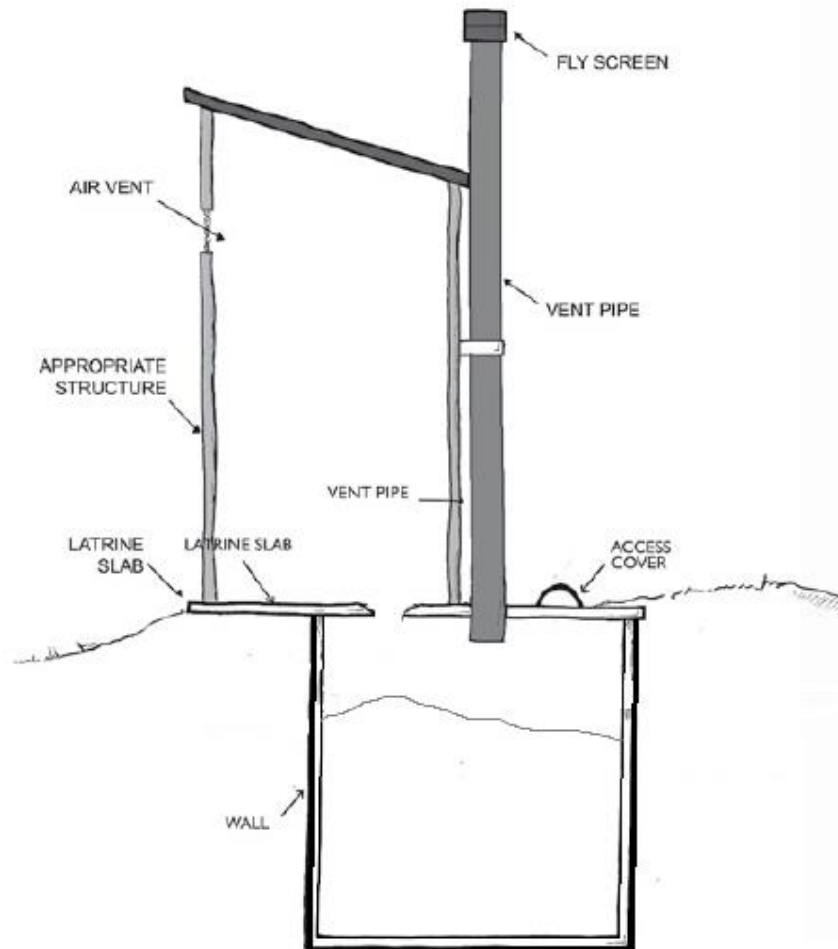


# Technical Brief: Sizing Holding Tanks

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(Credit: Adapted from Lifewater, 2010)

# Technical Brief: Sizing Holding Tanks

## 1 Introduction

A sanitation system deals with human excreta from the time it is “captured” in a latrine until it is used or disposed of safely. Sanitation systems are built for people, are managed by people, and affect people’s daily lives. The latrine is the part of a sanitation system that people interact with the most. The latrine is made up of the:

- “Front-end” or the user interface: the parts that every user interacts with, including the toilet (seat or pan), slab and superstructure
- “Back-end” or excreta storage: the pit, tank or chamber used to store excreta

A permanent holding tank (also called cesspit or a sealed pit, tank or chamber) can be used to store excreta. It is a watertight tank that is usually built belowground. Because there is no infiltration of liquid into the soil, a holding tank must be emptied more frequently than a septic tank or pit. It should be emptied by a trained service team. There must be safe treatment, use or disposal so that sludge is not dumped unsafely in the environment. Due to the cost of frequent emptying, holding tanks may not be suitable for family or communal latrines. They are only appropriate when there are no other feasible sanitation options, such as in certain challenging environments.

This Technical Brief is to help project implementers determine the size of holding tanks. You will learn about the factors that contribute to sizing a holding tank and the key information that is needed. Practice questions and solutions are also given.

For more information on latrine projects, CAWST’s Technical Briefs and Fact Sheets provide details on:

- How to select, site and construct latrines
- Latrine emptying
- Sludge treatment, use and disposal
- Approaches for sustainable latrine project implementation

Please see the Guide to CAWST Sanitation Resources for a complete glossary, list of abbreviations, unit conversions, and an overview of available resources.

CAWST focuses on the planning, design and implementation of on-site sanitation projects for low-income communities not connected to a sewer. For such communities, household or decentralized sanitation offers a hygienic and affordable solution.

CAWST’s free, open content resources and schedule of international training workshops can be found at: [www.cawst.org/resources](http://www.cawst.org/resources) and [www.cawst.org/training](http://www.cawst.org/training).

## Technical Brief: Sizing Holding Tanks



### Note about Units

This Technical Brief uses metric units (e.g., metres, square metres, cubic metres, litres). For unit conversions to the imperial system or US Customary system, please see below, or refer to the Guide to CAWST Sanitation Resources for more conversions.

Length	Volume
1 m = 3.28 feet	1 m <sup>3</sup> = 35.3 ft <sup>3</sup> = 264 gallons (US)
1 cm = 0.39 inches	1 L = 0.26 gallons (US) = 33.8 fluid oz (US)
	1 L = 0.22 gallons (imperial) = 25.2 fluid oz (imperial)



### Definitions

**Anal cleansing material:** Solid materials used to cleanse oneself after defecating and/or urinating.

**Anal cleansing water:** Water used to cleanse oneself after defecating and/or urinating.

**Dry latrine:** A latrine that operates without flush water. Inputs can include urine, feces, small amounts of anal cleansing water and dry cleansing materials.

**Excreta:** Urine and feces that is not mixed with any flushwater. Excreta contains many nutrients and pathogens.

**Infiltrate:** To pass into or through something. Infiltration is the process by which liquid from a latrine pit enters the surrounding soil.

**Impermeable:** Liquids cannot pass through (also called watertight).

**Slab:** A latrine slab is a solid base that a person can stand on while using the latrine. It is the barrier between a person defecating and the pit, tank or chamber that safely stores the excreta. It has a drop hole, pour flush pan or seat through which the excreta enters the pit, tank or chamber. The slab may be made of wood, bamboo, plastic, or concrete.

**Sludge:** Also called fecal sludge. Excreta removed from a tank. It may contain flush water, anal cleansing water, and other anal cleansing materials. It may be raw or partially treated.

**Sludge accumulation rate:** The volume of sludge that builds up in a tank per person per year.

**Wet latrine:** A latrine that operates with water for flushing (pour flush or cistern flush).

# Technical Brief: Sizing Holding Tanks

## 2 Design Basics

The size of a holding tank and how fast it fills up depends on a number of factors, including how many people use the latrine and how much water goes into the tank. To design a holding tank, you need to consider the following five pieces of information (also called variables):

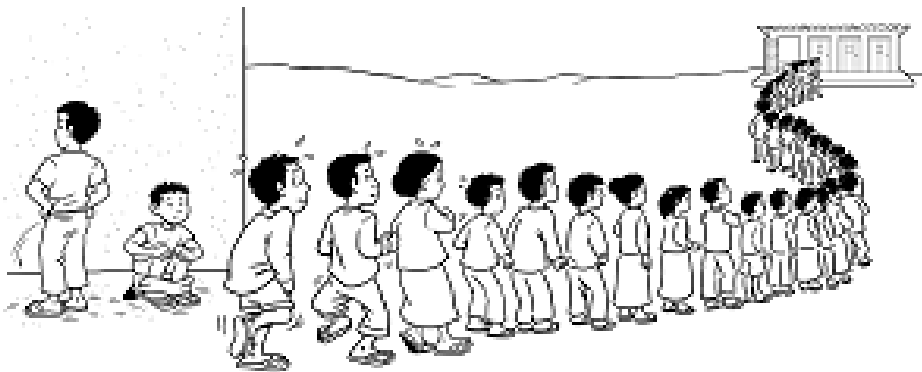


### Key Information Needed to Design a Holding Tank

1. **Number of users (N):** The number of people that will use the latrine on a regular basis.
2. **Lifetime (Y):** The length of time it takes to fill the tank.
3. **Holding tank shape and dimensions:**
  - **Length (L)** and **Width (W)** for a rectangular or square tank, or
  - **Diameter (d)** (the distance from one side of the circle to the opposite side, through the middle) for a circular tank.
4. **Holding tank depth (D):** How deep the tank is.
5. **Sludge accumulation rate (R):** The volume of sludge that builds up in the tank per person per year.

## 3 Number of Users

The number of people using the latrine on a regular basis will affect how quickly the tank fills and, therefore, the size required. This is usually the number of people in the household.



## 4 Lifetime

Holding tanks usually fill up very quickly, and need to be emptied frequently. The lifetime can usually be measured in months (or even days), unlike a pit latrine that can last for years.

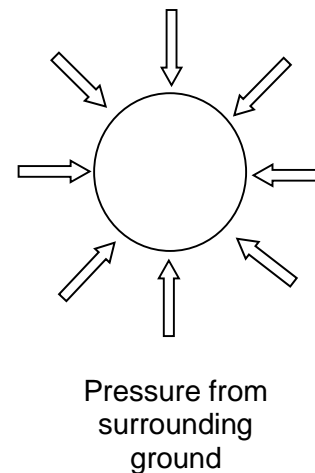
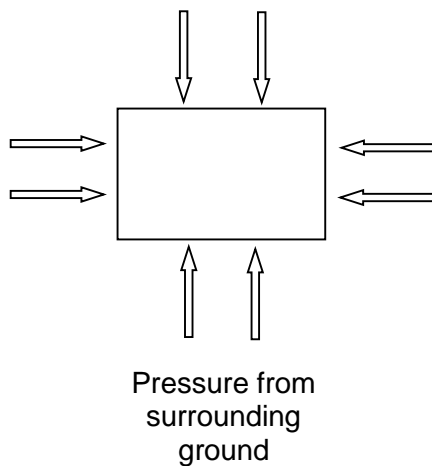
# Technical Brief: Sizing Holding Tanks

## 5 Tank Shape and Dimensions

You need to decide on the shape of the tank before starting any calculations. The common tank shapes are square, rectangular or circular. The tank design often follows local traditions. You may find that most households in the same community use similar tank shapes and dimensions.

When choosing your tank shape, consider the following for tanks dug into the ground:

- Circular tanks are less likely to collapse at greater depths (more than 1.5 metres) because the pressure from the surrounding soil is evenly spread.
- Square or rectangular tanks tend to collapse more often at greater depths because pressure is placed on the four walls. This leaves the corners to absorb the stress.



(Credit: Lifewater International, 2009)

## 6 Tank Depth

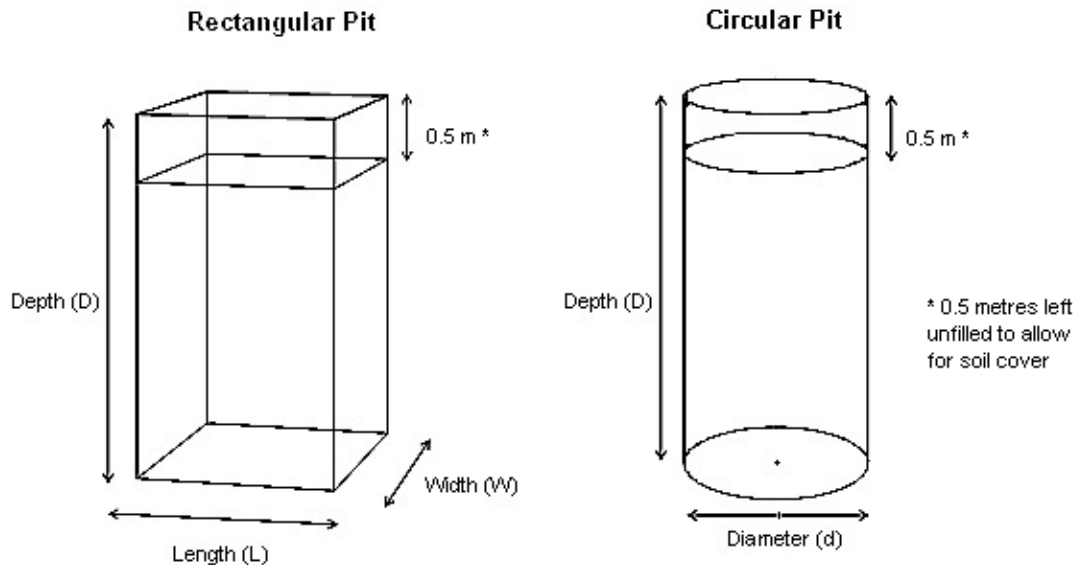
The total tank depth should include:

- The depth or volume of the tank that will be filled with excreta
- At least 0.5 metres at the top of the tank that is left unfilled – the tank is considered full when the excreta is within 0.5 metres from the slab or the top of the tank

The depth of the tank will depend on soil conditions, cost of lining, and emptying method. The groundwater level will not affect the depth of holding tanks as they are completely sealed.

The tank depth includes an extra 0.5 metres which is left unfilled at the top. This is to ensure there is a buffer space, to prevent the excreta from getting too close to the users (so users can't see it, aren't afraid they might come into contact with it, and to stop users from getting splashed).

# Technical Brief: Sizing Holding Tanks



(Credit: Lifewater International, 2009)

Square and Rectangular Tank Variables	
<b>D =</b>	Depth (metres)
<b>L =</b>	Length (metres)
<b>W =</b>	Width (metres)
<b>N =</b>	Number of Users (people)
<b>R =</b>	Sludge Accumulation Rate (litres/person/year)
<b>Y =</b>	Lifetime (years)

Circular Tank Variables	
<b>D =</b>	Depth (metres)
<b>d =</b>	Diameter (metres)
<b>N =</b>	Number of Users (people)
<b>R =</b>	Sludge Accumulation Rate (litres/person/year)
<b>Y =</b>	Lifetime (years)



## Emptying Tanks

Holding tanks should ideally be emptied by mechanical methods to help protect public health and safety. However, this may not be the reality in situations where vacuum tanker services are unavailable, unaffordable or cannot access the tank.

Manually emptying sludge (with shovels and buckets) from tanks deeper than 1.5 metres is impossible, unless the emptier climbs inside the tank, which is a serious health and safety risk. Vacuum tankers can usually only suck down to a depth of 2 to 3 metres, and the truck must be able to park within 30 metres of the tank (depending on the strength of the pump).

A compromise must be made between the tank depth and the frequency and difficulty of emptying. Shallow tanks (less than 1.5 metres deep) are easier to empty and have less health risks to emptiers than do deeper tanks, but they need to be emptied more often (Buckley et al., 2008; Still and Foxon, 2012; Tilley et al., 2014).

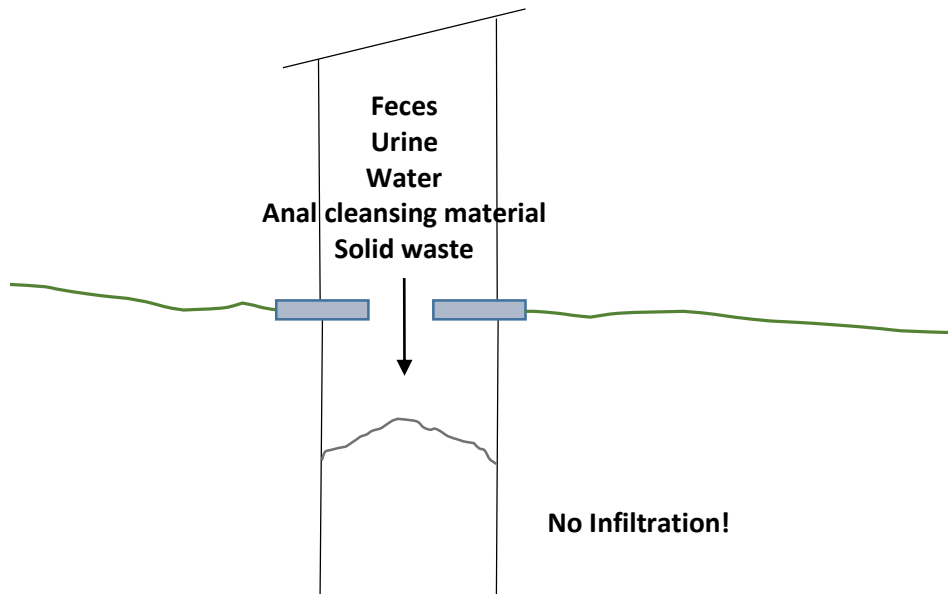
# Technical Brief: Sizing Holding Tanks

## 7 Sludge Accumulation Rate

Sludge accumulation rate is how quickly sludge builds up in the holding tank over time. The units are usually litres/person/year. Because holding tanks fill up quickly, you could also use litres/person/day, which calculates the life of the tank in days.

Because there is no infiltration, and not usually enough time for much biological degradation, sludge accumulates at the rate material is added to the latrine ( $\text{Volume In} = \text{Volume Out}$ ). To figure out the sludge accumulation rate in this case, you just add up everything that goes into the holding tank.

The diagram below illustrates how a tank fills up over time.



Sludge accumulation in a holding tank

There are various estimates and studies that try to quantify how much people excrete. There is less information available about how much flush water, anal cleansing water/materials or solid waste ends up in latrines.

There are several social, technical and environmental factors which affect the sludge accumulation rate. They are discussed in the following sections.

### 7.1 Amount of feces and urine excreted daily by individuals

An individual produces about 0.12–0.5 kg (or litres) of feces per day and 0.6–1.5 L of urine per day. This amount varies considerably depending on age, water consumption, climate, diet and occupation. For example, high protein diets produce less excreta, high fibre diets produce more. Children and older people produce less excreta than adults. Sick people may defecate more often than healthy people.

## Technical Brief: Sizing Holding Tanks

There are various estimates and studies that try to quantify how much people excrete. The following tables show estimates found in literature.

### Estimates of Feces Excreted by Individuals

Amount of feces per person per day	Amount of feces per person per year	Reference
0.12–0.40 L Average 0.26 L	44–146 L Average 95 L	Franceys (WHO), 1992
0.12–0.40 L	110 L	Still & Foxon, 2012 (Vol 1 and Vol 2)
136 g	50 kg	SuSanA, 2012
135–270 g	49–99 kg	Gotaas, Composting, (1956) in Jenkins, 2005
250 g	90 kg	WSP CLTS Trainer Training, 2007
400 g	146 kg	assumption in Duke Uni biogas research project on SuSanA forum
0.12–0.4 kg/day 400 g (adults) 150 g (children)	146 kg (adults) 55 kg (children)	Rieck, 2012

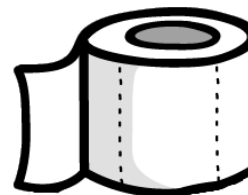
Note: 1 kg = 1 L (Rieck, 2012)

### Estimates of Urine Excreted by Individuals

Amount of urine per person per day	Amount of urine per person per year	Reference
1.0–1.2 L	365–438 L	Franceys, 1992
0.8–1.5 L	290–550 L	WHO 2006 in Reick, 2012
0.6–1.5 L	440 L	Still & Foxon, 2012 (V1 and V2)
Not available	500 L	SuSanA, 2012
1.0–1.3 L	365–475 L	Gotaas, 1956 in Jenkins, 2005

## 7.2 Type of anal cleansing material used

Paper and absorbent anal cleansing materials will soak up some liquid in the holding tank, while plastic and hard materials will not. In Sweden, it was estimated that people use about 8.9 kg of toilet paper per person per year (Vinneras, 2002 in Rieck, 2012). If toilet paper is expensive, this amount may be less.



Bulky or hard anal cleansing materials should not be flushed down a pour flush toilet, but should be collected separately.

People who use water for anal cleansing may use between 1–2 litres per latrine use, or 4–10 litres per person per day (Mara, 1985). Local data should be collected about how much water is used. Some cultures may require using more; if water is scarce it may be less.



## Technical Brief: Sizing Holding Tanks

### 7.3 Amount of flush water used

The amount of flush water used depends on the type of toilet, water storage vessel and user habits. Latrines that use water to flush and will have more water to store in the tank than dry latrines. Pour flush toilets usually require between 2–3 litres per flush, or 4–10 litres per person per day (Mara, 1985). Some pour flush pans may be operated with only 1 L.

The amount of flush water used can vary depending on the user and their habits. For example, healthy people generally defecate 2–3 times per day, but unhealthy people may defecate more often.



(Credit: AKVO, n.d.)

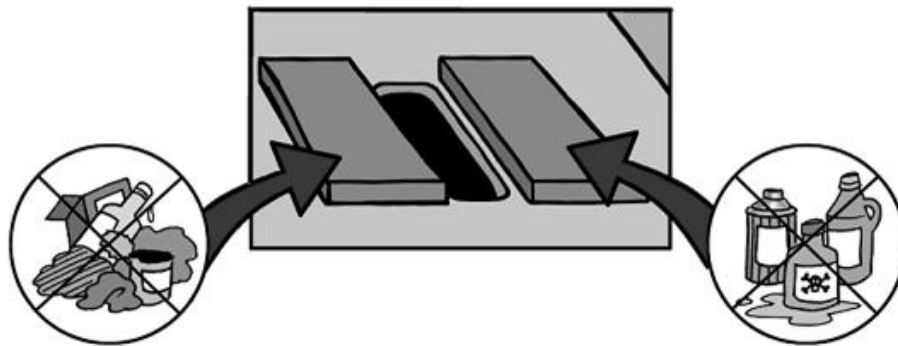
The amount of flush water may also depend on the volume of the container available in the latrine or the size of the water container people bring with them to the toilet for flushing.

Local data should be collected about whether people flush only after defecation, or after both defecation and urination.

### 7.4 Other materials disposed in the latrine

In reality, people often dispose of garbage into latrines in the absence of a proper solid waste management system. Solid waste may include sanitary products used for menstrual hygiene, condoms, health care waste (such as used needles), paper, metal, glass and organic material (such as kitchen and garden waste).

Adding other materials, especially those that do not easily decompose, will increase the sludge accumulation rate. It may add as much as 5-10% of the waste volume going into the tank (Buckley et al., 2008; Still and Foxon, 2012). These materials will also make the tank difficult, and potentially unsafe, to empty.



# Technical Brief: Sizing Holding Tanks

## 8 An Uncertain Science

Sizing latrine pits, tanks and chambers is an uncertain science! There are many factors that affect the rate at which sludge builds up in the latrine, and it cannot always be estimated ahead of time with accuracy. For example:

- The number of individuals using a latrine may fluctuate throughout the week and over the years.
- The volume each person contributes to the latrine will be affected by age, diet, whether they are away from the home during the day, and a variety of other factors
- Flushing practices may vary – some people may use more or less water, some people may flush only after defecation or after either defecation and/or urination.
- It is difficult to predict how much anal cleansing material people will use and the effect it will have on the sludge volume.
- It is difficult to predict how much solid waste people will put in the latrine. However, user education and a solid waste collection program can reduce the amount of solid waste put into the latrine.
- If holding tanks are not built properly, they may
  - Leak (infiltrate) liquid into the surrounding soil, which may cause the holding tank to fill up less quickly
  - Leak rainwater, surface water or groundwater into the holding tank, causing it to fill up more quickly.

Using local experience is a good way to estimate the lifetime or fill rate for latrines. However, it is not appropriate to compare latrine lifetimes if:

- The proposed latrine is a different type (e.g., a holding tank cannot be compared to an unlined pit)
- The user situation is very different (e.g., 15 users instead of 4, or users are displaced people during an emergency rather than settled villagers)
- The environmental conditions are very different (e.g., soil is clay instead of sand)



### Design Note

Often people build their tanks as big as they can afford to, and then empty it as required.

# Technical Brief: Sizing Holding Tanks

## 9 Calculating the Tank Size

This section will explain the formulas that are used to calculate holding tank sizes.

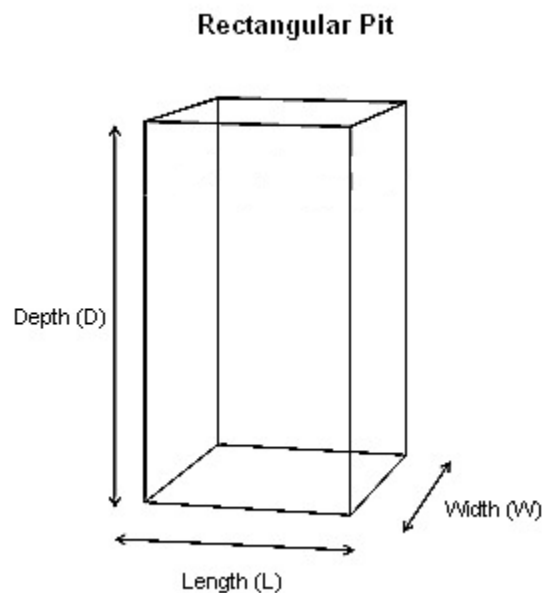
### 9.1 Calculating Tank Area and Volume Based on Dimensions

We will start with the tank shapes and the formulas that are needed to figure out the tank area and volume, based on its dimensions.

#### 9.1.1 Rectangular Tank

Area and volume for a rectangular tank can be calculated from the three tank dimensions:

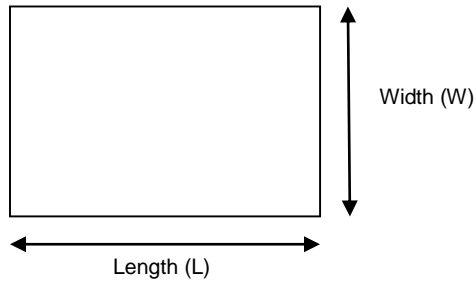
- **Depth**
- **Length**
- **Width**



A rectangular tank shape is made of 3 sets of rectangles that have different dimensions:

1. **Top and bottom** are the same
2. **Front and back** are the same
3. **Side and side** are the same

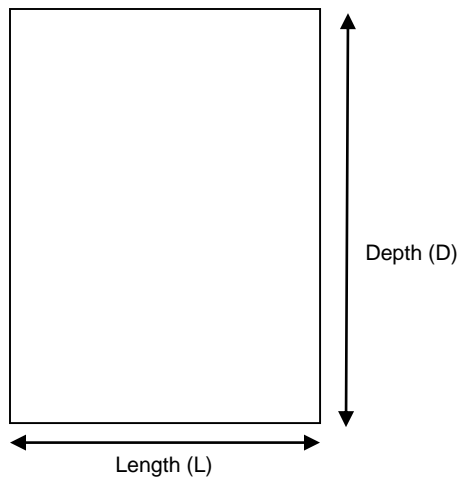
## Technical Brief: Sizing Holding Tanks



### ***Top and Bottom***

This is the shape that you see when you look at the tank from above.

The length and width of the tank are most likely determined by the size of slab you have or can build.

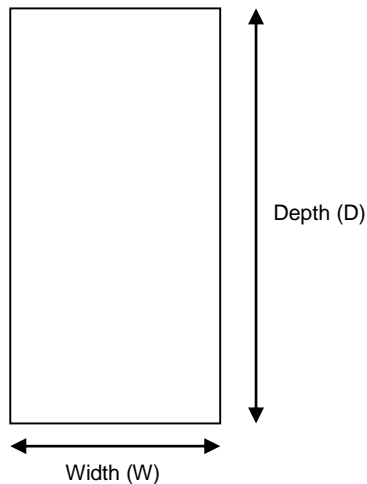


### ***Front and Back***

You create the depth as you dig your tank.

The *front and back* rectangle shares the same length dimension as the *top and bottom* rectangle.

The dimensions of this rectangle are length (L) and depth (D).



### ***Side and Side***

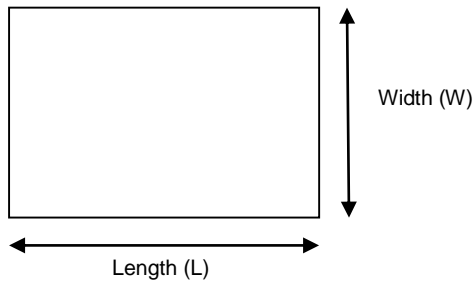
The *side and side* rectangle has the same depth (D) as the *front and back* rectangles.

It also has the same width (W) as the *top and bottom* rectangles.

# Technical Brief: Sizing Holding Tanks

## Area

In latrine tank calculations, *area* refers to the area of the *top and bottom* rectangle.



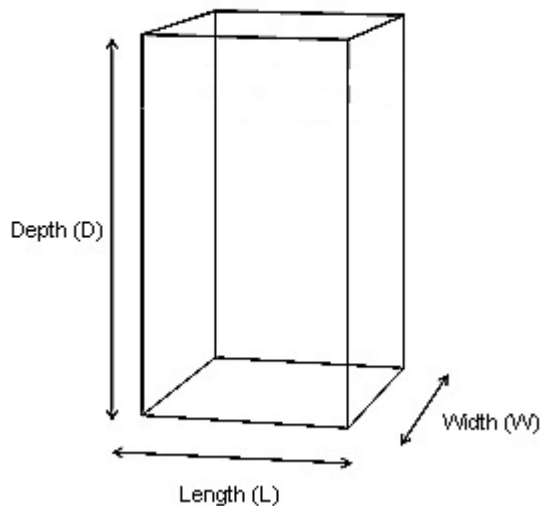
$$\text{Area} = \text{Length} \times \text{Width}$$

$$A = L \times W$$

- Length and width are measured in metres (m)
- Area is measured in square metres (m<sup>2</sup>)

## Volume

### Rectangular Pit



$$\text{Volume} = \text{Area} \times \text{Depth}$$

$$V = A \times D$$

$$V = L \times W \times D$$

*From the formula above, we know that  $A = L \times W$*

In tank calculations, the volume formula is often rearranged to solve for depth.

$$\text{Depth} = \frac{\text{Volume}}{\text{Area}}$$

$$D = \frac{V}{A}$$

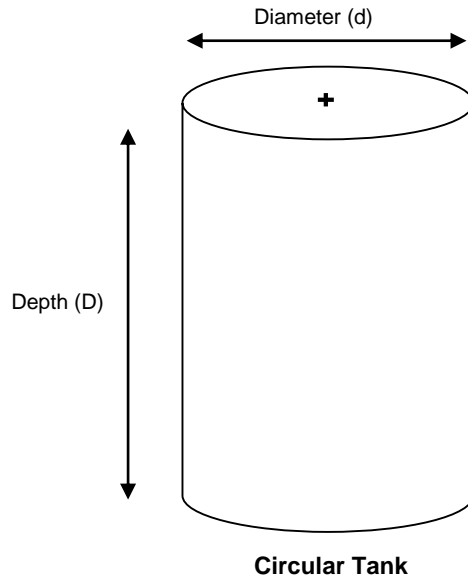
$$D = \frac{V}{L \times W}$$

- Depth is measured in metres (m)
- Area is measured in square metres (m<sup>2</sup>)
- Volume is measured in cubic metres (m<sup>3</sup>)

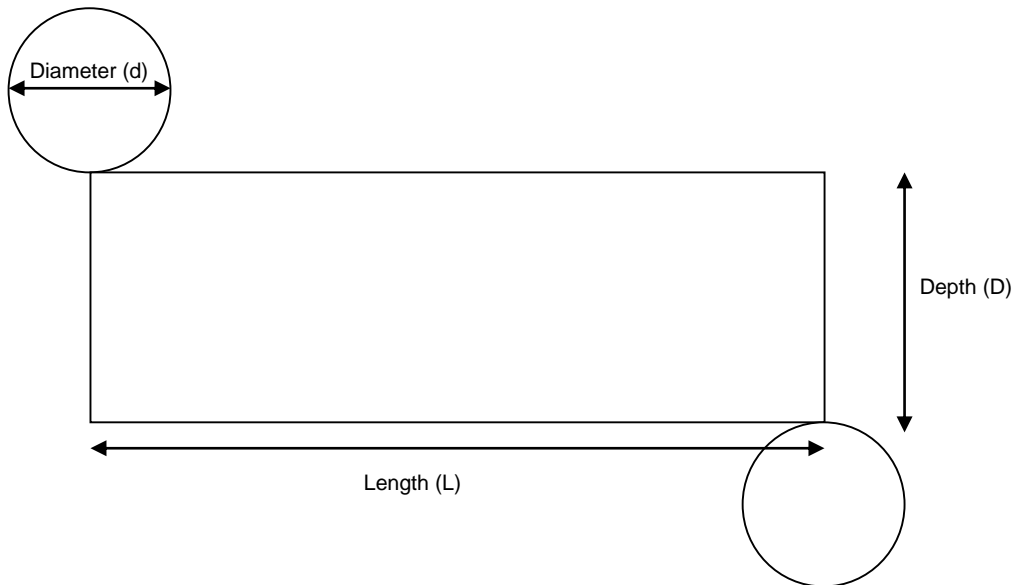
## Technical Brief: Sizing Holding Tanks

### 9.1.2 Circular Tank

Area and volume for a circular tank can be calculated from the two tank dimensions: **depth and diameter** (the distance across the middle of the circle).

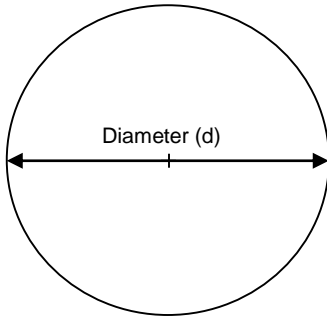


A circular tank shape is called a cylinder. It is made up of two identical circles that are the top and the bottom, and a rectangle that wraps around them. If you were to unroll a cylinder and lay it flat on the ground it would look like this:



# Technical Brief: Sizing Holding Tanks

## Area

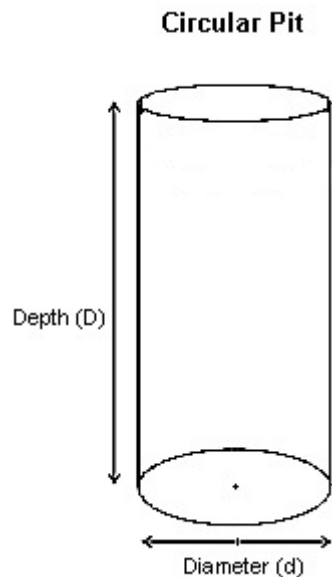


$$Area = Diameter^2 \times \frac{3.14}{4}$$

$$A = d^2 \times \frac{3.14}{4}$$

- Diameter is measured in metres (m)
- Area is measured in square metres (m<sup>2</sup>)
- 3.14 is a rounded value for the ratio pi (π)

## Volume



$$Volume = Area \times Depth$$

$$V = A \times D$$

$$V = d^2 \times \frac{3.14}{4} \times D$$

*From the formula above, we know that*

$$A = d^2 \times \frac{3.14}{4}$$

In tank calculations, the volume formula is often rearranged to solve for depth.

$$Depth = \frac{Volume}{Area}$$

$$D = \frac{V}{A}$$

$$D = \frac{V}{(d^2 \times \frac{3.14}{4})}$$

- Depth is measured in metres (m)
- Area is measured in square metres (m<sup>2</sup>)
- Volume is measured in cubic metres (m<sup>3</sup>)

## Technical Brief: Sizing Holding Tanks

### 9.2 Calculating the Required Tank Volume

The volume of latrine tank required is calculated based on its usage. The following formula provides us with the volume of tank required:

#### Amount of Material Entering the Tank

- This part of the formula tells us how much material (e.g., excreta, anal cleansing material) will be entering the tank.
- The 1000 is a conversion value to change the units from litres (found in the sludge accumulation rate) to cubic metres.

#### Extra Space Needed

- This part of the formula accounts for the extra volume needed at the top of the tank. Excreta will not fill this space.
- This is the formula for volume, where 0.5 metres is the depth of the extra space.

$$\text{Volume} = \frac{\text{Number of users} \times \text{Sludge accumulation rate} \times \text{Lifetime}}{1000} + 0.5 \times \text{Area}$$

$$V = \frac{N \times R \times Y}{1000} + 0.5 \times A$$

V: Volume (m<sup>3</sup>)  
N: Number of users  
Y: Days in use (day)  
A: Area (m<sup>2</sup>)  
R: Sludge accumulation rate (litres/person/day)

This formula can be rearranged to solve for the number of days that the latrine tank can be used.

$$\text{Lifetime} = \frac{(\text{Volume} - 0.5 \times \text{Area}) \times 1000}{\text{Number of users} \times \text{Sludge accumulation rate}}$$

$$Y = \frac{(V - 0.5 \times A) \times 1000}{N \times R}$$



## Technical Brief: Sizing Holding Tanks

### 9.2.1 Calculate Sludge Accumulation Rate

The sludge accumulation rate, or fill rate, is calculated by adding the accumulation rates of all the materials going into the tank per person per day, including:

- Feces
- Urine
- Flush water
- Anal cleansing water
- Toilet paper

$$R_{\text{Sludge}} = R_{\text{Feces}} + R_{\text{Urine}} + R_{\text{Flush Water}} + R_{\text{Cleansing Water}} + R_{\text{Toilet Paper}}$$

R: Accumulation rate (litres/person/day)

If solid waste (garbage) is added into the tank, the sludge accumulation rate needs to increase by a certain percentage. The volume of solid waste is based on the sludge volume. It is usually between 5-10% of the sludge volume going into the tank (Buckley et al., 2008; Still and Foxon, 2012). The solid waste accumulation rate can be calculated using this formula:

$$R_{\text{Solid Waste}} = R_{\text{Sludge}} \times \text{Solid Waste (\%)}$$

For example, if solid waste adds 5% to the sludge volume:

$$R_{\text{Solid Waste}} = R_{\text{Sludge}} \times 0.05$$

And if solid waste adds 10% to the sludge volume:

$$R_{\text{Solid Waste}} = R_{\text{Sludge}} \times 0.10$$

The solid waste accumulation rate ( $R_{\text{Solid Waste}}$ ) now needs to be added to  $R_{\text{Sludge}}$  to find the total fill rate:

$$R = R_{\text{Sludge}} + R_{\text{Solid Waste}}$$

# Technical Brief: Sizing Holding Tanks

## 9.3 Summary of Formulas

Use the information in this section as a reference and to help work through the example and practice questions.

**Table 6: Summary of Formulas**

What Are You Calculating?	Formula to Use	Variables to Find
<b>Area: Rectangular</b>	$A = L \times W$	A: Area (m <sup>2</sup> ) L: Length (m) W: Width (m)
<b>Area: Circular</b>	$A = d^2 \times \frac{3.14}{4}$	A: Area (m <sup>2</sup> ) d: Diameter (m)
<b>Depth: Rectangular</b>	$D = \frac{V}{A}$	D: Depth (m) V: Volume (m <sup>3</sup> ) A: Area (m <sup>2</sup> )
<b>Depth: Circular</b>	$D = \frac{V}{A}$	D: Depth (m) V: Volume (m <sup>3</sup> ) A: Area (m <sup>2</sup> )
<b>Volume: Rectangular</b>	$V = D \times A$	V: Volume (m <sup>3</sup> ) D: Depth (m) A: Area (m <sup>2</sup> )
<b>Volume: Circular</b>	$V = d^2 \times \frac{3.14}{4} \times D$	V: Volume (m <sup>3</sup> ) d: Diameter (m) D: Depth (m)
<b>Tank Volume</b>	$V = \frac{(N \times R \times Y)}{1000} + 0.5 \times A$	V: Volume (m <sup>3</sup> ) N: Number of users Y: Days in use (days) A: Area of tank base (m <sup>2</sup> ) R: Sludge accumulation rate (litres/person/day)
<b>Lifetime</b>	$Y = \frac{(V - 0.5 \times A) \times 1000}{N \times R}$	V: Volume (m <sup>3</sup> ) N: Number of users Y: Days in use (days) A: Area (m <sup>2</sup> ) R: Sludge accumulation rate (litres/person/day)

# Technical Brief: Sizing Holding Tanks

## 10 Practice Questions

**Summary of Estimated Accumulation Rates**

Materials	Range (Per Person Per Day)	Average (Per Person Per Day)
Feces	0.12 – 0.40 L	0.26 L
Urine	0.6 – 1.5 L	1.05 L
Flush water	2–3 L per flush for a pour flush toilet 4–25 L per flush for a cistern flush toilet 2–3 flushes per day = 4–9 L for pour flush toilet = 8–75 L for cistern flush toilet	6.25 L for pour flush toilet 41.5 L for cistern flush toilet
Anal cleansing water	1–2 L per use 2–3 uses per day = 2–6 L	4 L
Toilet paper	24 g (0.024 L)	24 g (0.024 L)
Solid waste	If added to holding tank, add an extra 5-10% of volume	If added to holding tank, add an extra 5-10% of volume

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### Question 1

- Number of users: 6 people
- Holding tank: Plastic rectangular tank with a volume of 2 m<sup>3</sup> (= 2000 L)
- Dimensions: 1 m wide x 1 m long x 2 m deep
- Toilet: Pour flush toilet that uses 2.5 L to flush
- Anal Cleansing: People use water for anal cleansing
- Solid waste: No solid waste is put into the holding tank

How often must the tank be emptied by vacuum truck?

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### Question 2

- Number of users: 8 people
- Holding tank: Fully lined impermeable circular pit with a volume of 2 m<sup>3</sup> (= 2000 L)
- Dimensions: Depth = 1 m; diameter = 1.6 m
- Toilet: Dry toilet
- Anal Cleansing: Paper, which is thrown into the toilet
- Solid waste: Garbage is thrown into the pit, assume 10%

How often must the tank be emptied?

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### Question 3

- Number of users: 12 people
- Holding tank: Rectangular plastic tank with a volume of 5 m<sup>3</sup> (= 5000 L)
- Dimensions: 1 m wide x 2.5 m long x 2 m deep
- Toilet: Pour flush toilet that uses 2 L to flush
- Anal Cleansing: Leaves, which are collected separately
- Solid waste: No solid waste is put into the holding tank

How often must the tank be emptied?

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### Question 4 (Challenge Question)

- Number of users: 6 people
- Holding tank: To be calculated, household plans to dig a 1 metre diameter fully lined impermeable pit
- Toilet: Dry toilet
- Anal Cleansing: Paper, which is thrown into the pit
- Solid waste: Some garbage is thrown into the pit, assume 5%
- Lifetime: Pit is to be emptied every 6 months (every 182 days)

What volume should the pit be? How deep will the pit be?

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## Solutions to Practice Questions

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### Question 1

Material	Accumulation Rate	
Feces	R <sub>Feces</sub>	0.26 L per person per day
Urine	R <sub>Urine</sub>	1.05 L per person per day
Pour flush water	R <sub>Flushing Water</sub>	2.5 L x 2.5 flushes per person per day = 6.25 L per person per day
Anal cleansing water	R <sub>Cleansing Water</sub>	4 L per person per day
Toilet paper	R <sub>Toilet Paper</sub>	none
Solid waste	R <sub>Solid Waste</sub>	none
<b>TOTAL</b>	<b>R</b>	<b>11.56 L per person per day</b>

- The total sludge accumulation rate = 11.56 L/person/day

To find out the time it will take for the holding tank to fill up, we need to use the formula:

$$Y = \frac{(V - 0.5 \times A) \times 1000}{N \times R}$$


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Step 1: Calculate the area of the tank.

$$A = L \times W = 1 \times 1 = 1 \text{ m}^2$$


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Step 2: Fill in the formula.

$$Y = \frac{(2 - 0.5 \times 1) \times 1000}{6 \times 11.56} = \frac{1.5 \times 1000}{69} = 21.7$$

The tank will need to be emptied every 21 days.

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## Question 2

Material	Accumulation Rate	
Feces	R <sub>Feces</sub>	0.26 L per person per day
Urine	R <sub>Urine</sub>	1.05 L per person per day
Pour flush water	R <sub>Flushing Water</sub>	none
Anal cleansing water	R <sub>Cleansing Water</sub>	none
Toilet paper	R <sub>Toilet Paper</sub>	0.024 L per person per day
Sub-total	R <sub>Sludge</sub>	1.33 L per person per day
Solid waste (10%)	R <sub>Solid Waste</sub>	0.13 L per person per day
<b>TOTAL</b>	<b>R</b>	<b>1.46 L per person per day</b>

- The total sludge accumulation rate = 1.46 L/person/day

To find out the time it will take for the holding tank to fill up, we need to use the following formula:

$$Y = \frac{(V - 0.5 \times A) \times 1000}{N \times R}$$


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Step 1: Calculate the area of the tank.

$$A = d^2 \times \frac{3.14}{4} = 0.8^2 \times \frac{3.14}{4} = 0.5$$


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Step 2: Fill in the formula.

$$Y = \frac{(2 - 0.5 \times 0.5) \times 1000}{6 \times 11.56} = \frac{1.75 \times 1000}{69} = 25.3$$

The tank will need to be emptied every 25 days.

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### Question 3

Material	Accumulation Rate	
Feces	R <sub>Feces</sub>	0.26 L per person per day
Urine	R <sub>Urine</sub>	1.05 L per person per day
Pour flush water	R <sub>Flushing Water</sub>	2 L x 2.5 flushes per person per day = 5 L per person per day
Anal cleansing water	R <sub>Cleansing Water</sub>	none
Leaves	R <sub>Toilet Paper</sub>	none
Solid waste	R <sub>Solid Waste</sub>	none
<b>TOTAL</b>	<b>R</b>	<b>6.31 L per person per day</b>

- The total sludge accumulation rate = 6.31 L/person/day

To find out the time it will take for the holding tank to fill up, we need to use the following formula:

$$Y = \frac{(V - 0.5 \times A) \times 1000}{N \times R}$$

Step 1: Calculate the area of the tank.

$$A = L \times W = 2.5 \times 1 = 2.5$$

Step 2: Fill in the formula.

$$Y = \frac{(5 - 0.5 \times 2.5) \times 1000}{12 \times 6.31} = \frac{3.75 \times 1000}{75.7} = 49.5$$

The tank will need to be emptied every 49 days, approximately every 7 weeks.

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## Question 4 (Challenge Question)

Material	Accumulation Rate	
Feces	R <sub>Feces</sub>	0.26 L per person per day
Urine	R <sub>Urine</sub>	1.05 L per person per day
Pour flush water	R <sub>Flushing Water</sub>	none
Anal cleansing water	R <sub>Cleansing Water</sub>	none
Toilet paper	R <sub>Toilet Paper</sub>	0.024 L per person per day
Sub-total	R <sub>Sludge</sub>	1.33 L per person per day
Solid waste (5%)	R <sub>Solid Waste</sub>	0.067 L per person per day
<b>TOTAL</b>	<b>R</b>	<b>1.4 L per person per day</b>

- The total sludge accumulation rate = 1.4 L/person/day

To find out the time it will take for the holding tank to fill up, we need to use the following formula:

$$V = \frac{(N \times R \times Y)}{1000} + 0.5 \times A$$


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Step 1: Calculate the area of the tank.

$$A = d^2 \times \frac{3.14}{4} = 1^2 \times \frac{3.14}{4} = 0.79$$


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Step 2: Fill in the formula.

$$V = \frac{(6 \times 1.4 \times 182)}{1000} + 0.5 \times 0.79 = \frac{1529}{1000} + 0.4 = 1.9$$

The volume of the tank will need to be 1.9 m<sup>3</sup>.

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Step 3: Calculate the depth of the pit.

$$D = \frac{V}{(d^2 \times \frac{3.14}{4})} = \frac{1.9}{(1^2 \times \frac{3.14}{4})} = 2.4$$

For a 1 m diameter fully lined impermeable pit, the depth would be 2.4 m.

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## 11 Additional Resources

**CAWST Sanitation Resources.** Available at: [www.cawst.org/resources](http://www.cawst.org/resources)

- CAWST's education and training resources are available on a variety of sanitation topics including latrine design, siting and construction; latrine parts and technologies; latrine emptying and transporting sludge; sludge treatment, use and disposal; and latrine project implementation.

**SuSanA Forum.** <http://forum.susana.org/>

- SuSanA is a network of sanitation practitioners, experts and academics. This forum is a place for members to discuss questions, exchange practical advice and discuss current research. One does not have to be a member to read and learn from the discussions.

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