Designation: E2717 – 18

Standard Practice for Estimating the Environmental Load of Residential Wastewater[1]

This standard is issued under the fixed designation E2717; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides a set of instructions for estimating the environmental load of residential water, as it is discharged from a residence. The environmental load is calculated based on the number and type of fixtures in the home, the common household chemicals used, and the number of people in the home. While the format is broadly applied internationally, the parameters stated herein reflect North American averages and would need to be modified if used elsewhere.

1.1.1 *Averages Method*—The Averages Method provides an estimate of the annual environmental load for the average U.S. single-family home based on 2000 U.S. Census[2] and 2007 U.S. Census Data[3] and U.S. EPA⁄625⁄R-00⁄008 characterization of residential wastewater flows.[4]

NOTE 1—Census 2000, taken April 1, 2000, counted 281 421 906 people in the 50 states and the District of Columbia. The questionnaire included seven questions for each household: name, sex, age, relationship, Hispanic origin, race, and whether the housing unit was owned or rented. In addition to these seven questions, about 17 percent of the households got a much longer questionnaire including questions about ancestry, income, mortgage, and size of the housing unit.

1.1.2 *Unique Product Parameters Method*—The Unique Product Parameters Method provides an estimate of the annual environmental load, where the home/product parameter values are the same as those used for the Averages Method except for estimated amounts of chemical contaminants listed in Table 1 or average total annual use of products as listed in Table 1, or both.

1.1.3 *Adjusted Averages Method*—The Adjusted Averages Method provides an estimate of the annual environmental load, where home/product parameter values differ from those used for the Averages Method, except that chemical contaminants associated with products do not vary. (Table 1 remains the same for: Typical Water Contaminants, Estimated Amount of Contaminant in Product (%), and the Percent Waste.)

1.1.4 *Additional/Alternative Chemicals Method*—The Additional/Alternative Chemicals Method provides an estimate of the annual environmental load, of chemicals used that are not listed in Table 1.

1.1.5 The Unique Product Parameters Method, Adjusted Averages Method, and Additional Chemicals Method may be used in combination with each other.

1.2 Instructions are provided for a single-family home. Estimates may be expanded to an aggregate number of single-family homes by assuming an average home size and multiplying by the number of homes. Estimates may be adapted to multi-unit residential buildings by factoring the home parameters for size, occupancy, and fixtures as necessary.

1.3 For the purpose of this practice, *environmental load* refers to chemical contaminants that may be dissolved or suspended in water.

1.3.1 Estimates of environmental load do not include organic matter common for urine, feces, and vomit.

1.3.2 Estimates of environmental load do not include bulk food waste such as kitchen scraps.

1.3.3 Estimates of environmental load do not include bulk cellulose waste such as toilet paper.

1.3.4 Estimates of environmental load do not include other solid wastes, such as wrappers, not covered by the waste groups covered in 1.3.1 through 1.3.3.

1.3.5 Actual environmental load may vary depending on types and amounts of chemicals used in a specific home and the number of people in the home.

1.4 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

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[1] This practice is under the jurisdiction of ASTM Committee E60 on Sustainability and is the direct responsibility of Subcommittee E60.01 on Buildings and Construction.

Current edition approved Aug. 1, 2018. Published September 2018. Originally approved in 2011. Last previous edition approved in 2011 as E2717–11. DOI: 10.1520/E2717–18.

[2] Available from U.S. Census Bureau, 4600 Silver Hill Road, Washington, DC 20233, http://www.census.gov/main/www/cen2000.html.

[3] Available from U.S. Census Bureau, 4600 Silver Hill Road, Washington, DC 20233, https://www.census.gov/construction/chars/pdf/c25ann2007.pdf and http://www.census.gov/population/www/socdemo/hh-fam/cps2007.html.

[4] United States Environmental Protection Agency (EPA), *Onsite Wastewater Treatment Systems Manual*, February 2002, https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30004GXI.txt.

TABLE 1 Chemical Contaminants Attributable to Wastewater

Product Type	Typical Uses	Typical Water Contaminants	Average Total Product Used Per Year	Assumptions	Estimated Amount of Contaminant in Product (%)	Percent Waste
Antiperspirant / Deodorant	Controls sweat and body odor (feet, underarms, genitalia)	Aluminum[A]	66.56 oz/year	Usage per year is based on 10 sticks per person	22.22	65 – 95
Bar Soap	Used for daily hygiene	Sodium Salts	48 oz/year	Usage per year is based on 1 bar a month per residence	80	100
Liquid Soap (hand and dishwashing)	Used for daily hygiene	Sodium Salts	90 oz/year	Usage per year is based on 1 bottle a month per residence	3	100
Shampoo	Used for daily hygiene	Propylene Glycol	174 oz/year	Usage per year is based on 1 bottle a month per residence	6	100
		Sodium Larueth Sulfate			30	
Mouthwash	Used to enhance oral hygiene	Ethanol	277.92	Usage per year is based on 23.16 oz per month	20.48	95
Pharmaceuticals	alleviate pain and improve health	varies	≤1.87 lb/year	passed through urine[B]	varies	100
		varies	~0.03 lb	disposed (dumped) in waste water	varies	
Bleach	removal of stains from laundry	Sodium hypochlorite	624 oz/year	usage per application based on 2 washes a week.	6.78	5 – 100
Disinfectant	removal of mold and mildew; cleanser for toilets and dishwasher	Sodium hypochlorite	324 oz/year (found in spray cleaners)	usage per application is based on overall cleaning regime once every two weeks.	2.73	37.5 – 50
	cleaning tubs and sinks	Ammonium Hydroxide	336 oz/year	usage per application is based on overall cleaning regime once every two weeks.	7.5	95 – 100
Drain Cleaner	Unclogs drains. Dissolves grease and hair.	Sodium hydroxide or potassium hydroxide	64 oz/year	Drain cleanser would not be used in a regular cleaning regimen. Usage would result from unique situations. Assume average usage is 16 oz per application. Assume 64 oz is the average amount needed per year.	Sodium Hydroxide: 2.32 Potassium Hydroxide: 47.5	100
Automatic Dishwasher Soap	Used for cleaning dishes	Phosphates	378 oz/year	Usage per year is based on 31.5 oz per month	30	100
Laundry Detergent	Used to remove dirt, oil, grease, and stains from clothes. Sanitizes clothes and may provide a fragrance to the fibers.	Ethanol/SD Alcohol 40	208 oz/year	usage per application based on 2 large load washes a week, using 2 oz per wash.	0.67 – 5	100
		Sodium tetraborate anhydrous			0.83 – 5	
		Monoethanolamine (MEA)			0.67 – 2.67	
Toilet Bowl Cleaner	sanitize and remove stains	Hydrochloric Acid	96 oz/year	usage per application is based on overall cleaning regime once every two weeks.	10.19	100

TABLE 1 *Continued*

Product Type	Typical Uses	Typical Water Contaminants	Average Total Product Used Per Year	Assumptions	Estimated Amount of Contaminant in Product (%)	Percent Waste
Swimming Pool Cleaning Agents	sanitize water	chlorine	0.001 lb	sand filter backwash	n/a[C]	100
	filter water	Minerals (calcium, magnesium, manganese, iron, and others)	0.218 lb	sand filter backwash	n/a	100

[A] Includes various oxides of aluminum.
[B] Human adults urinate about 1-2 liters a day. Five percent of the volume of normal urine contains solutes. Some solutes are formed from normal biochemical activity within the cells of the body. Other solutes are the results of chemicals that originated outside of the body, such as pharmaceuticals. For average dosage of four pills daily, 2 liters of urine a day could contain up to 0.002 lb of active pharmaceuticals. Then in one year, a human may pass 0.73 lb of pharmaceuticals. The annual average amount of pharmaceuticals passed through urine for a residence is: 1.87 lb.
[C] The average chemical concentration of pool water, for one pool, is calculated with consideration to the total amount of pool water that can flow into city lines during a backwash procedure (reverse flow). The total amount of flow reversed depends on three parameters: filter size, flow rate, and duration of time for a backwash. The three most common swimming pool filters are: sand filters, diatomaceous earth filters, and cartridge filters. A backwash procedure is often implemented for pools with a sand filter or diatomaceous earth filter.
The following are average values used in calculating the average chemical concentrations for a sand filter:
filter size: 2.68 square feet
flow rate: 13.5 gallons / square foot / minute
duration: 3 minutes
Multiplying these three parameters gives the average amount of reverse flow: 108.54 gallons.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[5]

E2114 Terminology for Sustainability Relative to the Performance of Buildings

3. Terminology

3.1 *Definitions*—For terms related to sustainability relative to the performance of buildings, refer to Terminology E2114.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *environmental load, n*—chemical contaminant(s) dissolved or suspended in water.

3.2.1.1 *Discussion*—Environmental load more broadly may refer to the amount of contaminant(s) in a given medium; however, for the purpose of this practice, the scope is isolated to the study of water that leaves a residence from a fixture(s).

3.2.2 *fixture, n*—permanently or semi-permanently installed device.

3.2.2.1 *Discussion*—The term as used in this standard encompasses not only plumbing fixtures such as water closets and urinals but also water-using equipment such as dishwashers.

3.2.3 *parametric ratio, n*—a ratio that compares the quantities of like parameters, such that the numerator is the unique parameter, and the denominator is the average parameter.

3.2.4 *percent waste, n*—the amount of a contaminant discharged through the wastewater system.

3.2.5 *unique parameter, n*—a parameter that differs from the average parameter and depends on unique characteristics of a residence.

3.2.6 *waste factor, n*—the calculated environmental load for a given chemical contaminant.

3.2.6.1 *Discussion*—For the average waste factor, multiply the annual amount of contaminant by the percent waste.

4. Summary of Practice

4.1 This practice estimates the annual environmental load, exclusive of biological waste, food waste, paper waste, and other solid wastes on wastewater for an average home in the U.S.

4.1.1 This practice may be used to estimate the environmental load of a specific residential building by utilizing specific home parameters (such as the number of people, the total square footage of the home, types/quantity of fixtures) and specific product parameters (such as type and quantity), or by modifying the percentage factors for product usage listed in Table 1, or by a combination thereof.

4.2 This practice may be used to estimate the environmental load attributable to a residential area by multiplying the environmental load calculated for an average single-family home by the number of single-family homes in the residential area. If multi-unit residences are included in the residential

[5] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 2 Environmental Load for Average U.S. Single-Family Home

Chemical Contaminant	Waste Factor
Aluminum	9.61 – 14.05 oz
Phosphates	113.4 oz
Sodium Hypochlorite	5.43 – 46.73 oz
Ammonium Hydroxide	23.94 – 25.20 oz
Sodium Hydroxide or Potassium Hydroxide	1.48 or 30.40 oz
Ethanol/SD Alcohol 40	55.47 – 64.47 oz
Sodium Salts	93.3 oz
Propylene Glycol	10.44 oz
Sodium tetraborate anhydrous	1.73 – 10.40 oz
Monoethanolamine (MEA)	1.39 – 5.55 oz
Hydrochloric Acid	9.78 oz
Pharmaceuticals	1.9 lb
Chlorine	0.001 lb
Minerals (Calcium, Magnesium, Manganese, Iron, and Others)	0.218 lb

area, additional modification will be necessary to factor size, number of fixtures, and occupancy rates.

5. Significance and Use

5.1 There is increasing concern regarding water quality. The first national-scale U.S. examination of these organic wastewater contaminants in streams, conducted by the Toxic Substances Hydrology Program of the U.S. Geological Survey (USGS), indicated that a broad range of chemicals found in residential, industrial, and agricultural wastewaters commonly occurs in mixtures at low concentrations downstream from areas of intense urbanization and animal production. The chemicals include pharmaceuticals, natural and synthetic hormones, detergent metabolites, plasticizers, insecticides, and fire retardants. One or more of these chemicals were found in 80 % of the streams sampled.[6]

5.2 This practice may be used by building owners and design professionals to assess water stewardship impacts of a residence. In particular, it is intended to inform design decisions and operation decisions regarding estimated wastewater quality impacts of a building.

5.3 This practice may be used by planners and water treatment professionals to assess water stewardship impacts of a residential area. In particular, it is intended to inform infrastructure decisions regarding estimated wastewater quality impacts of a residential service area.

5.3.1 This practice may be used to estimate the types and amounts of non-biological wastes entering a wastewater system. Such knowledge is becoming increasingly important in developing sustainable approaches to water stewardship.

5.4 Table 2, Environmental Load for Average U.S. Single-Family Home, does not list all chemicals used in homes; in order to obtain a more accurate estimation, the chemicals used in specific homes should be listed. In addition, it may be helpful to monitor wastewater to determine variances, if any, from the estimated environmental load.

[6] *Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams*; USGS Fact Sheet FS-027-02 (PDF [372k]) June 2002; http://toxics.usgs.gov/pubs/FS-027-02/index.html.

6. Home and Product Parameters

NOTE 2—The home parameters for population, square footage, and fixture data are based on information from the U.S. census reports. However, not all single family homes have a swimming pool. For purposes of this practice, it is estimated that one out of every ten houses will have a swimming pool. Methods to calculate the environmental load for homes that do not have a pool, or that have alternate treatments, are provided in Section 7.

6.1 *Home Parameters*—Home parameters utilized in this practice are as follows:

6.1.1 *Size*—Average single-family home size is 2521 square feet.

6.1.2 *Occupancy*—Average single-family occupancy is 2.56 occupants.

6.1.3 *Fixtures*—Average single-family fixtures are: 3 sinks, 2.5 toilets, 2 tubs, 0.7 dishwashers, 1 clothes washer (laundry machine), and 0.1 pools.

NOTE 3—According to 2007 U.S. Census Data,[3] the average number of family households was 78 425 000. The number of bathrooms in new single-family houses were:
1.5 for 24 000 houses,
2 for 305 000 houses,
2.5 for 319 000 houses, and
3 for 252 000 houses.

6.2 *Product Parameters*—Product parameters utilized in this practice are as follows:

6.2.1 *Personal Care Products*—Average personal care products are antiperspirant/deodorant, bar soap, liquid soap, shampoo, and mouthwash with chemical contaminants to wastewater as indicated in Table 1.

6.2.2 *Pharmaceuticals*—Average pharmaceuticals and associated chemical contaminants to wastewater are as indicated in Table 1.

6.2.3 *Cleaning Products*—Average cleaning products are bleach, disinfectant, drain cleaner, automatic dishwasher soap, laundry detergent, toilet bowl cleaner, and swimming pool cleaning agents with chemical contaminants to wastewater as indicated in Table 1.

6.2.4 *Chemical Contaminants*—Chemical contaminants are estimated based upon typical residential routine operation and maintenance as indicated in Table 1. Contaminants are estimated based on product inflows as indicated in Table 1. Depending on relative quantities of inflow products and reaction agents at a given time, there may be additional chemical contaminants produced. For example, an acid will react with a base to form a salt.

7. Procedure

7.1 *Calculating the Environmental Load—Averages Method:*

7.1.1 Determine if the home and product parameters are consistent within plus or minus 25 % of the average parameters listed in sections 6.1 and 6.2, respectively.

7.1.2 If the parameters are consistent with the average parameters, the estimated environmental load shown in Table 2 will apply for a single family home.

NOTE 4—The waste factors in Table 2 were calculated as explained in 7.2.2.

7.1.3 If the parameters are not consistent within plus or minus 25 % of the average parameters, calculate the environmental load in accordance with 7.2, 7.3, or 7.4, or a combination thereof.

7.2 *Calculating the Environmental Load—Unique Product Parameters Method:*

7.2.1 Modify Table 1 data for average annual use of products and estimated amount of chemical contaminants per product as necessary to reflect specific home/product parameters of the single-family residence for which the environmental load is being estimated.

7.2.2 Multiply the "Average Total Amount of Product Used Per Year," by the "Estimated Amount of Contaminant in the Product" and the "Percent Waste" to determine the environmental load of each contaminant, for each product.

7.2.3 To determine the environmental load of each contaminant for the entire table, group the environmental loads of identical contaminants, then add each environmental load per contaminant group.

7.3 *Calculating the Environmental Load—Adjusted Averages Method:*

7.3.1 For each Product, evaluate the unique parameters affecting environmental load as indicated in Table 3. Where an answer to a Table 3 question is "yes," multiply the waste factor by a ratio that relates the unique parameter to the average parameter.

7.3.2 To determine the environmental load of each contaminant for the entire table, group the environmental loads of identical contaminants, then add each environmental load per contaminant group.

7.4 *Calculating the Environmental Load—Additional/Alternative Chemicals Method:*

7.4.1 Review the products used in Table 1. Determine if the products and associated chemicals are applicable to the residence, and modify Table 1 as necessary.

7.4.1.1 Revise products to reflect actual products and rate of products used. For example, if the residence does not have a pool, then a value of "0" would be entered for Swimming Pool Cleaning Agents in the columns entitled "Average Total Product Used Per Year" and "Percent Waste."

7.4.1.2 If products are used that are not listed in Table 1, identify the product and amount of annual use. Identify information for associated chemicals. Multiply the "Average Total Product Used Per Year" by the "Estimated Amount of Contaminant in Product (%)" and the "Percent Waste" to determine the environmental load of each chemical contaminant, for each product.

7.4.2 To determine the environmental load of each contaminant for the entire table, group the environmental loads of identical contaminants, then add each environmental load per contaminant group.

8. Report

8.1 Report shall indicate entity responsible for developing estimate and shall include the following information:

8.1.1 *Date*—Record the date the report was prepared.

8.1.2 *Location*—Record the location of the residential structure for which the estimate is calculated.

8.1.3 *3 Relationship to Average Parameters*—Record the relationship to average home and product parameters. Identify any variations from the home parameters. Identify any variations from the product parameters. Where there are variations, or where information was adapted, note the method used (that is, reference 7.2, 7.3, or 7.4 as applicable). Include revisions to Table 1 summary as applicable.

8.1.4 *Environmental Load*—Record the estimated annual environmental load. Indicate the waste factor for each chemical contaminant.

8.2 Refer to Appendix X1 for an example of reporting format.

9. Keywords

9.1 environmental load; sustainability; waste management; wastewater; wastewater treatment; water management; water stewardship

TABLE 3 Considerations for Unique Parameters Affecting Environmental Load

1.	Is the product used on humans?	If yes, identify the number of people within the residence, on whom the product will be used. Let this number be represented by, "H". Divide this number by the average number of people, "B_H". In this example, the parametric ratio is "H/B_H". Next, let "W_H" represent the waste factor. Multiplying the parametric ratio by the waste factor gives the environmental load. Example: $(H / B_H) * (W_H)$ = Environmental Load
2.	Is the product used on floor surfaces?	If yes, identify the total square footage of the residence. Let this number be represented by, "F". Divide this number by the average number of square footage, "B_F". In this example, the parametric ratio is "F/B_F ". Next, let "W_F" represent the waste factor. Multiplying the parametric ratio by the waste factor gives the environmental load. Example: $(F / B_F) * (W_F)$ = Environmental Load
3.	Is the product used in plumbing fixtures?	If yes, identify the total number of fixtures for which to product will be used. Let this number be represented by, "Ap". Divide this number by the average number of fixtures, "B_{Ap}". In this example, the parametric ratio is "A_p/B_{Ap}". Next, let "W_{Ap}" represent the waste factor. Multiplying the parametric ratio by the waste factor gives the environmental load. Example: $(Ap / B_{Ap}) * (W_{Ap})$ = Environmental Load
4.	Does the amount of product used depend on a regular maintenance schedule?	If yes, identify the frequency of cleaning regime per year. Let this number be represented by, "C_F". Divide this number by the average cleaning frequency "B_{CF}". In this example, the parametric ratio is "C_F/B_{CF}". Next, let "W_{CF}" represent the waste factor. Multiplying the parametric ratio by the waste factor gives the environmental load. Example: $[(C_F) / B_{CF}] * (W_{CF})$ = Environmental Load
5.	Are pharmaceuticals used in the home?	If yes, determine the number of occupants within the residence who may urinate pharmaceuticals in a toilet. (Note: children under 5 and some adult citizens may urinate in diapers.) Let this number be represented by, "P_{UT}". Divide this number by the average number of people, "B_{UT}". In this example, the parametric ratio is "P_{UT}/B_{UT}". Next, let "W_{UT}" represent the waste factor. Multiplying the parametric ratio by the waste factor gives the environmental load. Additionally, estimate 0.03 lb of pharmaceutical waste per residence will be disposed directly into the wastewater system. Determine the number of occupants within the residence who may dispose of pharmaceuticals in waste water (for example, down the toilet). Let this number be represented by, "O_{ph}". Divide this number by the average number of people, "B_{Ph}". In this example, the parametric ratio is "O_{Ph}/B_{Ph}". Multiplying the parametric ratio by 0.03 lb gives the environmental load. The total pharmaceutical environmental load will be the annual sum of pharmaceuticals urinated in the toilet and the amount of pharmaceuticals dumped in the toilet Example: $[(P_{UT}/B_{UT}) * (W_{UT})] + [(O_{Ph} / B_{Ph}) * 0.03$ lb] = Environmental Load
6.	Does the home have a swimming pool with a sand or diatemaceus earth filter?[A]	If yes, the average chemical concentration of pool water is calculated with consideration to the total amount of pool water that can flow into city lines during a backwash procedure (reverse flow). To account for unique parameters, multiply 108.54 gallons by the appropriate parametric ratio. If more than one parameter differs from the average, it may be necessary to multiply 108.54 gallons by more than one parametric ratio. To determine the environmental load of swimming pool chemicals, multiply each chemical concentration in Table 1 by the amount of reverse flow. Multiply the final result(s) by ten.

Example 1: Calculate the reverse flow for the following conditions:
filter size: 1.5 square feet
flow rate: 12 gallons / square foot / minute
Duration: 3 minutes

In this example, two parameters differ from the average: filter size and flow rate.
The filter size parametric ratio is the unique filter size, divided by the average filter size:
(1.5 square feet) / (2.68 square feet)
The flow rate parametric ratio is the unique flow rate, divided by the average flow rate:
(12 gallons / square foot minute) * (square foot minute / 13.5 gallons)

Then the reverse flow is:
(108.54 gal) * [(1.5 sf) / (2.68 sf)] * [(12 gal / sf min) * (sf min / 13.5 gal)] = 54 gal
where gal = gallon, sf = square feet, and min = minute

[A] Ensuring a clean and clear swimming pool involves removing foreign particles, and maintaining the chemical balance in the pool. To achieve this, a variety of chemicals may need to be added or reduced on occasion, that could have a direct impact on the environmental load entering a city water system. However, frequent testing and maintenance is performed to achieve ideal chemical and particulate concentrations for a healthy pool. Assuming the ideal concentrations represent the average concentrations of particulates and chemicals in pool water, the ideal concentrations will serve as average concentrations in this practice.