Guidelines for Quantifying Food Waste in Effluent, and in Sludge from On-site Treatment

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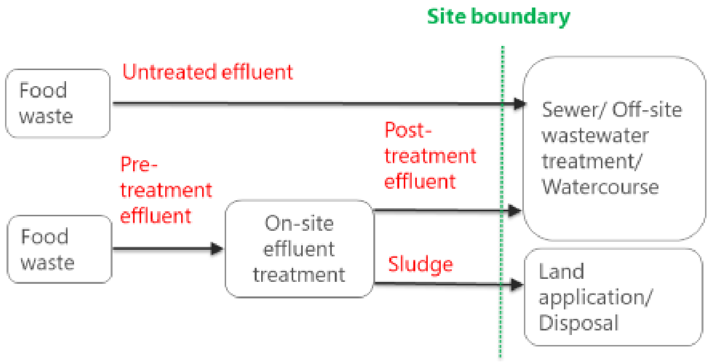
1.0 Introduction

WRAP and UK food businesses have agreed some common guidelines for measuring and reporting on food surplus and waste, consistent with the global Food Loss and Waste Accounting and Reporting Standard (FLW Standard). These have been produced in support of the UK Food Waste Reduction Roadmap - to help the UK meet the Sustainable Development Goal (SDG) 12.3 target to halve food waste[1] by 2030.

This document should be used in conjunction with the wider UK Guidelines, which are available here. It provides a number of pragmatic approaches for businesses to quantify the amount of food waste they discharge (1) to sewer/wastewater treatment[2] (2) as part of sludge generated from on-site treatment of effluent. The approaches are applicable to all companies, but most relevant to businesses that regularly dispose of a food waste in effluent, namely those involved with: food production and manufacturing; hospitality and food service (HaFS); and to a lesser extent, retail.

2.0 Terms, sources and destinations

Food waste in effluent can be managed and discharged in a variety of ways. It can be treated both on and off site. The following diagram sets out the routes by which effluent is discharged and the terms used throughout this guide.



3.0 Options for Quantifying Food Waste in Effluent, and in Sludge from On-site Treatment

For reporting purposes, food waste discharged to sewer/wastewater treatment should be expressed as weight. This is usually calculated as tonnes/year food waste, in the state in which it arose. Other measures are also useful when quantifying food waste in effluent, such as concentration, usually expressed as grams/litre. Both types of measure are used in this guidance. Calculations wherever possible, should be based on measurements derived in a systematic, reproducible way to maintain consistency from year to year.

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[1] Food Waste is defined in the UK Guidelines as any food, drink and inedible parts removed from the human food supply chain and sent to any destination other than redistribution to people, animal feed or bio-based materials/biochemical processing. It does not include cosmetics, tobacco, or substances used only as drugs. It does not include processing agents used along the food supply chain, for example, water to clean or cook raw materials.

[2] This guidance uses the definition stated in the Food Loss and Waste Accounting and Reporting Standard (FLW Standard) and the UK Guidelines i.e. Sending material down the sewer (with or without prior treatment), including that which may go to a facility designed to treat wastewater.

3.1 Direct Approach

This approach can be used by a wide range of sectors and involves identifying each of the possible entry points for food waste into the sewer/wastewater treatment system across the site in question and measuring the amount (mass) of food waste discharged. In essence, this approach quantifies food waste *before* it becomes part of effluent. Primary data gathered at this stage can then be used as a starting point from which to extrapolate the total mass of food waste entering the sewer/wastewater treatment system. It is best suited to sites where the number of entry points is relatively limited and the mass of food waste entering the sewer can be readily assessed. Resources from WRAP are available here, to help map waste flows.

A worked example of the direct approach can be found here

3.2 Mass Balance Approach

This approach is most suitable to food production and manufacturing. It involves producing a food mass balance for each site which details all inputs (typically derived from purchasing data) and outputs such as sales, food surplus rejects, food waste sent to destinations other than sewer/wastewater treatment, sludge from on-site effluent treatment etc. The difference between these inputs and outputs represents the quantity of food waste discharged to sewer/wastewater treatment.

This approach relies heavily on the availability of weight data such as purchasing and sales figures and accurate knowledge of all other material flows. Also, it can be complicated by the loss or gain of water during the food preparation process. A worked example which tackles these issues can be found here.

3.3 Analytic Approach

This approach is useful where effluent is regularly tested. Here, chemical analysis of a site's effluent is used to estimate the amount of food waste discharged to sewer/wastewater treatment. Larger scale food manufacturing sites may have a trade effluent consent or environmental permitting requirements. To demonstrate compliance, such sites generally test for the levels of authorised parameters which indicate the contamination levels of effluents.

Some of these parameters have a relationship with the amount of food waste in effluent. Such parameters include the following common examples:

- Suspended solids (SS)
- Biological oxygen demand (BOD)
- Chemical oxygen demand (COD)

However, this approach is complicated by the potential presence of non-food materials in the effluent e.g. soil particles from grading/washing fresh produce, meaning that there is not always a direct relationship between commonly measured parameters and food waste. On-site treatment of effluent will also alter the relationship between analytic parameters and food waste.

Calculations using the analytic approach become difficult where effluent contains a wide range of food wastes with different COD levels. As a result, this approach is best suited to sites which process a single raw material (such as milk processing at dairies[3]). In circumstances where there are a range of products involved, it can be used as a compliment to either the direct measurement or mass balance approach, to 'sense check' the results.

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[3] COD conversion factors used in the dairy sector can vary by +/- 0.005kg, as the fat content of milk has an impact on the COD load. More details can be found here: http://www.wrap.org.uk/sites/files/wrap/dairy-sector-guidance.pdf

A worked example of the analytic approach can be found here.

3.4 Measuring Food Waste in Sludge from On-Site Treatment

Sludge is generated at large food manufacturing and production facilities which pre-treat effluent on-site before discharge to the sewerage system. This allows sites to meet regulatory compliance requirements and remain within trade effluent consent limits for volume and concentration. A range of treatment techniques are used[4], which are designed to remove materials dissolved or suspended in effluent. In most cases these processes generate a sludge which is then discharged in addition to effluent. These sludges will contain food waste. Possible approaches to calculating the food waste discharged in sludge are included here.

4.0 Identifying the most suitable quantification approach

To help decide which quantification approach to apply, the following table presents the key advantages and disadvantage in each case.

Calculation Approach	Advantages	Disadvantages
Direct Approach	• Highest degree of accuracy likely. • Applicable to a range of circumstances and therefore repeatable across multiple sites.	• May not be feasible for complex sites with many potential sources of food waste being discharged to sewer.
Mass Balance Approach	• Can be used in cases where the direct and analytic approaches are not possible.	• Requires extensive data on a site's inputs and outputs. • Calculations can be technically complex.
Analytic Approach	• Calculations are based on analysis of effluent itself, potentially enhancing accuracy. • Where trade effluent is regularly monitored, data for use in the analytic approach is readily available.	• Requires effluent sampling data. • Can be complicated by the presence of non-food waste elements in effluent. • Multiple types of food waste entering the effluent present difficulties with assigning a single COD value.

Notes:
- The level of accuracy required for the amount of food waste discharged to sewer/wastewater treatment should reflect its overall relevance[5] to a site's total amount of food waste.
- Data should be calculated in a consistent way each year to facilitate comparison over time.
- Assumptions and the degree of uncertainty should be stated.

5.0 Quantification Approaches

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[4] Common effluent treatment processes include Dissolved Air Flotation, Activated Sludge, Anaerobic Digestion and others.

[5] The FLW Standard defines 'relevance' as the decision-making needs of the intended users.

5.1 Direct Approach

- Undertake a site walkthrough and identify all potential routes by which food waste might enter the sewer/wastewater treatment system. This could include:
    - Flushing of food-containing pipework (such as beer tap lines).
    - Cleaning of vessels where food is prepared.
    - Disposal of unfinished food (e.g. stock, soup) and drinks to drain.
    - Washing down floors or other surface areas.
    - Macerating food waste in in-sink waste disposal units.
- Create a table (in Microsoft Excel or similar) in which each identified route is listed, noting the measurement approach that will be taken.
- For each route, measure the contribution of food waste discharged to sewer/wastewater treatment per event (for example, the quantity discharged to drain each time pipework is flushed or a vessel is cleaned). Note that if possible, the process should be based on repeated measurements and an average taken to improve accuracy.
    - To assist with this, a trial could be conducted where pipework is emptied to a container instead of to drain, allowing it to be captured and its quantity more accurately calculated. In the HaFS setting, liquid waste (e.g. left over drinks) could be collected during a typical service or day and used as the starting point for extrapolating quantities for an average week/month/year.
- For each identified route, calculate the frequency this route contributes to sewer/wastewater treatment (number of events per year).
- The total contribution of this route can then be calculated by multiplying the contribution per event by the number of events per year.
    - If there is significant variation in the contribution per event, then an average contribution should be used when calculating the route's total contribution. This should be based on a sufficiently large and robust sample (a minimum of 20 samples is recommended if the material flow makes a significant contribution to overall waste).
- The total site contribution is then given by the sum of all the source contributions.

5.2 Mass Balance Approach

- Identify all the **inputs** for the site and calculate the total mass (kg/tonnes) involved in product manufacture. Typically, this information can be found by analysing purchasing data.
- Quantify the total mass (kg/tonnes) of all **outputs** for the site, including categories such as:
    - Sales of food products
    - Food surplus going to re-distribution, animal feed, or bio-based materials/biochemical processing (e.g. rendering)
    - Food waste directed to anaerobic digestion, composting, landfill, incineration and/or land application
    - Sludges containing food waste removed through on-site treatment of effluent.

- A notable aspect of the mass balance approach is the need to account for water gain or loss during the food production process (e.g. soaking grains prior to processing, or evaporation during baking). The mass of water as an ingredient should be included as an input and the mass of water lost through evaporation should be included as an output.

- The calculated amount of food waste directed to effluent is then given by the difference between site food inputs and site food outputs. A worked example can be found here.

5.3 Analytic Approach

- Obtain effluent sampling data and determine average levels of COD.

  - Where effluent is treated on-site, sampling should occur **before** the treatment process. If this is not possible, then treated samples can be used to measure food in the material discharged to sewer, but any food waste present in sludge should be added to the results to calculate the total food waste directed to sewer/wastewater treatment and sludges from on-site treatment. Possible approaches for measuring food waste in sludge can be found here.
  - Where no treatment of effluent takes place on site, sampling should be made at the discharge point.
  - COD sampling can be undertaken by contacting an analytical laboratory and either organising sample bottles which can be filled by site staff, or contracting the sampling process out to an environmental engineering consultancy. UKAS (the United Kingdom Accreditation Service) maintains a list of accredited testing laboratories[6].
- For sites that process a single raw material (such as a dairy which processes raw milk), and it can be reasonably assumed that all COD in effluent comes from food waste, the following process can be applied:
  - Determine the COD of the food that is processed at the site, and which may be directed to sewer/wastewater treatment. This can be achieved by sending samples of food ingredients and/or products to an accredited laboratory for analysis[6].
  - Determine the total effluent discharge volume for the site
  - Determine the average COD of the effluent generated by the site. If effluent is treated on site, sampling should occur before pre-treatment. Where there is no on-site pre-treatment, sampling should occur at the discharge point.
  - The amount of product which has been directed to effluent is then given by the following calculation:
    (Effluent Volume x Effluent COD) ÷ Food Waste COD

- Conversion factors. Some industries provide figures to allow simple conversions to occur. These need to be sourced for each sector in question. For example, the dairy industry provides a means of using COD results to calculate 'milk equivalents', using the following relationship: 1 kg COD = 0.223 kg milk (total COD masses are obtained by multiplying COD concentrations by total effluent volumes)[3]. As another example, Greencore, a manufacturer of convenience foods has developed a correlation between calorific value of food products and COD levels. Details of this approach can be found here.
- If the site processes a variety of raw materials and produces a variety of products, the analytic approach can be used to verify the food waste in effluent results obtained via the direct or mass balance approaches according to the following:
  - If the food waste in effluent results obtained are high, the COD results should be high also.
  - If the food waste in effluent results obtained are low, the COD results should be low also.

[6] To access a list of accredited testing laboratories, enter 'chemical oxygen demand' in the search function located at: www.ukas.com/search-accredited-organisations/

- For reference, food waste in effluent results typically range from 0 - 55 grams per litre; the COD of raw industrial effluent before treatment is typically ≥20,000 mg/litre; and a range of COD levels of food products is given in the following table.

Food	COD mg/kg product	COD kg/tonne product
Beer (lager)	125,000	125
Milk	180,000	180
Wine (red)	320,000	320
Sugar	1,100,000	1,100
Cider	120,000	120
Wheat flour	1,500,000	1,500
Cream	1,104,000	1,104
Yoghurt	220,000	220
Egg (no shell)	490,000	490
Blood (pig)	270,000	270

- If either of the above points are contradicted by the comparison undertaken, re-investigate the approach used to calculate food waste in effluent.
- Where a number of products or inputs are present in effluent, a weighted average for COD can be used, or the COD of the largest contributor to food waste.

5.4 Measuring food waste in sludges from on-site treatment

- Obtain data on the total mass of sludge produced from on-site effluent treatment. This can often be secured from liquid waste management or land spreading contractors that manage the removal of the sludge, or can be calculated by using bin volumes, sludge densities and frequency of collections.

- Take a representative sample of sludge and send it to a testing laboratory[6] for compositional analysis. For the sample to be representative, it should reflect sludge produced as a result of typical onsite activity patterns. If there are large variations in production processes across different days, multiple samples on different days may be required, and an average produced (weighted if necessary). Information regarding specific bottles and procedures for taking the sample should be sought from the laboratory used for testing. To account for added water and non-food material (this is especially relevant to the fresh produce sector, where products are often washed to remove soil), ideal measurements to establish are:
  - Dry matter content (g dry matter/g of total matter)
  - Inert material content (g dry inert matter/g total matter). Options for measuring inert material content should be discussed with the testing laboratory.

- Calculate the mass of food waste. The quantification approach taken will depend on the type of effluent treatment used and the nature of the sludge generated.

  - In the case of physical separation systems (e.g. screens, settlement tanks etc.) and coagulation-based processes such as Dissolved Air Filtration (DAF), the following basic calculation can be used to quantify the dry weight of food waste in sludge:

    (Total sludge mass (kg) x dry matter content (dry kg/kg)) – (Total sludge mass (kg) x inert matter content (dry inert kg/kg))

  - In the case of a biological process such as activated sludge or anaerobic digestion, the calculation is more complex due to the potential increase or decrease in mass which takes place during the treatment process. Liaison with the site's effluent treatment technology provider is therefore recommended to account for this effect.

- All the approaches described above for calculating food waste in sludge use dry matter data to account for the presence of water. However, in order to report on the weight of food waste in the form in which it was generated, dry matter results need to be converted back to their original 'wet weight'. This should be done using data concerning the water content of food products or inputs, which can be gathered by sending samples to a laboratory for analysis. Where a number of products or inputs are present in sludge, a weighted average for water content can be used, or the water content of the largest contributor to food waste.

6.0 Worked examples

6.1 HaFS: Direct approach

In a HaFS setting, food waste directed to effluent will arise from back of house activities (e.g. cleaning of equipment, disposal of unused/out of date liquid foods, use of macerators[7]), and from front of house operations (e.g. unfinished food and drinks, spills, cleaning of equipment).

To facilitate the use of the direct approach, records should be kept regarding:

- Front of house quantities of food waste directed to drain, such as flushing beer lines or disposing of unfinished drinks.
- Back of house quantities of food waste directed to drain, such as cleaning food preparation equipment. If macerators are in use, records should also be kept of quantities of solid food waste treated in this way prior to disposal to sewer.

As an example, a large hospitality operator manages 27 different bar sites. In order to estimate their food waste to sewer/wastewater treatment, they select one site to investigate, and subsequently extrapolate the results for the whole business. To do this, they select a site which represents average business activity (for example in terms of drinks sold) and make the reasonable assumption that food waste would track business activity closely.

Like the other sites in the business, the selected bar operates with three sources of food waste directed to sewer/wastewater treatment:

- <u>Unfinished customer drinks</u>: To address this, the bar picks a typical night of operation, and asks table clearing staff to empty unfinished drinks into a container which is then measured at the end of the night. The quantity of unfinished drinks collected, comes to a figure of 28.3 litres. The bar is open five nights per week, so the annual total is estimated at 7,358 litres/year.
- <u>Flushing beer lines during keg changeovers</u>: Here, a trial was used to measure the volume lost in each keg changeover, giving a figure of 2 litres. Purchasing records then revealed that the bar used 950 kegs during the year, resulting in a total beer loss of 1,900 litres for that year.
- <u>Back of house cleaning operations</u>: Measurement of quantities was not possible here, so the bar estimated that 0.01 litres of drink remains in each glass directed to washing. Given that records indicate that a total of 1,550 drinks are sold per night, this gives a total food waste to sewer/wastewater treatment of 15.5 litres per night, or 4,030 litres per year.

Adding these three factors together gives a total food waste figure for the bar of 13,288 litres/year, and 358,776 litres/year across the entire business. For reporting purposes, this should be converted into mass, using an average drinks density. For example, if the density of drinks is

[7] The use of macerators varies throughout the UK, depending on the regulations in place in each country.

assumed to be 1.0 g/ml, the mass of food waste for the business as a whole is approximately 359 tonnes.

6.2 Retail: Direct approach

Food waste directed to effluent in the retail sector is likely to be quite restricted, most often involving the clean-up of breakages and spills of liquid products at RDCs (Regional Distribution Centres) or stores.

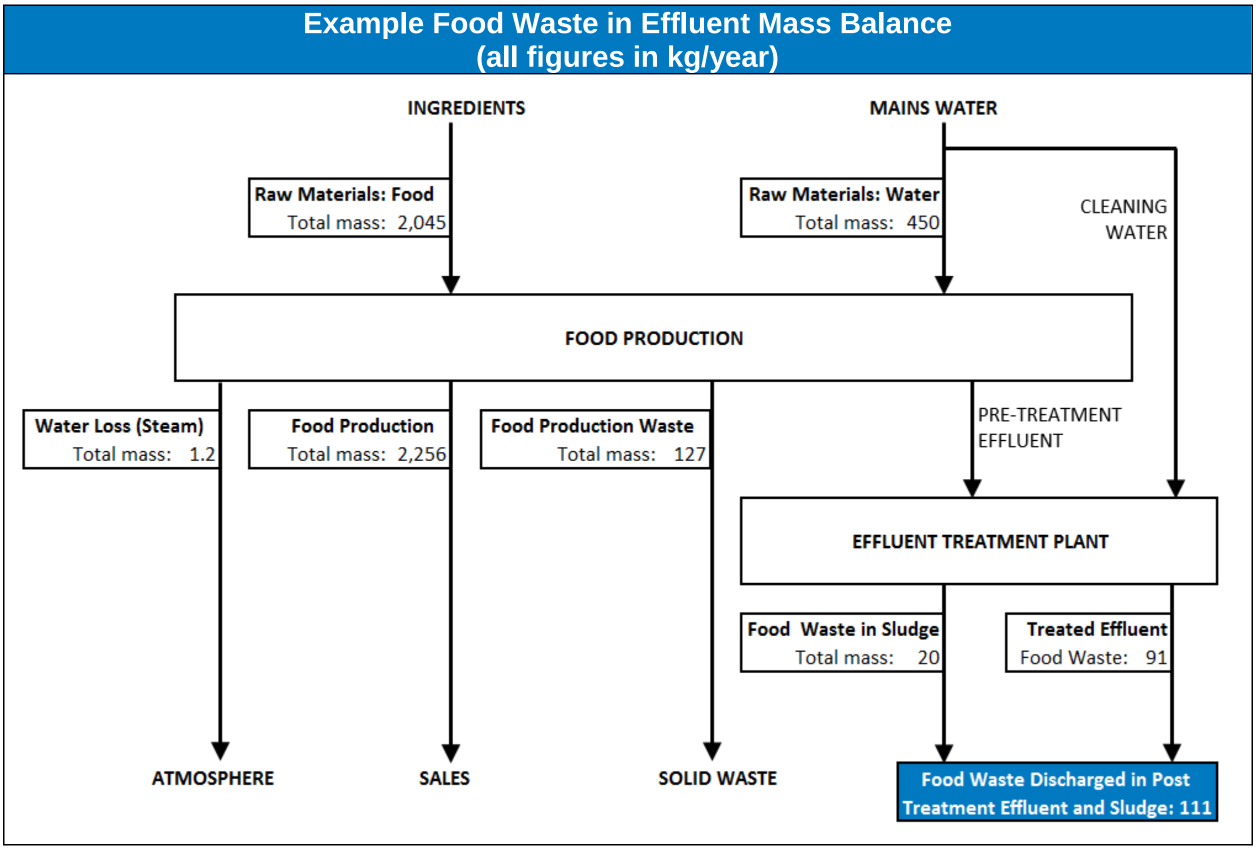
In these circumstances the direct approach might be most appropriate. This would involve:

- Records of food waste discharged to drain, such as logs for when product was spilled and disposed of.
- Calculation or estimation of the food waste disposed of due to clean-up of spills.

For example, an RDC may log a total of 825 broken or spilled items during a year, which resulted in a total of 620 litres of wasted product. Discussion with cleaning staff at the site reveals that an estimated 75% of each spill is soaked up using spill kits, which are subsequently disposed of to landfill. The remainder is mopped up, with cleaning materials subsequently rinsed in a sink directed to drain. This would give a total of 155 litres of food waste directed to sewer/wastewater treatment for that year. For reporting purposes, this should be converted into mass, using an average density for spilled liquids. For example, if the density of spilled liquids is assumed to be 1.0 g/ml, the mass of food waste for the RDC is approximately 0.16 tonnes.

6.3 Food production and manufacturing: Mass balance approach

The following diagram represents a mass balance for a site making ready meals:



Note that, in this mass balance, the effect of adding water as an ingredient is taken into account as an **input**, and losing water as steam is taken into account as an **output**. (Water losses in steam can be difficult to assess, but a convenient method might be to either weigh a sample of products before and after they are heated, or compare dry weights of ingredients against those of finished products). Since the mass balance approach is intended to calculate the mass of food waste, the above calculation only includes water which is used as an ingredient in the product. The mass of water used for cleaning and other incidental uses does not need to be accounted for in the mass balance.

Food waste in pre-treatment effluent can be calculated as follows:

Food Inputs – Food Outputs

= (Raw Materials: Food + Raw Materials: Water) – (Water loss (steam) + Food Production + Food Production Waste)

= (2,045 kg/year + 450 kg/year) – (1.2 kg/year + 2,256 kg/year + 127 kg/year)

= 111 kg/year

This figure can be further broken down, by calculating the amount of food waste discharged in sludge. Approaches for calculating food waste in sludge from on-site treatment can be found here. In this example, 111 kg/year food waste is made up of 20 kg/year discharged in sludge from on-site treatment and 91 kg/year discharged in post-treatment effluent.

The analytic approach could be used to cross check this against effluent testing results undertaken at the site as a 'sense check'.

6.4 Food production and manufacturing: Analytic approach

A site processes juice concentrate, principally through dilution, and packages it for sale. The juice concentrate is sampled and tested for COD, which gives an average result of 500,000 mg/litre. The site is a large producer of effluent, and has a dedicated effluent meter, which shows that 100,000 litres of effluent is discharged each year. Effluent is treated on site and sampling carried out pre-treatment, returns an average COD value of 500 mg/litre. The site is confident that the vast majority of COD loading in effluent is caused by juice waste.

The amount of juice concentrate which is directed to effluent is given by the following calculation:

(Effluent Volume x Effluent COD) ÷ Food Waste COD

= (100,000 litres/year x 500 mg/litre) ÷ (500,000 mg/litre)

= 100 litres/year

Thus the quantity of food waste discharged in effluent is 100 litres of juice concentrate. For reporting purposes, this should be converted into mass, using the density of the juice concentrate. For example, if the density of the juice concentrate is 1.2 g/ml, the mass of food waste is 120 kgs.

6.5 Food production and manufacturing: Measuring food waste in sludges from on-site treatment

A convenience food manufacturing site uses a non-biological treatment system to remove solids from its effluent. A sludge sample which is representative of on-site operations is taken from the system, and tested for its dry matter content and inert matter content, giving results of 0.05 dry kg/kg and 0.02 dry inert kg/kg. The site produces a total of 23,000 kg of sludge each year.

The amount of food waste in sludge can be estimated as follows:

(Total sludge mass (kg) x dry matter content (dry kg/kg)) – (Total sludge mass (kg) x inert matter content (dry inert kg/kg))

= (23,000 kg/year x 0.05 dry kg/kg) – (23,000 kg/year x 0.02 dry inert kg/kg)

= 690 kg/year

The average dry weight of the food product produced at the site is 0.20 dry kg/kg. Thus this quantity of food waste in sludge is equivalent to 3,450 kg/year of food product.

7.0 FAQs

Q: How does sludge fit into the guidance?

A: Sludge is generated at large manufacturing and production facilities that pre-treat effluent on-site. A range of effluent treatment processes can be used from physical systems which trap particles (filters, screens etc.) to chemical and biological systems such as Anaerobic Digestion[4]. These guidelines include approaches for calculating food waste in discharged effluent and also in sludge discharged from on-site treatment. Different approaches are provided for different types of on-site effluent treatment.

Q: Is it a requirement to report the amount of food waste sent to the sewer/wastewater destination?

A: Where an organisation has identified sewer/wastewater treatment as a destination which is 'in scope' amounts should be reported. However, the principle of relevance[5] applies. Thus where the amount of food waste discharged to sewer/wastewater treatment is not considered to be relevant (e.g. in comparison to other destinations), no reporting is needed and this exclusion should be stated.

Q: How accurate does the amount of food waste reported need to be?

A: The level of accuracy needed to report on food waste in effluent relates to the principle of 'relevance'[5]. Calculations should be accurate enough to support the decision making needs of the intended users. The approaches used to calculate food waste in effluent should be stated, as well as an evaluation of the level of uncertainty.

Q: How do I account for water which is added to, or lost from food, which then becomes waste?

A: The FLW Standard states that food waste should be reported in the state in which it was generated before water was added, or lost. Any calculations used to estimate the original weight of the food waste should be described.

Q: How do I account for water which is used for cleaning or diluting food waste in effluent?

A: If water is added to food waste, users of the FLW standard are required to report on food waste excluding the added water. For example, if a brewery disposed of 100 litres of beer, diluted with 900 litres of water, into the sewer, it is required to report its food waste as only the 100 litres of beer (converted into the weight equivalent as required by the FLW Standard). If a calculation is needed to estimate the original weight of food waste, users of the standard are required to describe the approach used[8].

Q: Where can I find additional guidance on this topic?

A: Appendix A and Section 3.2 of the Guidance on FLW Quantification Methods provide guidance for an entity seeking to quantify food waste that goes to the sewer or wastewater treatment. This may occur where water has been added (see related requirement in Section 6.7 of the FLW Standard[8]).

[8] FLW Standard, Section 6.7, Related issues, Water added to or removed from FLW