Ontario Onsite Wastewater Association

OOWA's Best Practices Series:
Flow Balancing and Flow Equalization

Produced by the OOWA Onsite Technical Committee

Version 1.0
BP 05: Flow Balancing and Flow Equalization

Drafted: October 2018 – July 2020
Issued: August 01, 2020

Table of Contents

1.0 Overview

Flow balancing is a design approach for onsite sewage treatment systems that stores predictable, short-term peak sewage flows and pumps it to the downstream components over the course of several subsequent hours or days. Flow balancing is similar to flow equalization and the terms are often used interchangeably. Generally speaking, flow equalization is typically achieved over a 24-hour period to reduce diurnal peaks whereas flow balancing is intended to store and reduce peak flows over multiple days, perhaps over a weekend or other predictable high use event.

For the purposes of this document, flow balancing will refer to attenuation of flows over a period of multiple days, and the term flow equalization will refer to attenuation over a period of hours within the day. It is important that the designer understands of the time period being considered for attenuation of peak flows, regardless of the terminology being used.

When considering flow balancing or equalization, a designer must have a thorough understanding of influent sewage flow patterns, in order to identify when the peak flows occur, what their durations are, and how long and low the off-peak periods are. Flows must be predictable with a distinguishable pattern of high flow and low flow days. A site that has predictable maximum day flows, followed by significantly lower off-peak periods, may be a good candidate for flow balancing.

Design questions include:
- How big does the balancing tank need to be?
- How are the components sized after the balancing tank?
- What are the settings for the pump?
- Where does the balancing tank go in the system?

1.1 Reasons to consider flow balancing

Onsite sewage systems are typically sized based on maximum day sewage flows, estimated according to building code values. This approach ensures that the system always has sufficient treatment and disposal capacity, even for maximum occupancy events. This approach works well for smaller systems, when flows may be highly variable from day to day with no predictable pattern, and for less sophisticated treatment technology. However, for larger systems it may result in an under-utilized system which may struggle to achieve performance objectives.

When large systems are sized according to maximum day flows, the system may consist of large components i.e. septic tank and leaching bed that is fully used on only one or two days per week and highly under-utilized the rest of the time. In these cases, if the flow pattern is predictable and the difference between high flow days and low flow days is significant, a balancing tank can be used to "even out" the flows over the week.

Incorporating flow balancing has many advantages if implemented thoughtfully and in accordance with good engineering practice. Sewage system components installed downstream of the balancing tank can be sized at less than the maximum day flow, resulting in smaller unit components. However, at least one additional tank, as well as additional pumps and timer controls, are required. This may reduce the overall footprint of the system and may also represent savings in capital costs. Flow balancing evens out both the hydraulic and organic loadings to the treatment system (soil or treatment unit) resulting in better, more effective primary and secondary processes. This may result in better effluent quality on average over the long term.

The use of flow balancing also provides an operator or owner with more information for diagnostics and systems analysis, since pumps are timer controlled and control panels are more sophisticated. This can provide some flexibility in the dosing regime, allowing an operator to optimize performance over time. It also provides some simple tools to monitor flows through various parts of the system.

2.0 Jurisdictional review

Although flow balancing is a relatively common design approach for large onsite sewage systems, few jurisdictions in North America have a regulatory approach. The following sections summarize local guidelines and include a short review of requirements elsewhere to provide some assistance to Ontario designers, as we do not have any local prescriptive requirements for flow balancing.

2.1 Local Guidelines and Regulations - OBC and MECP

Balancing tanks are mentioned in the Ontario Building Code, but the information can be difficult to find. Appendix A, A-8.2.1.3 (1) and (2) of the OBC outlines some information for balancing tanks. Balancing tanks should be sized in accordance to "good engineering practice" to ensure peak flows can be accommodated. The building code also suggests that components downstream of the balancing tank may be sized on the average weekly flow. No specific guidance is provided on how to determine the average weekly flow or how to size the balancing tank.

The Ministry of Environment's 1982 Manual notes that balancing tanks may be needed where the peak day or peak hour flow is much higher than average flows (Section 9.3.3.b and 9.3.8.b) and balancing tanks are to be sized to accommodate the flows during peak periods and include pumps/controls to discharge an even daily flow to the sewage system (9.3.5.b). The manual notes typically it is variable daily flows that give rise to balancing (as opposed to variable hourly flows), such as a country restaurant which sees weekend flows far in excess of flows during the work week. The sizing of the balancing tank pumping system and sewage system downstream of the balancing tank should be at least equal to the average daily flow for the week (9.3.8.b). The manual states balancing tank size should be based on the peak volume of sewage that will accumulate during high flow days when the outgoing pumping rate is exceeded, plus some additional capacity to accommodate unexpected peaks higher than design or pump failure. Further, the manual notes a high-level alarm should be installed to provide warning of unexpected high flow, pump failure or blockage.

CSA B65-12 also includes a short section on flow balancing. Section 7.3 states that "if the daily flow is expected to vary substantially among the days of the week, a flow equalization and management method (e.g., a balancing tank, timer, and pump) to balance the flow over a seven-day period may be used to allow the system design to be based on the averaged seven-day flow (i.e., the balanced daily flow)." This is consistent with the approach outlined in both the OBC and the MOE design guidelines.

The OBC does require flow equalization when discharging highly treated effluent to a shallow buried trench or Type B dispersal bed. According to the building code, effluent must be discharged to the bed evenly over a 24-hour period on an hourly basis. This approach requires the use of a timer controlled pump to ensure hourly dosing and to limit the amount that is dosed each hour to ensure even distribution over 24-hours.

2.2 American Jurisdictions

Several American jurisdictions have varying degrees of regulations regarding the use of balancing tanks. Some states, including Maryland, Michigan, Minnesota, North Carolina, Oklahoma and Vermont provide guidance regarding the size and/or storage capacity of the balancing tank. Other states (Minnesota and Pennsylvania) provide guidance regarding the balanced design flow and appropriate safety factors. Some of the design guidelines from other jurisdictions are included in the information provided below. For a more detailed list of references refer to Section 9.

3.0 Site & System Considerations

Generally, most jurisdictions allow flow balancing to be considered where there are significant variations in sewage flows on certain days of each week which are known and predictable. Some jurisdictions only allow flow balancing for non-residential uses. Flow balancing and the preferred approach should always be discussed with your local building official prior to proceeding with detailed design.

There are numerous examples of non-residential uses that lend themselves to this design technique, because they experience predictable flow patterns. A simple, straightforward balancing application would be a situation where the maximum day use or occupancy is predictable and isolated to one or two days per week. The system must be able to accommodate the maximum day flow days, but the design flow used for sizing system components does not necessarily need to be the maximum day flow. Examples of non-residential uses that may be suitable for flow balancing include:

- Churches
- Campgrounds
- Banquet facilities
- Golf Courses
- Weekend retreats/resorts

These types of uses tend to have a predictable flow pattern of maximum day and low-flow days that can be used to assess what an appropriate pre- and post-balanced design flow would be.

Flow balancing is most typically used for non-residential occupancies. If consideration is being given to using flow balancing for a residential application, this should be carefully considered and approached with caution. Under the current OBC, the design flows are calculated based on the number of bedrooms, number of fixtures, and square footage of the home, ensuring a robust, conservative design that can accommodate the maximum occupancy of the home. Establishing a design basis for flow balancing for a residential occupancy could be challenging as flow patterns are not necessarily regular and predictable over time. Even seasonal residential occupancies, such as cottages, which may be occupied on a more sporadic basis, should be approached with caution, as changes in habit or ownership may affect sewage flow patterns very quickly.

The following situations may be poor candidates for flow balancing:

- Sewage flows are similar day to day throughout an entire week (i.e. most residential);
- Maximum day flow is less than four times the weekly average day flow (i.e. low peak factor);
- The schedule of peak flows is unpredictable, and therefore could lead to excessive high-level alarm events, or large uncertainty in how to size the balancing tank;
- The balancing tank pumps & controls introduce electrical components into an otherwise passive system (balancing may still be more cost-effective even with the addition of electrical systems, but must be discussed with the owner)

3.1 Flow Equalization

Flow equalization can be considered where the sewage is generated within only a few hours of the day. Examples would be a school where the majority of sewage flows are generated over a 6-hour period (9AM to 3PM), or a dance studio or gymnastics club where flows are generated over a 4-hour period (5-9PM). In such situations flow equalization may not necessarily be intended to decrease downstream component sizing; however, it may help improve sewage system performance and reduce risk of failure. This is the main objective of the OBC clause requiring hourly dosing over a 24-hour period for shallow buried trench leaching beds and Type B Dispersal Beds.

3.2 Treatment System Considerations

Where sewage flows occur during a short period of the day, or only a few days each week, all types of leaching beds will benefit from balancing. However, it is up to the designer to understand whether flow balancing provides sufficient benefit to the leaching bed to warrant the added complexity.

Certain types of leaching beds, specifically shallow buried trenches and Type B dispersal beds are required by the OBC to have flow equalization over a 24-hour period. These two types of leaching beds require effluent from a Level 4 Treatment Unit to be dosed on an hourly basis, thereby necessitating flow balancing by oversizing the pump tank.

With respect to treatment units, most manufacturers prefer flow balancing before the treatment unit particularly for larger design flows and non-residential applications. This tends to favour placing balancing tanks before or after the septic tank but before the treatment units. Such flow balancing improves the performance and reliability of the treatment units.

4.0 Design Approaches

4.1 Balancing Tank Location

It is important to consider the point in the system where balancing is to occur, as this impacts the sizing of all system components both upstream and downstream of the balancing tank, as well as the type of pumping system that is appropriate.

Balancing can be implemented at the front-end of the sewage system. In this case, the balancing tank must be designed to accommodate raw sewage as it is generated. In this location the balancing tank would be equipped with either sewage pumps or grinder pumps and should be benched or otherwise configured to ensure that solids are directed towards the pumps, rather than settling out in the balancing tank. The balancing tank should be sized based on the maximum storage requirements over the course of the balancing period (plus an appropriate safety factor), and the downstream system components (septic tank, treatment unit, leaching bed, etc.) should be sized based on an appropriate post-balanced design flow.

Alternatively, the balancing tank can be placed after the treatment tankage to provide balancing to the leaching bed. In this case, all upstream components (i.e. septic tanks, treatment units, etc.) would need to be sized to accommodate the maximum daily design flow calculated as per OBC requirements. The leaching bed would be sized to accommodate the post-balanced design flow. In this case, the balancing tank could be equipped with effluent pumps, and the tank would not necessarily require benching.

Balancing can also be implemented at other intermediate points in the system (i.e. to balance flows to a treatment unit). At all times, any system components upstream of the balancing tank must be sized to accommodate the maximum daily design flow.

Consideration should be given to the most effective and cost-efficient point in the system to implement the balancing. If treatment units are included in the design it is recommended to balance flows upstream of the treatment unit, to ensure a consistent hydraulic and biological load to the treatment unit.

4.2 Pre & Post Balanced Design Flows

All components before the balancing tank must be sized according to the maximum day sewage flow (i.e. OBC design flow). If the balancing tank is the first tank, then only the balancing tank is sized for the maximum day flow, with some consideration for what is being discharged to downstream components and emergency storage volumes. The sizing of the balancing tank is discussed further in the next section. If the balancing tank is installed after the septic tank (or any other component), then the septic tank must also be sized for the maximum day flow in accordance with OBC requirements. However, all components downstream of the balancing tank may be sized according to the "balanced design flow".

The most common approach to determining an appropriate balanced design flow is to average the sewage flow over the balancing period. This is consistent with the OBC, MECP and CSA B65 guidelines.

In order to determine the average day flow, a designer must be able to assign anticipated sewage flows for each day in the balancing period.

Some of these days will be maximum day flows as determined in accordance with OBC regulations, but some days may be estimates based on lower occupancies. Daily flow during low flow days may be developed through an understanding with the building owner of how the occupancy, use or level of business changes between the maximum occupancy periods and other times. The flow may be derived using the OBC design flows at the reduced occupancy levels, or an estimate can be made of a relative reduction in flow, such as half the occupancy might suggest an off-peak flow equal to half of the maximum day.

In some cases, actual water use or sewage flow data may be used. Once sewage flows for each day have been assigned, the designer may obtain the average for the balancing period (i.e. the total volume over the balancing period divided by the number of days in the balancing period). This balancing period average day flow becomes the "balanced" design flow. The pumps installed in the balancing tanks must be designed and controlled in such a way that the maximum flow delivered to downstream components does not exceed the balanced design flow.

It may be prudent to consider a safety factor for the balanced design flow, in order to accommodate variables that may be outside the designer's control, such as change of use patterns, etc. Designers should be conservative when assigning sewage flows over the balancing period in order to ensure that the system will have sufficient capacity to accommodate variations in use and flow patterns. This is discussed further in the section below.

In some instances, it may be desirable to retrofit an existing system with a balancing tank, in order to better accommodate occasional high flow days which may be temporarily exceeding the hydraulic capacity of the system. In these cases, the balanced flow may be equal to the rated capacity of the downstream components. However, in these cases a careful analysis of the flow pattern should be completed to ensure that balancing can be accommodated. In some instances, flows may be too high to be effectively balanced.

Depending on the occupancy type, the peak hour flow may also be needed to confirm that high level alarms would not be triggered during the day.

4.3 Safety Factor for Balanced Design Flows

There are no hard and fast rules about whether a safety factor should be employed, and if so what an appropriate factor of safety might be; it is ultimately the discretion of the designer. Higher factors of safety (25% to 50% or more) may be contemplated if the occupancy or use could change if there is a new owner and the flows could increase. A lower factor of safety (10% to 25%) could be used where the occupancy or use is unlikely to change or there would not be a new owner, for example, a church.

Jurisdictions that require safety factors are listed in the table below.

Jurisdiction	Method of Calculating Design Flow for Components After the Balancing Tank
Minnesota	Design balanced flow = calculated balanced flow / 0.7 = calculated balanced flow x 1.43
Pennsylvania	Design balanced flow = calculated balanced flow + 20%

Another method for adding some modest conservatism to the downstream components is to calculate the balanced flow by assuming treatment over fewer days. For example, 6 days instead of 7 days which gives an extra 17% capacity as factor of safety.

4.4 Balancing Tank Volume

Ensuring that the balancing tank has sufficient active storage to accommodate maximum day flows during peak periods while delivering a pre-determined volume to downstream components is a critical part of balancing tank design. Careful consideration of the expected sewage flow pattern is required in order to determine the appropriate volume. The method for determining the balancing tank volume can be based on average flows, maximum day flows (i.e. OBC design flow), safety factors or some combination of the foregoing.

An effective way to determine the minimum storage volume required is to complete a mass balance calculation over the balancing period. Typically, this might be one week however the balancing period can be extended if required. For each day in the balancing period, the mass balance approach should consider how much sewage is entering the tank, how much is leaving the tank (this should be equal to the balanced flow as determined above) and how much must be stored, as follows:

Volume in tank today = Previous day's stored volume + Volume into tank – Volume pumped out of tank

The minimum storage volume required in the balancing tank will be equal to the maximum storage volume required over the balancing period. Note this is the absolute minimum active storage volume in the tank. The designer must also consider volume required for emergency storage, contingency for extreme high flow events, non active tank volume, tank up by pumps etc.

Note when completing the mass balance over the course of the balancing period it is important the volume of sewage stored in the balancing tank returns to zero. The balancing tank should ideally start off empty at the beginning of the high flow event, slowly fill up over the course of the high flow days, and the start to empty over the course of the low flow days. If the volume stored in the balancing tank does not return to zero before high flow events resume, then the balancing tank will just continue to fill, which will lead to an untenable situation where flows are transferred to downstream components that do not have adequate treatment capacity. Refer to Appendix 1 for an example.

Other approaches to sizing the balancing tank from American jurisdictions are outlined in the table below.

Jurisdiction	Method of Calculating Balancing Tank Volume
Maryland	Storage requirements for flow equalization should be calculated using a graphical approach where the cumulative inflow volume is plotted verses time
Michigan	Volume = peak day flow OR calculated storage volume + 20%, whichever is higher, plus volume for pump submergence
Minnesota	Add 20% to the calculated storage volume
North Carolina	Volume = pump submergence volume (min. 300 mm tank depth) + calculated storage volume + emergency storage equal to the peak day volume
Oklahoma	Minimum 3,800 L (1,000 US gal) Volume = 2 x design peak day sewage flow (if flow > 1,900 L/d) Pump controls to be set so the balancing tank is never more than half full.
Vermont	Volume = 2 x average daily flow (not peak day flow)

4.5 Equalization Tank Volume

Flow equalization is typically used to even out peak flows that may only occur over a few hours of 24 hour period. Flow equalization may be employed for residential systems, to avoid hydraulic or organic overloading during peak hour events, or to smooth out diurnal peaks and spread flow out over 24 hours. For these applications, the equalization tank must have sufficient capacity to accommodate peak hourly flows, and sufficient storage for the duration of the peak events, taking into account how much is leaving the equalization tank on an hourly basis. Therefore, identifying the flow pattern over a 24 hour period becomes critical.

There are several reference guidelines available to assist with this approach. The 10-States Standards recommends that with a diurnal flow pattern, the volume required to achieve the desired degree of equalization can be determined from a cumulative flow plot over a representative 24-hour period. The cumulative storage method involves a simple tabulation of inflow, outflow, differential storage, and total storage every hour for 24-hours, wherein the maximum cumulative storage volume would be the required minimum equalization tank volume with no safety factor. This is very similar to the mass balance approach described in Section 4.4. An added safety factor of 25 – 50% should be applied to account for unusual peaks or mechanical problems.

This method is recommended if the diurnal flow pattern is known or can be estimated. The NSF Standard 40 protocol includes a residential flow pattern where the assumed flow profile is 35% of flow from 6AM – 9AM, 25% of flow from 11AM – 2PM, and 40% of flow from 5PM – 8PM, with zero flow for periods between. This is a reasonable approach for residential applications. The hourly outflow is equal to the maximum day flow divided by 24 hours.

Where a flow pattern is unknown an alternate approach is required. The total daily design flow may be divided by 24 hours to estimate an average hourly flow; however, it is highly unlikely that the flow will be evenly divided over 24 hours. Therefore, it is generally recommended that an hourly peaking factor of between 2.4 and 6 times the hourly design flow be applied. The designer must have a good understanding of the 24 hour flow pattern in order to apply an appropriate hourly peaking factor. Note that an hourly peaking factor of 6 means that 6 times the average hourly design flow enters the system in 1 hour; or as there is 24-hours in the day, 6 hours represents 25% of the daily design flow in 1 hour. Peaking factors above 6 are rarely used and represent extreme cases, as there would otherwise be very little flow over the remainder of the day.

Refer to Appendix I for an example of flow equalization for a residential application over 24 hours.

A simplified method is presented by the USEPA) using the Rectangular Wave Method, where:

$$V_{EQ} = \frac{Q_A(x-1)^2}{(x^2-1)}$$

Where: V_{EQ} = volume of the equalization tank, and
x = ratio of peak to average flow = ratio of average to minimum flow

As an example, if the design flow is 10 m^3/d and the peaking factor is 6, the calculated equalization tank size according to the Rectangular Wave Method is 7.14 m^3 or 71.4% of design daily flow.

Using the above examples and methods, a generally conservative estimate of equalization tank size for diurnal flow equalization is 75% of design daily flow.

6.0 Pumps and Controls

The balancing tank contains one or more transfer pumps to move sewage at a predetermined daily rate from the balancing tank to the downstream sewage system (i.e. septic tank, treatment unit, or leaching bed). The daily rate should be equal to the downstream sewage system capacity and must be on a timer. Refer to "OOWA's Pump Chamber Guidance Document for assistance in how to set up pumping systems.

Where the balancing tank is the first tank (i.e. receiving raw sewage), best practice recommends the transfer pump be:

- Submersible sewage pump able to pass a minimum 50 mm [2"] solid and downstream piping should also be minimum 50 mm [2"]; or
- Submersible sewage grinder pumps,
- For industrial/commercial/institutional sites, arranged as alternating duplex pumps that will use only the functioning pump if one pump fails for redundancy purposes.

When the transfer pump fails or is unable to transfer enough sewage out of the balancing tank, the balancing tank effectively becomes a holding tank. Like holding tanks, the balancing tank must be equipped with an audible and visual alarm to warn the owner/operator when there is a problem. The alarm float should be set to activate at a level corresponding to the maximum normal design storage volume, and any safety factor volume should be available above the high level point.

Details on pump controls and accessories (control panels, float switches, etc.) can be found in "OOWA Best Practices: Pump Chamber Guidance Document". Specific to equalization and balancing tanks, the pump activation level controls must include either a wide angle low level switch that can be set to activate and deactivate over a volume greater than one dose cycle, or use 2 separate narrow angle floats to start and stop the pump(s). The high level alarm should be a separate float switch. If a level transducer or other sensor is used to activate the pump, redundant high and low level float switches are recommended. Additionally, the control system may include an override level setting that would run the pump(s) at an alternate setting at a level above the normal working volume (i.e. increased timer settings, parallel operation, or continuous operation) if the downstream components would not be adversely impacted by this temporary condition. Any control components in contact with raw sewage (upstream of primary clarification or septic tank) must be suitable for the application and wired in accordance with the Ontario Electrical Safety Code.

Any pump chamber, including equalization and balancing tanks, must include adequate ventilation to take in or displace air due to the varying liquid volume. This may be provided by a separate vent pipe on tank, by using a vented lid, or by connecting to the main building vent stacks.

7.0 Pre-submission Consultation Recommendations

It is a best practice to discuss a proposed flow balancing concept with your local regulator, such as building official or health inspector for systems under the OBC or MECP representative. Generally speaking, flow balancing cannot be used to de-rate a site from jurisdiction under MECP to the OBC. If the calculated maximum day sewage flow is greater than 10,000 L/d, the site is regulated by the MECP regardless of how the downstream flows are handled. This should be clarified with your local building department prior to proceeding with detailed design, as interpretation of this clause varies from municipality to municipality. At minimum, a flow balance calculation should be developed as part of the design package and submitted to the regulatory authority along with all other typical design deliverables.

8.0 System Optimization Tips

The designer, installer or system operator should follow-up after installation of flow balancing and adjust the pump timer for optimal performance:

- Pump cycle counter is low: if the pump timer is set up during installation to deliver the maximum sewage volume the downstream components were designed for, but the actual sewage generation is much lower than anticipated by the design, the pump may not activate very often leading to low counts on the pump's cycle counter. This situation means the balancing tank is not actually doing any balancing, because as sewage is generated and the low float rises to activate the timer the sewage will be pumped out and deactivate the timer again. If this is the case, the pump timer can be adjusted to decrease the dose volume to less than the design capacity and extend the time over which the balancing tank will store and transfer sewage.

- Many nuisance alarms, pumping is less than capacity: if the owner is reporting many nuisance alarms, and the pump timer was initially set to transfer less than the design sewage volume, the pump on time and/or frequency can be increased. But be careful to not increase the timer so the pump is transferring an amount greater than the downstream design sewage flow.
- Many nuisance alarms, pumping is at capacity: if the owner is reporting many nuisance alarms and the pump timer is already set to deliver the maximum design sewage flow, then further investigations are required to determine if there is a leaking fixture or the facility is generating more sewage than the design anticipated.

9.0 References

9.1 List of references

CSA B65-12 Installation Code for Decentralized Wastewater Systems, 2012

10-States Standards - Recommended Standards for Wastewater Facilities: Policies for the Design, Review, and Approval of Plans and Specifications for Wastewater Collection and Treatment Facilities, 2014 Edition, A Report of the Wastewater Committee of the Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers

Ontario Building Code, 2014

Ontario Ministry of Environment, Conservation & Parks, Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems, 1982

US Environmental Protection Agency - *Evaluation of Flow Equalization in Municipal Wastewater Treatment*, EPA-600/2-79-096, Brown & Caldwell, May 1979

10.0 Appendix I

10.1 Flow Balancing Example

There are three main items of interest in a flow balanced system: (A) What is the design flow for the sewage system components after the balancing tank? (B) What volume of balancing tank is needed? (C) How are the pumps and controls set up?

To help explain the calculations, an example restaurant will be used:

- Rural restaurant
- Not 24-hours
- 60 seats
- Nearly full on the weekends
- Closed on Mondays and Tuesdays
- Other weekdays only open for lunch with about a quarter of the customers compared to the weekend

Design flows

The following information is needed to calculate design flows in a flow-balanced system:

- Maximum day flow
- Daily flow during off-peak days

The maximum day flow is estimated by the usual approach, from OBC Table 8.2.1.3.B. This flow reflects maximum occupancy or use of the facility.

For the restaurant example, the OBC Table 8.2.1.3.B. identifies a rate of 125 L per seat for restaurant (not 24-hour) x 60 seats = 7,500 L/d. This is the design maximum day flow. However, based on the restaurant usage we can see this flow would not occur every day of the week. The low usage during weekdays makes this restaurant a candidate for flow balancing.

For the restaurant, there will be little to no flow on Mondays and Tuesdays when it is closed, and 25% x 7,500 = 1,875 L/d as the daily flow on Wednesday, Thursday and Friday. However, the designer will want to have a discussion with the owner as to future plans for the restaurant, to understand the potential to open up on Monday and/or Tuesday or open for dinner as well as lunch. For the example, assume the owner reports they have no plans to open for dinner during the week, but they might open for lunch on Monday and Tuesday as well.

The design flow after balancing can now be calculated. Typically, balancing will be done over one week, although other time periods might be appropriate depending on the schedule of use of the facility. For the restaurant, one week makes the most sense because that is the repeating schedule of use. So, the daily and weekly flows are calculated as follows:

Day of the Week	Sewage Volume, L – Current Use	Sewage Volume, L – Future Use (open Mon & Tues also)
Monday	0	1,875
Tuesday	0	1,875
Wednesday	1,875	1,875
Thursday	1,875	1,875
Friday	1,875	1,875

Saturday	7,500	7,500
Sunday	7,500	7,500
WEEKLY TOTAL	20,625	24,375
Average Daily Flow over 7 days	2,946	3,482

The weekly total sewage volume is calculated by adding up the daily volume over each day of the week, and then that weekly total is divided by 7 to calculate the weekly-average daily sewage flow.

For the restaurant, the weekly-average daily sewage flow is about 3,000 L/d at current use (40% of peak day) but would be about 3,500 L/d if the restaurant does open for lunch on Mondays and Tuesdays (47% of peak day). These values represent the flow pumped out of the balancing tank each day to the downstream sewage system (septic tank, treatment units (if used), and leaching bed).

At this point in the calculations the designer needs to make a judgement decision about what "factor of safety" they want to put on the design. The factor of safety is the amount of extra treatment capacity for the downstream sewage system over and above the calculated weekly-average daily sewage flow.

Factor of safety = (chosen design flow) / (calculated weekly-average daily flow)

For the restaurant example, the designer might contemplate if there is a new owner they could open for dinner every day in addition to lunch. However, it is unlikely a rural restaurant would achieve full use (equal to weekends) during the work week even being open for dinner. So, the designer could choose a design treatment capacity of 4,500 L/d (60% of peak day) which gives a factor of safety of 4,500 /3,500 = 1.3. This means there is 30% extra weekly capacity in case the restaurant use changes. Alternatively, the factor of safety can be included by choosing fewer than 7 days for the balanced flow to be treated e.g. 6 days or even 5 days. This latter approach then has extra days of treatment capacity available as the factor of safety.

Assume the balanced design flow for the sewage system components after the balancing tank will be 4,500 L/d for the restaurant example.

Volume of Balancing Tanks

Now that the sewage system flow has been chosen, which is equal to the daily volume of sewage pumped out of the balancing tank, the design volume of the balancing tank can be calculated.

The minimum storage volume is determined by calculating how much sewage accumulates in the tank in the design week.

This is best understood using the restaurant example, which has the following design flows:

- Weekend peak flows: 7,500 L/d
- Weekday flow: 1,875 L/d
- Daily flow pumped to sewage system: 4,500 L/d

Using a flow balance, the sewage volume contained in the balancing tank on any day is calculated as:

Volume in tank today = Previous day's volume + Flow into tank – flow pumped out of tank

This volume is calculated each day of the week, and the day with the highest peak flow should be first in the sequence.
The restaurant example results in the following storage volume calculations:

Day	Start Vol., L	Added Daily Flow, L	Pumped to Treatment, L	Ending vol., L
Saturday	0	7,500	-4,500	3,000
Sunday	3,000	7,500	-4,500	6,000
Monday	6,000	1,875	-4,500	3,375
Tuesday	3,375	1,875	-4,500	750
Wednesday	750	1,875	-2,625	0
Thursday	0	1,875	-1,875	0
Friday	0	1,875	-1,875	0

The calculation starts with Saturday as the first day as it (along with Sunday) has the highest peak flow. The calculations then proceed in order of the week from that day forward. For the restaurant example, the largest amount of sewage that is stored is 6,000 L. Therefore, the balancing tank cannot have a working volume any less than this amount.

But again, similar to choosing a design flow for the downstream sewage system, the designer has discretion on the factor of safety to apply to the storage volume. Best practice recommends providing additional storage volume to allow for unplanned peak flow higher than design and/or storage of sewage to allow time for a service call, plus the sewage volume always in the bottom of the tank which keeps the pump submerged.

There are several methods that a designer might arrive at a suitable balancing tank volume including emergency storage:

Method	Resulting Balancing Tank Working Volume for Restaurant Example
Balancing tank can store the peak day volume	7,500 L

Assume there is no flow to treatment on a peak day	Sunday: 3,000 + 7,500 – 0 = 10,500 L
Add an additional percentage amount based on designer's experience	Say 50%, so 6,000 x 50% = 3,000 L 6,000 + 3,000 = 9,000 L
Emergency storage volume equal to response time for service or pump-out	Assume ½ day to get a septic pump truck. Half of the peak day = 7,500 /2 = 3,750 L 6,000 + 3,750 = 9,750 L

After assessing emergency storage in several different ways, the designer is likely to be able to choose a satisfactory balancing tank size with suitable emergency storage volume.

For the restaurant example, the designer might see that three of the four methods suggest balancing tank volumes in the approximate range of 9,000 to 11,000 L. The designer might then choose a standard precast holding tank from their local supplier that fits this range. As there are no prescriptive requirements, ultimately the designer has flexibility in the final tank selection to match what is commercially available with what the best for the treatment system design.

10.2 Flow Equalization Example

The following table illustrates a flow equalization calculation for a residential application with a maximum daily design flow of 10,000 L/day with constant outflow and cumulative storage. This could be applied to the pump chamber sizing for a shallow buried trench leaching bed. For inflow, the NSF Standard 40 protocol flow pattern (35% from 6AM – 9AM, 25% from 11AM – 2PM, and 40% from 5PM – 8PM, with zero flow in between) has been applied. This flow profile results in peaking factors of 2 to 3.2 which is within the range recommended in Section 4.5. Hourly outflow is equal to the total daily design flow divided by 24 hours.

Maximum Day Flow = 10,000 L/d					
Time	Peak Factor	Volume In (L)	Volume Out (L)	Differential Storage	Cumulative Storage
6:00	2.8	1167	417	750	750
7:00	2.8	1167	417	750	1500
8:00	2.8	1167	417	750	2250
9:00	0	0	417	-417	1833
10:00	0	0	417	-417	1416
11:00	2	833	417	417	1833
12:00	2	833	417	417	2250
13:00	2	833	417	417	2667
14:00	0	0	417	-417	2250
15:00	0	0	417	-417	1833
16:00	0	0	417	-417	1416

17:00	3.2	1333	417	917	2333
18:00	3.2	1333	417	917	3250
19:00	3.2	1333	417	917	4167
20:00	0	0	417	-417	3750
21:00	0	0	417	-417	3333
22:00	0	0	417	-417	2916
23:00	0	0	417	-417	2499
0:00	0	0	417	-417	2082
1:00	0	0	417	-417	1665
2:00	0	0	417	-417	1248
3:00	0	0	417	-417	831
4:00	0	0	417	-417	417
5:00	0	0	417	-417	0

Note: numbers in the table have been rounded to the nearest whole number.

Therefore, the required minimum active equalization volume is 4167 L. If 50% emergency capacity is included the recommended active storage volume is 6250 L. The graph below shows inflow, outflow and storage patterns.