Chapter 3
Wastewater Generation And Characterization

3-1. General

This chapter provides generally available data that can be used to calculate water usage and wastewater generation, and to characterize the wastewater in terms of typical pollutant concentrations and characteristics.

3-2. Visitation and Length of Stay

a. Capacity calculations. Visitation (percent occupancy) and length of stay are important to consider when calculating the capacity of a recreational wastewater treatment system. Because visitation and length of stay are affected by factors such as season, climate, nearness to population centers, and types of facilities, the design engineer should base the capacity calculations on existing or projected visitation records, which are typically maintained by the recreation area manager.

b. Direct calculations. In the absence of such records, visitation data may be obtained by direct head count, admission fees, trailer count, and traffic count. Caution must be exercised when using traffic count because of internal movement of automobiles from area to area as well as outside traffic passing the check point. If outside traffic automobiles are included in the vehicle volume count, it will result in double counting the number of visitors.

3-3. Variations in Visitation

Visitation at recreational areas fluctuates vastly from season to season and from day to day within peak season. Percent occupancy should be used to calculate the maximum treatment system capacity. Percent occupancy can be estimated from historical records, where available, and by using equation (3-1). Table C-1 presents visitation data obtained from typical USACE recreational areas (Francingues 1976, Middleton USAEC). Where historical data are not available, equivalent population factors must be used as specified in TM 5-814-3, Chapter 4.

$$\text{Percent Occupancy} = \frac{\text{Recorded Income (\$/campsite/period)}}{\text{(No.Days/period)} \times \text{Campsite Fee (\$/day)} \times \text{No.Campsites} \times 100} \tag{3-1}$$

3-4. Water Usage and Wastewater Generation

a. Overview. The complexity of human activities in recreational areas makes estimating water usage and wastewater generation a difficult task. Table C-2 lists the facilities that typically exist at recreational areas which contribute to water usage and wastewater generation flows. The design engineer must account for the wastewater generated from all possible sources. Data for water usage and wastewater generation at typical USACE recreational areas are presented in Table C-3 (Metcalf & Eddy 1972). In addition, data for specific types of recreational area establishments including marinas are presented in Table C-4 (Corbitt 1990). Table C-5 lists comparative water use rates for various home appliances such as automatic dishwashers and garbage disposals (EPA-625-R-92/005, Matherly 1975, and Metcalf & Eddy 1972).

b. Flow estimation methods. There are two basic approaches used to estimate wastewater flows from recreational areas: the fixture unit method and the per capita method.

(1) Fixture unit method.

(a) Before using this method, the design engineer should obtain data on the number of fixture units at the site. Table C-6 lists the minimum number of sanitary fixture units required per site type (Penn Bureau of Resources, USDOI 1958). For marinas and other places where boats are moored, this number is based on the total number of seasonal slips and/or the number of transient slips, as appropriate. Sanitary facilities for marinas should be located conveniently within 152 m (500 ft) walking distance from the shore end of any dock. These sanitary facilities must be appropriately marked with signs readily identifiable.

(b) The data shown in Table C-7 can be used to estimate the wastewater flow based on the number of fixture units (Penn Bureau of Resources, USDOI 1958). (It should be noted that the data presented in Table C-7 represent hourly rates and are not directly related to fixture units as used in the plumbing codes to determine pipe sizes.) When using the fixture unit method, allowances should be made for special features such as trailer hookups, holding tanks, etc. Caution must also be used when applying the fixture unit method to estimate wastewater flows as this method is valid only when the number of fixtures is properly proportioned to user population. For user areas with minimum fixture comfort stations and a high percent occupancy, the fixture unit method may produce an underestimate of the wastewater flow.

(2) Per capita method.

(a) Table C-3 presents data which can be used to predict wastewater flows based on the per capita generation rate. The unit flows presented in Table C-3 are in agreement with water usage rates at various USACE recreational areas. The data presented in Table C-4 can be used as an additional design guide where site-specific flow data are not available. In computing wastewater flows from sanitary facilities servicing marinas only, assume for this method that each boat slip is equivalent to two persons.

(b) In addition, for marinas or other places where boats are moored which have a boat launching ramp and provide boat trailer parking space only while the boat is in use, the design flow must be increased by 38 L/d/capita (10 gal/d/capita) per boat trailer parking space. Where restaurants or motels are operated in conjunction with a marina or other place where boats are moored, the following will be used to determine the design wastewater flow:

- Motels: 246 L/d/capita (65 gal/d/capita) per constructed occupant space or a minimum of 492 L/d/room (130 gal/d/room).

- Restaurants: 190-680 L/d/customer seat (50-180 gal/d/customer seat). Each installation must be evaluated according to local conditions.

3-5. Monthly and Daily Flow Distribution

a. Monthly flow distribution. Monthly flow distribution at a specific site should be based on historical records or on flow data from a reasonably similar site. If these data are not available, then the general flow distribution shown in Table C-8 can be used. The monthly flow distribution data presented in Table C-8 are representative of recreational areas at inland reservoirs with moderate climatic conditions similar to those of the mid-Mississippi valley (Francingues 1976).

b. Daily flow distribution.

(1) The daily flow distribution is directly related to the percent occupancy on weekdays and weekend. The maximum daily flows can be estimated by both the fixture unit method and the per capita method.

(2) Weekend day (maximum). If using the fixture unit method, assume the maximum utilization of all fixtures and use the factors presented in Table C-7. For the per capita method, use predicted visitation data for the busiest month and the factors presented in Table C-3.

(3) Weekday (maximum). For both methods, assume 30-80 percent of the values obtained for weekend day. To select the appropriate value, consider the relative number of visitors on weekends compared to weekdays.

3-6. Wastewater Characterization

Wastewater from recreational areas can be characterized either as waterborne wastes such as those from picnic and camping areas, or as specialty wastes such as those from areas which use vaults, holding tanks, sanitary disposal (dump) stations, etc.

a. Waterborne wastes. Typical characteristics of waterborne recreational wastes are summarized in Table C-9 (Francingues 1976, Matherly 1975, Metcalf & Eddy 1972, and USAEWES). The concentrations of different pollutant parameters are not significantly different from those of domestic wastewater except for TKN and ammonia nitrogen (NH_3-N). It should be noted that wastewater characteristics may differ from facility to facility within a given recreation area. For example, picnic areas typically produce wastewater with higher nitrogen concentrations than do camping areas.

b. Specialty wastes. Identifying the sources and the characteristics of specialty wastes is an important element in the selection of the treatment process. Specialty wastes are generated from three sources: vaults, dump stations, and fish cleaning stations.

(1) Vault wastes.

(a) Vault wastes or septage from pit privies can be grouped into four categories: septic tank sludge (septage), vault waste, recirculating and portable chemical toilet waste, and low-volume flush waste. The organic strength, solids content, and chemical composition for these waste types must be known. Table C-10 presents the typical characteristics of a 3800-L (1000-gal) load of nonwater carriage waste (Smith 1973).

(b) Vault wastes with chemical or oil recirculating toilets are estimated to have the same organic characteristics as a standard vault (nonleaking), as reported by U.S. Forestry (Simmons 1972). Table C-11 summarizes the common pollutant parameters of vault wastes (Harrison 1972 and Simmons 1972). Vault wastes characterization data from other sources are summarized in Table C-12 (USAEWES). As can be seen in Tables C-11 and C-12, significant differences exist in the chemical (COD) and biological (BOD_5) composition of vault wastes. The BOD_5 and the COD concentrations in vault wastes depend upon detention time, dilution water entering the vault, and chemical additives.

(c) The values shown in Tables C-10 and C-11 are from primitive camping sites where a small amount of dilution water enters the vault with short detention times. These values may be considered as maximum composition values for vault wastes. The data in Tables C-11 and C-12 were obtained from areas receiving considerably more use, longer detention times, and large volumes of dilution water which accounts for the lower BOD_5 values. The addition of chemical oxidizing and liquefying agents contributes to lower BOD_5 values. Suggested design values for BOD_5 are: (1) the high values to be used for watertight vaults with no chemical additives; (2) 8800 mg/L for vaults without chemical additives which are frequently pumped and with moderate dilution; (3) 2500 mg/L only when chemical agents are added to the vault.

(2) Dump station wastes.

(a) Dump station wastes are basically generated from travel trailer and recreational watercraft wastes. Many travel trailer and recreation watercraft manufacturers have installed low-volume water flush and chemical recirculating toilets with holding tanks for trailer and boat wastes. Because indiscriminant dumping of these wastes into waterways, along highways, and at recreational areas is prohibited, the installation of sanitary disposal stations for boats and travel trailers is necessary.

(b) Availability of adequate treatment for sanitary wastes from boats and travel trailers is a major problem in most recreational areas (Robin and Green). Pump-out facilities are often many miles from the collection system of municipal treatment plants. The treatment of dump stations waste by conventional biological methods is not reliable because of the potential toxic effects of some chemical additives. Without large dilution, these wastes may cause treatment process upsets or otherwise affect treatment process efficiency. After a heavy weekend of recreational activity, shock loadings of dump station wastes have been shown to disrupt small municipal treatment plants (Robin and Green). Therefore, holding tanks, special treatment facilities, or arrangement for off-site treatment should be provided for dump station waste. Methods for special treatment include dilution of the biological and chemical load, equalization, and chemical treatment to neutralize toxic pollutants.

(c) The National Small Flow Clearinghouse (NSFC) has compiled a document outlining recent studies by researchers and scientists regarding the effects of chemical and biological additives on septic systems (NSFC-1). This document also lists additive manufacturers.

(d) The characteristics of the wastewater from 11 sanitary dump stations are summarized in Table C-13 (AOAC 1982, USEPA-1). A study of wastes from recreational water crafts revealed that these wastes also are highly concentrated, deeply colored, and contain variable amounts of toxic compounds (Robin and Green). The characteristics of typical waste pumpage from recreational water crafts are presented in Table C-14. Based on this study, it was concluded that arsenic, beryllium, molybdenum, or selenium were not detected in any of the 64 samples analyzed (Robin and Green). Mercury was detected in six samples at concentrations ranging from 6 to 9 mg/L. Relatively low concentrations (less than 0.2 mg/L) of cadmium, copper, manganese, nickel, and silver were found in most samples. Significantly high concentrations of aluminum, calcium, magnesium, tin, potassium, iron, and sodium were found. Toxic levels for certain metals were detected in individual samples as follows: cadmium as high as 104 mg/L, lead 79 mg/L, zinc 3540 mg/L, and copper 133 mg/L (Robin and Green).

(3) Fish cleaning station wastes. Typical characteristics of wastewater from fish cleaning stations are summarized in Table C-15 (Matherly 1975).

c. Septage. Septage is generally considered as the collection of sludge, scum, and liquid pumped from a septic tank. A broader definition might include any combination of liquid/solid waste retrieved from pit privies, vault, or other remote collecting or holding tanks. Septage generally contains hair, grit, rags, stringy material, and/or plastics and is highly odorous. Suspended solid concentrations in septage are as high as 5000 mg/L of inert material and 10 000 mg/L of volatile suspended matter. Total solids have been reported at 15 000 mg/L of inert material and 25 000 mg/L of volatile solids (WEF MOP-8).