroom	20 gpd per slip without bathhouse; 30 gpd per slip with bathhouse. Septic tank capacity at least 6x expected daily flow and 2x design adsorption field area	50 gpd per person Septic tank capacity 6x expected daily flow and design absorption field area 2x residential size for same daily flow
Virginia (Commonwealth of VA 2000)	225 gpd minimum (includes toilet, bathing and handwashing facilities, food prep and laundering), additional 75 gpd per person over 2 people	10 gpd per slip if toilet facilities; 16 gpd per slip if toilet and shower; also holding tank volume regulated per # of serviced boats	50 gpd flow per campsite

Because many marinas and campgrounds across the Tennessee Valley are seeking to add or expand their onsite wastewater systems, an understanding of the characteristics of wastewaters from these facilities is essential to improving system designs, reducing impacts on the environment and supporting sustainable growth in the marina/campground industry.

As a result of nationwide programs including the Clean Marina Initiative, many boaters have become more aware of the environmental concerns associated with direct discharge of their wastewaters to their recreational reservoirs and streams. The Clean Marina Initiative is a voluntary, incentive-based program promoted by NOAA and others that encourages marina operators and recreational boaters to protect coastal water quality by engaging in environmentally sound operations and maintenance procedures (The Office of Ocean and Coastal Resource Management 2003). Therefore, more people are appropriately using holding tanks and properly emptying them at pump-out stations. However, many people use additives in their holding tanks to reduce or eliminate odors. Some of these additives contain toxic materials, including formaldehyde and quaternary ammonium compounds. It is unknown whether these compounds affect the performance and longevity of decentralized wastewater systems. This study seeks to discover whether these toxics persist in the DWS, and if so, to evaluate their impacts. This is especially critical for marina DWS, because these systems are located adjacent to our reservoirs and streams and inadequate DWS could impact these waters even when no failure is apparent on the surface of the ground.

Without understanding the characteristics of marina/campground wastewater, DWS may be under-designed and fail to protect human health and the environment, or they may be over-designed and not cost-effective. Ultimately, this study seeks to provide a better waste characterization of pump-out wastes to DWS designers to promote cost-effective designs that protect human health and the environment.

2 Holding Tank Additive and Deodorizer Review

2.1 Methodology

The first phase of this investigation was to explore the various options consumers have in purchasing holding tank additives and deodorizers. After a series of products were identified, they were further evaluated to determine the active ingredients in each product and whether any common characteristics were present, especially toxic chemicals. The identified products were found through common avenues of purchase, including catalogs from major vendors (e.g. West Marine), inventories at discount stores (e.g. Wal-Mart), and products sold at partnering marinas. It is important to note that the list of products and active ingredients is by no means all-inclusive; it is certain that other products exist, some sold elsewhere by a regional vendor or through the internet, others simply overlooked.

2.2 Types of Additives/Deodorizers

Holding tank additives and deodorizers fall into two primary categories based on the type of treatment they provide. These categories are chemical treatment and bio-enzymatic treatment. Chemical treatments are typically the most common and least environmentally friendly. They kill the bacteria immediately and use a deodorizer to mask odors. Chemical treatments are not designed to dissolve the waste. They also must be added regularly. Bio-enzymatic treatment products, on the other hand, are bacterial in nature and are more environmentally friendly. The beneficial bacteria in these products produce enzymes to change the waste into a food source for the bacteria. Since they have a food source, the beneficial bacteria are then able to reproduce and keep working, so frequent re-application is unnecessary. The end product of this cycle is water, carbon dioxide and more bacteria, dissolving the waste in the process (Nolan 1999). A majority of the treatments discovered in this study were chemical in nature, with only a few that were enzymatic and bio-active.

2.3 Literature Review Results

A total of 18 products were examined. Of these, four had formaldehyde or paraformaldehyde listed on their Materials Safety Data Sheets (MSDS). Another product contained quaternary ammonium compounds. Of the remaining 13 products, the most frequent components listed in the MSDSs were ammonium chloride compounds and sodium nitrate, with each chemical used in three products. Two products had no hazardous materials listed on the MSDS, and two consisted primarily of bacteria cultures. The remaining products listed various active ingredients including methyl alcohol, surfactants and EDTA.

In the course of the research, it seemed apparent that there was a delineation of the level of environmental awareness among the different retail sources. Products sold at discount stores, where cost may be the prime factor, tended to carry harsher components that worked via chemical treatment. Products sold in catalogs frequently covered a wider range of products. In those cases where a partnering marina had a store with an inventory that included holding tank products, the products had a tendency to be those described as more environmentally friendly. This may be due to the fact that the marinas that agreed to partner with TVA for this project were more likely to be environmentally conscious and already had close working relationships with the Clean Marina coordinators in their watersheds, which resulted in a greater knowledge of biological and non-toxic products. If an additive is deemed necessary, the Tennessee Valley Clean Marina Guidebook, published by TVA's Clean Marina Initiative team, suggests that an enzymatic or other 'green' additive should be used. Section one of this guidebook, Sewage Management, and the introduction to the program are included in Appendix A. However, if a holding tank is frequently and completely pumped-out, odor should not be a problem.

3 Identification of Marina/Campground Partners

3.1 Selection Goals

RS and EESE jointly developed a set of factors to use in selecting marinas and campgrounds to participate in the study. The two primary factors were that the facility had a pump-out system that sent wastewater to a DWS, and that the owner/operator was willing to discuss their DWS, pump-out set-up and wastewater with TVA and would allow samples to be taken and discussed in this report. All marina partners in this study were identified by the Clean Marina Initiative (CMI) coordinators from the RS Watershed Teams, who introduced EESE staff to the owners/operators and facilitated partnership opportunities. The partnering campgrounds were chosen by recommendations from TVA's Facilities Management (FM). All partners remain anonymous in this report to facilitate more open discussion of their facilities.

The ideal in selecting marina and campground partners was to get a 'representative' sample of facilities in the Valley that used DWS. To aid in determining what constituted a 'representative' marina, a matrix was developed to identify the varying characteristics of Valley marinas (Appendix B). These characteristics included geographic location (e.g. east, central, west), main stem vs. tributary reservoir, size of facility (number of slips/RVs, estimated volume of pump-out waste) and components of the effluent stream (only pump-out, or auxiliary facilities such as restaurants, boat cleaning operations, campgrounds or offices).

In addition to the factors, sampling goals also were taken into account during initial site selection. Preferably, three sampling locations were desired at each facility to show how wastewater is treated as it moves through the DWS. Locations were sought where access was available to the raw pump-out wastewater (to analyze the potentially highest concentration of possible toxic compounds), the influent to the septic tank (mixed raw wastewater) and the septic tank effluent (partially treated wastewater). Many septic tanks have dual chambers separated by a baffle. For this study's purposes, the septic tank influent site refers to either the first chamber in the septic tank or the first septic tank when two are in series. The septic tank effluent site refers to the final chamber in the last septic tank in a series. Ideally, actual septic tank effluent would be sampled from the tee, which is another area that is isolated by a baffle before discharge to the drainfield; however, access to this location was not possible. Again, ideally, samples of the effluent where it leaves the drainfield (which is the final treatment stage) would be desirable; however, that is beyond the scope of this study because it would require installation of lysimeters in the drainfield. Finally, the accessibility and practicality of sampling the pump-out wastes and DWS was also considered in selection of marina and campground parnters.

3.2 Selection Process

Once the selection goals were established, CMI coordinators were asked to compile a list of potential partners in Valley watersheds. To help the CMI coordinators determine which marinas would be most suitable, EESE staff met with them to describe the goals of the project and to distribute a brief document with bulleted talking points. This document, also located in Appendix B, was used to help the CMI coordinators discuss the project with marinas to determine if they would be interested in partnering after the first round of ‘representative’ marina selections were made.

Initially, the CMI coordinators suggested a list of 36 marinas they considered potentially suitable for the study. This list was narrowed down to 12, who were then contacted by the CMI coordinators to determine level of interest. EESE staff then worked with the CMI coordinators to meet with the willing marinas to discuss the project and answer any concerns, and to schedule a time to sample their wastewaters. As more was learned about sampling access at the marinas and partnerships were formed, it became apparent that it would be an undue burden on the owners/operators to provide access to all the desired sampling points at each facility; in fact, access to two sampling locations was considered fortunate. This fact slightly modified the sampling mission; instead of being able to characterize the wastewater at several points in the treatment process at each marina or campground, the goal became to draw comparisons among the different facilities’ wastewaters, depending on the point in the process train, or similar effluent characteristics.

Identification of partnering marinas and campgrounds was an ongoing process throughout the summer of 2003. Partnering campgrounds were easy to locate, because they were TVA-owned (and often TVA-designed) facilities; it was simply a matter of choosing facilities that contributed most to obtaining a representative sample. Locating partnering marinas was more difficult because they are independently owned and the study fell during their peak operations. Many of the initial proposed facilities did not actually use DWS, so there was an ongoing effort to identify marinas that fit the project goals. Ultimately, 11 marinas and three campgrounds partnered with EESE for this project, for a total of 14 facilities studied.

3.3 Site Characteristics

Table 2 displays the characteristics of each marina/campground that took part in the wastewater characterization study. As shown, the most frequent sampling locations were the holding tanks and the final chambers of the septic tanks. Often, when septic tanks were used, they had two compartments but there was only access to the second chamber, or effluent side of the tank. Of the locations where samples of the raw wastewater from the holding tank were available, four sites then pumped the effluent to a septic tank, while the other two had alternative systems (wetland and pump-and-haul).

Some of the columns in the table below need clarification. The geographic location refers to the facility’s relative location in the Valley. The west region encompasses all of the Pickwick and Wilson Watershed Team region, and a small part of the Wheeler Watershed Team area. The central region includes the remainder of the Wheeler Watershed Team area, as well as all of Guntersville and parts of Melton Hill and Chickamauga-Nickajack. The east region consists of the remainder of the Melton Hill and Chickamauga-Nickajack Watershed Team areas, and all of the Hiwassee, Little Tennessee, Clinch-Powell, Cherokee-Douglas and Holston regions. The delineation of these regions is shown in Figure 1. In addition, Figure 2 shows the Tennessee River watershed, broken down into subwatersheds based on the eight-digit hydrologic unit code (HUC). The highlighted watersheds in this map are those that had participating marinas or campgrounds.

The facility size of the marinas and campgrounds refers to the number of slips in the marinas and the number of RV hook-ups in the campgrounds. The count reflects the average number of full slips and hook-ups in the summer season. A small facility consists of fewer than 100 served, a medium facility ranges from 100 to 200 served, and a large facility serves more than 200.

The wastewater streams column refers to the wastewater components that contribute to the DWS. Although the initial selection goals supported a group of DWS sites with widely varying wastewater streams, most owners/operators send pump-out waste to a separate DWS. Many of these systems were relatively new, explained by the growing need for pump-out stations. These facilities may have found it more convenient and/or cost-effective to simply install a new DWS rather than incorporating the pump-out waste into an existing system. When additional waste streams are described below, restrooms include only toilets and sinks, while bath houses also have showers.

Table 2: Marina/Campground Characteristics

Facility ID	Facility Type	Geographic Location	Facility Size	Wastewater Streams	Sampling Locations
A	Marina	West	Medium	Pump-out Only	Septic Tank Effluent (Final Chamber)
B	Marina	West	Large	Pump-out + 1 Restroom	Septic Tank Effluent (Final Chamber)
C	Marina	Central	Medium	Pump-out + 2 Restrooms	Holding Tank & Septic Tank Effluent (Final Chamber)
D	Marina	Central	Large	Pump-out + Bath Houses	Septic Tank Influent (1st Tank) & Effluent (Final Chamber)
E	Marina	East	Medium	Pump-out Only	Septic Tank Effluent (Final Chamber)
F	Marina	Central	Large	Pump-out Only	Holding Tank
G	Marina	West	Medium	Pump-out + 2 Restrooms	Septic Tank Effluent (Final Chamber)
H	Marina	West	Small	Pump-out + 2 Restrooms	Holding Tank
I	Marina	East	Medium	Pump-out Only	Holding Tank
J	Marina	East	Large	Holding Tank + 2 Restrooms	Holding Tank & Septic Tank Influent(1st Tank)
K	Marina	Central	Small	Pump-out Only	Holding Tank
L	Campground	West	Small	Pump-out Only	Septic Tank Effluent (Final Chamber)
M	Campground	East	Small	Pump-out Only	Septic Tank Influent (1st Tank) & Effluent (Final Chamber)
N	Campground	East	Small	Pump-out Only	Septic Tank Effluent (Final Chamber)

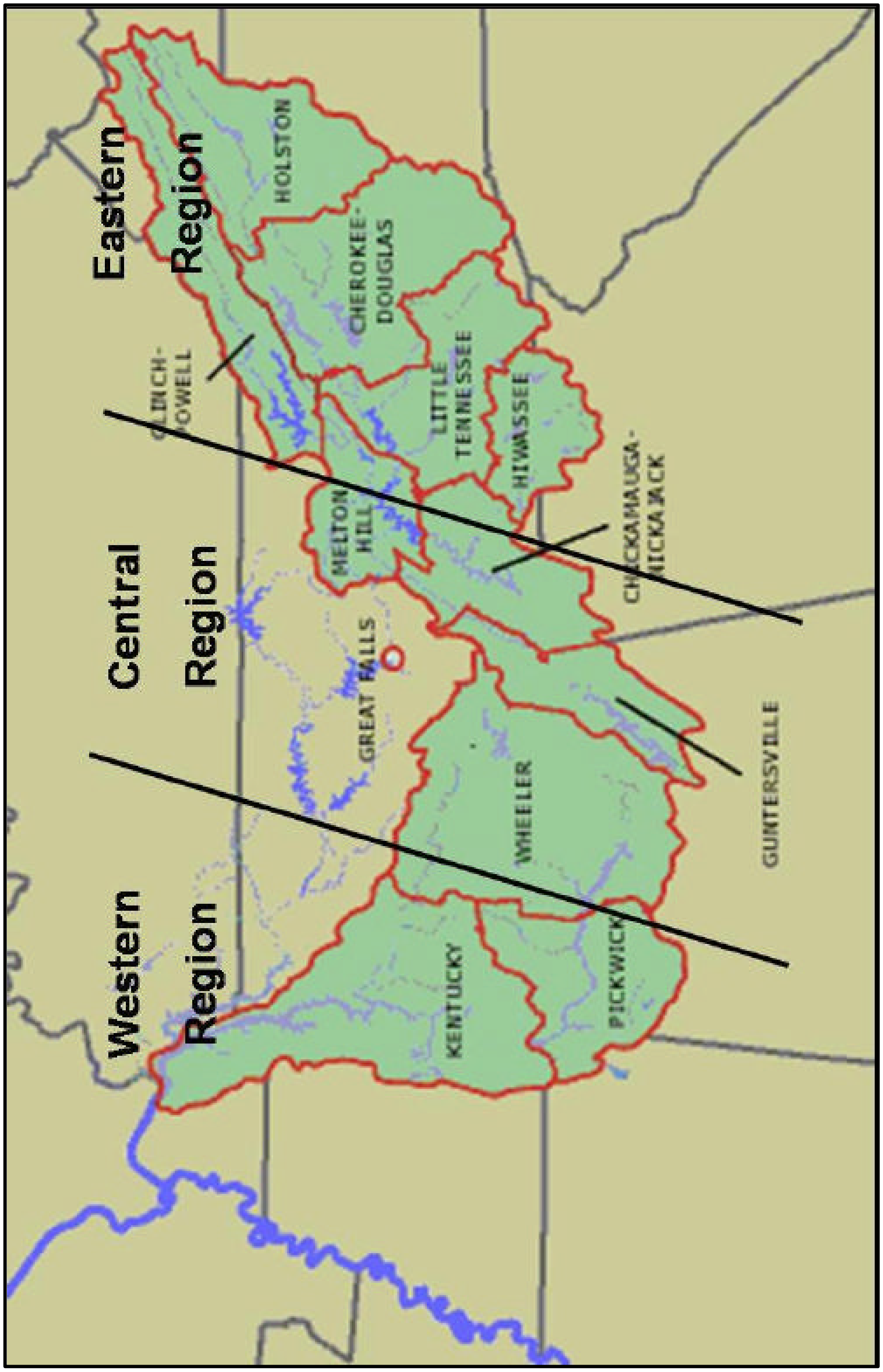

Figure 1: Delineation of the Tennessee River Watershed Regions

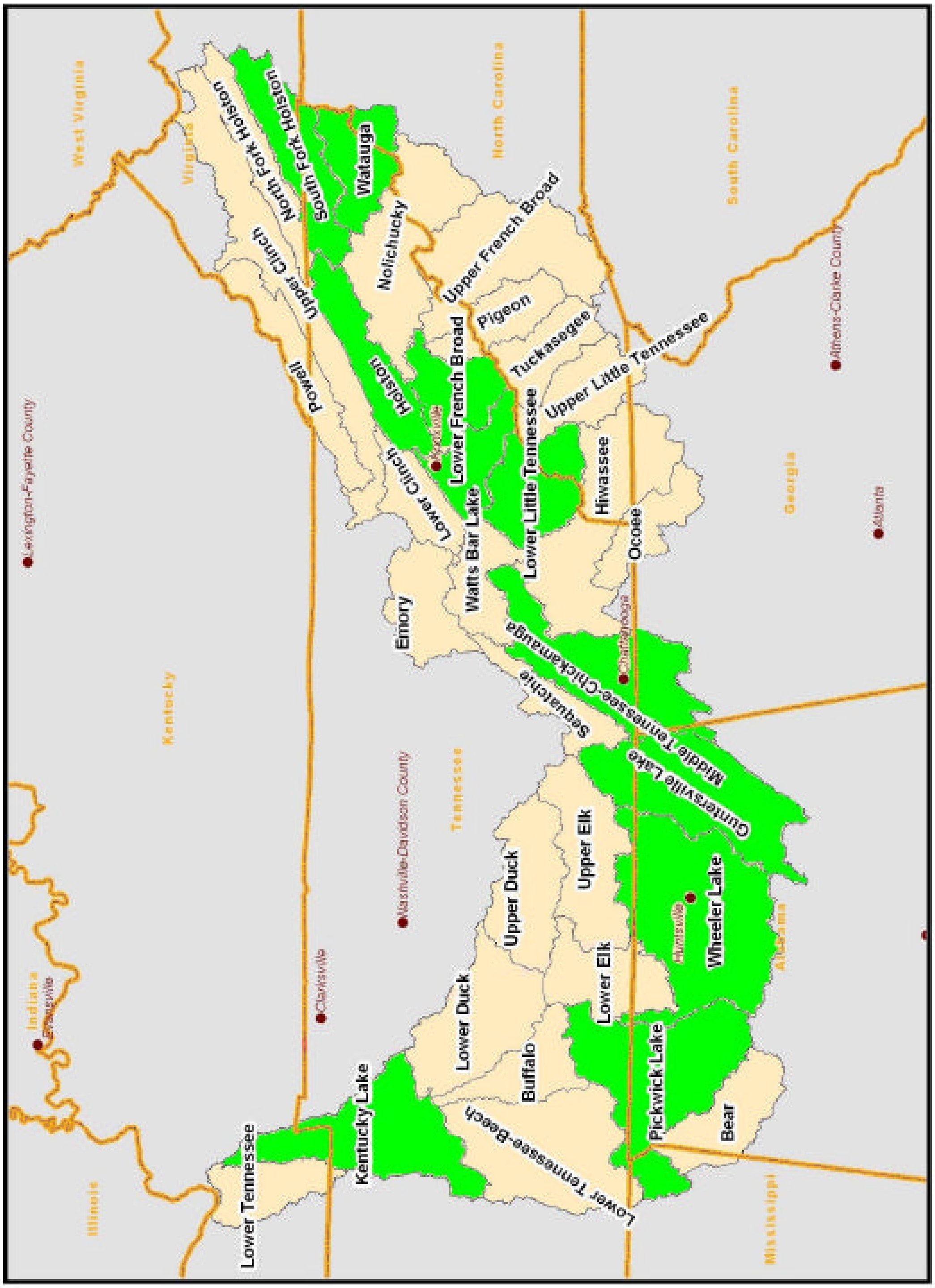

Figure 2: Tennessee River Watershed, 8-Digit HUC Level, Subwatersheds with Marina/Campground Partners

4 Marina/Campground Sampling Events

4.1 Laboratory Parameters

Several wastewater parameters were analyzed in this project. These include alkalinity, pH, five day biological oxygen demand (BOD_5), chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), ammonia-nitrogen, nitrate+nitrite-nitrogen, total phosphorus, oil and grease, Microtox, fecal coliform and *e. coli*. The first ten parameters (alkalinity through oil and grease) were analyzed by TVA's Central Laboratory Services (CLS), Microtox was analyzed by Technical Laboratories, Inc., and the two bacteria parameters were analyzed by TVA's Resource Stewardship group. Below is a detailed discussion of each parameter, including its relevance to this study, inferences that can be made by values higher and lower than 'typical' and what typical values are assumed to be.

Alkalinity:
Alkalinity is the measure of the buffering capacity of the wastewater, and is measured in mg/l as calcium carbonate. An increase in the alkalinity of a wastewater corresponds to a related increase in the difficulty of changing pH. Thus, a high alkalinity characterizes a wastewater as very stable, pH-wise. Medium to high alkalinity is favorable for biota, because it allows nitrification (elimination of ammonia) to occur.

pH:
The measurement of pH indicates how acidic or basic an effluent is, on a scale of one (most acidic) to 14 (most basic). A pH level that corresponds to ideal septic tank conditions typically ranges between six and nine. A pH that is less than five or greater than nine is often difficult to treat by biological means.

Five Day Biochemical Oxygen Demand (BOD_5):
The biochemical oxygen demand is a measure of the amount of oxygen required to biologically stabilize a waste stream. In a five day biochemical oxygen demand (BOD_5) analysis, the result, in mg/l, is the amount of oxygen consumed in that five day period. BOD_5 is a contaminant of concern because increased levels of BOD_5 indicate the capacity for greater uptake of dissolved oxygen in the receiving water. Increased depletion of dissolved oxygen, in turn, creates anoxic (lack of oxygen) conditions in receiving waterbodies, which is harmful to aquatic life. DWSs that are operated correctly, and have good soil characteristics, can potentially remove greater than 95% of the BOD_5 in the system (including the soil adsorption system), which would make the chances of groundwater contamination very slim. In residential wastewater, the typical BOD_5 value for raw waste is 450 mg/l, with an expected range in septic tank effluent of 100 to 250 mg/l (Crites and Tchobanoglous 1998).

Chemical Oxygen Demand (COD):
Chemical oxygen demand (COD) also measures the amount of oxygen needed to decompose organic matter. However, it involves a strong chemical process which includes more refractory or harder to digest material. Therefore, it represents total, long-term organic loading. Also measured in mg/l, COD is a contaminant of concern for the same reason as BOD_5; an excess of both indicates a likelihood for developing

anoxic conditions, which harm aquatic life. COD values are always higher than BOD_5 values, and COD is considered to be a more reliable and reproducible indicator of oxygen demand. In residential wastewater, raw effluent COD values average around 1050 mg/l, with an expected septic tank effluent range of 160 to 500 mg/l (Crites and Tchobanoglous 1998).

Nitrogen Species – Nitrogen as Total Kjeldahl Nitrogen (TKN), Ammonia-Nitrogen (NH_4) and Nitrate+Nitrite-Nitrogen (NO_2+NO_3):
Nitrogen as total Kjeldhal nitrogen (TKN), ammonia-nitrogen (NH_4) and nitrate+nitrite-nitrogen (NO_2+NO_3) make up the three categories of nitrogen nutrients that were measured in the sampled wastewater. Nitrogen is a pollutant of concern in wastewater because in excessive concentrations it can stimulate excessive algal growth, a symptom of eutrophication. Eutrophication is an aquatic condition in which high nutrient concentrations promote algae blooms, which cause large diurnal swings in dissolved oxygen content in the water as they photosynthesize during daylight and respire at night. When they die, additional depletion of dissolved oxygen in the water is caused as a result of algal decomposition. The resulting low level of dissolved oxygen in the water is harmful to aquatic life.

TKN is the sum of ammonia-nitrogen and organic nitrogen in wastewater. TKN averages 70.4 mg/l in raw residential wastewater, and is typically 50 to 90 mg/l in treated DWS effluent (Crites and Tchobanoglous 1998). Nitrogen is typically found in the forms of organic matter and ammonia in raw effluent. After completing treatment in a DWS, the nitrogen is primarily in ammonia form, about 85% as ammonia. Ammonia-nitrogen averages 40 mg/l in raw residential wastewater, and from 30 to 50 mg/l in DWS effluent (Crites and Tchobanoglous 1998). When the effluent is discharged to the drainfield, the aerobic bacteria below the biomat and in the upper vadose zone (the layer of soil immediately below the surface, but above the water table, where there is both water and air in the soil, but the soil is not saturated with water) convert nearly all of the ammonia to nitrite, which is then easily oxidized to nitrate.

Unconverted ammonia in receiving waters is of concern because it is toxic to some aquatic organisms. Nitrite is a threat in surface waters because it is extremely toxic to most fish and other aquatic life; however, since it is so easily converted to nitrate, it is rarely found in significant concentrations. High concentrations of nitrates are also a concern because it causes ‘blue baby syndrome’ in drinking water, which can interfere with the oxygen-carrying capacity of an infant’s blood. In wastewater, the nitrite concentration is rarely greater than one mg/l. Nitrates in septic tank effluent usually range from two to 30 mg/l, depending on the degree of nitrification (Crites and Tchobanoglous 1998).

Total Phosphorus:
Similar to nitrogen, phosphorus is a pollutant of concern in surface waters because it is an aquatic plant nutrient that contributes to eutrophication and its associated dissolved oxygen depletion. Total phosphorus averages around 17 mg/l in untreated residential sewage, and typically ranges from 12 to 20 mg/l in septic tank effluent (Crites and Tchobanoglous 1998). Phosphorus removal processes have not yet been widely developed in onsite systems; however, many soils are able to process phosphorus for many years before problems develop. Older DWS are more at risk for phosphorus contamination.

Oil and Grease:
Oil and grease, measured in mg/l, can cause many problems in decentralized wastewater systems. They tend to coat equipment and living organisms and clog soils. In addition, the presence of oil and grease in tanks (e.g. septic tanks) contributes to scum layer formation, which requires periodic removal through pumping. An oil and grease level of approximately 160 mg/l is average in residential raw septic waste, with septic tank effluent ranging from 10 to 50 mg/l (Crites and Tchobanoglous 1998).

Microtox:
The Microtox assay is a screening analysis to determine relative toxicity of a wastewater stream. The Microtox analysis is based on the light output of luminescent bacteria. The presence of toxic compounds reduces the light emitted by the bacteria. The results are based on the percent of sample necessary, in a solution of wastewater and dilution water, to decrease the light output of the bacteria by one-half. For example, a result of EC50% equal to five would mean that you would need five parts waste to ninety-five parts dilution water (for a total of 100%) to achieve a 50% decrease in the number of test bacteria. Therefore, the lower the EC50%, the less wastewater needed for the EC50%, and thus the more relatively toxic the wastewater.

The Microtox procedure was not used in this study as a measure of absolute toxicity. To achieve those results, each sample would have to be calibrated for each specific toxicant of concern, as well as historic results. Instead, Microtox was used in this study as a preliminary screening factor for toxicity, to get a general idea of relative toxicity among the samples and to identify any abnormally high or low values.

Pathogen/Bacterial Indicators – Fecal Coliform and *E. coli*:
Fecal coliform and *E. coli* (*Escherichia coli)* were used in this study as indicators to determine if there may be a concern with pathogens. Direct pathogen testing is difficult, and these indicators are normally used in most wastewater monitoring. Pathogens are a concern because they can cause communicable diseases through direct or indirect body contact or ingestion of contaminated water or shellfish. Pathogens can travel long distances in groundwater and are a particular threat when they migrate to surface waters or pool on the ground surface. Fecal coliform are commonly found in the range of 10^6 to 10^8 (one million to one hundred million) most probably number (MPN)/100 ml in raw wastewater and septic tank effluent (Crites and Tchobanoglous 1998).

4.2 Sample Collection

Samples were collected one time during the peak season of marina and campground operations, from late July to late August 2003, to get a ‘snapshot’ of the harshest conditions that the onsite systems face. Most of the marina and campground sampling events were scheduled simply around the owner/operator’s availability; however, there was also an emphasis on sampling the sailing marinas near the end of the summer, since their peak season is during the more windy seasons of spring and fall. The peak season for all the other facilities (e.g. campgrounds and powerboat marinas) fell during the summer months when bulk of the sampling took place.

The specifics of the sampling events are expressed in the detailed workplan in Appendix C; an overview of the sampling procedures and precautions are described below. The sampling event summary is discussed in terms of safety precautions, basic procedures and equipment, and important lab information.

During the sampling events for this study, working safely was a primary goal. A detailed safety analysis was performed before and after each sampling event by going over a series of questions in standard TVA forms. The possibility of pathogen contamination was the driver for most of the safeguards used during the sampling events. The personal protective equipment (PPE) for this study included Tyvek suits, latex gloves, and safety glasses for all sampling events. Life jackets were also required for the one site that was accessed by boat. Procedurally, safety was ensured by disinfecting with rubbing alcohol all equipment that would be re-used. Usually, this included wiping down the oil and grease sampler, screwdriver, and bucket (if used). Each filled sample bottle was rinsed with water before being secured in a Ziploc-style bag for transportation to the lab. All labeling was completed prior to sampling to prevent contamination of the writing instruments. Finally, anti-bacterial handwash was supplied for the sampling team to disinfect their hands and arms before a more thorough wash-up that took place on-site. All trash from the sampling event was bagged and disposed of in dumpsters at the site.

The sampling itself usually took about an hour from set-up to departure, with a two-person sampling team. Upon arrival, the sampling team checked in with the owner/operator to gain access to the sampling site(s). Once access was secured, final material preparation took place, including labeling the bottles, opening the Ziploc bags, securing the oil and grease bottle to the sampler, and setting out the rinsing and disinfection equipment for use. After preparation, PPE was applied, and sampling began. All samples except oil and grease were collected with a disposable glass coliwasa tube, dispensed into the sampling container and tightly closed. The bacteria samples were always the last samples collected because they had the shortest holding time, six hours. The lab requires that oil and grease be sampled directly. This was done by securing the bottle to a 4-foot PVC pipe with screwdriver-tightened metal ties. The bottle was then lowered to the wastewater surface and the sample was skimmed from the top, where oil and grease would be concentrated in the surface layer. With sampling complete, one member of the sampling team rinsed each of the sample containers and bagged them separately in Ziploc bags to prevent leaks during transportation. The other person disinfected the re-usable gear. After all this was complete, the samples were placed on ice in a cooler, the access portal was re-closed, and all trash was disposed of appropriately. Samples were then returned immediately to the labs for analysis.

Each laboratory parameter has a specific container, holding time and collection procedure that had to be followed during sampling. All samples had to be placed on ice in the dark in coolers during transportation to the lab. These laboratory factors are displayed in Table 3.

Table 3: Laboratory Parameter Characteristics

Parameter	Sample Container	Holding Time	Additional Notes
Alkalinity	1-L Polyethylene	N/A	Best measured on-site
pH	1-L Polyethylene	N/A	Best measured on-site
BOD_5	1-L Polyethylene	48 hrs	N/A
COD	125-ml Polyethylene	28 days	N/A
Nutrients (Nitrogen)	250-ml Polyethylene, spiked with H_2SO_4	28 days	Leave head space in bottle (due to acid)
Total Phosphorus	250-ml Polyethylene, spiked with H_2SO_4	28 days	Leave head space in bottle (due to acid)
Oil and Grease	1-L Glass Widemouth (Clear), spiked with H_2SO_4	28 days	Leave head space in bottle (due to acid)
Microtox	125-ml, Glass (Amber), Teflon-Lined	48 hrs	Leave no head space in bottle (no air bubbles)
Bacteria (Fecal/*E. coli*)	Whirl-Pak® sample bags	6 hrs	N/A

5 Presentation and Discussion of Laboratory Results

5.1 Overview

The laboratory results are presented parameter-by-parameter. In each section, the lab results for the selected parameter(s) are displayed in tabular and graphical format. Following these illustrations, the implications of these results for the parameter(s) in that section are discussed.

When the data is displayed in tables, the marina/campground is identified by the letter (‘A’ through ‘N’) associated with the facility in Table 1 (page 11, “Marina/Campground Characteristics”). The sampling location is noted in the second column, as ‘HT’ (holding tank), ‘STE’ (septic tank effluent from a final septic tank chamber) or ‘STI’ (septic tank influent from the first septic tank chamber or first septic tank in a series). This identifying information is followed by the lab results, units of measurement and any other relevant information. Marina holding tank results are presented first, followed by marina septic tank influent and effluent, then campground septic tank influent/effluent.

After the data is discussed by parameter, there is an analysis of the results based on the wastewater treatment train. This consists of a closer examination of facilities with multiple sampling sites to look at the changes in effluent characteristics throughout the treatment process.

5.2 Alkalinity/pH

The pH results range from 6.48 to 8.20, all of which are within the range that is conducive to septic tank operations. Alkalinity, on the other hand, is less than the laboratory’s method detection limit (MDL) of one mg/l for all but two facilities, H and D2. In typical residential DWS, alkalinity normally exists as a component of the water from sinks, showers, toilet flushes, or cleaning agents, and as a result of the breakdown of organics in anaerobic systems, including septic tanks.

The lack of alkalinity in these systems in unexplained, although a few potential contributing factors have been identified. In residential wastewater, there is normally alkalinity in the influent due to greywater. Pump-out systems are often designed to use little or no water; therefore, there may be no measurable amount of alkalinity in the raw wastewater. The alkalinity in raw waste and the holding tank additives is unknown, so it is undetermined if there is any alkalinity present when the waste reaches the DWS.

Alkalinity is present at two sites, H and D2. Site H is a holding tank that receives both pump-out waste and the wastewater from two restrooms. Of these two waste streams, the restroom wastewater is the larger component. This introduces a fair amount of greywater into that holding tank, which may in turn allow for the alkalinity present. Site D2 is the effluent from the second septic tank in a system with two septic tanks in parallel. The DWS at this facility receives wastewater from both a pump-out station and restrooms with showers. In this case, it appears that the alkalinity is a by-product of the anaerobic processes in the septic tanks, since no alkalinity is present at site D1, the effluent from the first septic tank in the treatment train. The alkalinity and pH results are displayed in Table 4 and Figure 3 below.

Table 4: Laboratory Results, Alkalinity and pH

Facility ID	Sampling Location	Result, Alkalinity (mg/l)	Result, pH (Standard Units.)	Temperature Measurement
Holding Tank – Raw Wastewater (Marina)				
C1	HT	< 1	7.93	19.7 C
F	HT	< 1	6.93	24.1 C
H	HT	174	6.48	22.5 C
I	HT	< 1	7.49	21.0 C
J1	HT	< 1	6.88	21.0 C
K	HT	< 1	8.20	21.1 C
Septic Tank – Treated Wastewater (Marina)				
A	STE	< 1	7.20	24.6 C
B	STE	< 1	6.84	19.9 C
C2	STE	< 1	7.14	21.1 C
D1	STI	< 1	7.00	20.5 C
D2	STE	361	6.89	20.0 C
E	STE	< 1	7.00	22.6 C
G	STE	< 1	6.99	23.9 C
J2	STI	< 1	6.25	21.1 C
Septic Tank – Treated Wastewater (Campground)				
L	STE	< 1	7.17	20.1 C
M1	STI	< 1	7.08	22.4 C
M2	STE	< 1	7.09	22.6 C
N	STE	< 1	6.96	23.7 C

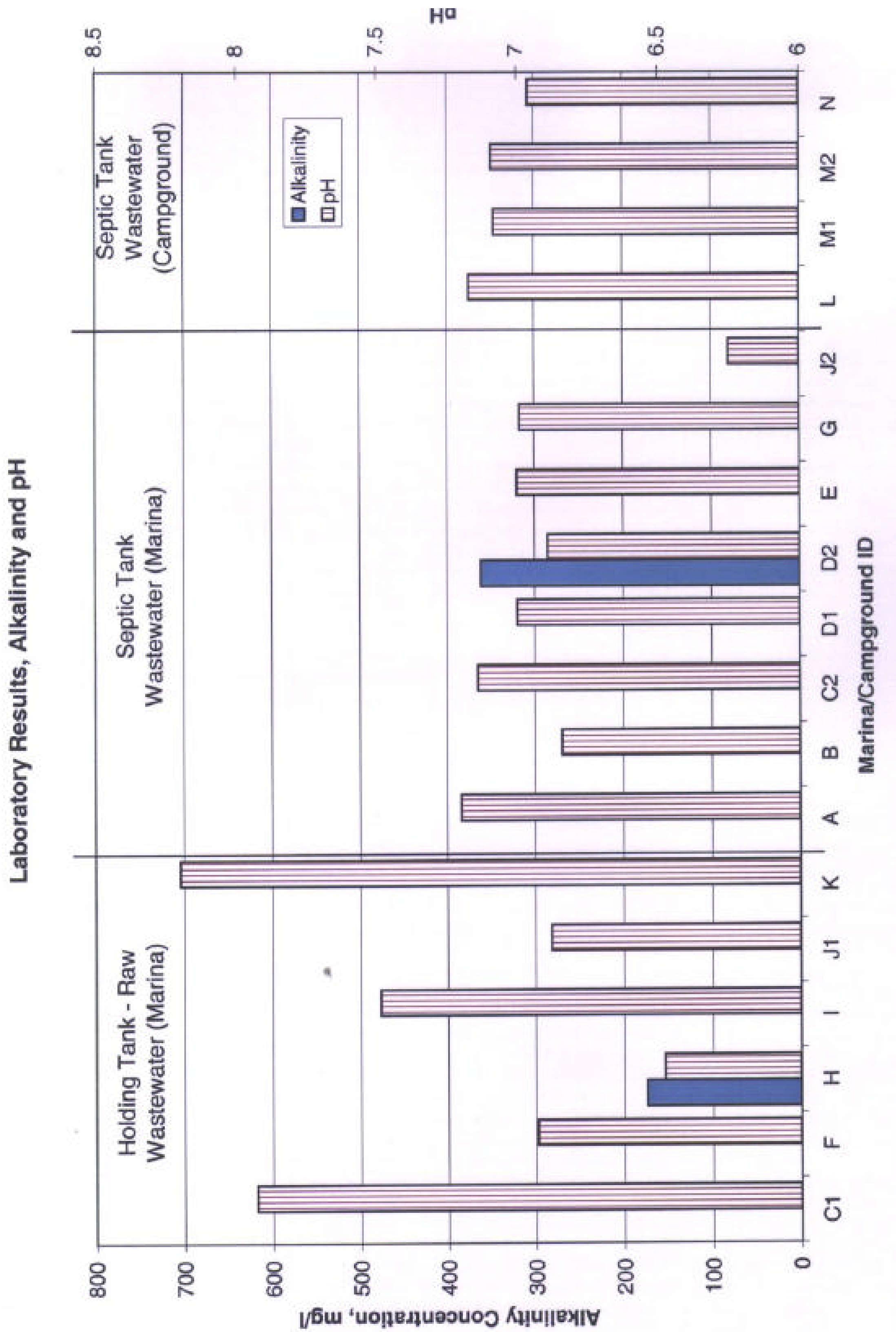

Figure 3: Laboratory Results, Alkalinity and pH

5.3 Five Day Biochemical Oxygen Demand (BOD_5)/Chemical Oxygen Demand (COD)

Both the BOD_5 and COD results are significantly higher than the typical ranges found in residential wastewater. Several of the holding tank BOD_5 values were two to three times as high as typical residential wastewater (450 mg/l). The septic tank final chamber (STE) values for BOD_5 and COD were also two to three times the expected ranges of residential septic tank effluent (BOD_5 = 100-250 mg/l; COD = 160-500 mg/l). The concerns associated with high BOD_5 and COD loadings are an increase in the organic load to the drainfield and potential growth of the biomat. The biomat is an organic layer located at the bottom and sides of a drainfield, which aids in wastewater treatment by removing pathogens and ensuring slow, steady flow through the drainfield. If the drainfield becomes too thick, it can clog the system, preventing drainage (Septic-Info.Com 2002). Though the concentrations of these pollutants are high, one can not determine the absolute effects of these concentrations on the drainfield. Significant unknowns in these measurements are flow levels and the frequency of discharge to the drainfield. If the flow into the drainfield is low, the total daily loadings (pounds/day) of BOD_5 and COD being discharged may be low as well. Furthermore, if there is only high flow on a seasonal basis (e.g. coinciding with summer, the peak season), the soils may be able to dry up in the off-season, which would allow for re-aeration of the biomat and rejuvenation of the drainfield.

Typically, COD levels are greater than BOD_5 levels. This is because the BOD_5 test measures the oxygen digested biologically in a five-day period. Organic materials which are not easily digested may often not be captured in this test. The COD test, on the other hand, chemically digests all organic material, measuring all oxygen used in those reactions. In our laboratory results, four of the samples resulted in BOD_5 levels being greater than COD levels. Though infrequent, this can occur in wastewater with ammonia concentrations greater than 10 mg/l. The ammonia interferes with the laboratory measurements because it may also be oxidized, causing higher BOD_5 results. The COD test, in contrast, is unaffected by ammonia. The effects of ammonia can be mitigated by the use of nitrification inhibitors during the lab analyses, but those inhibitors are not used by the lab that ran the analyses.

Finally, in the laboratory results, site K stands out as being significantly lower than the rest of the results. The pump-out system at that facility had seen very low use over the summer, so it is assumed that the lack of recent wastewater is the reason for those low results. The BOD_5 and COD laboratory results are displayed below in Table 5 and Figure 4.

Table 5: Laboratory Results, BOD_5 and COD			
Facility ID	Sampling Location	Result, BOD_5 (mg/l)	Result, COD (mg/l)
Holding Tank – Raw Wastewater (Marina)			
C1	HT	262	1574
F	HT	1158	2266
H	HT	1047	201
I	HT	1383	810
J1	HT	940	2600
K	HT	53	69
Septic Tank – Treated Wastewater (Marina)			
A	STE	395*	737*
B	STE	644*	1615*
C2	STE	118	108
D1	STI	326	351
D2	STE	130	9
E	STE	901*	3590*
G	STE	255	2906*
J2	STI	406	2500
Septic Tank – Treated Wastewater (Campground)			
L	STE	657*	1848*
M1	STI	1537	2035
M2	STE	1117*	1247*
N	STE	377*	2463*

* These values are greater than twice the normal residential septic tank effluent concentrations of BOD_5 ~ 175 mg/l and COD ~ 330 mg/l.

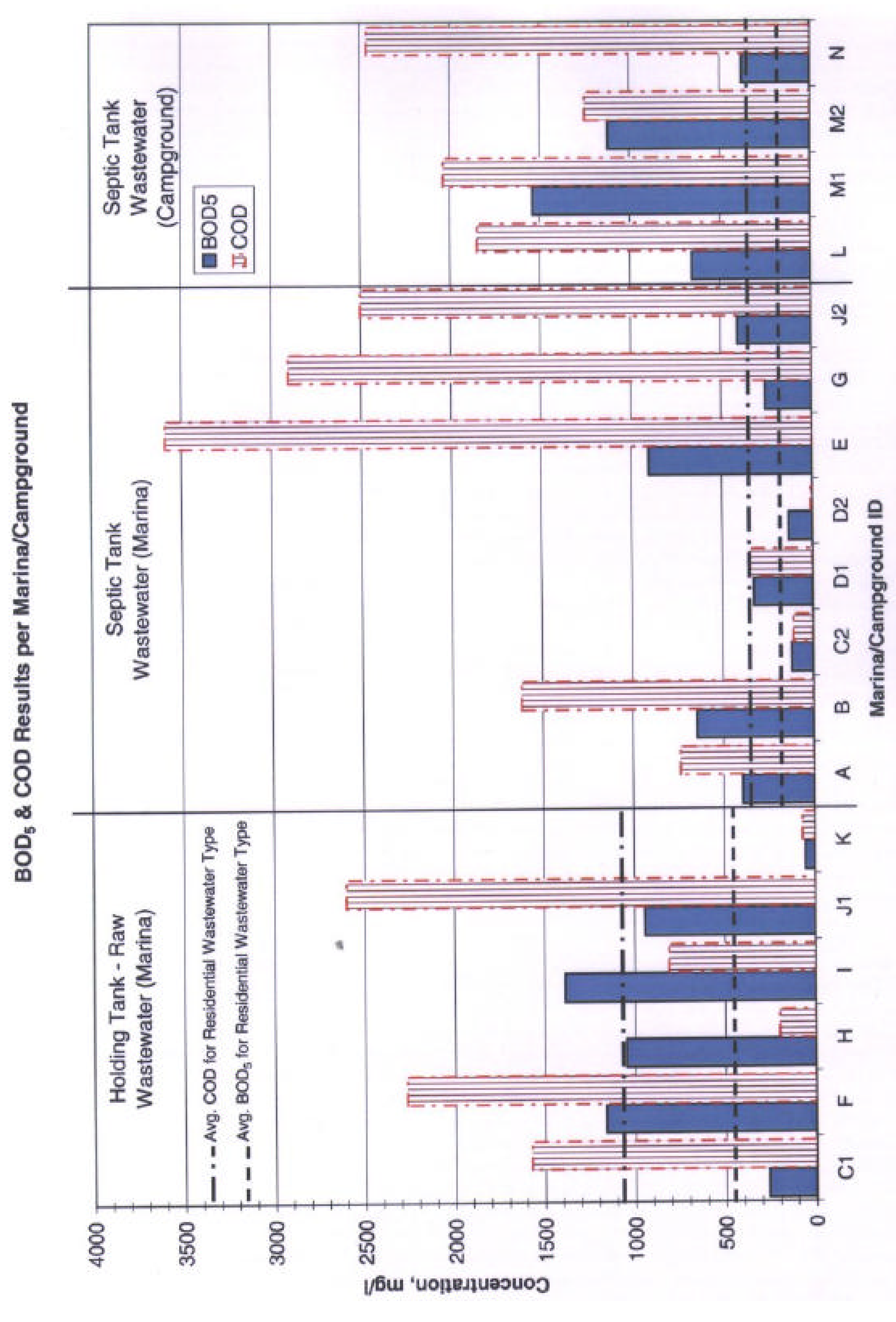

Figure 4: Laboratory Results, BOD_5 and COD

5.4 Nitrogen (TKN, NH_4, NO_2+NO_3)

The laboratory results for the three nitrogen measurements showed that most TKN and ammonia-nitrogen measurements were significantly higher than typical residential wastewater, and nitrate-nitrite results were all lower than those found in typical residential wastewater. Most of the holding tank TKN values were ten to twenty times as great as raw residential wastewater (70 mg/l). Most of the septic tank final chamber (STE) TKN values were two to ten times those normally found in treated DWS effluent (50-90 mg/l). Most ammonia-nitrogen concentrations in the holding tanks were six to thirty times that of raw residential wastewater (40 mg/l). Most of the ammonia-nitrogen concentrations in the STE samples were five to twenty times greater than those normally found in DWS effluent.

The nitrogen results seem to contradict each other and some of the other parameters' results, when placed in the context of residential DWS. Nitrogen as TKN is defined as the sum of organic nitrogen and ammonia-nitrogen. In residential systems, the ratio of organic nitrogen to ammonia-nitrogen is usually more balanced, instead of weighing heavily towards ammonia, as shown in the pump-out results. The lack of organic nitrogen, and excess of ammonia indicates that the anaerobic bacteria in the septic tanks were thriving at converting the organic nitrogen to ammonia. This implies that the wastewater is non-toxic. However, the Microtox results, discussed in detail in a later section, indicate that the wastewater in these systems may be relatively more toxic than residential wastewater. If the wastewater were toxic, though, the expectation would be for all of the nitrogen to be in its organic form.

The high ammonia-nitrogen concentrations may also be due to the additives and deodorizers used on the holding tanks before pump-out. Some chemical additives list quaternary ammonium or ammonium chloride among their active ingredients. When these compounds are used, they would introduce a significant source of ammonia to the wastewater.

The nitrate+nitrite-nitrogen levels are much lower than the range found in typical residential wastewater (2-30 mg/l). There are likely not enough nitrates in the raw wastewater to produce any significant amount of alkalinity, even though denitrification (which produces alkalinity) is taking place. The earlier discussion of the alkalinity levels, or lack there-of, shows that alkalinity is clearly not being produced in excess of that used by other processes.

Finally, since nitrogen as TKN is the sum of organic nitrogen and ammonia-nitrogen, the TKN results should be greater than or equal to both the organic nitrogen and ammonia-nitrogen results. However, it is shown in the laboratory results that in half of the results (nine of eighteen) the ammonia-nitrogen concentrations are greater than the TKN concentrations. This inconsistency may be partially attributed to the high level of dilution needed in the laboratory to achieve readable results, and the loss of precision in the method that accompanies each dilution. In addition, the lack of homogeneity in the samples may contribute to the atypical results.

Ultimately, the results from the various nitrogen species produce more questions than answers, and may be the focus of future detailed studies to determine what is at work in these systems. The laboratory results are presented below in Table 6 and Figures 5 and 6.

Table 6: Laboratory Results, Nitrogen Species (N as TKN, Ammonia and Nitrate+Nitrite)

Facility ID	Sampling Location	Result, TKN (mg/l)	Result, Ammonia-Nitrogen (mg/l)	Result, Nitrate+Nitrite-Nitrogen (mg/l)
Holding Tank – Raw Wastewater (Marina)				
C1	HT	1400	1200	0.48
F	HT	1300	1300	0.49
H	HT	50	28	0.33
I	HT	740	870	0.30
J1	HT	240	270	0.03
K	HT	92	98	0.46
Septic Tank – Treated Wastewater (Marina)				
A	STE	400*	400*	0.16
B	STE	440*	400*	0.06
C2	STE	140*	200*	< 0.01
D1	STI	300	250	0.03
D2	STE	68	80	0.02
E	STE	820*	890*	0.20
G	STE	120*	110*	0.08
J2	STI	190	200	0.07
Septic Tank – Treated Wastewater (Campground)				
L	STE	830*	800*	0.13
M1	STI	680	700	0.15
M2	STE	470*	490*	0.06
N	STE	640*	620*	0.25

* These values are greater than twice the concentrations in normal residential septic tank effluent (TKN ~ 70 mg/l and ammonia-nitrogen ~ 40 mg/l).

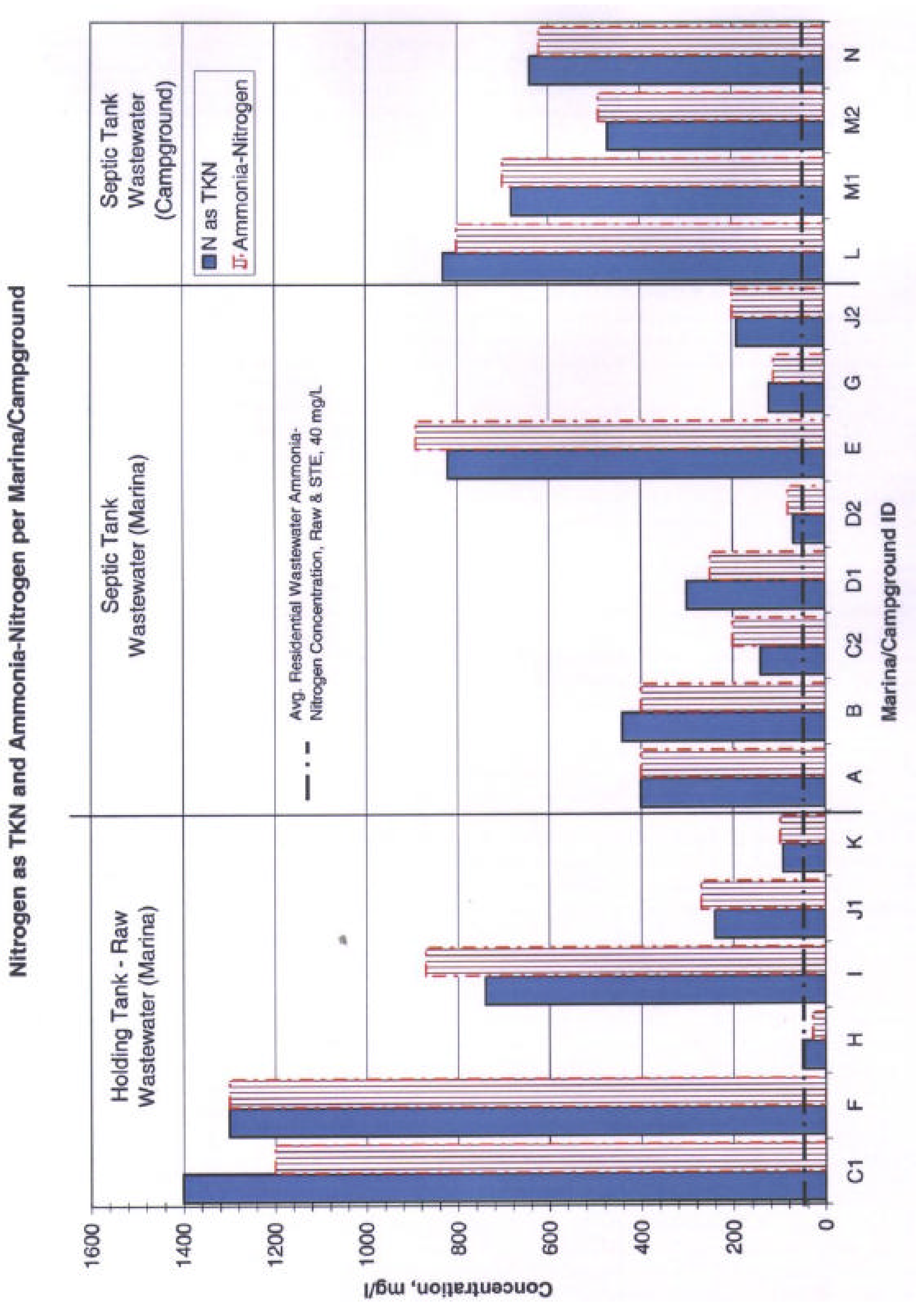

Figure 5: Laboratory Results, Nitrogen as TKN and Ammonia-Nitrogen

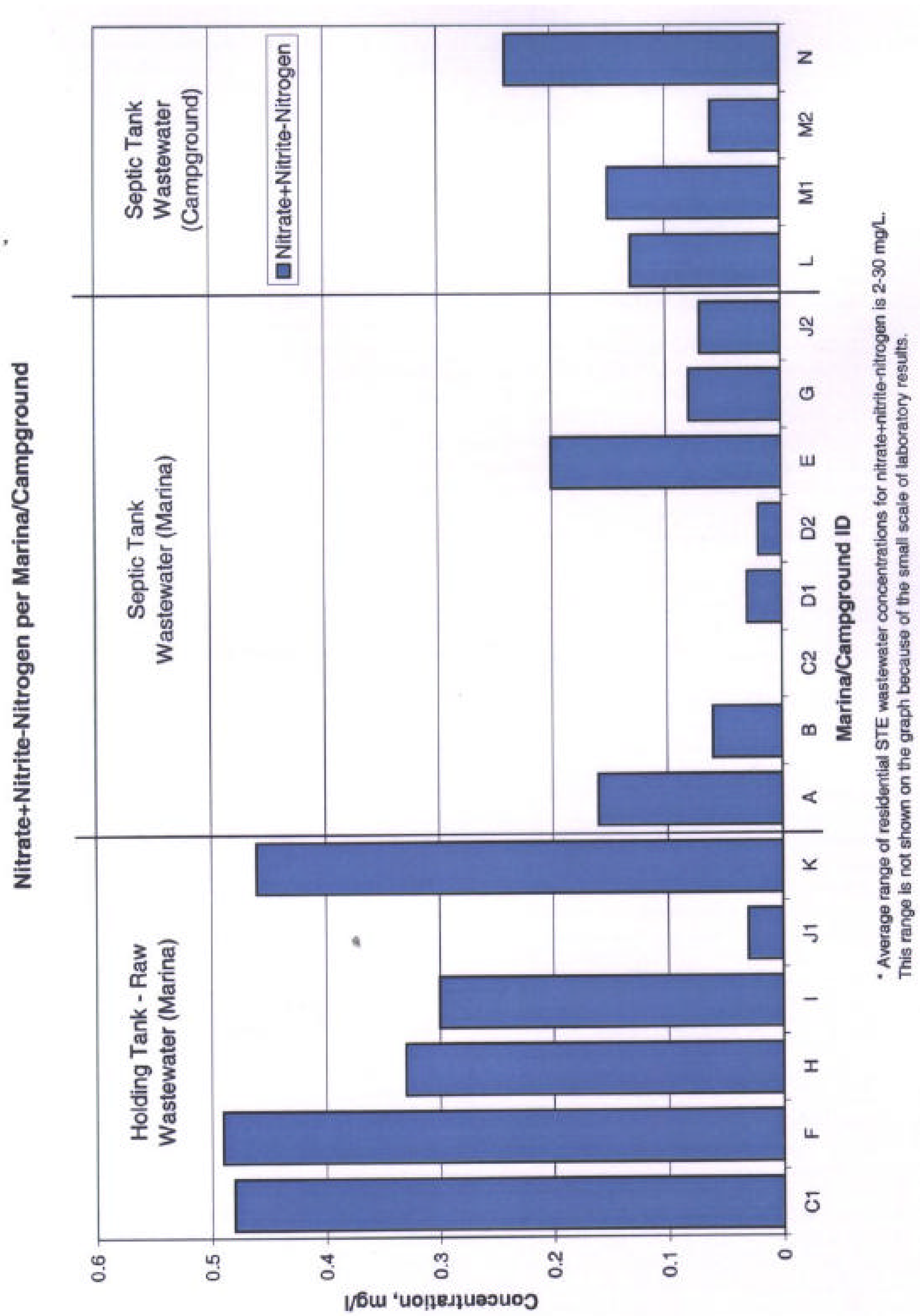

Figure 6: Laboratory Results, Nitrate+Nitrite-Nitrogen

5.5 Total Phosphorus

With a range of results from 5.5 to 130 mg/l, many of the total phosphorus concentrations are significantly greater than those typically found in residential waste, which normally ranges from 12 to 20 mg/l. Again, it is likely that the pump-out levels are much greater than those of residential waste due to the lack of dilution in the wastewater.

The high concentrations of phosphorus in these systems do not necessarily mean that there will be a problem once the treated effluent reaches the drainfield. While the concentrations themselves are elevated, the likelihood of a problem in the drainfield depends upon the flow going into the drainfield and the characteristics of the receiving soil.

All of the facilities that have more than one sampling point, C, D, J and M, show a decrease in phosphorus levels along the treatment train. Typically, phosphorus is not treated biologically in the septic tank, so this decrease may be attributed to the phosphorus being captured within the particulates that settle out in the tank. The laboratory results for total phosphorus are presented below in Table 7 and Figure 7.

Table 7: Laboratory Results, Total Phosphorus

Facility ID	Sampling Location	Result, Phosphorus (mg/l)
Holding Tank – Raw Wastewater (Marina)		
C1	HT	34
F	HT	130
H	HT	11
I	HT	79
J1	HT	33
K	HT	5.5
Septic Tank – Treated Wastewater (Marina)		
A	STE	37*
B	STE	42*
C2	STE	15
D1	STI	33*
D2	STE	6.9
E	STE	96*
G	STE	18
J2	STI	31
Septic Tank – Treated Wastewater (Campground)		
L	STE	78*
M1	STI	67
M2	STE	44*
N	STE	100*

* These values are greater than twice the concentration found in normal residential septic tank effluent (~ 16 mg/l).

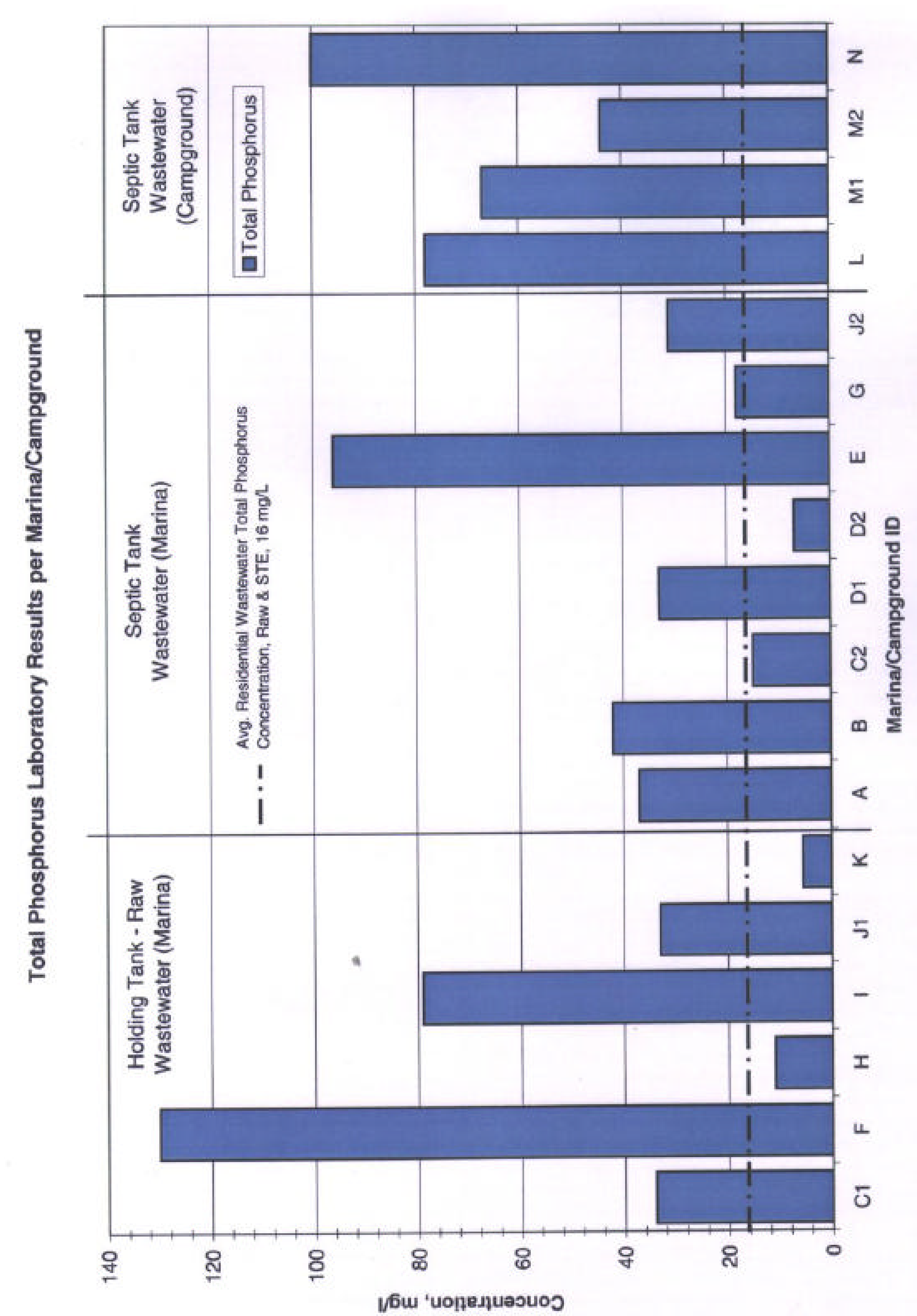

Figure 7: Laboratory Results, Total Phosphorus

5.6 Oil and Grease

Most of the oil and grease results, shown in Table 8 and Figure 8, fall within the expected residential waste range of 10 to 50 mg/l. In contrast to domestic waste, the pump-out systems do not have high concerns about the oil and grease derived from cooking/kitchen waste. EPA sampling guidelines prohibit transferring oil and grease samples from one container to another. Therefore, the sample bottle must be filled directly. The sample bottle also contains an acid preservative so the bottle can not be overfilled nor can the bottle be completely submerged. These requirements meant that the oil and grease samples must be skimmed from the final chamber at the surface layer. Unfortunately, this is where floating oil and grease is concentrated. Thus the oil and grease concentrations in the septic tanks are likely greater than the actual concentrations being introduced into the drainfield. The effluent leaving the septic tanks is behind another baffle, and should not draw from the surface layer.

Table 8: Laboratory Results, Oil and Grease

Facility ID	Sampling Location	Result, Oil and Grease (mg/l)
Holding Tank – Raw Wastewater (Marina)		
C1	HT	< 5
F	HT	76
H	HT	50
I	HT	48
J1	HT	48
K	HT	< 5
Septic Tank – Treated Wastewater (Marina)		
A	STE	40
B	STE	130
C2	STE	6
D1	STI	98
D2	STE	8
E	STE	91
G	STE	49
J2	STI	9
Septic Tank – Treated Wastewater (Campground)		
L	STE	24
M1	STI	140
M2	STE	8
N	STE	240

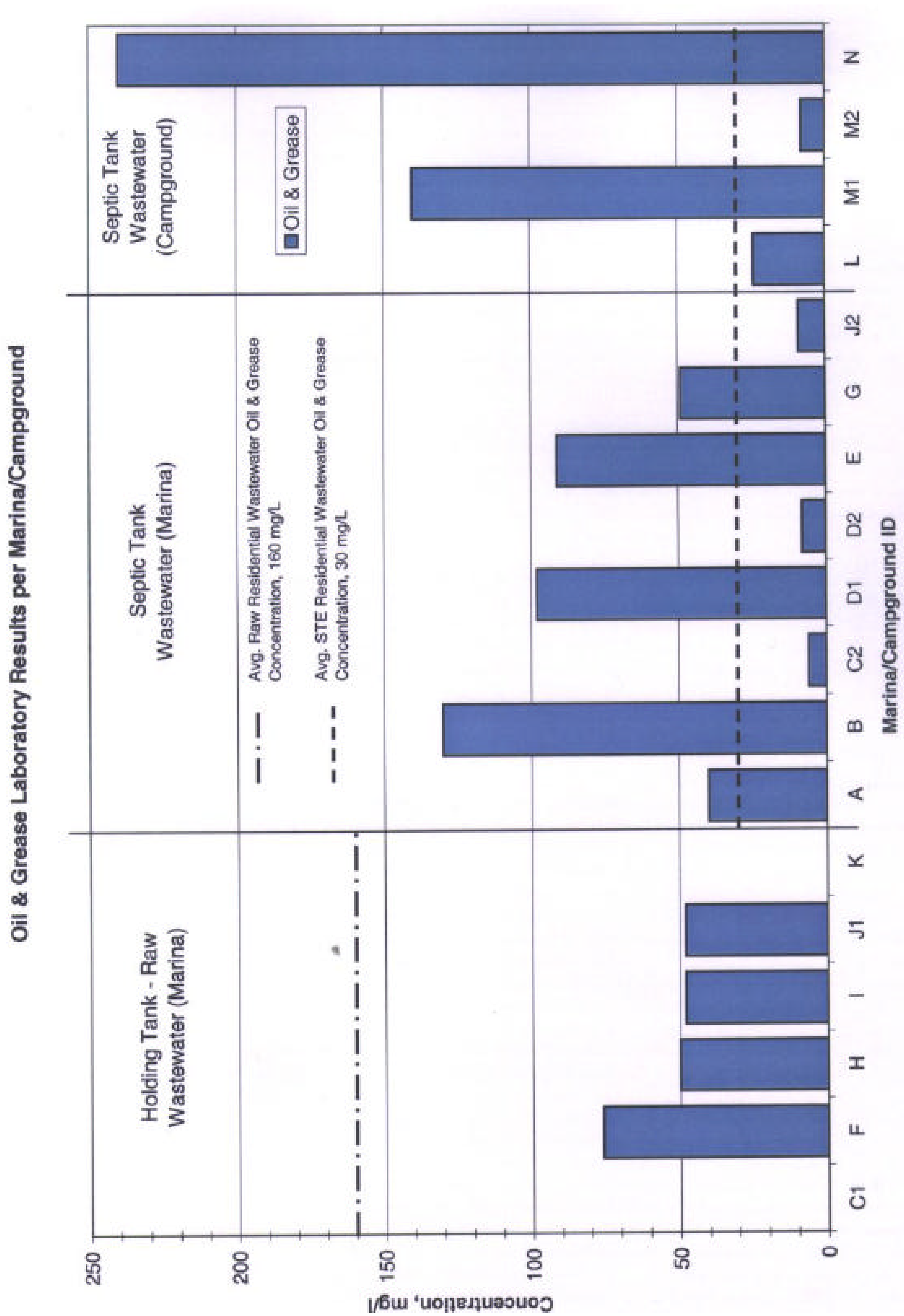

Figure 8: Laboratory Results, Oil and Grease

5.7 Microtox

The Microtox results range from solutions of one percent wastewater to 45 percent wastewater being needed to reach the EC50%. Only two of the results are greater than ten, with eleven of them being less than five. With the exception of site H, there are no significant differences among the various sites. Nor is there a trend in the facilities that have two sampling locations regarding treatment in the DWS; two of the sites decrease in relative toxicity, while the other two increase in relative toxicity. Again, with Microtox, a lower number is more toxic than a larger number. The Microtox results are presented in Table 9 and Figure 9.

Table 9: Laboratory Results, Microtox

Facility ID	Sampling Location	Result, Microtox (EC50%)
Holding Tank – Raw Wastewater (Marina)		
C1	HT	7
F	HT	1
H	HT	45
I	HT	6
J1	HT	10
K	HT	2
Septic Tank – Treated Wastewater (Marina)		
A	STE	3
B	STE	6
C2	STE	2
D1	STI	4
D2	STE	13
E	STE	1
G	STE	2
J2	STI	6
Septic Tank – Treated Wastewater (Campground)		
L	STE	3
M1	STI	2
M2	STE	4
N	STE	1

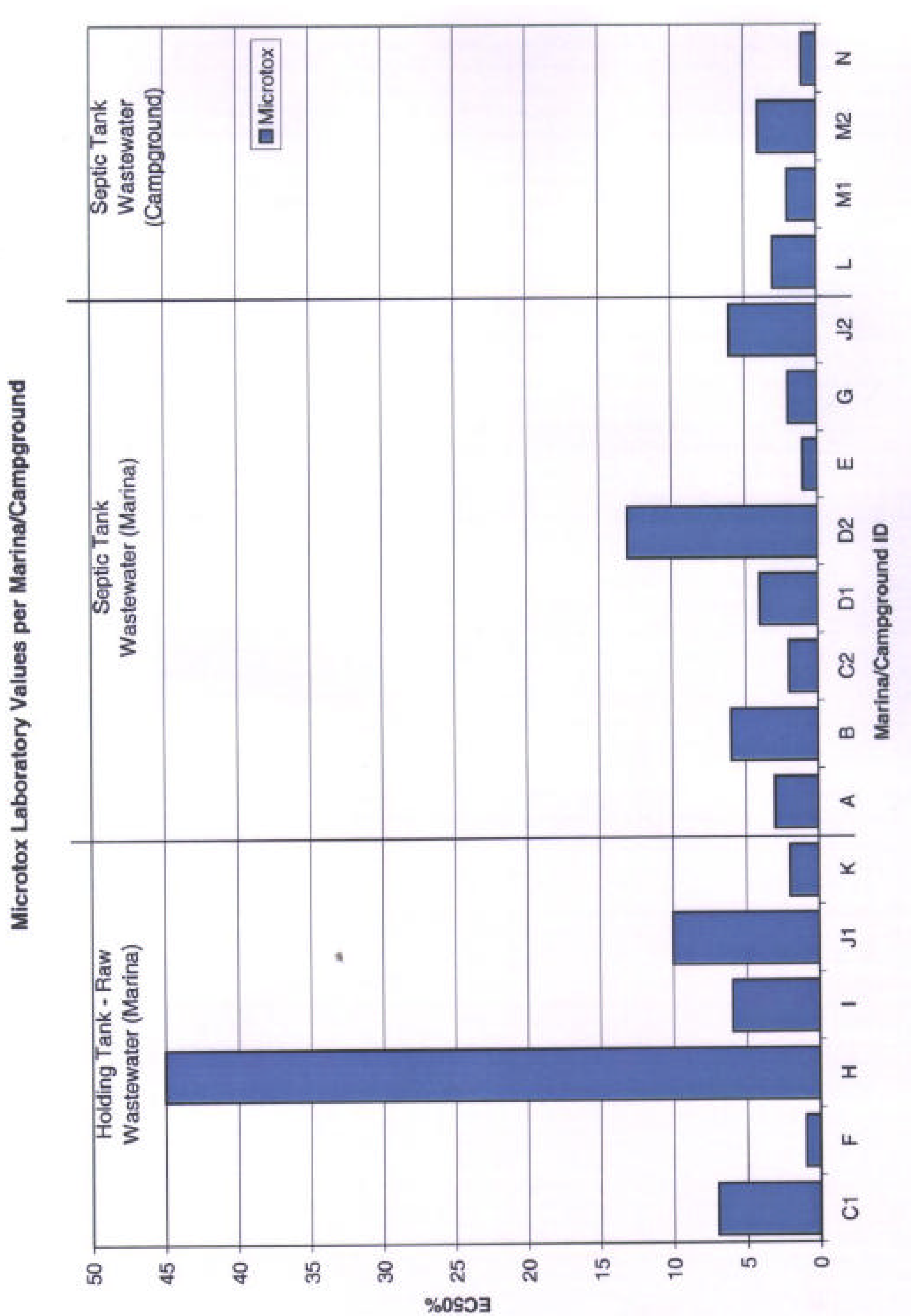

Figure 9: Laboratory Results, Microtox

5.8 Pathogen/Bacteria Indicators

The laboratory results for the two bacteriological parameters, *E. coli* and fecal coliform, vary greatly among the different facilities. The *E. coli* results range from 310 MPN/100 ml to 12,424,800 MPN/100 ml. The fecal coliform results range from less than 100 MPN/100 ml to 49,600,000 MPN/100 ml. The results are presented as ranges because several dilutions were run on all the samples in order to obtain numeric results for each site, even those with very high bacteria counts. The range of results can also be attributed to the fact that the colonies are not distributed evenly throughout the wastewater; it is likely that few samples from the same sampling location would have identical results. Those results that have either a greater than (>) or less than (<) sign before them indicate a population beyond the sensitivity of the analysis at the dilutions used.

Fecal coliform levels in untreated wastewater and septic tank effluent typically ranges from 10^6 to 10^8 MPN/100 ml in septic tank effluent and untreated wastewater. All of the results from the marinas and campgrounds fall in or below this range. Typically, 90% of fecal coliform consists of *E. coli* (Onsite Wastewater Demonstration Project n.d.), so it is assumed that these results should also fall approximately in the range of 10^6 to 10^8 MPN/100 ml in raw wastewater and septic tank effluent. As shown below, the *E. coli* results also fall within or below this expected range.

Since *E. coli* is only one component of fecal coliform, it would be expected that the fecal coliform results would always be greater than the *E. coli* results. This is mostly the case in the holding tank data (excluding sites C1 and K, which have relatively very low populations); however, in most of the septic tank samples (excluding J2 and potentially L) the *E. coli* results exceed the fecal coliform results. This trend is unexplained. The samples for all dilutions for both tests were drawn from the same container. The wastewater and dilutions were stirred before each sample was drawn, so analysis technique is considered to not be the cause of this discrepancy. The laboratory results for both *E. coli* and fecal coliform are presented in Table 10.

Table 10: Laboratory Results, Bacteria Indicators (*E. coli* and Fecal Coliform)

Facility ID	Sampling Location	Results, *E. coli* (MPN#/100 ml – some results listed as a range)	Results, Fecal Coliform (MPN#/100 ml – some results listed as a range)
Holding Tank – Raw Wastewater (Marina)			
C1	HT	400	< 100
F	HT	> 967,680	> 16,000,000
H	HT	358,400 – 368,320	2,666,667
I	HT	19,608 – 35,360	26,667 – 74,800
J1	HT	> 967,680	48,000,000 - 49,600,000
K	HT	310-486	400
Septic Tank – Treated Wastewater (Marina)			
A	STE	310,000	< 500,000
B	STE	483,840	46,000 - 110,000
C2	STE	24,890 – 34,658	2,600 – 10,000
D1	STI	> 483,840	410,000
D2	STE	> 483,840	17,400 - 314,000
E	STE	86,640 - 136,800	300 – 2,000
G	STE	856,000 – 1,160,000	133,333 – 835,000
J2	STI	20,480 – 31,062	48,300 – 146,667
Septic Tank – Treated Wastewater (Campground)			
L	STE	> 4,838	8,300 - 30,000
M1	STI	173,290 - 182,400	260 – 17,600
M2	STE	1,338 – 1,961	400 – 800
N	STE	12,424,800	266,667 – 5,333,333

5.9 Comparisons

Four of the facilities in this study, C, D, J and M, had multiple sampling sites. This provided the opportunity to evaluate the level of treatment being provided through the various systems. Each of the four comparisons below demonstrates unique characteristics along the treatment train. Facilities C, D and J are marinas, while facility M is a campground. Facility C compares the holding tank and final chamber of the septic tank, the two extreme ends of our available sampling locations. Facility D compares the wastewater in two septic tanks that are in series before discharge to the drainfield. Facility J compares the holding tank to the first septic tank in a series of two tanks, representing the septic tank influent. Finally, facility M, like facility D, compares the wastewater in two septic tanks in series; however, these results are unique since it is the one comparison of campground characteristics within the treatment train. Tables 11 through 14 show a side-by-side comparison of the sampling sites by parameter, with discussions of these results below the respective tables.

Table 11: Comparison of Laboratory Results at Facility C from Holding Tank to Septic Tank, Final Chamber

Parameter	C1 (Holding Tank)	C2 (Septic Tank, Final Chamber)
Alkalinity	< 1 mg/l	< 1 mg/l
pH	7.93 @ 19.7 C	7.14 @ 21.1 C
BOD_5	262 mg/l	118 mg/l
COD	1574 mg/l	108 mg/l
Nitrogen as TKN	1400 mg/l	140 mg/l
Ammonia-Nitrogen	1200 mg/l	200 mg/l
Nitrate+Nitrite-Nitrogen	0.48 mg/l	< 0.01 mg/l
Phosphorus	34 mg/l	15 mg/l
Oil & Grease	< 5 mg/l	6 mg/l
Microtox	7 = EC50%	2 = EC50%
E. coli	400 MPN/100 ml	24,890 – 34,658 MPN/100 ml
Fecal Coliform	< 100 MPN/100 ml	2,600 – 10,000 MPN/100 ml

The DWS at marina C consists of a holding tank that receives pump-out waste, and when the tank is filled to a specified volume, the wastewater is pumped to a single septic tank. Here it is combined with restroom wastewater before being discharged to the drainfield. In many categories, marina C shows a marked improvement in effluent quality across the DWS. The BOD_5 levels were cut in half and the COD levels were reduced by more than 90%. In addition, each of the nitrogen species showed decreases of greater than 80%. However, the TKN and ammonia-nitrogen concentrations are still two to five times greater than average residential values after this reduction. Since phosphorus is not treated biologically, it is assumed that a significant portion of the phosphorus became bound in the settleable solids. It is assumed that the increase in oil and grease can be attributed to the additional waste streams that become part of the wastewater after the holding tank, in the septic tank. The relative toxicity increased through the treatment process for unknown reasons, as did the bacterial indicators.

Table 12: Comparison of Laboratory Results at Facility D from Septic Tank #1, First Chamber to Septic Tank #2, Final Chamber

Parameter	D1 (Septic Tank #1, First Chamber)	D2 (Septic Tank #2, Final Chamber)
Alkalinity	< 1 mg/l	361 mg/l
pH	7.00 @ 20.5 C	6.89 @ 20.0 C
BOD_5	326 mg/l	130 mg/l
COD	351 mg/l	9 mg/l
Nitrogen as TKN	300 mg/l	68 mg/l
Ammonia-Nitrogen	250 mg/l	80 mg/l
Nitrate+Nitrite-Nitrogen	0.03 mg/l	0.02 mg/l
Phosphorus	33 mg/l	6.9 mg/l
Oil & Grease	98 mg/l	8 mg/l
Microtox	4 = EC50%	13 = EC50%
E. coli	> 483,840 MPN/100 ml	> 483,840 MPN/100 ml
Fecal Coliform	410,000 MPN/100 ml	17,400 – 314,000 MPN/100 ml

Marina D has no separate holding tank; instead, the pump-out waste is gravity-fed directly to the first septic tank. This facility has two septic tanks in series to initially treat the wastewater before it is discharged to the drainfield. Similar to facility C, the BOD_5 and COD levels were drastically reduced across the two tanks. Again, the nitrogen species also were reduced, though not in as large proportions as facility C. The phosphorus levels are again assumed to be lowered due to binding with solids that settle out. The large decrease in oil and grease demonstrates the importance of a baffled DWS. In this case, the relative toxicity of the wastewater decreased across the system, as did the fecal coliform levels. Due to the large number of *E. coli* colonies, no upper bound of their levels was derived in the lab analyses, so it is unsure whether those total levels increased or decreased. Finally, the wastewater in the final chamber of the second septic tank was one of two samples in the study to have measurable levels of alkalinity. It is unknown if this is a result of processes in the septic tank or the additional wastewater in the waste stream from six bathhouses located on-site.

Table 13: Comparison of Laboratory Results at Facility J from the Holding Tank to Septic Tank #1

Parameter	J1 (Holding Tank)	J2 (Septic Tank #1, Final Chamber)
Alkalinity	< 1 mg/l	< 1 mg/l
pH	6.88 @ 21.0 C	6.25 @ 21.1 C
BOD_5	940 mg/l	406 mg/l
COD	2600 mg/l	2500 mg/l
Nitrogen as TKN	240 mg/l	190 mg/l
Ammonia-Nitrogen	270 mg/l	200 mg/l
Nitrate+Nitrite-Nitrogen	0.03 mg/l	0.07 mg/l
Phosphorus	33 mg/l	31 mg/l
Oil & Grease	48 mg/l	9 mg/l
Microtox	10 = EC50%	6 = EC50%
E. coli	> 967,680 MPN/100 ml	20,480 – 31,062 MPN/100 ml
Fecal Coliform	48,000,000-49,600,000 MPN/100 ml	48,300 – 146,667 MPN/100 ml

Marina J has a holding tank that receives both pump-out waste and wastewater from two restrooms. This combined wastewater is then pumped to the first septic tank in a series of two tanks before discharge to the drainfield. Like the other cases, the BOD_5 levels were reduced by one-half. However, this still left the final chamber septic tank BOD_5/COD values at levels two to five times greater than those normally found in residential septic tank effluent. Again, the COD, TKN and ammonia-nitrogen levels reduced, but by lower percentages than the other two marinas. Very little phosphorus settled out in this first component of the treatment train, while large oil and grease reductions were made. Both bacteriological colony levels were greatly lowered; however, the relative toxicity increased (as in facility C). In looking at these results, it is important to note that this is only the first step in the treatment process, and there is yet a second septic tank and the drainfield before the total treatment is completed.

Table 14: Comparison of Laboratory Results at Facility M from Septic Tank #1, First Chamber to Septic Tank #2, Final Chamber

Parameter	M1 (Septic Tank #1, First Chamber)	M2 (Septic Tank #2, Final Chamber)
Alkalinity	< 1 mg/l	< 1 mg/l
pH	7.08 @ 22.4 C	7.09 @ 22.6 C
BOD_5	1537 mg/l	1117 mg/l
COD	2035 mg/l	1247 mg/l
Nitrogen as TKN	680 mg/l	470 mg/l
Ammonia-Nitrogen	700 mg/l	490 mg/l
Nitrate+Nitrite-Nitrogen	0.15 mg/l	0.06 mg/l
Phosphorus	67 mg/l	44 mg/l
Oil & Grease	140 mg/l	8 mg/l
Microtox	2 = EC50%	4 = EC50%
E. coli	173,290 – 182,400 MPN/100 ml	1,338 – 1,961 MPN/100 ml
Fecal Coliform	260 – 17,600 MPN/100 ml	400 – 800 MPN/100 ml

The DWS at campground M consists of two septic tanks in series, with the partially treated water sent to a dosing tank before being discharged to a several-zone drainfield. This case shows water quality improvements in BOD_5, COD, TKN, ammonia-nitrogen, nitrate-nitrite nitrogen, phosphorus, oil and grease, relative toxicity, and both bacteriological parameters. As at site J, the septic tank #2 final chamber samples also reveal wastewater with BOD_5, COD, TKN and ammonia-nitrogen concentrations three to six times greater than those normally found in residential septic tank effluent.

6 Conclusions

6.1 Summary of Results

The initial focus of this study was to perform a preliminary screening on marina and campground pump-out waste to determine if the characteristics of this wastewater implied potential water quality concerns. The laboratory results for the STE (septic tank, final chamber) sites illustrated that the concentrations of several of the parameters were well above normal design (residential) waste. For example, 50% of the BOD_5 values, 58% of the COD and total phosphorus values and 67% of the nitrogen as TKN and ammonia-nitrogen results showed concentrations that were more than twice as strong as residential wastewater effluent. The drainfield is an important component of the treatment system that was not evaluated in this study. However, the high concentrations of BOD_5, COD, TKN, ammonia-nitrogen, and Microtox in the STE samples suggest that standard drainfields receiving pump-out wastewaters may be severely overloaded.

6.2 Recommendations for Further Studies

To determine whether drainfields are capable of effectively treating this high strength wastewater, we recommend a second-phase study to evaluate the effluent quality below the drainfield, to give an indication of final effluent quality. At this point in the treatment process, the treated wastewater would be impacting either groundwater or surface water and could then be discussed in terms of water quality and drinking water standards. If these standards are met, it would be shown that the total DWS are designed appropriately, and the systems have no adverse impacts on water quality. This study would focus on a few facilities, and would monitor them for a longer time period, approximately a year. This longer-term study would show if the soil is rejuvenated in the marina and campground off-season, and if a biomat is maintained year-round.

In summary, this study was initiated because one incident (from the western Tennessee marina alluded to in Section 1.3, which discussed the project background) suggested that there were potential concerns about the treatment of wastewater at campgrounds and marinas, due to the nature of the wastewaters. This study was developed as a screening to validate the observations at that marina; that is, to determine if the more concentrated, harsh wastewater is a concern across the Valley for DWS at marinas and campgrounds that treat pump-out waste. The laboratory results validate the concern of wastewater quality at marinas and campgrounds; however, the quality of the completely treated effluent from the drainfield is still unknown. The results of this screening imply two alternatives for future study, 1) applying advanced treatment to the wastewater so it enters the drainfield at concentrations similar to residential septic tank effluent or 2) evaluating drainfield performance to determine if the drainfield effectively treats the pump-out wastewater as it passes through. Most of the DWS at marinas and campgrounds in the Valley do not currently have advanced treatment systems onsite; therefore, the next study should be an evaluation of drainfield performance. This study would determine if standard drainfields can handle pump-out wastes before developing advanced treatment systems to meet water quality standards at marinas and campgrounds. The presence of high concentrations of pollutants of concern indicate a need for greater understanding of the marina and campground wastewater effluent and treatment in order to assure that, in the future, DWS designs for these systems truly do eliminate impacts to water quality in and around their watersheds.

Acknowledgements

The time and talents of many people were necessary to complete this body of work. First and foremost, we'd like to thank the marina and campground owners and operators who explained their operations to us and allowed us to pull all the samples. Within TVA, we appreciate the efforts of the Clean Marina Initiative coordinators who helped locate suitable and willing marina/campground partners, all those who helped with the actual sampling, and our in-house wastewater experts who advised with the technical aspects of this project. Finally, we'd like to extend many thanks to the people at all the labs who analyzed the samples, for accepting so many samples in such a short time span, often on short notice. Without all your help, this project would not have been possible.

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Appendix A
Tennessee Valley Clean Marina Guidebook, Introduction and Section 1 (Sewage Management)

Tennessee Valley Clean Marina Guidebook

A product of the Tennessee Valley
Clean Marina Initiative

Prepared by
Tennessee Valley Authority
Chattanooga, Tennessee

2001

The Tennessee Valley Authority developed and authored this guidebook to support marina operators and owners who are voluntarily striving to protect the water resources of the Tennessee Valley. This manual is intended as an educational tool and reference for reducing water pollution and erosion from marina and boating activities. It does not constitute a complete reference to State, Federal, or local laws. Relying on the information in this book will not protect you legally. It is not intended to be legal advice, and should not be relied upon as such. This book may not be relied upon to create a right or benefit substantive or procedural, enforceable at law or in equity by any person.

Tennessee Valley Authority, contributing agencies, organizations, and individuals do not assume any liability for the accuracy or completeness of the information in this publication. Inclusion in this book is not an endorsement of the companies listed. Final determination of the proper handling and disposal of waste is the sole responsibility of the generator.

For more information on the Tennessee Valley Authority, please visit the website: www.tva.gov.

Tennessee Valley Authority
Resource Stewardship
1101 Market Street, PSC 1E
Chattanooga, Tennessee 37402-2801
423.876.4178

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Agencies and organizations working cooperatively to support development and implementation of the Tennessee Valley Clean Marina Initiative include:

Alabama Department of Environmental Management
Alabama Marina Police
The Assistant United States Attorney General
Boone Lake Association
Boone Watershed Partnership
Environmental Crimes Joint Task Force
Federal Bureau of Investigation, Knoxville Division
Friends of Norris Lake
Johnson City Clean Team
Johnson City Power Squadron
Keep Bristol Beautiful
Kentucky Marina Association
Norris Lake Dock Owners Association
Project R.O.S.E. (Recycled Oil Saves Energy)
Tennessee Basin Clean Water Partnership
Tennessee Marina Association
Tennessee Wildlife Resources Agency
Tim's Ford Council
Tim's Ford State Park
TVA Police
United States Coast Guard
USDA Forest Service

And numerous marina managers and owners committed to protecting the water resources of the Tennessee Valley.

Introduction

The Tennessee Valley Clean Marina Initiative (TVCMI) is a voluntary program developed and implemented by Tennessee Valley Authority (TVA) and its watershed partners to promote environmentally responsible marina and boating practices. This program, established in support of the National Clean Boating Campaign, will help marina operators protect the very resource that provides them with their livelihood: clean water. It is designed as an ongoing program to reduce water pollution and erosion in the Tennessee River watershed. The effort will encourage boater education, coordination among state agencies and better communication of existing laws, as well as offer incentives for creative and pro-active marina operators.

The TVCMI includes seven *management measures* that were identified by marina operators as priorities:

- Sewage management
- Fuel Management
- Solid Waste and Petroleum Recycling and Disposal
- Vessel operation, maintenance, and repair
- Marina siting, design, and maintenance
- Stormwater management and erosion control
- Public education

Each management measure is discussed in detail in one of the sections of this guide. Each section offers several *best management practices* (BMPs), individual activities or structures that can be used alone or in combination to achieve the management measures. The BMPs include both pollution prevention practices and source reduction practices.

TYPES OF PRACTICES ADDRESSED THROUGH THE CLEAN MARINA INITIATIVE

Pollution prevention practices occur at the spot where the pollutants are created or used. Pollution prevention measures include all practices that can prevent pollution from either being created or being released into the environment. They are often the first, best, least costly, and most effective ways to prevent contaminants from entering the water.

Source reduction practices occur after pollutants have been created and entered the environment. Source reduction practices are those used between where pollutants are released and the surface water. They include practices that capture, filter, screen, trap, contain, absorb, chemically neutralize, or divert to municipal sewer lines any pollutants before they can get into the water. Recycling is a form of source reduction.

The scope of this guide is broad, covering diverse nonpoint source pollutants from marinas and recreational boating. Because all waterbodies and marinas are different, not all practices and techniques described in this guide will be applicable to all situations. Also, BMPs are continually being modified and developed as a result of experience gained from their implementation and the innovation of marina owner and operators across the country.

This guide can assist marina owners and managers in identifying potential sources of nonpoint source pollution and offer potential solutions. Finding the best solution to any nonpoint source pollution problem at a marina requires taking into account the many site-specific factors that together comprise the setting of a marina.

BENEFITS OF ACHIEVING CLEAN MARINA DESIGNATION

By participating in the TVCMI your marina can demonstrate its commitment to addressing water quality issues. If successful, it could help the marine industry avoid new regulations. Marina operators, who depend on boaters for their income, have the utmost interest in protecting the resource upon which they rely so heavily. Studies have shown that the most important aspect in a marina for boat owners is cleanliness. By operating a clean, safe marina and flying the Clean Marina flag, you have an advantage in attracting new customers. Chances are, the new customers you attract will be more environmentally responsible, thus reducing your liability from careless boaters.

You also have opportunities for new revenue sources such as selling and promoting the use of "green" products in your marina store. Renting equipment such as vacuum sanders to your customers also presents a new source of revenue. Additionally, by reducing, reusing and recycling, marina operators can cut the costs of waste disposal/removal while encouraging environmentally sensitive behavior. Using non-disposable products and products that allow re-use can also save on the cost of supplies. These practices are mutually beneficial for your marina and the resource on which it depends.

STEPS TO BECOMING A TENNESSEE VALLEY CLEAN MARINA

The first step toward Clean Marina designation is to sign the pledge card included in the introductory material delivered to your marina. These are also available at your nearest TVA Watershed Team Office. In signing the pledge card, you commit "to controlling pollution and erosion at your facility and to promoting water-protective behavior with the boating public" as you work toward attaining Tennessee Valley Clean Marina status. Return a copy of the pledge card to the appropriate TVA Watershed Team and keep the original to display at your marina. Watershed Teams will provide you with a Clean Marina Checklist and a *Tennessee Valley Clean Marina Guidebook* to get you started.

The second step is to review the Clean Marina Checklist carefully to understand the goals and objectives of the initiative. If you have any questions, the Watershed Team and their partners for your reservoir is on hand to provide assistance.

Make a preliminary assessment of your marina using the Clean Marina Checklist. You may want to reference the guidebook as you do this, as it includes recommended actions to address the various checklist items. At the same time, consider which actions you need or want to select in order to reach Clean Marina status. When you have completed your marina assessment, contact your TVA Watershed Team to schedule a visit. With your checklist to guide you, review your assessment with the team member who visits, identify areas where improvements are indicated, and work with them to develop a plan of action for attaining Clean Marina status.

TVA and its partners can provide assistance, help you find needed resources and answer, or help find the answer, to any of your questions. The goal is to have all Valley marinas who wish to participate successfully certified as a Clean Marina within two years of committing to be a part of the program. When your marina has succeeded in implementing the agreed to actions on the checklist, contact the Watershed Team to schedule an endorsement visit.

After the successful endorsement visit, you will receive a Tennessee Valley Clean Marina certificate acknowledging your commitment and authorization to use the Clean Marina logo. You will also receive a Clean Marina flag to fly from your property. Your marina will be recognized in press releases, on the TVA Web site, and in other Clean Marina promotions and events.

Sustaining your Clean Marina status is easy. Simply complete a new self-assessment once every two years using the Tennessee Valley Clean Marina Guidebook and Checklist. When it is time for your self-assessment, call your Watershed Team to receive the most current checklist. Complete the self-assessment and set up a meeting with a TVA Watershed Team member for a visit to reaffirm your Clean Marina status. As rules and regulations are not static, you will be notified if there are any changes in the contents of the guidebook and checklist. You will also receive fact sheets on new technologies and products as they become available.

CONTACT INFORMATION FOR TVA WATERSHED TEAM OFFICES

Upper Holston Watershed Team: Boone, Bristol Project, Fort Patrick Henry, South Holston, Watauga, and Wilbur

Suite 218
4105 Fort Henry Drive (HFB 1A-KPT)
Kingsport, TN 37663
423.239.2000

Cherokee-Douglas Watershed Team: Cherokee, Douglas, Nolichucky, and French Broad

2611 West Andrew Johnson Highway (WPB 1A-MOT)
Morristown, TN 37814
423.587.5600 or 423.632.3791

Clinch-Powell Watershed Team: Clinch, Norris, and Powell
P.O. Box 1589 (ABL 1A-N)
Norris, TN 37828
865.632.1539

Melton Hill Watershed Team: Great Falls, Melton Hill, and Watts Bar
2009 Grubb Road
Lenoir City, TN 37771
865.988.2440

Little Tennessee Watershed Team: Fontana, Fort Loudoun, Tellico, and Little Tennessee
Suite 300
804 Highway 321 North (HWY 1A-LCT)
Lenoir City, TN 37771
865.988.2420

Hiwassee Watershed Team: Apalachia, Blue Ridge, Chatuge, Hiwassee, Nottely, and the Ocoees
221 Old Ranger Road (MLO 1A-MRN)
Murphy, NC 28906
828.837.7395

Chickamauga-Nickajack Watershed Team: Chickamauga and Nickajack
1101 Market Street (PSC 1E-C)
Chattanooga, TN 37402
423.876.4178

Guntersville Watershed Team: Guntersville
2325 Henry Street (WTR 1A-GVA)
Guntersville, AL 35976
256.571.4280

Wheeler Watershed Team: Lower Elk and Wheeler
Reservation Road, (SB 1M-M)
P.O. Box 1010
Muscle Shoals, AL 35662
256.386.2560

Pickwick Watershed Team: Bear Creek, Cedar Creek, Little Bear Creek, Pickwick, Upper Bear Creek, and Wilson

Reservation Road (SB 1H-M)
P.O. Box 1010
Muscle Shoals, AL 35662
256.386.2560

Elk-Duck Watershed Team: Columbia Project, Duck, Elk, Normandy, and Tims Ford

P.O. Box 1010 (CTR 2U-M)
Muscle Shoals, AL 35662
256.386.2568

Kentucky Watershed Team: Beech River Project, Kentucky, and Lower Duck

202 W. Blythe Street (LM 1A-PAT)
P.O. Box 280
Paris, TN 38242
731.641.2000

Using the Guidebook

"Helpful Hint: As you read through the Guidebook, you will find that the practices listed in each section correspond to the items listed in the Checklist."

The *Tennessee Valley Clean Marina Guidebook* is a reference tool complementing the self-assessment checklist. The sections in the checklist correspond to the sections in the guidebook. As you work through the checklist, refer to the applicable guidebook section for background information and recommended actions. The section called "Programs to Control Nonpoint Pollution" summarizes the requirements of TVA, local, state and federal agencies and is referred to in applicable chapter items.

Two other publications will provide further support and details important to successful implementation of the Clean Marina program:

- *Sewage Systems for Recreational Boats* - a joint publication of Tennessee Wildlife Resources Agency and Tennessee Valley Authority that offers the text of the state and federal laws and provides detailed information on sewage system design, and equipment selection, installation and maintenance, and
- *2001 Guide for the Safe Operation and Maintenance of Marinas* – by the National Water Safety Congress, the recommendations in this publication provide a guide for minimum safety requirements for the operation and maintenance of marinas to assure adequate protection of the public from mishaps, encouraging compliance with applicable state and local codes, the National Fire Protection Association Codes, the National Electric Code, and Code of Federal Regulations, Title 40, Subchapter I Solid Wastes, Part 280.

All actions required by regulation and law are not negotiable and must all be implemented in order to achieve Clean Marina status.

Section 1 Sewage Management

Background

Raw or improperly treated boat sewage is harmful to human health and water quality. Sewage contains nutrients that can stimulate pathogens (fecal coliform bacteria and viruses) and plant growth (algae and aquatic plants).

"Consider including information about the MSD regulations in your lease agreements with boat owners."

Gastroenteritis, hepatitis, and other waterborne diseases may be passed directly to people who swim in contaminated waters. Pathogens can affect health directly through contact in the water or indirectly through the consumption of contaminated shellfish.

Microorganisms present in sewage need oxygen. When sewage is discharged to waterways it reduces the amount of oxygen available to fish and other forms of aquatic life. The heavy nutrient load in sewage encourages excessive algal growth, which in turn blocks life-giving sunlight from reaching subsurface vegetation providing habitat for aquatic life. When the algae die, the bacteria active during the decomposition process reduce the levels of dissolved oxygen.

Progress has been made toward eliminating discharges of sanitary waste from boats through designation of no discharge zones, installation of pumpouts nationwide, and the growing number of boater education programs. Efforts to reduce sewage discharges and to educate boaters about the impacts caused by sewage discharges needs to continue, and marinas can play a direct and important role in these matters.

1. Comply with federal, state and local wastewater outfall and septic system regulations. Ⓡ

It is illegal to discharge raw sewage from a vessel within U.S. territorial waters. Discharge of any pollutant from a point source (outfall) into waters of the U.S. requires a National Pollutant Discharge Elimination System (NPDES) permit from the state. In addition, written permission (permit or other appropriate document) from the municipality must be obtained for discharging into a municipal sewer; written permission from the state and local groundwater/drinking water authorities must be obtained for discharging into the groundwater; and all septic systems must be permitted by the county and inspected for proper installation by the county health department.

For example, if a marina in Tennessee has, or plans to install, a holding tank for wastewater and therefore needs to obtain a State Operating Permit and have the engineering plans approved, the manager should contact the Tennessee Division of Water Pollution Control at the nearest Environmental Assistance Center (1.888.891.TDEC). A marina can also contact the Tennessee Division of Groundwater Protection at this number if such information is needed as a septage/wastewater hauler licensed in Tennessee.

A TVA Section 26a permit may also be required for activities subject to wastewater permits. Check with your Watershed Team. TVA may request copies of other federal, state, and local permits, licenses, and approvals required for your facilities when you apply for a TVA 26a permit.

2. In "No Discharge" reservoirs, require that marine sanitation device (MSD) Type III holding tanks be pumped into sewage treatment systems and no sewage be discharged overboard. Ⓡ

A "No Discharge Area" (NDA) is an area of water that requires greater environmental protection and where even treated sewage cannot be discharged from a boat. In NDAs, Type I and Type II systems must be secured so no discharge can be released. All freshwater lakes, reservoirs, and rivers not capable of interstate vessel traffic are defined by the Federal Clean Water Act as NDAs. With the approval of the U.S. Environmental Protection Agency, states may establish other NDAs in waters of the state.

The most common form of a TYPE III system is a holding tank. Type III systems do not allow sewage to be discharged. If an overboard discharge system ("Y" valve) is installed after the holding tank, the "Y" valve must be secured to prevent overboard discharge of raw sewage in all U.S. waters.

Good plumbing is the key to controlling holding tank odors. Fiberglass and metal tanks are highly resistant to permeation. Specially labeled flexible "sanitation hoses" and PVC piping are also highly impermeable. Hoses should be run the shortest route possible and be as straight as possible. Wherever it is practical, rigid pipe should be used below the level of the holding tank and wherever sewage will tend to accumulate. Seals should be tight and the number of connections kept to a minimum. Odors can be further controlled by use of enzyme-based deodorizing products in the holding tank.

Other forms of Type III systems include recirculating and incinerating systems. A Coast Guard label is not required.

3. Keep inventory records of all sewage pumpout users, dates, and volumes pumped. Ⓡ

A sign-in sheet at your pumpout enables you to measure usage and monitor users.

4. In "Discharge" reservoirs, require that no untreated or improperly treated sewage be discharged overboard. Ⓡ

The Federal Clean Water Act requires that any vessel with an installed toilet be equipped with a certified Type I, Type II, or Type III MSD. Whatever system is utilized, it is illegal to release untreated sewage in U.S. territorial waters. When MSD I's and II's are used, it is critical to disinfect the waste appropriately in order to be in compliance with the regulation.

"Check with your state about grant funding for installation of pumpout facilities."

Type I systems macerate, or mechanically cut, solids, disinfect the waste with a chemical additive or with chlorine disassociated from salt water with an electronic jolt, and discharge the treated sewage overboard. To be in compliance with the law, the fecal coliform bacteria count of the effluence (waste being released) may be no greater than 1,000 per 100 milliliters and may not contain any floating solids.

Type II systems are similar to Type I systems except that the Type II's treat the sewage to a higher standard, require more space and have greater operating energy requirements. In Type II systems the effluent fecal coliform bacteria levels may not exceed 200 per 100 milliliters and total suspended solids may not be greater than 150 milligrams per liter.

Deodorizing agents may or may not be used in both these systems. Most products available to control odors do not disinfect. Labels must be read carefully and directions followed to assure that appropriate chemicals are being used to reduce bacteria count to acceptable levels.

Boats 65 feet in length or less may install a type I, II, or III device. Vessels over 65 feet must install a Type II or III device. Type I and Type II systems must display a certification label affixed by the manufacturer.

5. Have a pumpout system that meets the needs of your marina users either free or at a reasonable cost, or have an agreement with a mobile pumping service for servicing boats in your marina.

Four types of onshore sewage collection systems to handle sewage from boat holding tanks and portable toilets are available—fixed point systems, dump stations, portable/mobile systems, and dedicated slipside systems.

- *Fixed-point collection systems* include one or more centrally located sewage pumpout stations. The stations are usually located on the fueling dock, so that fueling and pumpout operations can be done at the same time.

- A *dump station or a wand attachment* for a fixed-point system may be a satisfactory disposal facility in a marina where boats use only small portable toilets.

- *Portable/mobile systems* are similar to fixed-point systems. A portable unit includes a pump and a small storage tank. The unit is moved where the boat is docked. Portable pumpout facilities might be the most feasible, convenient, accessible, regularly used, and affordable way to ensure proper disposal of boat sewage.

- *Dedicated slipside systems* provide continuous wastewater collection at select slips in a marina. Slipside pumpouts are particularly suited to large houseboats and other extended use vessels. Dedicated slipside pumpout points could be provided to slips designated for boats receiving heavy use, while the rest of the marina could still be served by either a fixed point or mobile pumpout system.

Provide pumpout services at convenient times and either free or at a reasonable cost. Pumpout stations should be available to all boats that are able to access them and cannot be restricted to marina members. Keeping fees low or offering pumpouts for free encourages boaters to use pumpouts. Remember that no more than $5.00 may be charged if Clean Vessel Act grant funds were accepted to purchase and/or install your system.

The presence of a pumpout station promotes a public perception that you are environmentally responsible. With increased emphasis on the need for holding tanks to be pumped out regularly throughout the Valley, more customers will also be drawn to your dock. Each arriving vessel represents an opportunity to sell fuel, hardware and food items.

6. Have a dump station or a wand attachment to empty portable toilets.

MSD requirements do not apply to vessels with portable toilets. Portable toilets must be properly emptied on shore. Remind boat owners with portable toilets that it is illegal to discharge raw sewage to any U.S. waterway. This may be accomplished through signs or other methods.

7. Keep pumpout stations clean and easily accessible, and/or have marina staff do pumpouts.

Free pumpouts are certainly an attraction for customers, but cleanliness and ease of use are popular features as well. Customers are more likely to use pumpouts if they are kept clean and neat. It is especially important to periodically disinfect the suction connection of a pumpout station by dipping or spraying it with disinfectant, in order to control bacteria and odors.

The ability of a pumpout station to attract new customers is magnified when pumpouts are done by marina staff. Consider installing a buzzer or paging system so that boaters at the pumpout station can easily locate the attendant. If the station is unattended, be sure that clear instructions for use are posted.

Post highly visible signs for passing boaters, making them aware of your pumpout facility or directing them to the nearest public pumpout if you do not have one available.

8. Regularly inspect and maintain your sewage facilities.

A pumpout system that is well maintained will run more efficiently, saving on repair costs in the future. Regular inspections of the pumpout system help insure that any problems are repaired immediately, before they become more serious problems. A regular maintenance schedule and a maintenance log ensure a septic system operates efficiently. It is advisable to establish a maintenance agreement with a qualified contractor for service and repair of pumpout facilities if one is available in your area.

Marina workers should handle waste collection with care, taking precautions to avoid coming into direct contact with sewage. Make rubber gloves and respirators available to workers who maintain or repair your pumpout system or MSDs and encourage their use.

Do not allow rinse water or residual waste in the hoses to drain into the reservoir or river. Keep the pump running until it has been re-primed with clean water.

Dispose of collected waste in the most environmentally sound way possible. One of the best options for disposing of the collected waste is to connect directly to a public sewer line. If sewers are not available a holding tank is usually the option available to you.

The contents of the tank must be pumped periodically and trucked to a treatment plant. Holding tank size and location is generally determined by the local health department. Selection of a well-qualified, licensed, dependable hauler is key to effective disposal of collected waste from a holding tank system.

9. Hold MSD inspections periodically at your marina, assuring that MSDs are properly installed and functioning; appropriate chemicals are being used in MSD Types I and II if they are approved for use in your reservoir; and "Y" valves are tied down so no raw sewage may be released into the water.

Malfunctioning marine sanitation devises (MSDs) are a cause of nonpoint source pollution. Marina operators can help boat owners discover the MSD malfunctions by offering Type I and II MSD inspections free or for a small charge. Follow-up maintenance service can remedy any problems found during inspection. Environmental audits and retrofits on engines, bilges, fuel systems, and MSDs can be an additional revenue source for your marina.

It is strongly recommended that holding tanks equipped with Y-valves have the valves in the closed position to prevent accidental discharge into boating waters. Marina operators can provide Y-valve lock downs to patrons to ensure that the valves remain in the closed position.

In the Tennessee Valley you may request the assistance of the U.S. Coast Guard Auxiliary, state wildlife or natural resources officers, or TVA Police to assist with this effort.

Boaters may be encouraged to run dye tablets through their Type I and Type II systems outside of the marina basin. If a system is operating properly, no die will be visible. Maintenance is required if dye can be seen in the discharge.

10. Maintain records of MSD inspections, noting boat owners, registration numbers, and all violations identified on date of inspection.

Maintaining records of MSD inspections will help you identify repeat violations and provide you with documentation of warnings issued.

11. Designate your marina as a "No Discharge" marina and prohibit sewage discharges within your marina basin/harbor limits.

Federal law prohibits discharge of untreated sewage into all TVA reservoirs, but does allow, in "discharge" reservoirs, the use of Type I and II marine sanitation devices (MSDs) which pre-treat boat sewage before it is discharged overboard. A marina operator may prohibit sewage discharges altogether within the marina with the addition of a clause to the slip rental contract stating that sewage discharge is not permitted.

To go further, you can state that failure to comply with the MSD laws and marina policy will result in expulsion from the marina and forfeiture of fees. In follow-through, if a customer fails to observe the law or honor your contract:

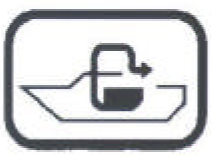
- Discuss the matter with the customer,
- Mail a written notice asking that the offending practice stop immediately and keep a copy for your records, and
- If this does not get desired results, evict the boater.

If a tenant is discharging raw sewage, you may report him to your state agency with jurisdiction over boating waste. Provide as much information as possible: name of owner, ID number, location, etc.

12. Establish equipment requirement policies that prohibit the use of "Y" valves on MSDs, such as installation of tie-downs.

Only the relatively few boats that do travel out beyond the 3-mile limit may use a "Y" valve to discharge overboard. Yet the reality is that many boats that never enter the ocean have "Y" valves, seacocks, and thru-hulls installed. "Y" valves (also called cheater valves) have no purpose except to bypass the holding tanks or release untreated sewage. This is clearly illegal and not good for water quality.

"The national pumpout symbol is an easy way to advertise the availability of pumpout facilities."



A number of marinas, nationally, are no longer allowing "Y" valve use or thru-hull fittings. Many states provide "Y" valve tie downs that are numbered for distribution and tracking purposes. For example, in the state of Tennessee, marina operators may request tie-downs from the Boating Division of the Tennessee Wildlife Resources Agency. "Y" valves may also be locked closed using small locks, wire or tie-downs purchased from a variety of suppliers, but use of the state-supplied tie-downs is the preferred option when they are available. Their use allows you to match the tie-down to a specific boat and identify if the seal has been broken in order to release untreated sewage.

Thru-hull fittings may be plugged solid before allowing boats with holding tanks to sign a lease agreement for space in your marina.

13. Have clean, functioning restrooms available 24 hours a day.

Clean, dry, brightly lit restrooms in marinas will generally be used instead of boat toilets, especially if easy to get to. Restrooms are the best way to reduce boat toilet use, especially when they are pleasant, functional, and safe. Keep dock, paths, and restroom/shower areas well lit at night for safety and security.

Appendix B
Selection Matrix and Talking Points

Marina Selection Matrix

Marina Name	Have OWTS	Have Pump-Out	Willing to Partner (High, Med, Low)	Size (Vol. Pumped)	Location (Reservoir or Stream)	Restaurant (Yes/No)	Boat Cleaning (Yes/No)	Fish Cleaning (Yes/No)	Other

Watershed Team ____

CMI Coordinator ____________________________

Address____

Phone: _________________

E-mail: ___________________

Marina/Campground Wastewater Characterization Talking Points

Marina/Campground Wastewater Issues

- Many marinas and campgrounds are adding or expanding sanitary waste pump-out systems
- Sanitary waste holding tanks often have disinfectants or deodorizers added (some include toxic ingredients, such as formaldehyde or quaternary ammonia).
- Increased wastes place new and unknown stresses on onsite wastewater systems (OWS), such as septic tank-absorption fields.

Operational or Design Failures

- Designers/installers can not properly select the type and size of treatment system without knowing what is in the wastewater.
- Systems may be either too small and not protect human health and the environment or may be too large and not cost-effective

Current Project = 1st Step

- Characterize the wastewater at marinas and campgrounds that use OWS
- EESE has partnered with Resource Stewardship to identify representative facilities willing to partner in this study.

Marina/Campground Selection Factors

- Facility uses an OWS not a city sewer and has a pump-out facility which discharges to the OWS
- Cooperative owner/operator = access and information about use and wastewater
- Geographic location (east, central, west) or mainstem vs. tributary
- Size of facility (volume of pump-out waste, gallons/week)
- Auxiliary facilities, such as campgrounds, restaurants, boat cleaning operations, or fish cleaning
- Ease of physical access to pump-out wastes and OWS for sampling

Sampling Locations

Three locations to show how wastewater is treated as it moves through the OWS. Ideally we would also sample as it left the drainfield completely treated but that is beyond the scope of this study.

- Pump-out wastewater (potentially highest concentration of possible toxic compounds)
- Influent to septic tank (mixed raw wastewater)
- Septic tank effluent (partially treated wastewater)

Benefits

- Determination of the presence or absence of toxic materials, such as formaldehyde or quaternary ammonia compounds
- Knowledge of potential impacts to onsite treatment system performance and possibly the environment
- Better onsite wastewater treatment designs reducing impacts on the environment and supporting growth in the marina/campground industry

Appendix C
Marina/Campground Study Workplan

Marina Characterization Sampling Workplan

BACKGROUND

Many marinas and campgrounds across the Tennessee valley would like to expand; however, they may be limited by available dripfield area if central sewer is not available. This study seeks to characterize the wastewater coming from pumpout systems and in the septic tanks, to determine what effects, if any, are caused by the use of additives and deodorizers in holding tanks. Eleven marinas and three campgrounds have been chosen, with the objective of getting a 'representative' mix of marinas across the valley in terms of size, and other included waste streams (restaurants, bathrooms, RVs, etc).

OBJECTIVE

The object of this work is to sample the wastewater/sewage at marinas and campgrounds across the Valley to characterize the systems.

SCHEDULE

Initial site visits will be conducted in June and July to determine sampling sites. Sampling visits will take place in July, August and early September.

WORK DESCRIPTION

Summary:
After determining appropriate sampling sites at each marina/campground, gain access to the holding tanks and septic tanks. First, all samples except the bacteria samples and oil and grease will be collected with a disposable glass coliwasa tube and dispensed into the bottles for the Central Labs' and Microtox analyses. Next, the bacteria samples (e. coli & fecal coliform) will be collected with the glass coliwasa tube (collected as late as possible due to their short holding time of six hours). Finally, the oil and grease 'dipper' will be used to collect the oil and grease sample. When all samples have been collected, they will be placed on ice in coolers. The bacteria samples are to be delivered immediately to the appropriate field lab, with the others being delivered to the Central Lab and Technical Laboratories (Microtox) promptly.

Detail:
<u>Preparation</u>
Prior to the sampling event, all bottles will be labeled according in a standard format, and lab custody sheets will be prepared. Several coolers will be packed, to transport the samples back to Chattanooga, and a source for ice will be identified on the way to

the sampling site. Upon arrival at the marina/campground, the EESE contact will be met to alert them of our presence, and to ensure that the holding tank/septic tank is ready to be accessed. Before opening the tank, all sampling personnel will put on splash-proof clothing (Tyvek) and gloves, and will have safety glasses ready to put on before the sampling begins. The coliwasa tube, oil and grease 'dipper' and drip bucket will be cleaned and ready for sampling. Rinse water will be available at the sampling location. A brief safety meeting will take place prior to sampling at each location.

Central Lab (except oil and grease) and Microtox Sampling

If the samples are being collected via a valve, the valve will be opened, and the wastewater will pour directly into the sample bottles. If the sample must be collected from inside a tank, a disposable glass coliwasa tube will be used to collect and dispense the samples. If there is a crust on the wastewater surface, it must be broken up and maneuvered out of the way of the coliwasa tube. To operate the coliwasa tube, it must be lowered into the wastewater column with the inner tube held up to allow effluent to flow in. When the sampling tube is thought to be full, or has been placed at a reasonably full depth, the inner tube is to be lowered in place. This will secure the opening that seals the coliwasa tube to fall into place. If the wastewater level remains constant as the coliwasa tube is pulled from the tank, then you know it is sealed.

Once the coliwasa tube is removed from the tank, it will be held over the sample bottle, with the sampling bottles placed beneath it to catch the wastewater as it is released from the coliwasa tube. This can be done over the tank with little leakage, since flow out of the coliwasa tube is easily controlled by how much the inner tube is lifted. Each bottle will be filled with remaining head space dictated by lab needs. After the bottles are filled and sealed, they will be washed with the rinse water and set aside.

All samples are to be taken from cleaner to dirtier, being from effluent wastewater to influent wastewater. By doing this, the only one coliwasa tube will be needed per given marina/campground. Any error induced in the laboratory results in this manner is considered acceptable for this preliminary study.

Bacteria Sampling

The bacteriological sampling is to be completed last among the samples gathered with the coliwasa tube, since it has the shortest holding time of six hours. For these samples, the effluent in the coliwasa tube will be released directly into the sampling bags, up to the indicated level. The bags are then flipped over three times quickly to seal them, with the wire ties folded over the top to secure the bag. During this sampling, it is important to ensure that the chemical tablet remains in the bag. After the bags have been filled and sealed, they are rinsed and set aside.

Oil and Grease Sampling

Again, if the oil and grease sample is being collected via a valve, the valve will be opened, and the wastewater will pour directly into the sample bottle. Should the sample be taken from inside a tank, the bottle will be secured into the dipping equipment for the sample to be collected directly. If there is a crust on the wastewater surface, it must first be broken up with a stick or other hard object, and pushed out of the way of the ‘dipper.’ The person sampling must be sure to lower the bottle into the wastewater at an angle upright enough to prevent the preservative from pouring out of the bottle. This sample will be skimmed from the top as much as possible. A small amount of head space in the bottle is permissible. Once the sample bottle has been sealed, it will be rinsed clean with distilled water, and set aside for re-bagging.

Post-Sampling

After all samples are collected, they are to be placed upright on ice in a cooler, with each bottle in a ziploc bag for extra protection. Sampling personnel are to make sure that the sample collection time is clearly written on each bottle. The oil and grease dipper, and screwdriver used to attach and release the sampling bottle, are to be thoroughly disinfected with rubbing alcohol, along with any other re-usable equipment that may have been contaminated. All disposable sampling clothing (Tyvek, gloves) and the glass coliwasa tube are to be disposed of in dumpsters on site. After sampling personnel have thoroughly cleaned the equipment and returned the sampling location to its original state, the access points are to be closed, and marina personnel notified. Our marina contacts will be thanked again for their time and participation, and any follow-up questions will be answered. Samples will then be transported to their appropriate labs as quickly as possible.

Sampling Bottles/Holding Times

Parameter	**Bottle**	**Holding Time**
Alkalinity	1-L Poly	N/A
Ammonia-Nitrogen	250-ml Poly, Spiked	28 days
BOD	1-L Poly	48 hours
COD	125-ml Poly	28 days
Nitrate+Nitrite	250-ml Poly, Spiked	28 days
Nitrogen, TKN	250-ml Poly, Spiked	28 days
Oil & Grease	1-L Clear Glass, Spiked	28 days
Bacteria (e.coli/fecal coliform)	Whirl-Pak® Sample Containers	6 hours
pH	1-L Poly	N/A
Total Phosphorus	250-ml Poly, Spiked	28 days
Microtox	125-ml Amber Glass, Teflon-Lined	48 hours (to get to lab)

RESPONSIBILITIES

The responsibilities of all project personnel are listed below. All personnel involved should review this document and reference documentation thoroughly. All questions and/or comments should be directed to the Project Manager.

Project Manager – Charlie McEntyre
The Project Manager is responsible for scoping meetings, project planning and overseeing the development of the workplan, including job safety analysis and project cost estimate. Charlie is the technical leader, while Melissa is the customer contact, financial manager and technical assistant. During the operation of the sampling, Charlie will be available for guidance and technical assistance.

Team Engineers – Melissa Matassa & Jonathan Walker
The Team Engineers are responsible for coordinating with the Project Leader to provide engineering assistance during the project. Melissa will be the primary contact with the lab, and the partnering marinas and campgrounds. In addition, she will schedule all site visits and sampling events and will lead the writing of the final report. Jonathan will provide assistance in collecting samples.

SAFETY

Personnel are responsible for their own standard safety supplies/equipment, including their TVA badge. At a minimum, this should include safety boots, rain gear, gloves, Tyvek suits and safety glasses. Life jackets are required when boat transport to the sampling site is necessary. The Team Engineers will also conduct a brief safety meeting prior to the beginning of the project, addressing:

- Job safety analysis (JSA)
- Potential safety hazards associated with the project and how to avoid them.
- Necessary safety equipment for the sampling area (e.g. gloves, safety glasses, etc.)

SUPPLIES AND EQUIPMENT

In addition to safety considerations, the following supplies and equipment serve as a checklist of items needed for the project. All personnel should review the list and contact the Team Engineer if there are any questions or if other supplies or equipment are needed.

- Vehicles
- Weather-Proof Note Pads
- Portable Radios/ Cell Phones
- Tool Box/ Hand Tools
- Coolers (Minimum 3)
- Stopwatch for Composite Collection
- Ziploc Bags (for sample bottles)
- Splash-proof Clothing (including gloves)
- Anti-bacterial Soap
- Fine/Extra Fine Point Industrial Sharpies
- Digital Camera
  - Pocket Knife
- Sampling Bottles (listed above)
  - Ice for Packing Samples
  - Sufficient Disposable Coliwasa Tubes
- Oil & Grease Collection Equipment
- Trash Bags
- Plastic Bucket

EES CONTACTS

Project Manager

Charlie McEntyre
MR 2U-C
(423) 751-4123

Environmental Engineers

Melissa Matassa
MR 2U-C
(423) 751-3709

Jonathan Walker
MR 2U-C
(423) 751-2643

CUSTOMER CONTACTS

RS – CMI Coordinator:
Linda Harris
PSC 1E-C
(423) 876-4178

DELIVERABLES

- Project Implementation
- Job Documentation, Including Appropriate Records/Forms and On-site Safety Review
- Final Report