SECTION IV ESTIMATING WASTEWATER CHARACTERISTICS

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TABLES

SECTION IV ESTIMATING WASTEWATER CHARACTERISTICS

A. Introduction

This section provides information on wastewater characteristics for residential, commercial and institutional sources obtained from various published sources. In addition, significant information on wastewater characteristics gleaned from the engineering reports and Discharge Monitoring Reports (DMRs) in the files of the Department for large scale on-site wastewater renovation systems (OWRS) is also presented herein.

It is important to understand that historical data on wastewater characteristics is accurate for the time and place in which they were obtained. In many cases the historical data is based on statistical analyses of the results obtained from grab samples of relatively small sample sizes. These analyses assume the results can be described by arithmetically normal distributions, which is not necessarily true.

Most of the historical OWRS data are based on grab samples of septic tank effluent. The acceptability of characterization of septic tank effluent using grab samples is based on the premise that the septic tank effluent has been "homogenized" by the physical and biological activity that takes place within the septic tank. This may be a reasonable assumption where the wastewater flow rate is low, no large wastewater flow surges occur, the wastewater characteristics are relatively uniform on a temporal basis, and there is ample detention time in the septic tank. These conditions may be approached most of the time in the case of residential wastewater sampling. However, this is generally not the case for septic tanks receiving commercial, institutional and community wastewater.

Some factors that influence the results obtained from sampling of septic tanks include:

1. Configuration of the septic tank(s) sampled, including shape [rectangular or circular cross-section], volume, length to width ratio, liquid depth, number of compartments, the type and arrangement of baffles, the presence of effluent screens, and actual liquid detention time.

2. Frequency of pumping (cleaning) the tank (i.e. too great a depth of solids in the tank adversely effects the pollutant removal efficiency of the tank).

3. Whether the sample(s) were taken shortly after the tank(s) had been pumped.

4. Sampling protocol, including location and depth in which the samples were taken, whether the samples were randomly taken, the preparation and handling of sample containers, and the time elapsed between sampling and testing.

5. Temperature in the septic tank (varies with the seasons).

6. Number of samples taken.

7. Method(s) of analyzing test results.

8. Laboratory accuracy.

Variations in some or all of these factors may cause the sample results to be biased.

While septic tanks serving individual residences typically provide a retention time of 2 to 3 days or more, many septic tanks receiving commercial, institutional and community wastewater have much lower retention times, generally less than 24 hours. For example, the Manual of Septic Tank Practice (U.S. Public Health Service-1972) recommended that, for wastewater flows greater than 1,500 gpd, the minimum effective tank capacity should equal 1,125 gallons plus 75 percent of the daily flow. This recommendation has been widely followed for design of large-scale OWRS. Consider that, for a flow of 5,000 gpd, the recommended volume = 3,750 gal. + 1,125 gal. = 4,875 gal, which would provide a nominal detention time of somewhat less than one day. Thus, if the Manual of Septic Tank Practice recommendation is followed, it can be expected that the percent removal efficiencies for pollutants often discussed for residential septic tanks will not be realized in the case of septic tanks serving commercial, institutional and community facilities.

The intent of providing information herein on characteristics of residential and the domestic fraction of commercial and institutional wastewater is to indicate the wide range in values of such characteristics. It is not intended that such information be used directly to prescribe values for design of an OWRS for a particular facility without substantiation by obtaining field samples of wastewater from existing facilities as nearly similar as possible to that for which the OWRS is being proposed, or from the existing facility where a replacement system, or system upgrade, is required.

B. Residential Wastewater Characteristics

1. Published Information

Information obtained from publications dating from 1981 to the present is shown in Table No. 1 and Table No. 2 on pages 13 and 14 respectively.

2. Data from Department Files

Data available from Department files on residential-type wastewater characteristics is generally derived from multiple dwelling unit facilities such as elderly housing and retirement communities. Data for such facilities are provided in Table No. 4 on Page 16.

C. Commercial and Institutional Wastewater Characteristics

1. General

Characteristics of the domestic fraction of commercial and institutional wastewater, and in cases of wastewater from community systems serving a mixture of residential, commercial and institutional sources, can differ significantly from the values typically used for residential wastewater. Failure to realize this initially during the design of a large scale OWRS system can lead to early failure of the system, regardless of how carefully all other design factors are determined. Therefore, in estimating the wastewater characteristics for a proposed project, very careful attention must be directed to determine the sources contributing wastewater and the proportion and characteristics of wastewater received from each source. In addition, temporal variations in the characteristics must be investigated; this is particularly important when characterization of the wastewater is made by obtaining samples from similar projects.

Data on Food Processing and Serving Establishments are given in Table 3. Data on other commercial and institutional facilities are given in Table 4. Background information on the data contained in these tables is given in "Characteristics of Wastewater from Residential, Commercial and Institutional Facilities"(Jacobson-2002). That paper is available from the Department upon request.

2. Food Processing and Serving Establishments

On-site subsurface wastewater absorption systems (SWAS) serving restaurants and other food processing and serving establishments often fail within a short time after being installed. Failure has been evidenced by severe clogging of the infiltrative surface of the SWAS, resulting in backup of wastewater into the building sewers and/or surfacing of inadequately treated wastewater to the ground above the SWAS. These problems generally resulted from failure to take the wastewater characteristics into account when sizing the on-site facilities such as grease trap(s), septic tank(s) and SWAS.

Food processing and serving establishments can include the following:

- Full Service Restaurants
- Fast Food Restaurants
- Cafeterias
- Diners
- Delicatessens
- Seafood Shops
- Butcher Shops
- Bakeries
- Pie/Pastry Outlets
- Ice Cream Parlors
- Hotels with Restaurants
- Motels with Restaurants
- Clubs with Dining Room Service
- School Kitchens
- Hospital Kitchens
- Nursing Home Kitchens
- Life Care/Retirement Facilities with common dining room service
- Shopping Centers with Supermarkets and/or Restaurants
- Supermarkets
- Travel Centers with Restaurants

Restaurants are by far the most common food processing and serving establishments that experience problems with an on-site SWAS. Restaurant wastewater typically has a higher organic strength (BOD_5) and TSS, and a much higher content of fats, oils and grease (FOG) than residential wastewater. The high FOG content compounds the effect of the high organic strength of restaurant wastewater.

At the high temperatures used for many food-processing operations, animal fats, such as butter and lard, and oils from cooked meat are in liquid form. Such fats and oils tend to solidify as the temperature drops and thus a major portion (60-80%) can be separated from the wastewater by cooling under quiescent conditions in properly designed grease traps. However, in recent times, many restaurants have increased their use of vegetable oils in lieu of solid fats. Vegetable oils are harder to separate, as they are in liquid form at much lower temperatures than animal fats and oils. In some instances, specially designed grease interceptors and other grease recovery devices must be used to remove these oils.

Many restaurants have ineffective means for removing FOG, with the result that relatively high concentrations of FOG can pass through the septic tank serving the restaurant and reach the biomat that forms on the infiltrative surfaces of the SWAS. When this happens, the FOG can clog the biomat and thereby prevent passage of the wastewater through the infiltrative surfaces. In addition, the high oxygen demand exerted by restaurant wastewater can cause anaerobic conditions to exist below the biomat if the infiltrative surfaces of the SWAS have been sized on the basis of typical residential wastewater infiltrative surface hydraulic loading rates.

When such conditions occur, the results will be a reduced ability of the unsaturated soil beneath the SWAS to remove contaminants from the wastewater and degradation of the ground water quality. Where enhanced pretreatment will not be provided to reduce the strength of the restaurant wastewater to or below that of residential wastewater, it is necessary to provide adequate pretreatment for removal of FOG, and reduce the infiltrative surface hydraulic loading rate to account for the high strength of such wastewaters. Additional discussion on pretreatment of restaurant and other food processing establishment wastewaters is contained in Section IX and additional discussion on infiltrative surface loading rates for such wastewaters is contained in Section X.

U.S. EPA (1978) provided the data on the characteristics of raw wastewater from 12 restaurants in three different locations in the U.S. This information is given in Table 3.

Siegrist, et al (1984) investigated the design and performance of septic tank-soil absorption systems for restaurant wastewaters. The investigation consisted of three phases: a preliminary field survey of 42 restaurants; a field investigation of 12 restaurant systems selected from the results of the first phase, and a laboratory experiment using small dia. column type lysimeters. The results of sampling of the 12 restaurants selected in phase 2 are given in Table 3.

Stuth and Guichard (1989) provided information on fast food and full service restaurants in Oregon. This information is given in Table 3.

Garcia and Louch (1994) indicated that a sampling study in St. Louis involving 660 samples taken from untreated wastewater from 88 food establishments found the following FOG concentrations:

- 32% ≤ 200 mg/L
- 29% ranged between 200 -500 mg/L
- 21 % ranged between 500 -1000 mg/L
- 18% ≥ 1000 mg/L

Garcia and Louch (ibid) stated that an ideal temperature of less than 110°F is required to facilitate efficient oil and grease separation**.** They stated that the average FOG removal efficiency of a grease trap was in the range of 70-80% provided that the grease trap is properly designed and cleaned at proper intervals. (It is not clear whether this statement applies to vegetable oils.)

If an average removal efficiency of 75% is assumed, the grease trap effluent FOG concentrations for the raw wastewater FOG concentrations given above should be as follows:

Raw Wastewater mg/L	Grease Trap Effluent mg/L
≤100	<25
≤ 200	≤ 50
200-500	50-125
500-1000	125-250
≥1000	>250

FOG concentration in residential wastewater is ≤ 50 mg/L (usually ranging from 20 to 30 mg/L). From the table above, it can be seen that in order for the FOG in grease trap effluent to approach the FOG concentration in residential wastewater, the raw wastewater FOG from food establishments should be ≤ 200 mg/L, preferably ≤ 100 mg/L. This concentration can only be approached if best waste management practices are established for kitchens and other facilities that generate FOG laden wastewaters.

Laboratory experiments on grease trap effluent from a full service restaurant in Baltimore serving typical American fare yielded the following results (Unpublished - 2002):

Sample No .	Grease Trap Temp. °F.	Grease Trap FOG, mg/L	Cooled Sample* Temp. °F.	Cooled Sample* FOG, mg/L
1	130	1100	75	235
2	125	1050	75	220
3		1175	85	630
			75	275
			65	210

* Samples cooled in Laboratory

Stuth-(1992) stated that if the temperature in the grease trap is below 80°F (27°C) the best results that can be anticipated will be 100 mg/L, and when temperatures exceed 80°F, grease trap efficiency decreases.

Lowery (1994) provided information on influent to an underground grease trap serving the kitchen of a student cafeteria kitchen at a university in Texas. The cafeteria serves 1000 students per week during summer session and up to 25,000 students per week during the normal school year. This information is shown in Table No. 3.

Stuth and Garrison (1995) provided information on full service and fast food restaurants in Oregon. This information is shown in Table No. 3**.**

Stuth and Wecker (1997) surveyed the FOG in kitchen wastewater from six establishments with a range of flows and menus. All six discharged their kitchen gray-water to grease traps, with the effluent then co-mingled with the blackwater from restrooms. The results of grab samples taken at different times on the same day, or on two different days, are shown in Table 3. Stuth and Wecker (ibid.) stated that few conclusions can be drawn from this survey as the FOG, pH and temperatures were significantly different. Stuth and Wecker (ibid.) stated that while grease traps are beneficial, their level of FOG reduction is over-rated. Grease trap recommendations on sizing, multi-compartments, and proximity to facility served could not be drawn from the results of this survey. It was evident that a small-sized grease trap with a limited detention capacity is of limited value in removing FOG.

Chen et al. (2000) provided data on the characteristics of raw restaurant wastewater. They collected a total of 48 samples from five restaurants at the Hong Kong University of Science and Technology for characterization. Since restaurant wastewater is a mixture of wastewater from cleaning meat and vegetables, washing dishes, pans, and other vessels, and rinsing floors, Chen et al. (ibid) expected that the composition of the wastewater would vary significantly depending upon the cuisine served. Also, the food served at a given restaurant depends on the time of service, i.e., breakfast, lunch or dinner. Hence they considered it almost impossible to have one set of data to characterize restaurant wastewater. Instead, they provided a range of values of each parameter for each restaurant.

Matejcek et al (2000) conducted a thorough, well-documented study on long term acceptance rates for restaurant wastewater. Phase I of the study investigated several effluent properties from food service establishments that employ onsite sewage treatment and disposal systems (OSTDS). Septic tank effluent from a total of 19 restaurants located in North Central Florida was sampled. Each restaurant was sampled twice. Results varied greatly between sites, establishment categories and sampling events. Additional qualitative analyses (GCMS) were run to determine the presence of trace organics from degreasers and cleaning agents. The results of the GCMS analyses showed no detectable levels of toxic organics from cleaning products, nor were any compounds detected that might inhibit anaerobic activity or negatively impact effluent characteristics.

The results of statistical analyses showed that the number of samples collected were insufficient to make a statistical determination of variations between establishment categories.

Food Service Establishment Categories Established by Matejcek et al (2000)

Category	Restaurant Type
1	Restaurants operating less than 16 hrs/day
2	Single Service Restaurants operating less than 16 hrs/day
3	Single Service Restaurants operating more than 16 hrs/day
4	Bars and Cocktail Lounges
5	Drive-in Restaurants
6	Food Outlets
7	Convenience Stores

In Phase II of the study, Matejcek et al (ibid) determined wastewater physical and chemical characteristics of 133 samples of septic tank effluent from fifteen randomly chosen food service establishments in Florida. The effluent data were sorted into high, medium- and low-strength categories using carbonaceous biochemical oxygen demand ($CBOD_5$) total suspended solids (TSS) and oils and greases (O&G). Sample collection was changed from single grab samples taken in Phase I to 24-hour composite samples. Sample concentrations over 1200 mg/L $CBOD_5$, 1000 mg/L TSS and 200 mg/L O&G were considered outliers and not a statistical representative sample and therefore were not included in the statistical analysis. The results are shown in Table 3. These results indicate that when 24-hour composite samples are taken, the $CBOD_5$, TSS and O&G values may be less than those of grab sample values as obtained in a manner similar to that used in the Phase I study.

3. Health Care Facilities (Excluding Hospitals)

Health care facilities generate wastewater from such facilities as restrooms, laundries, kitchens and barber/beauty shops. Generally, the wastewater characteristics are similar to medium strength residential wastewater, although in some instances the FOG content may be somewhat greater due to increased use of body oils and lotions that eventually are included in the wastewater due to removal from the body surfaces during bathing.

4. Hotels, Inns and Resorts

Hotels, inns, and resort wastewaters are generated from hotel room restrooms, public restrooms, restrooms in individual retail shops, restaurants, kitchens serving banquet facilities, barber/beauty shop, laundries and other similar facilities. Generally, the wastewater characteristics are similar to medium strength residential wastewater except for the wastewater component from restaurant and other food service facilities.

5. Offices

Wastewater from office buildings is generated in office restrooms, public restrooms, and, in some instances retail shops, restaurants and snack bars. While similar in many respects to residential wastewater, office wastewater is apt to have higher nitrogen concentrations because of the lack of dilution from bath and shower wastewater and other low strength wastewater components found in residential wastewater.

6. Supermarkets

Supermarket wastewater characteristics are highly variable from day to day and throughout the day. In addition to the normal residential type of constituents, this wastewater often contains cleaning agents that can be toxic to wastewater treatment biological processes. The Department is aware of several instances where floor cleaning chemicals and/or sanitizers (quaternary ammonium compounds) have inhibited the biological treatment processes resulting in degradation of the treated effluent. Where wastewater from existing supermarkets is being sampled, analysis should include various types of cleaning compounds. Prior to sampling, an inventory of cleaning compounds used in the establishment should be conducted; this will provide insight into what type of chemicals might be present in the wastewater. Nitrogen and FOG concentrations in supermarket wastewater are apt to be higher than residential wastewater where food processing is done at the supermarket.

7. Shopping Centers and Factory Outlets

Wastewater characteristics from shopping centers and factory outlets can vary widely, depending upon the presence or absence of supermarkets and other food preparation and serving establishments. Where such facilities are present, the wastewater is apt to be higher in organic strength, FOG, and nitrogen, and may contain chemicals that can inhibit microbial action required for adequate wastewater treatment. Refer to discussion on Supermarkets for further information.

8. Travel Centers (aka Truck Stops) and Truck Terminals

Travel centers, also sometimes referred to as truck stops, may generate wastewaters from full service restaurants, fast-food restaurants, ice cream shops, coffee shops, and barber shops, and their associated restrooms, as well as from separate rest room, shower and clothes washing facilities available to truck drivers, and from motels. Thus, estimating the wastewater characteristics for a travel center will require knowledge of the full development potential of the site, including any or all of the uses listed above. It will then be necessary to develop estimates of wastewater characteristics based on each proposed use, and, based on the estimated wastewater flows from each proposed use, develop a composite of each anticipated wastewater constituent. Flows from travel centers can be quite variable, and thus a reasonable safety factor should be included when estimating the wastewater strength. At some travel centers, facilities may be provided for accepting wastewaters from recreational vehicle holding tanks. Such wastewaters may require special consideration. (See 12. Roadside Rest Areas, on page 10.)

Information on wastewater characteristics of Travel Centers located in Texas, Connecticut, Tennessee and Arizona is presented in Table 4. The results obtained at the Texas travel center for BOD_5 and TSS are lower than those obtained at the other three locations, for unknown reasons. Separate samples were also taken and tested for volatile organics (EPA Methods 8010 and 8020). Traces of the substances listed below were detected; all other organics tested for were below the detectable limit.

TTHMs (Total Trihalomethanes)	29 μg/l
Benzene	4.6 μg/l
Ethyl Benzene	17.0 μg/l
Toluene	3.5 μg/l
Xylenes	8.6 μg/l

The sample from the Connecticut travel center was a flow proportioned 24-hour composite sample taken at travel center. Separate samples were also taken and tested for volatile organics (EPA Methods 8010 and 8020) Traces of the substances listed below were detected; all other organics tested for were below the detectable limit.

TTHMs	42.0 μg/l
Toluene	5.9 μg/l

The low levels of the synthetic organic chemicals found in the CT and TX travel center wastewater should not be inhibitory to the wastewater treatment processes and should be removed in treatment of the wastewater.

The Tennessee travel center results for BOD_5 ranged from 235 to 650 mg/L with a median value of 380 mg/L, while the results for TSS ranged from 70 to 707 mg/L with a median value of 285 mg/L. The facilities at the travel center from which these results were obtained included a 150-seat restaurant, 6 fuel islands and a two bay maintenance building. The daily flow was reported to vary from 17,500 to 22,500 gpd.

The BOD_5 concentrations in the Arizona travel center wastewater ranged from 215 to 428 mg/L, the TSS concentrations ranged from 146 to 275 mg/L, and the TN concentrations ranged from 34.0 to 53.1 mg/L. The daily flow during the seven-day period in which composite samples were obtained varied from 14,400 gpd to 24,110 gpd and averaged 18,960 gpd. The facilities at the travel center from which these results were obtained include a 165-seat restaurant, 10 truck-fueling islands, 4 automobile fuel islands and a fast food restaurant. Included in the main terminal building were a restaurant, general shopping area (no ice cream store, coffee shop, or barber shop) 24 toilets, 7 urinals, 8 showers and 2 clothes washing machines. (Test results of grab samples taken periodically by the wastewater treatment plant operator at this facility yielded BOD_5 concentration values ranging from 220 to 2,900 mg/L and TSS concentration values ranging from 87 to 2000 mg/L. These samples were taken for control of plant operations and were not intended to be representative of BOD_5 or TSS concentrations suitable for design purposes. However, these grab sample results are indicative of the wide range in BOD_5 and TSS concentrations that may be encountered at travel centers.

9. Schools

The characteristics of school wastewater will depend upon whether the school has showers and has a kitchen for serving meals to the students. Where the wastewater is generated only in restrooms, without showers, the organic strength and nitrogen content will be higher than normal residential wastewater. The organic strength and nitrogen content will be diluted somewhat if showers are provided, which usually is the case when the school has a developed athletic program. When meals are served, the wastewater may have a FOG content higher than residential wastewater; this will depend upon the type and number of meals served and the method of washing dishes and kitchen clean-up. The same caution should be taken with respect to cleaning compounds as in the case of supermarkets, restaurants and other food preparation and serving establishments.

10. Power Plants

Wastewater generated at power plants can be expected to have higher organic strength and a much higher nitrogen concentration than normal residential wastewater due to the high proportion of blackwater to gray water.

11. Summer Camps

The wastewater from summer camp facilities can be generated in several different facilities, and separate OWRS may be provided for each of these facilities. Characteristics of wastewater from residential cabins will depend upon whether the cabins are equipped only with toilets and urinals or also have showering facilities. Where only blackwater is generated, the wastewater will have a significantly higher organic strength and nitrogen content than normal residential wastewater, while in the case of cabins also equipped with showers, the wastewater strength and nitrogen content will be somewhat lower, but still probably higher than normal residential wastewater. Where an OWRS serves a camp dining hall that will discharge kitchen wastes with perhaps a small blackwater contribution from restrooms in the dining hall, the wastewater organic strength, FOG, and nitrogen content will be substantially greater than residential wastewater.

In the case of kitchen wastewater, the same caution should be taken with respect to cleaning compounds as in the case of supermarkets, restaurants and other food preparation and serving establishments.

12. Roadside Rest Areas, Camp Grounds and Marinas

Roadside rest area wastewater characteristics can vary widely, depending upon whether the area contains restaurants and whether there are provisions for accepting wastes from recreational vehicle holding tanks. In the latter case the wastewater would probably have a higher organic strength and nitrogen concentration than residential wastewater and could contain chemicals that inhibit bacterial action, and that possibility should be considered when reviewing test data on wastewater samples obtained from existing roadside rest areas. This same consideration should be given to wastewaters discharged at campgrounds and marinas.

13. Ski Resorts

Sources of wastewater at ski resorts include restrooms, showers, and food service facilities. The wastewater characteristics are similar to medium to high strength residential wastewaters. Where food service facilities are provided (fast food and/or full service restaurants and other food specialty shops), the wastewater may contain higher FOG concentrations than residential wastewaters. In such cases, the same caution should be taken with respect to cleaning compounds as in the case of supermarkets, restaurants and other food preparation and serving establishments. Where showers are not provided, the organic strength and nitrogen content are apt to be higher than normal residential wastewaters because of the high blackwater content.

D. Sampling for Estimation of Wastewater Characteristics

When an existing on-site system is being upgraded or replaced, the characteristics of the wastewater generated by the facility to be served should be determined from sampling of the facility's wastewater. Composite sampling is preferable if raw wastewater is being sampled. This sampling should be on a flow-weighted basis, and thus data on the changes in water use during the sampling period are required. In most cases, this will require installation of one or more water meters to monitor the variation in hourly water use during the sampling period.

The water meter(s) should also be read and recorded on a daily basis for a reasonable length of time to establish the water use characteristics of the facility, as this information will be needed for design of an upgraded or remedial on-site system. The "reasonable length of time" should include at least three of the busiest months of the facility's business.

In the case of restaurants and other food preparation and serving establishments, where the effluent from an existing grease trap or septic tank is being sampled, a series of grab samples, taken on several days that are representative of the restaurant's busiest days, may be substituted for composite sampling. The grab samples should be taken during the facility's busiest hours and during cleanup operations of each sample day. Water use should also be recorded for the sample days. Wastewater characteristics should include BOD_5, FOG (Fats, Oils and Grease) TSS, TN, TP, pH, temperature and alkalinity. Other data that should be obtained includes the number of restaurant seats, number of meals served per day, a description of kitchen operations and a description and count of the water using facilities in the kitchen and restrooms. The existence of grease traps and septic tanks should be confirmed and the types and liquid capacities determined. The existence of floor drains should be confirmed and the route and discharge endpoint of the floor drain piping should be mapped out. Finally, the types, chemical characteristics and amounts of all cleaners used for various purposes in the restaurant should be determined, along with data on the effects of such cleaners on the viability of anaerobic and aerobic microorganisms.

Procedures for sampling of wastewater from other types of facilities should be similar to those described above. However, information such as occupancy data, hours of operation and information on the numbers and types of water using fixtures from which the wastewater will be discharged is necessary rather than the information specifically applicable to restaurants and other food processing and serving establishments.

Where an on-site system is being designed for a new facility, wastewater flow data and pollutant characteristics must be estimated based on data available from existing similar types of facilities. The first choice would be to obtain this data by sampling the wastewater discharged from one or more facilities of approximately the same size and type. If it can be demonstrated that it is not feasible to obtain such data, it will be necessary to use information developed by others. For this latter case, information presented in Tables 1 through 4 herein may be helpful. It should be noted that the information presented in these tables is quite variable from facility to facility and at any particular facility, as can be seen from the relatively large deviations from the means of the given variables. Therefore, when using such information, an appropriate safety factor should be incorporated in the design of the on-site system to account for such variability.

TABLE No. 1

REVIEW OF CURRENT LITERATURE ON CONCENTRATIONS OF BOD_5 AND TSS IN RESIDENTIAL SEPTIC TANK EFFLUENT

Reference	BOD_5, mg/L						TSS, mg/L					
	No. of Samples	Median	Mean	Standard Deviation	Min.	Max.	No. of Samples	Median	Mean	Standard Deviation	Min.	Max.
Hargett, Tyler & Siegrist-1981 ASAE	10		153			92-225	10		44		22	45
Oregon DEQ Study-1982	70		217				70		146			
Hampton & Jones -1984 ASAE		185	164					26	47			
Siegrist, et al -1984 ASAE												
Multiple Home Developments												
Westboro, WI	15		168				15		85			
Bend, OR	4		157				4		36			
Glide, OR	4		118				4		52			
Manila, CA	4		189				4		75			
Washington State	7		129				7		47			
Converse et al. 1991 ASAE	25		150	54	47	239	30		99	102	44	572
Sherman & Anderson 1991 ASAE	36		141		111	181	36		161		64	594
Viraraghavan & Rana 1991 ASAE	44		222	63.4	141	421	44		134	62.6	51	290
Bruen & Piluk 1994 ASAE												
Site A			300						77			
Site B			202						123			
Site C			135						141			
Cagle & Johnson 1994 ASAE												
Placer County Study	15		160				15		73			
Osesek, et al. 1994 ASAE												
Site #1			271									
Site#2			126									
Rubin, et al. - 1995 NW												
1 residential site	10		169		158	178						
Stuth & Garrison-1995 NW												
1 residential site			183		102	264			57		18	80
1 residential site	16	255	243	59.5	165	347	16	57	59	15.7	30	80
Bounds - 1997 NW			156						84			
Loudon, et al. -1997 NW												
Normal Ranges					100	250					30	150
Converse & Converse - 1998 ASAE												
(20 septic tks w/screened vaults)	69	186	215	95	36	548	24	51	61	35	11	135
Jantrania, et al. 1998 ASAE												
Site #1	17		314	250	165	1211	17		81	63	37	285
Site #2	15		143	141	22	530	16		48	36	15	139
Site #3	15		270	119	99	570	16		60	21	37	16
Site #4	15		248	151	102	720	16		592	2067	29	8597
Site #5	10		155	58	120	224	11		53	23	26	108
Site #6	11		89	80	16	305	11		58	33	12	111
Site #7	11		264	64	164	409	11		72	32	16	120
O'Driscoll, et al. 1998 ASAE												
Baldwin County, 10 Residences(93-94)	120		132				120		200			
Tuscaloosa County			331						58			
Roy, et al. 1998 ASAE												
2 Family Home	18		162						92			
Sievers 1998 ASAE			297						44			
Thom, et al. 1998 ASAE												
Paris Site			192	44.1					32	10.5		
Scott Co. Site			193	56.5					68	83.4		
Anderson County			224	58.5					154	147.9		
Stuth - 1999 NW												
21 residential sites (unponded)			141		26	216						
8 residential sites (ponded)			247		150	416						
Henneck, et al. 2001 ASAE												
10 home cluster system (G. Lake)			184	43					27	8		
20 home cluster system (Lake Wash.)			63	31					64	62		
Lindbo & MacConnell 2001 ASAE												
Residential Site #2			114						143			
Residential Site #1			172						80			
Siegrist -2001 ASAE					140	200					50	100
Christopherson, et al. 2001 ASAE												
Winter	96		175	119			96		115	59		
Summer	92		120	88			92		72	65		
Watson and Choate-2001ASAE												
Terrell Site	25		147		13	261	25		255		20	2000
Gray Site	24		103		13	240	24		191		20	1150
Jones Site	17		203		34	382	18		910		31	4800
Mean of Means (unweighted)			183	mg/L*					90	mg/L**		

MANUALS & TEXTBOOKS

Reference	BOD_5, mg/L						TSS, mg/L					
	No. of Samples	Median	Mean	Standard Deviation	Min.	Max.	No. of Samples	Median	Mean	Standard Deviation	Min.	Max.
USEPA Manual - 1980, Table 6-1			142		7	480			76		10	485
Cantor and Knox -1985			140						75			
Crites & Tchobanoglous- 1998												
Without Effluent Filter or Garb. Gri.			180		150	250			80		40	140
Without Effluent Filter, w/ Garb. G.			190						85			
With Effluent Filter, w/o Garb. Gri.			130		100	140			30		20	55
With Effluent Filter & Garb. Gri,			140						30			

NOTES:

1.) ASAE = Proceedings of ASAE International Symposiums on Individual and Small community Sewage Systems in year shown.

2.) NW = Proceedings of the Northwest On-Site Wastewater Treatment Short Course and Equipment Exhibitions in year shown.

3.) Crites and Tchobanoglous (1998): with Effluent Screens, the BOD_5 and TSS would be reduced by 28% and 62% respectively.

4.) * Excluding values when septic tank effluent filters were known to be present.

5.) ** Excluding values when septic tank effluent filters were known to be present, and outliers of 592 and 910 mg/L.

TABLE No. 2

REVIEW OF CURRENT LITERATURE ON CONCENTRATIONS OF TOTAL NITROGEN AND PHOSPHORUS IN RESIDENTIAL SEPTIC TANK EFFLUENT

Reference	TN, mg/L						TP, mg/L					
	No. of Samples	Median	Mean	Standard Deviation	Min.	Max.	No. of Samples	Median	Mean	Standard Deviation	Min.	Max.
Hargett, Tyler & Siegrist-1981 ASAE	9*		41		32.8	64.8	11		18.4		8.5	27
Ronayne, et al .Oregon DEQ Study-1982	54		57.5									
Hampton & Jones -1984 ASAE			57*									
Siegrist, et al -1984 ASAE												
Multiple Home Developments												
Westboro, WI	15		57				15		8.1			
Bend, OR	4		41									
Glide, OR	4		50									
Manila, CA												
Washington State	7		34				7		11.4			
Converse et al. 1991 ASAE	30		59		24	132	25		5		3	7
Sherman & Anderson 1991 ASAE	36		36		33	54	36		11		7	15
Viraraghavan & Rana 1991 ASAE	44		46.8	8.8	34	81	44		10.9	2.8	5.2	17.1
Bruen & Piluk 1994 ASAE												
Site A			41.7						7			
Site B			46.9						5.1			
Site C			30.2						13.9			
Cagle & Johnson 1994 ASAE												
Placer County Study	15		61.8									
Osesek, et al. 1994 ASAE												
Site #1			76.6						9			
Site#2			28.7						4			
Rubin, et al. - 1995 NW												
1 residential site	10		48.6		39.8	65.5	10		6.5		5.9	7.7
Loudon, et al. -1997 NW												
Normal Ranges					25	70					5	15
Converse & Converse - 1998 ASAE												
20 septic tks w/screened vaults	70	55	58	23	9.7	144						
* Ammonia-Nitrogen only.												
Jantrania, et al. 1998 ASAE												
Site #1	16		95.6	60.3	52	316	16		8.7	6.6	4.8	33
Site #2	16		39.3	30.7	14	114	16		7.5	4.7	3	24
Site #3	16		153.3	59.8	33	328	16		16.7	7.1	7.4	30
Site #4	16		78.4	73.9	35	330.4	16		10	11	3.5	48
Site #5	11		78.1	9	59	106	11		7.8	1.2	5.2	9.5
Site #6	11		32.1	11.2	13.1	65	11		6.5	1.7	4.9	11
Site #7	11		76.2	12.9	61	97.5	11		11.4	1.9	8.5	15
O'Driscoll, et al. 1998 ASAE												
Baldwin County, 10 Res.-1993-94	120		50									
Roy, et al. 1998 ASAE												
2 Family Home	18		42									
Thom, et al. 1998 ASAE												
Paris Site	>72		46.2	10.9			>72		7.9	5		
Scott Co. Site	>72		70.3	15.8			>72		9.3	3.3		
Anderson County	>24		49.9	17.3			>24		7.4	3.5		
Henneck, et al. 2001 ASAE												
10 S.F. Home cluster system(G.Lake)	81		59	12			81		7.9	1.4		
20 S.F. Home cluster system (L. Wash.)	50		33	11			50		5.4	1.5		
Lindbo & MacConnell 2001 ASAE												
Residential Site #1			27.4						1.9			
Residential Sites #2,3, & 4			29.2						4.4			
Christopherson, et al. 2001 ASAE												
Winter	96	51		43			96	9		24		
Summer	92	47		36			91	8		5		
Siegrist -2001 ASAE					46	100					5	15
Mean of Means (unweighted)++			50.9						8.8			

MANUALS & TEXTBOOKS

Reference	TN, mg/L						TP, mg/L					
	No. of Samples	Median	Mean	Standard Deviation	Min.	Max.	No. of Samples	Median	Mean	Standard Deviation	Min.	Max.
USEPA Manual - 1980, Table 6-1	150		42		9	125						
Cantor and Knox -1985			40						15			
Crites & Tchobanoglous- 1998												
Without Effluent Filter or Garb. Gri.			68		50	90			16		12	20
Without Effluent Filter, w/ Garb. G.			75		50	90			16		12	20
With Effluent Filter, w/o Garb. Gri.			68		50	90			16		12	20
With Effluent Filter & Garb. Gri,			75		50	90			16		12	20

NOTES:

1.) ASAE = Proceedings of ASAE International Symposiums on Individual and Small community Sewage Systems in year shown.

2.) NW = Proceedings of the Northwest On-Site Wastewater Treatment Short Course and Equipment Exhibitions in year shown.

3.) ++ Excluding outliers of 153.3 for TN and 1.9 for TP.

TABLE No. 3

Wastewater Characteristics of Food Processing and Serving Establishments

Ref. No.	Facility Type	BOD_5, mg/L						TSS, mg/L					FOG, mg/L					Mean TKN/TN mg/L	Mean TP mg/L
		No. of Samples	Sample Type	Mean	Std. Dev.	Min.	Max.	No. of Samples	Mean	Std. Dev.	Min.	Max.	No. of Samples	Mean	Std. Dev.	Min.	Max.		
	Restaurants																		
R-1a	2 Restaurants in Honolulu, HI	10	R,C	640		525	759	10	500		202	800							
R-1b	5 Restaurants in Greensboro, NC	15	R,C	546		390	737	15	257		48	402							
R-1c	5 Restaurants in Philadelphia, PA	10	R,C	655		280	960	10	1,030		172	1,985							
R-2	12 Restaurants in Wisconsin																		
R-2a	Restaurants only	37	STE,G	506		245	880	36	177		28	962	32	83		26	256		
R-2b	Restaurants w/other Facilities	25	STE,G	196		101	333	25	73		9	176	25	39	39	3	96		
R-3	Restaurants in Oregon																		
R3-a	Full Service Restaurant		STE,G	1,074					289										
R3-b	Full Service Restaurant		STE,G	1,301					350										
R3-c	Fast Food Restaurant		STE,G	1,917					624										
R3-d	Fast Food Restaurant		STE,G	1,716					358										
R-4a	Full Service Restaurant		GTE,G	1,657					382										
R-4b	Full Service Restaurant		STE,G	1,377					120										
R-5	Student Cafeteria, Univ. in Texas																		
R5-1	Summer Session	15	R,G	576				15	460										
R5-2	Beginning of Fall Semester	25	R,G	992				25	620										
R5-3	During Fall Semester	13	R,G	1,628				13	992										
R-6	Restaurants in Oregon																		
R6-1	Full Service Restaurant	22	GTE,G	913			1,800	23	185			774	22	207			378		
R6-2	Fast Food Restaurant	7	STE,G	985			1,216	7	143			195	7	138					
R-7	Restaurant Kitchen Greywater																		
R7-1	Full Service, American Cusine	2	GTE,G										2	2487		1,424	3,550		
R7-2	National Fast Food Franchise	2	GTE,G										2	1,270		297	2,242		
R7-3	Full Service, American Cusine	2	GTE,G										2	193		152	234		
R7-4	International Fast Food Franchise	2	GTE,G																
R7-4a	First Grease Trap Effluent	2	GTE,G										2	712		692	732		
R7-4b	Second Grease Trap Effluent	2	GTE,G										2	323		306	340		
R7-5	Full Service, American Cusine	2	GTE,G										2	12,802		10,646	14,958		
R-8	Restaurants in Hong Kong																		
8-1	Chinese Restaurant	10	R,U			58	1,430	10			13	246				120	712		
R8-2	Western Cusine Restaurant	10	R,U			489	1,410	10			152	545				53	2,100		
R8-3	American Fast Food Restaurant	11	R,U			405	2,240	11			68	345				158	799		
R8-4	Student Canteen	14	R,U			900	3,250	14			124	1,320				415	1,970		
R8-5	Bistro	3	R,U			1,500	1,760	3			359	567				140	410		
R-9	Restaurants in Florida																		
R9-1	Restaurants operating <16 hrs/d	U	STE,G	761	266				226	19				83	75				
R9-2	Single Serv. Rest. Oper <16 hrs/d	U	STE,G	602	313				123	125				33	35				
R9-3	Single Serv. Rest. Oper>16 hrs/d	U	STE,G	548	290				141	158				80	94				
R9-4	Bars and Cocktail Lounges	U	STE,G	451	71				79	38				24					
R9-5	Drive-in Restaurants	U	STE,G	1,920	1,273				454	269				78	67				
R9-6	Convenience Stores	U	STE,G	441	237				43	20				18	18				
R10	15 Restaurants in Florida	109	STE,C	374	255	53	1009	128	77	49	9	268	122	36	33	5	196		
R11	Full Service Restaurant in CT	39	STE,G	362	149	97	729	39	192	141	18	670							
R12a	Kitchen in Full Service Restaurant in CT	1	STE,C	960				1	240										
R12b	Kitchen in Full Service Restaurant in CT	1	STE,G	878				1	116										
R13	Full Service Restaurant in CT																		
	Kitchen Graywater(Same Day)	4	GTE,G	925		790	1000	4	118		87	136	4	30		<3	60		
	Graywater and Blackwater(Same Day)	4	STI,G	700		520	800	4	93		64	117							
R14	Full Service Restaurant in Baltimore	7	R,G	1320		704	1679	7	490		223	722	7	328		96	469		
R15	Full Service Restaurant in Baltimore	10	GTE,G										7	187	128	85	510		
R16	Fast Food Restaurant in CT	1	STE,C	430				1	40									41	8.4
R17	Oriental Restaurant in CT	1	GTE,G	1380				2	106									52	13.2
R18	Fast Food Restaurant in Michigan																		
R18-a	Kitchen Graywater	6	R,G	3960				6	2090				6	460					3.4
R18-b	Washing Machine Effluent	6	R,G	2525				6	806				6	461					2.7

*** R=Raw; GTE = Grease Trap Effluent; STI = Septic Tank Influent; STE = Septic Tank Effluent; C = Composite; G=Grab, U = Unknown**

Ref No.	Reference (See Bibliography)
R-1	U.S.EPA (1978)
R-2	Siegrist, et al. (1984)
R-3	Stuth and Guichard (1989)
R-4	Stuth and Guichard (1989)
R-5	Lowery (1994)
R-6	Stuth and Garrison (1995)
R-7	Stuth and Wecker (1997)
R-8	Chen et al. (2000)
R-9	Matejcek et al. (2000)
R-10	Matejcek et al. (2000)
R-11	CT DEP Files
R-12	CT DEP Files
R-13	CT DEP Files
R-14	Unpublished (2002)
R-15	Unpublished (2002)
R-16	Unpublished (2002)
R-17	Unpublished (2002)
R-18	Unpublished (2002)

TABLE No.4

Wastewater Characteristics of Commercial and Institutional Facilities

Ref. No.	Facility Type	BOD$_5$, mg/L						TSS, mg/L					FOG, mg/L					Mean	Mean
		No. of Samples	Sample Type	Mean	Std. Dev.	Min.	Max.	No. of Samples	Mean	Std. Dev.	Min.	Max.	No. of Samples	Mean	Std. Dev.	Min.	Max.	TKN/TN mg/L	TP mg/L
HC-1	Skilled Nursing Facility	17	STE,G	171	114	64	271	17	100	99	14	426	17	13	9.6	2	37	35	N.A.
HC-2	Life Care Facility	26	R,G	154	62	41	272	26	159	58	74	288						34	N.A.
HC-3	Health Care Facility																		
	Facility No. 1	2	R,C	218				2	84				2					32	2.6
	Facility No. 2	1	R,C	276				1	199				1	10				43	9.5
	Facility No. 3	2	R,C	197				2	134				2					26	6.6
	Facility No. 4	1	R,C	159				1	72									28	8.3
	Facility No. 5	2	R,G	151				2	374									31	1.9
	Facility No. 6	2	R,G	432				2	638									38	7.6
I/ R-1	Inn & Resort w/Full Service Restaurant	20	R,G	195	147	41	726	20	249	303	20	1,200						62	11.8
I/ R-2	Inn w/Full Service Restaurant	10	STE,G	194	104	86	433	10	93	151	26	520						41	6.9
I/R-3	Inn w/no Restaurant		R,G	221		130	340		154		<5	274						33	N.A.
O-1	15,000 SF Office Building		R,C	240					96									97	10.0
	15,000 SF Office Building		STE,C	150					30									112	11.8
SM-1	Supermarkets in CT, MA, RI																		
SM1-a	Supermarket in CT	8	STE,G	479				8	156					64				39	N.A.
SM1-b	Supermarket in CT		STE,G	576															
SM1-c	Supermarket in CT		STE,G	164					66									55	N.A.
SM1-d	Supermarket in CT	17	STE,G	646				17	162									81	N.A.
SM1-e	Supermarket in MA	9	STE,G	250				9	132									69	N.A.
SM1-f	Supermarket in MA	8	STE,G	426				8	104									53	N.A.
SM1-g	Supermarket in MA	8	STE,G	215				8	86									69	N.A.
SM1-h	Supermarket in MA		STE,G	433															
SM1-I	Supermarket in RI		STE,G	720															
SM-2	Supermarket in CT																		
SM2-a	Influent to ST #1	3	R,G	838				3	172									85	29.5
SM2-b	Effluent from ST#2	3	STE,G	712				3	98									148	29.4
SM-3	Supermarket in CT																		
SM-3a		19	R,G	1132	650	149	2,571	20	313	255	25	1,075						245	N.A.
SM-3b		22	STE,G	883	338	582	2,166	24	178		13	480						189	N.A.
SHPG-1	Shopping Center in CT	46	STE,G	442	219	150	1,260	46	157	99	40	460						51	7.3
SHPG-2	Factory Outlet Complex in CT	4	R,G	118	17	108	143	4	99	55	49	175						117	38.9
SHPG-3	Factory Outlet Complex in CT	23	R,G	409	172	172	795	23	470	556	47	2,480						173	36.9
TC/TT-1	Travel Center in CT	3	R,G	>593				3	374									87	10
TC/TT-2	Express Delivery Truck Terminal	13	R,G	257		70	572	13	350		60	980						68	9.3
TC/TT-3	Travel Centers in TX, CT,TN, AZ																		
TC/TT-3a	Travel Center in Texas	1	U	240				1	120									39	4.1
TC/TT-3b	Travel Center in CT	1	R,C	332				1	294									59	7.9
TC/TT-3c	Travel Center in Tennessee	27	R,U	469				27	346									N.A.	N.A.
TC/TT-3ad	Travel Center in Arizona	7	R,C	349				7	215									40.3	N.A.
SCH-1	Middle School and High School in CT																		
SCH-1a	Middle School		STE,G	215					40									88	17.9
SCH-1b	Middle School		STE,G	115					110									133	3.1
SCH-1b	High School		STE,G	225		70												80	15.4
SCH-2	High School																		
	Septic Tank #1	2	STE,G	220		170	270	2	30		14	46	1	11				84	N.A.
	Septic Tank #2	1	STE,G	90					24									110	N.A.
	Septic Tank #3	2	STE,G	175		130	220	2	33				2	9				86	N.A.
SCH-3	Consolidated School																		
	Septic Tank #1	2	STE,G	146		126	165												
	Septic Tank #2	2	STE,G	117		105	128	2	59		38	80						108	N.A.
SCH-4	Middle School in CT	23	STE,G	304		92	599	24	135		19	1,960						141	N.A.
SCH-5	Boarding School in CT	8	R,G	329		184	510	8	177		121	240							
SCH-6	Schools in Vermont																		
	2 Elem., 2 High and 1 Private																	83	7.5
PP-1	Electrical Generating Facility, CT	12	R,G	324				12	305									136	N.A.
CMP-1	Summer Camp Dining Hall	3	R,G	1,633		1,500	1,800	3	465		74	1,200	2	106		41	170	79	14
	Summer Camp Dining Hall	3	STE,G	1,256		1,070	1400	3	70		33	100	2	17		17	34	76	18
CMP-2	Campground Holding Tank Pumpouts	3	STE,G	717		377	1117						3	91		8	240	650	74
MARINA	Marinas (2), Pump-out only	2	STE,G	648		395	901						2	65		40	91	610	66
	Marinas (4), Pump-out & Rest Rooms	4	STE,G	336		118	644						4	71		6	130	250	27
RRA-1	Interstate Roadside Rest Area, CT	2	STE,G	235		190	280	2	88		86	90	1	15				100	8.7
SKI-1	Ski Resorts																		
SKI-1a	Ski Resort in Oregon	U	R,U	395				U	321									77	12.7
SKI-1b	Ski Resort in Washington	U	R,U	382				U	372									80	13.2
SKI-2	Ski Resort in Vermont	14	R,U	242	53	151	347	14	196	81	68	330							

*** R=Raw; GTE = Grease Trap Effluent; STE = Septic Tank Effluent; C = Composite; G=Grab, U = Unknown**

Ref No.	Reference (See Bibliography)
HC-1	CT DEP Files
HC-2	CT DEP Files
HC-3	Unpublished (2002)
I/R-1	CT DEP Files
I/R-2	CT DEP Files
I/R-3	CT DEP Files
O-1	Unpublished (2002)
SM-1a to 1i	CT DEP Files
SM-2	CT DEP Files
SM-3	Unpublished (2002)
SHPG-1	CT DEP Files
SHPG-2	CT DEP Files
SHPG-3	CT DEP Files
TC/TT-1	CT DEP Files
TC/TT-2	CT DEP Files
TC/TT-3	Unpublished (2002)

Ref. No.	Reference (See Bibliography)
SCH-1	CT DEP Files
SCH-2	CT DEP Files
SCH-3	CT DEP Files
SCH-4	CT DEP Files
SCH-5	CT DEP Files
SCH-6	Unpublished (2002)
PP-1	Unpublished (2002)
CMP-1	Unpublished (2002)
CMP-2	Matassa, McEntyre and Watson
MARINA	Matassa, McEntyre and Watson
RRA-1	Unpublished (2002)
SKI-1	Clark (1969)
SKI-2	Unpublished (2002)

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