CHAPTER 6

OVERALL WATER BALANCE

6.1 INTRODUCTION

The overall water balance at the Rosslyn plant (see Figure 6.1) includes water used by the brewhouse (Chapter 3), the cellars (Chapter 4), packaging (Chapter 5) and general users (Section 6.2). Stormwater will not be considered as part of the overall water balance as there are no uncovered holding facilities at the plant. All rain water falling onto the plant, and surrounding areas within the plant's boundary fences, is diverted to stormwater conduits and discharged to the sewers.

6.2 GENERAL WATER USE

At the Rosslyn plant, additional water production/treatment facilities are present to supply the plant with, *inter alia,* steam, high temperature water, cold water, cleaning water and drying water. The utilities department is responsible for the management of these facilities, which are represented as general water in Figure 6.1. As shown in Figure 6.2, general water is utilised within three main areas, namely:

- boilerhouse – supplying high temperature water and steam for various purposes,
- site – supplying water for toilet facilities, canteen requirements, etc, and
- engine room – supplying water for the cleaning and cooling of gases.

6.2.1 Boilerhouse

The boilerhouse supplies high temperature water and steam to unit processes on the brewery site. High temperature water is distributed as a heating medium to, *inter alia*, the mash tun and the wort kettle. This water is circulated back to the boilerhouse and reheated to the required temperature for reuse. Water losses are inevitable and the water levels are made up with potable water.

The boilerhouse also supplies steam to the yeast drying plant, the deodorisers and the activated carbon filters. The steam supplied to the yeast drying plant is used to dry the scrap yeast (before it is bagged) and escapes to the atmosphere after contact with the wet yeast. At the deodorisers and activated carbon filters the steam is utilised for regeneration purposes before release to the atmosphere.

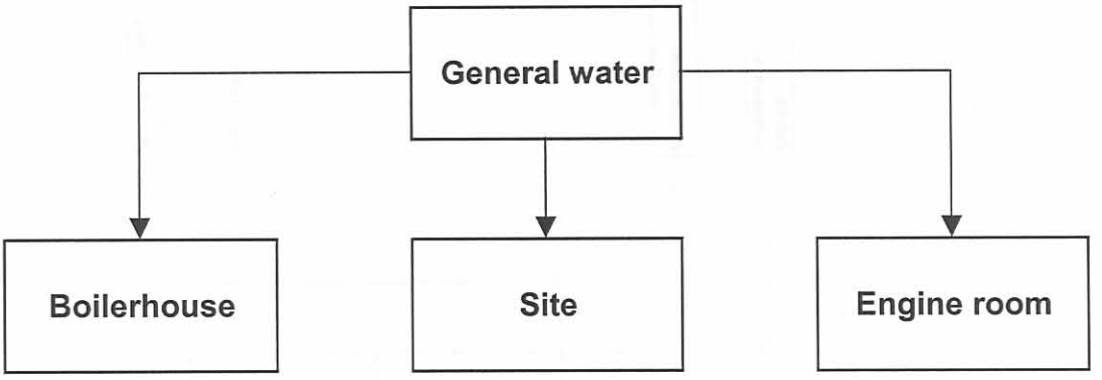
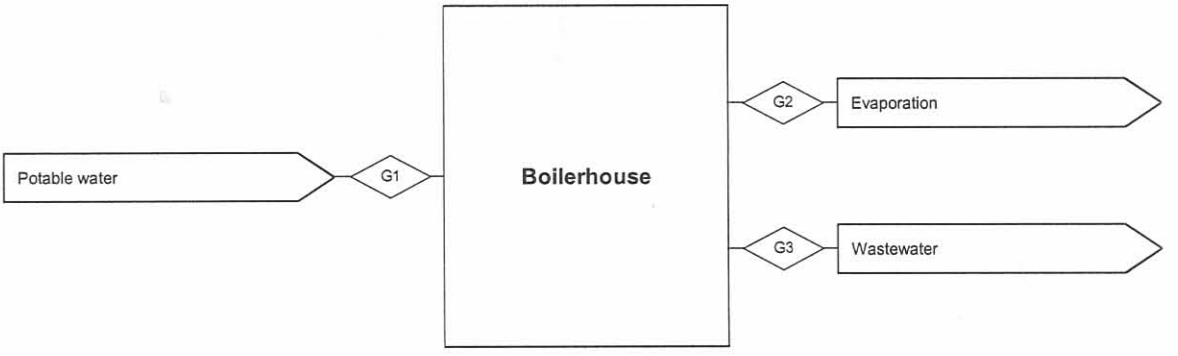


Figure 6.2 Breakdown of the water used for general purposes.



Stream	Volume per week (hl/week)	Source ⊕
G1	9 877	S15
G2	7 408	S3
G3	2 469	G1 – G2

⊕ Sources, other than streams, are presented at the end of each chapter.

Figure 6.3 Water balance over the boilerhouse.

The Rosslyn plant measures the total water utilised by the boilerhouse which equates to approximately 9 877 hl of water per week (Kristin, 2000). It is estimated that 75% of this water (7 408 hl per week) is evaporated to the atmosphere with the remainder incurred as losses to the drains (Van der Merwe, 2000). The water balance over the boilerhouse is shown in Figure 6.3.

6.2.2 Site water

Site water is utilised by Rosslyn personnel for general purposes, in the brewhouse, the cellars and the packaging hall. The water balance for site water is shown in Figure 6.4.

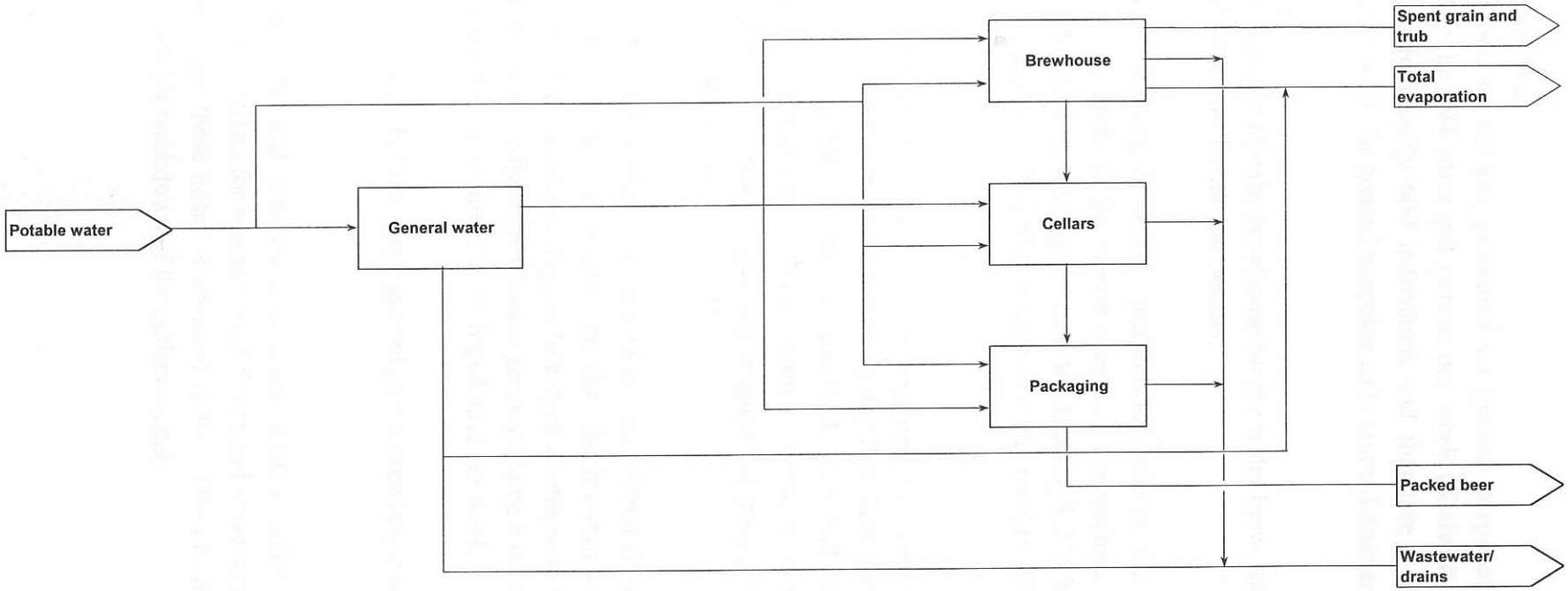


Figure 6.1 Flow diagram of the overall water balance at the Rosslyn plant.

General purposes

Water is used by the site personnel for general purposes and the volumes used are estimated to be 494 litres per person per week (Kadwell, 2001). The Rosslyn plant employs approximately 600 individuals and therefore 2 964 hl of water is used by personnel per week for general purposes and assumed discharged to the drains.

Brewhouse

Site water is utilised by the brewhouse for the water brew, the chilled liquor tanks and for the washdown of the floors and vessels.

Before the beginning of a new production cycle in the brewhouse, the brewhouse prepares a water brew to the correct operating temperature. It is estimated that a water brew is undertaken on average twice a week using 3 276 hl of water per brew (Isaacs, 2001). The resultant 6 552 hl per week of water used in the brewhouse is discharged to the drains.

At the Rosslyn plant, chilled liquor is prepared for wort cooling during a production cycle. However, since production occurs for five days per week, there may be chilled liquor remaining within the chilled liquor tank at the end of a production cycle. Should the temperature of this liquor deviate below its set point, it is discharged to the drains. It is estimated that 400 hl of chilled liquor (supplied from site water) is discharged to the drains on a weekly basis (Rex, 2001).

To ensure that the brewery remains clean, washdown of vessels and floors with high pressure hoses occurs. It is assumed that the brewhouse is washed for a combined average total of 15 hours per day for five days a week with these hoses (van der Merwe, 2000). If the flowrate through a hose is assumed to be 5 000 l/h on average, then 3 750 hl of water is used for washdown in the brewhouse per week.

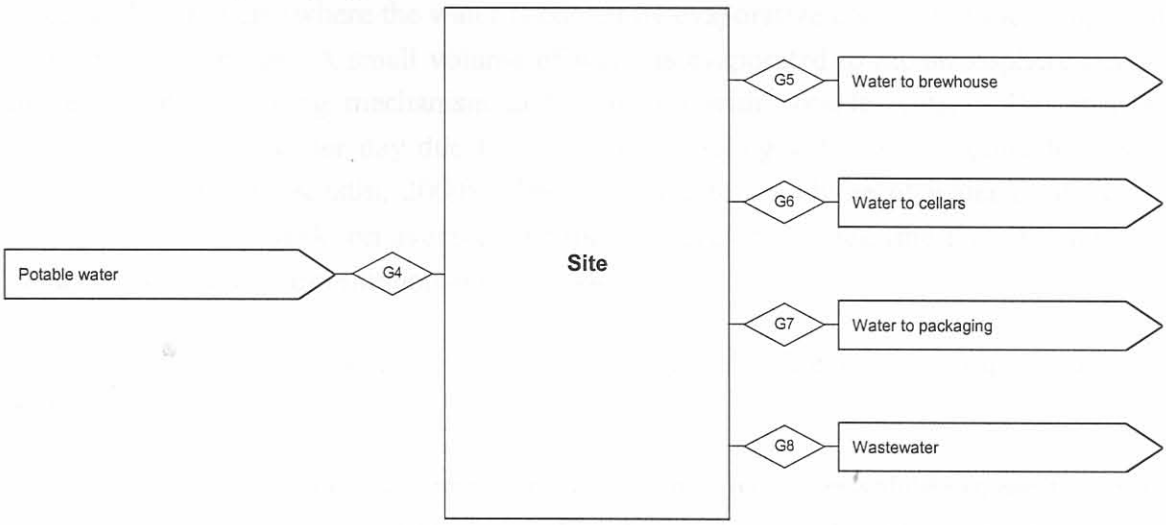
Therefore, 10 702 hl of site water is used by the brewhouse per week.

Cellars

It is estimated that high pressure hoses are used for a combined average total of 125 hours per week in the cellars for washdown of floors and vessels (van der Merwe, 2000). If the flowrate through these hoses is assumed to be 5 000 l/h, then 6 250 hl of site water is used per week for washdown of the cellars section.

Packaging

In the packaging hall site water is also used for washdown purposes. It is estimated that high pressure hoses are used for a combined average total of 21 hours per day (five days per week) for each of the five production lines (Myoli, 2001). If the flowrate through these hoses is assumed to be 5 000 l/h, then 26 250 hl of site water is used per week for washdown of the packaging hall.



Stream	Volume per week (hl/week)	Source ⊕
G4	46 166	G5 + G6 + G7 + G8
G5	10 702	S3, S5
G6	6 250	S3
G7	26 250	S14
G8	2 964	S16

⊕ Sources, other than streams, are presented at the end of each chapter.

Figure 6.4 Water balance for site water.

6.2.3 Engine room

The water balance over the engine room is shown in Figure 6.5. The engine room supplies water to the ammonia condensers, the closed circuit water cooling (CCWC) cycle, scrubbers and the foam traps.

Ammonia, used as a coolant throughout the brewery site, is cooled with water supplied by the engine room. The Rosslyn plant is equipped with two sets of six ammonia condensers. The average volume of water used per day, for seven days per week (the fermentation and storage vessels operate continuously), by both sets of ammonia condensers for evaporative cooling (which is lost to the atmosphere) is 4 332 hl (Kristin,

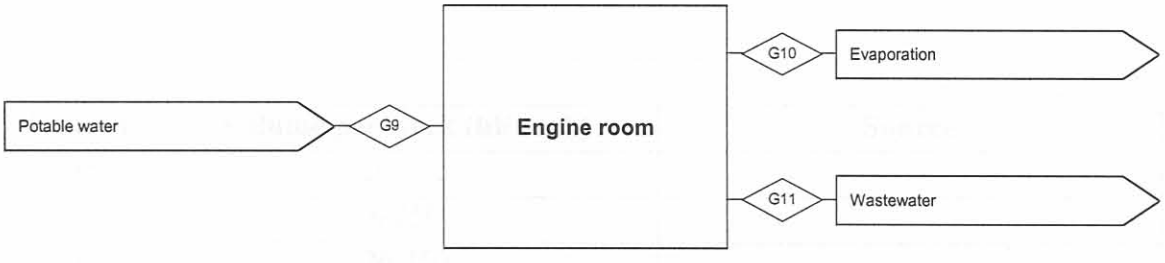
2000). Therefore, the total volume of water used per week, on average, by the ammonia condensers is 30 324 hl.

The engine room also supplies water to the closed circuit water cooling (CCWC) cycle which is used to cool, *inter alia,* the carbon dioxide compressors, air compressors and the mechanical seals on certain pumps. Water in the CCWC circuit is transferred through three cooling towers (where the water is cooled by evaporative cooling) to the equipment requiring the cooling. A small volume of water is evaporated to the atmosphere during the evaporative cooling mechanism and made up with potable water. The average volume of water lost per day due to evaporative cooling within the cooling towers is estimated at 392 hl (Kristin, 2000). Therefore, the total volume of water used by the CCWC circuit per week, on average, assuming a seven day week (the fermentation and storage vessels operate continuously), is 2 744 hl.

Therefore, 33 068 hl of water per week, supplied by the engine room, is evaporated to the atmosphere.

At the Rosslyn plant, three scrubbers are used to remove water-soluble impurities from CO_2. During contact of the CO_2 gas with water spray droplets in the scrubbers, water soluble impurities are dissolved in the water. Potable water is purged on a continuous basis to the scrubbers to prevent the build-up of contaminants. The internal surfaces of the scrubbers also require regular CIP cleaning to remove contaminants. Assuming that the three scrubbers are in operation (not necessarily operating at the same time) for seven days per week, the fermentation and storage vessels operate continuously, the total volume of water used per day, for make-up and CIP cleaning, is 1 891 hl (Kristin, 2000).

Therefore the volume of water used by the scrubbers per week is 13 237 hl.



Stream	Volume per week (hl/week)	Source
G9	48 370	G10 + G11
G10	33 068	S15
G11	15 302	S15

⊕ Sources, other than streams, are presented at the end of each chapter.

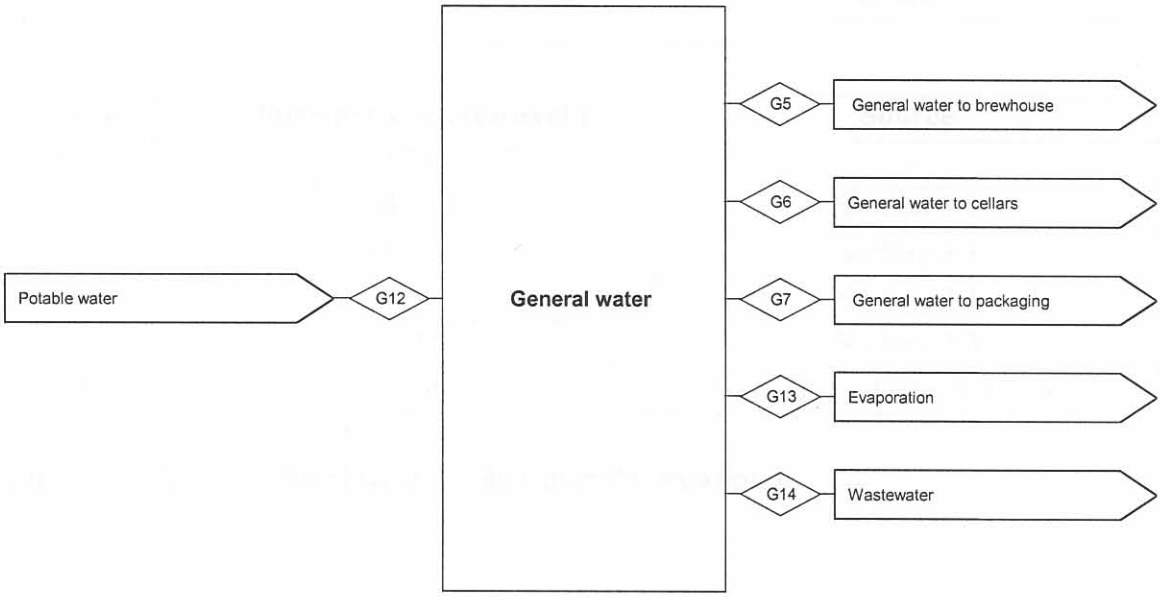
Figure 6.5 Water balance over the engine room.

The foam traps are fitted with water spray nozzles and screens to remove fob (beer foam) from the CO_2. For the continuous removal of fob, the traps have a continuous potable water supply to ensure that a constant level of water is maintained inside the foam traps, with excess water overflowing to the drains. The foam traps also undergo a regular CIP clean. The average volume of water used by the foam traps per day is 295 hl (Kristin, 2000).

Therefore, 15 302 hl of water is supplied by the engine room per week and is discharged to the drains.

6.2.4 Water balance for general water

The water balance for the general water used in the brewery is shown in Figure 6.6. 104 413 hl of water is used for general purposes by the boilerhouse, site and engine room.

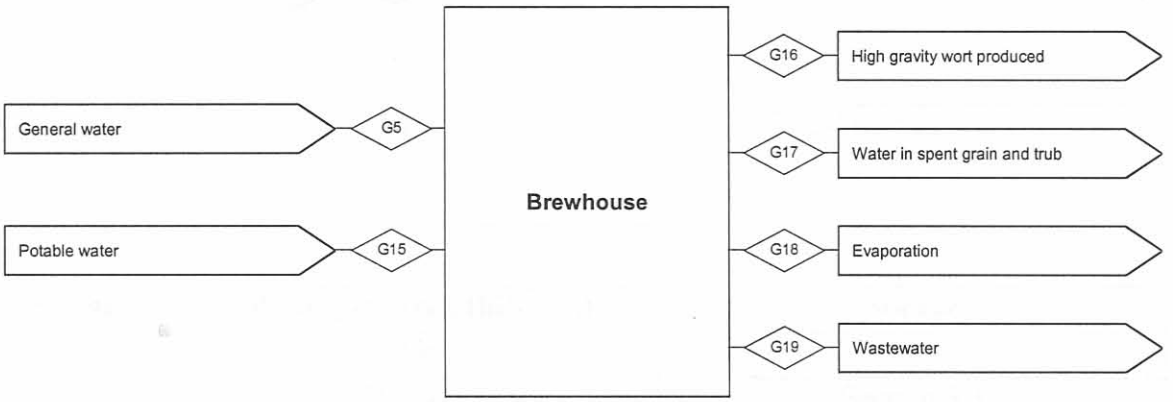


Stream	Volume per week (hl/week)	Source
G5	10 702	-
G6	6 250	-
G7	26 250	-
G12	104 413	G5 + G6 + G7 + G13 + G14
G13	40 476	G2 + G10
G14	20 735	G3 + G8 + G11

Figure 6.6 Water balance for general water.

6.3 BREWHOUSE WATER BALANCE

A simplified water balance over the brewhouse (from Chapter 3 and incorporating general water use) is shown in Figure 6.7. 151 874 hl of water is used per week by the brewhouse in the production of 70 560 hl of high gravity wort.

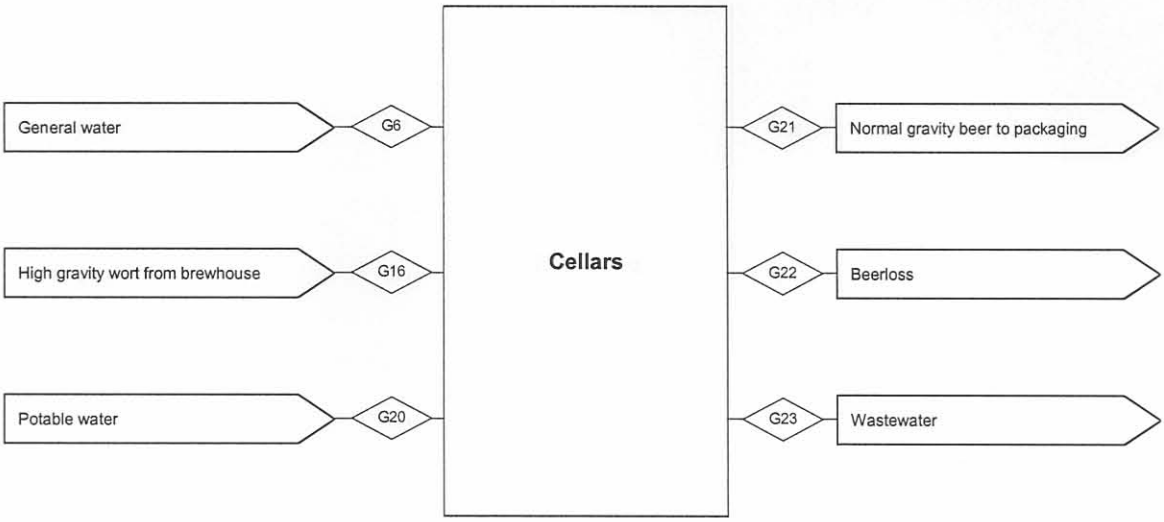


Stream	Volume per week (hl/week)	Source
G5	10 702	-
G15	141 172	Section 3.3
G16	70 560	Section 3.3
G17	3 200	Section 3.3
G18	5 024	Section 3.3
G19	73 090	G5 + G15 – G16 – G17 – G18

Figure 6.7 The simplified water balance over the brewhouse.

6.4 CELLARS WATER BALANCE

A simplified water balance over the cellars (from Chapter 4 and incorporating general water use) is shown in Figure 6.8. 99 098 hl of water per week is introduced into the cellars section to produce 100 064 hl of normal gravity beer.

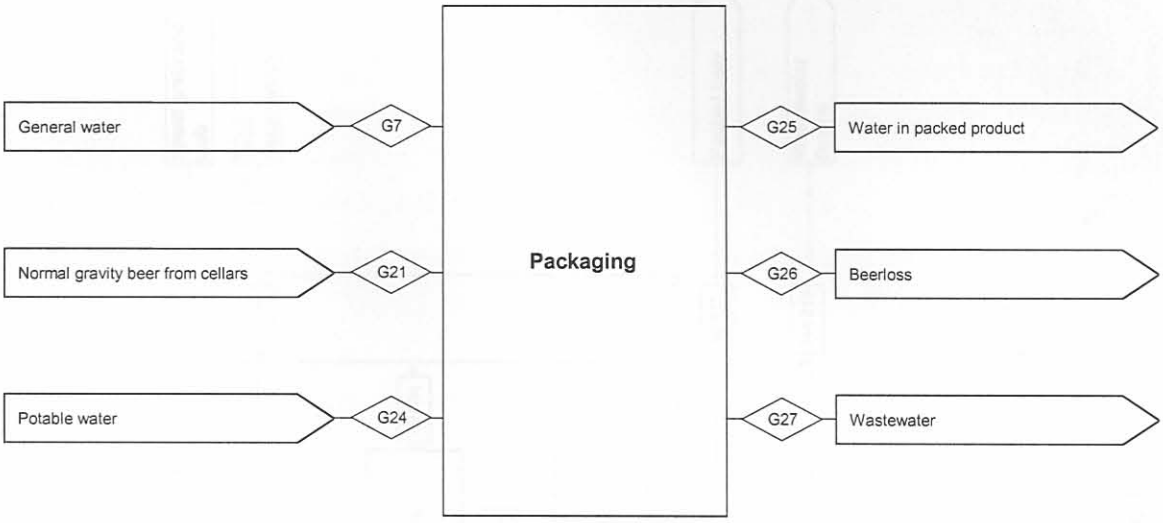


Stream	Volume per week (hl/week)	Source
G6	6 250	-
G16	70 560	Section 3.3
G20	92 848	Section 4.3
G21	100 064	Section 4.3
G22	3 168	Section 4.3
G23	66 426	G6 + G16 + G20 – G21 – G22

Figure 6.8 The simplified water balance over the cellars.

6.5 PACKAGING WATER BALANCE

A simplified water balance over the packaging section (from Chapter 5 and incorporating general water use) is shown in Figure 6.9. 179 540 hl of water per week is introduced into the packaging section for the production of 98 813 hl normal gravity beer.



Stream	Volume per week (hl/week)	Source
G7	26 250	-
G21	100 064	Section 4.3
G24	153 290	Section 5.3
G25	98 813	Section 5.3
G26	1 251	Section 5.3
G27	179 540	G6 + G17 + G25 + G28 – G29 – G30

Figure 6.9 The simplified water balance over the packaging hall.

6.6 OVERALL WATER BALANCE

The overall water balance at the Rosslyn brewery is shown in Figure 6.10. 491 723 hl of water is utilised to produce 98 813 hl of pack
ed beer product per week, resulting in

Ratio of water utilised : beer produced = 491 723/98 813 = 4,98 (hl/hl)

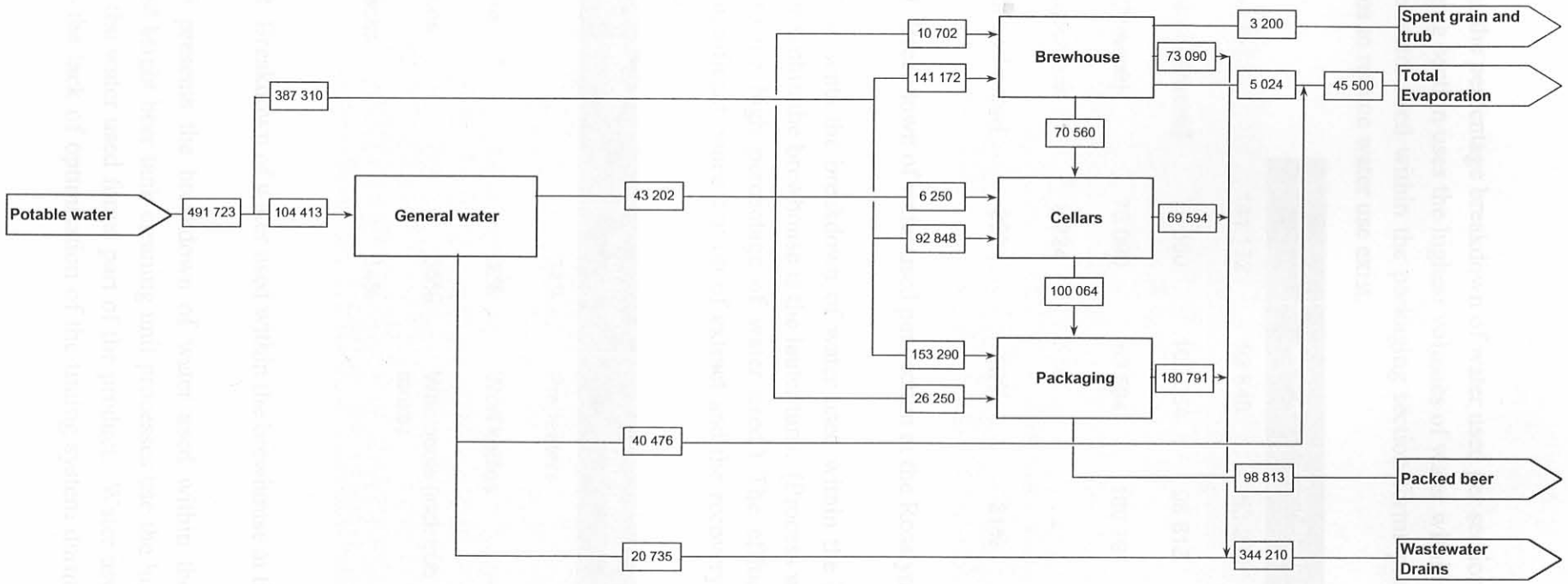


Figure 6.10 The flow diagram of the overall water balance at the Rosslyn plant (flows in hl/week).

In summary, the percentage breakdown of water used per section is shown in Figure 6.11. The packaging section uses the highest volumes of water within the Rosslyn plant. Since none of the water used within the packaging section forms part of the product, various opportunities to reduce water use exist.

	Brewhouse	Cellars	Packaging	General	Total
Water in [hl/week]	141 172	92 848	153 290	104 413	491 723
Water in product [hl/week]	70 560	100 064	98 813	-	98 813
Wastewater [hl/week]	73 090	69 594	180 791	20 735	344 210
Other and evaporation	8 224	-	-	40 476	48 700
Percentage of total water]	29%	19%	31%	21%	

Figure 6.11 Breakdown of water used per section at the Rosslyn plant.

Figure 6.12 presents the breakdown of water used within the brewhouse. The highest user of water within the brewhouse is the lauter tuns. (Process water is added to the mills attributing to the high percentage of water used.) The effluent from the lauter tuns contains a significant concentration of extract and the recovery of this liquor should be investigated.

Unit process	% of total	Unit process	% of total
Mills	34%	Preheaters	3%
Mash tuns	2%	Wort kettles	3%
Lauter tuns	35%	Whirlpools (incl. trub tanks)	9%
Underbacks	14%		

Figure 6.12 Breakdown of water used within the brewhouse at the Rosslyn plant.

Figure 6.13 presents the breakdown of water used within the cellars. Although the blending and bright beer tank cleaning unit processes use the highest water volumes, the majority of the water used forms part of the product. Water used within wort cooling is high due to the lack of optimisation of the timing system during the transfer of product

from the whirlpools to the fermentation vessels. Management of this process may significantly reduce the volumes used.

Unit process	% of total	Unit process	% of total
Wort cooling	21%	Maturation	8%
Yeast pitching	7%	Filtration	11%
Fermentation	11%	Blending & bright beer tank cleaning	41%
Racking	0%		

Figure 6.13 Breakdown of water used within the cellars section at the Rosslyn plant.

Water used in the packaging section and by general users do not form part of the product and possible opportunities to reduce the volumes consumed need to be investigated.

6.7 COST OPPORTUNTIES RELATED TO WATER MINIMISATION

Initiatives to minimise water used by the brewery will result in a reduction in both influent and effluent water costs. The brewery is charged 2c/kl of potable water by the Tshwane Metro local council. Effluent charges are based on the following formula :

$$\text{Rand} = \text{Volume [kl]} \times \left(0{,}64 + \frac{0{,}66 \times COD}{1000}\right), \text{ with COD in mg/l.}$$

With the current effluent volumes of 34 410 kl and an average chemical oxygen demand (COD) content of 3 500 mg/l, the Rosslyn plant is paying R 5,5 million in effluent costs. If it is assumed that the pecentage reduction in effluent volumes will subsequently result in the same percentage increase in COD concentration, then the water savings which can be attained by minimising water entering the plant is shown in Figure 6.14. From the graph it is clear that the brewery should be aiming to reduce water usage to the lowest levels possible, as the influence of this reduction, and the subsequent increase in COD concentration, continuously result in a reduction in the effluent costs.

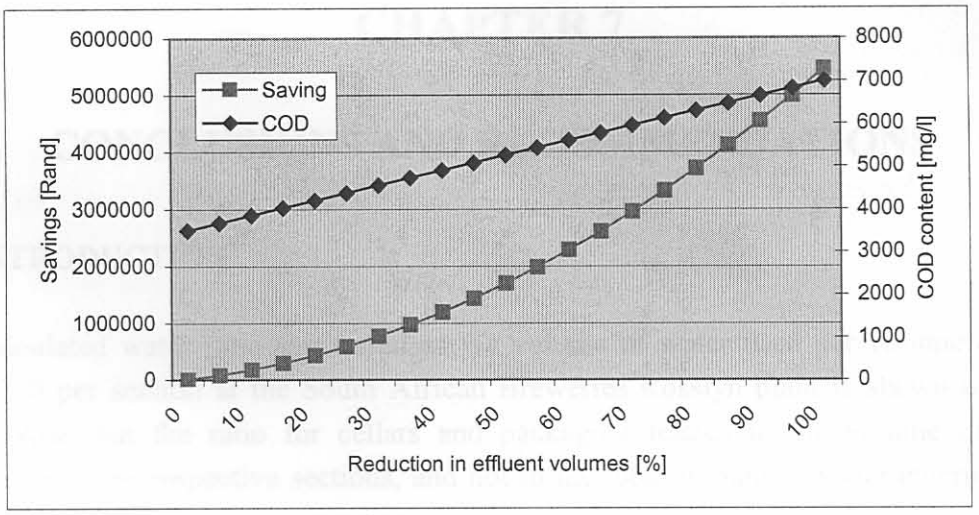


Figure 6.14 Water savings associated with water minimisation at the Rosslyn plant.

6.8 SOURCES

The sources used within this chapter for calculating the overall water balance are presented below.

Source	Reference
S3	Van der Merwe, A.I. (2000) "Water Report for Brewhouse and Cellars" report to SAB Rosslyn plant, Pretoria.
S5	Isaacs, N. (2001) "Operation in the SAB Rosslyn Brewhouse", Personal Communication, Rosslyn Brewery, Pretoria.
S15	Kristin, J. (2000) "Water Utilisation in the Utilities Department at the Rosslyn Brewery", report to SAB Rosslyn plant, Pretoria.
S16	Kadwell, J. (2001) "Water Usage in Utilities", Personal Communication, Rosslyn Brewery, Pretoria.
S17	De Villiers, C. (2001) "Average Values for Stormwater and Evaporation over the Rosslyn Region", Personal Communication, Pretoria.
S18	Rex, J. (2001) "Water Usage within the brewhouse", Personal Communication, Rosslyn Brewery, Pretoria.