CHAPTER 5

PACKAGING

5.1 INTRODUCTION AND BACKGROUND

The Rosslyn packaging section consists of five production lines of which three are quart lines (line 1, 4 and 5), one is a can line (line 2) and one is a handy line (line 3). The quart, can and handy packaging lines will be addressed separately due to differences in machines utilised on the lines and subsequent different water requirements. Due to the simplicity of certain processes on the production lines, certain water balances will also be combined.

5.1.1 Quart lines (returnable bottles)

The quart lines pack beer into 750 ml bottles, mainly returned from trade (new bottles are periodically introduced onto the production lines to replace older bottles). The hygiene of the returnable bottles is poor and good cleaning is vital to ensure that contamination of the beer is avoided. Each of the production lines is capable of bottling a specified volume of beer. At the Rosslyn plant, lines 1, 4 and 5 are rated to pack the following volumes of beer per hour:

Line 1 – 315 hl/h
Line 4 – 315 hl/h
Line 5 – 450 hl/h

The equipment used on each line may differ in age and manufacturer. For the purposes of this thesis, an average water consumption for the three lines will be assumed. As shown in Figure 2.4, a quart line consists of a depalletiser, a decrowner, an uncrater, a crate washer, a bottle washer, an empty bottle inspector, a filler, a crowner, a pasteuriser, a labeller, a recrater and a palletiser.

Depalletiser, decrowner and uncrater

The depalletiser, decrowner and uncrater use water for general cleaning purposes. Operators use high pressure hoses to clean the machinery and the surrounding areas.

Crate washer

The crate washer consists of numerous compartments (or zones) containing cleaning water to ensure the thorough cleaning of the crates. Two of the compartments in the crate

washer (the final rinse and pre-wash compartments), require clean water to be supplied continuously during the washing process to ensure that effective cleaning takes place. This water is discharged to the drains. The cleaning water in the other compartments of the crate washer is analysed weekly and if the water quality deteriorates below a certain level, the water contained within such a compartment will be discharged to the drains and replaced with potable water.

Bottle washer

Bottles returned from trade are cleaned in the bottle washer. As with the crate washer, the bottle washer also consists of several compartments where the bottles are presoaked in one or more water baths at increasing temperatures, passed through hot caustic baths, rinsed with caustic, hot water, cold water and eventually rinsed with potable water. As the bottles pass through the compartments, water is carried over to the following compartment by either adhering to a bottle's surface or by being trapped inside a bottle. Water is added on a continuous basis to ensure that the levels in the bottle washer remain balanced. In the final compartment of the washer, the bottles are continuously rinsed with potable water. This water is recycled to the first compartment of the bottle washer from where it is discharged to the drains after use. In general, the flowrate into the washer is 21 m^3/h (Schumacher, 2000).

The water used within the bottle washer must be clean enough to ensure that the bottles are cleaned sufficiently and the water within the compartments is analysed on a weekly basis. Should the quality of the water within a compartment be below the prescribed quality level, the water within that compartment is discharged to the drains. The compartment is then filled to the correct volume with potable water.

Empty bottle inspector

Prior to being filled with beer, the bottles are inspected for any cracks or dirt, which may not have been removed in the washer. Water for this machine is mainly used to ensure that the bottles are wet before being inspected to reduce the influence of scuff marks on inspection efficiency. After the bottles have been inspected, they are conveyed to the filler. The empty bottle inspector (EBI) and the surrounding area undergo a general clean on a shift basis.

Filler and crowner

Before the bottles are filled with the beer (which is stored in the BBT vessels), deaerated water is transferred through the filling lines to displace any air out of the lines. The lines

are simultaneously cooled to ensure that the temperature of the beer is not altered which would cause CO_2 to be released from the beer, adversely affecting the filling process.

The first stage of filling is the removal of the air residing in the bottle by applying a vacuum, created by a vacuum pump. At the Rosslyn plant, water is used to cool the vacuum pump (the pump may lose efficiency with increasing heat), as well as to create a water seal and therefore prevent air from entering the bottle. The water used by the vacuum pump is discharged to the drains.

Before the bottles are closed or crowned, a fine jet of water is sprayed into the bottle causing the beer to foam which in turn displaces air from the headspace above the beer. The bottles are closed immediately thereafter and rinsed with water to remove traces of beer. Should a bottle burst during filling, a set of sprays is activated which flushes the glass (also termed cullet) and the beer out of the area in which the burst occurred.

On completion of beer transfer, deaerated water is transferred through the line to transfer any beer remaining in the line to the filler. If there is a change in the brand of beer being packed, the pipeline is rinsed with water to remove traces of the previous brand. The pipelines, transferring beer to the filler, and the filler undergo a CIP clean on a weekly basis.

Pasteuriser

Tunnel pasteurisation is used at the Rosslyn plant. The pasteuriser contains several compartments filled with water at different temperatures. As discussed in Section 2.3.4.1, water is recycled between different compartments for either heating or cooling of the bottles. This is to ensure optimal energy and water usage. However, as the bottles are conveyed through the pasteuriser, water is carried over by the bottles to the next compartment, thus resulting in decreasing water levels within the pasteuriser compartments. Water is added to the pasteuriser to compensate for these decreasing levels within the compartments. The final rinse compartment of the pasteuriser uses water from the cooling towers to cool down the bottles which is then returned back to the cooling towers. The spray bars inside the pasteuriser are flushed with water, with the aid of high-pressure hoses, to ensure cleanliness. When the quality of the water contained within the compartments of the pasteuriser deteriorate to undesirable levels (due to, *inter alia,* bursting bottles), the water in these compartments is discharged to the drains and replaced with potable water.

Labeller, recrater and palletiser

The bottles are conveyed to the labeller where the labels are applied to the bottles. The labeled bottles are then conveyed to the recrater where they are placed into crates containing twelve bottles. Full crates are placed onto pallets which are then packed onto trucks and transported to distribution depots. The machines only use water for general cleaning purposes.

Chain lube

The conveyors are lubricated with a mixture of chain lube and water to reduce friction between the moving parts of the conveyor and between the conveyor and the bottles. It is estimated that 0,028 litre of chain lube is used per hl of beer packed and that the concentration of chain lube in the mixture is 0,4 % (Davis, 2000). Therefore the volume of water used for lubricating the conveyors is estimated to be 7 litre per hl of beer packed.

5.1.2 Can and handy lines (nonreturnable containers)

The Rosslyn plant has one can line (for 340 ml and 450 ml cans) and one handy line (340 ml bottles). The lines at SA Breweries' Rosslyn plant are rated to pack the following volumes of beer per hour:

Line 2 – 170 hl/h
Line 3 – 408 hl/h

As shown in Figure 2.5, a nonreturnable container line consists of the machine depalletiser, rinser, filler, seamer/crowner, pasteuriser, shrinkwrapper, traypacker and palletiser. The following analysis is based on average operations at the Rosslyn Plant.

Machine depalletiser

Water is used for general cleaning purposes of the machine. The operator uses high pressure hoses to clean the machinery and the surrounding areas.

Rinser

The bottles and cans are sprayed for a brief period of time with clean water to remove dust which may have collected within the container. Water runs continuously from the

rinser sprays to the drains. Water is also used for the general cleaning of the rinser and surrounding areas.

Filler and seamer/crowner

Similar to the quart lines, deaerated water is transferred through the filling lines prior to and on completion of beer transfer. Water is also used to CIP clean the beer lines and filler to ensure that no build-up of dirt occurs at any time.

Jetting with water also occurs on the nonreturnable bottle line to displace air from the airspace above the beer. However, unlike bottle filling, can filling does not require jetting of water on completion of the filling process. Instead a stream of CO_2 is passed into the can to break the beer bubbles. Once the cans have been filled and closed or seamed (or the bottles filled and crowned), they are rinsed with water to remove traces of beer. In addition, water is also used for general cleaning purposes.

Pasteuriser

The operation of the pasteuriser used on the can and handy lines is similar to that for the quart lines. Water is also used to make up the water levels in the compartments due to the carry over of water by the cans and bottles. The final compartment of the handy line uses water from the cooling towers to cool the bottles exiting the pasteuriser. This water is circulated back to the cooling towers and the levels in the cooling tower made up with potable water. However, the final compartment on the can line uses potable water to cool the cans exiting the pasteuriser and is discharged directly to the drains. The spray bars inside the pasteuriser are flushed with water, with the aid of high-pressure hoses, to ensure cleanliness. As discussed in Section 2.3.4.2, when the quality of the water used in the pasteuriser deteriorates below the relevant standard (Volmer, 2001), the water is discharged to the drains and replaced with water from the main supply. This normally occurs on a weekly basis.

Shrinkwrapper, traypacker and palletiser

As with the machine depalletiser, water is used for general cleaning purposes of these machines.

Chain lube

Similer to the returnable bottle line, a mixture of chain lube and water is also used on the nonreturnable container lines to lubricate the conveyors and reduce the friction between

the moving parts of the conveyor and between the conveyor and the containers. The water used for lubricating the conveyors is, similar to Section 5.1.1, estimated at 7 l/hl of beer packed.

5.2 WATER USE IN THE PACKAGING SECTION

The general water balance over the packaging section is shown in Figure 5.1. The packaging section packs 100 064 hl of beer per week (Section 4.3), prepared by the brewing section, into returnable bottles and nonreturnable cans and bottles.

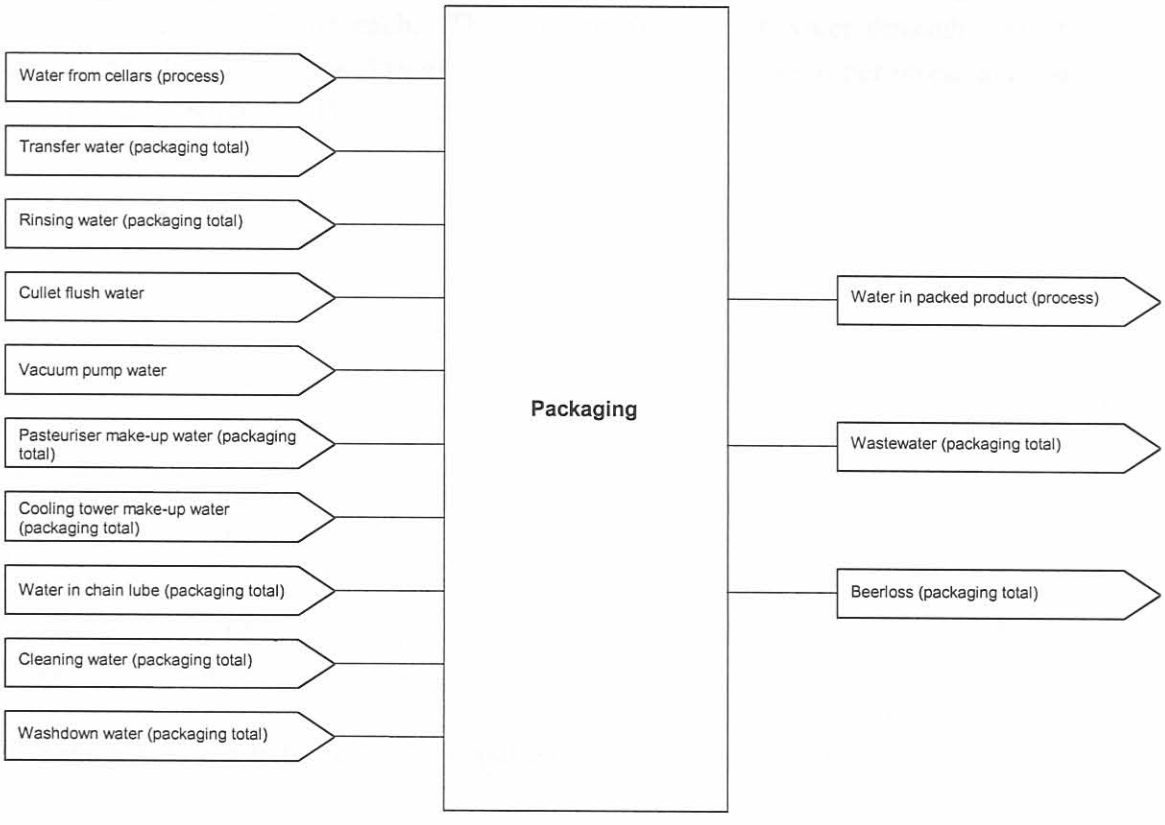


Figure 5.1 The general water balance over the packaging section.

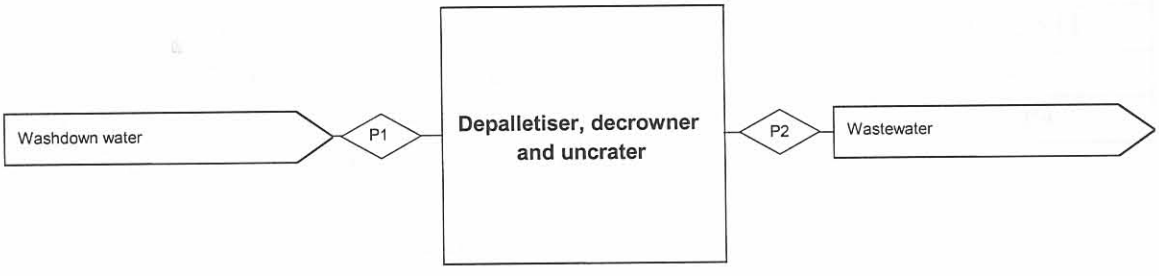
5.2.1 Water use on the quart line

Two quart lines at the Rosslyn plant are rated to pack 315 hl/h of beer while the third quart line is capable of packing 450 hl/h of beer. In terms of this thesis, an average line rating of 360 hl/hour for the three quart lines will be used. Given that the average volume of beer packed by all three lines per day is 14 835 hl (SAB, 2001), a single line packs, on average, 4 945 hl/day. With an average line rating of 360 hl/hour and an average line efficiency of 73,4 % (SAB, 2001), a line is active for approximately 19 hours per day.

A distinction will also be made in this thesis between cleaning and washdown water. Cleaning water will relate to water used for cleaning purposes inside a machine, whereas washdown water will refer to water used for cleaning machines on the outside.

Depalletiser, decrowner and uncrater.

The water balance for the depalletiser, decrowner and uncrater is shown in Figure 5.2. The depalletiser, decrowner and uncrater are washed daily with high-pressure hoses for approximately one hour each and undergo a thorough clean on a weekly basis for approximately two hours each. The average flowrate of water through these hoses is assumed to be 5 000 l/h and therefore 1 050 hl of water is used per week and discharged to the drains (SAB, 2001).



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P1	1 050	per week	1 050	S4
P2	1 050	per week	1 050	P1

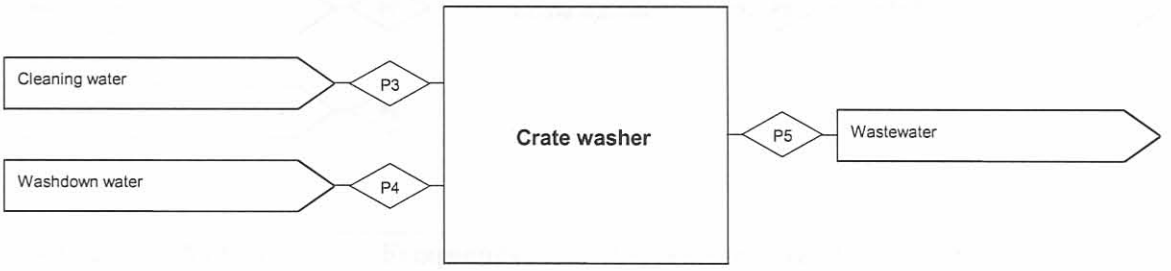
⊕ Sources, other than streams, are presented at the end of each chapter.

Figure 5.2 Water balance for the depalletiser, decrowner and uncrater (quart line).

Crate washer

The water balance for the crate washer is shown in Figure 5.3. To ensure that the water used to clean the crates remains within acceptable standards, an average of 58 hl/h of dirty water is discharged to the drains and replaced with potable water (SAB, 2001). If the machine is in operation 19 hours per day, an average of 5 510 hl of water per week is discharged to the drains. In addition, water (and chemicals) in specified compartments of the crate washer, with an average volume of approximately 96 hl (Volmer, 2000), is discharged once a week to the drains as per a predefined schedule and replaced with potable water. Therefore, 5 606 hl of water (in total) is used per week to ensure thorough cleaning of the crates and discharged to the drains. The crate washer and surrounding

area are also washed with high pressure hoses by an operator for an average of 6 hours per week. If it is assumed that the average flowrate through these hoses is 5 000 l/h, then 300 hl of water is used for washdown of the crate washer.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P3	5 606	per week	5 606	S10 and S11
P4	300	per week	300	S4
P5	5 906	per week	5 906	P3 + P4

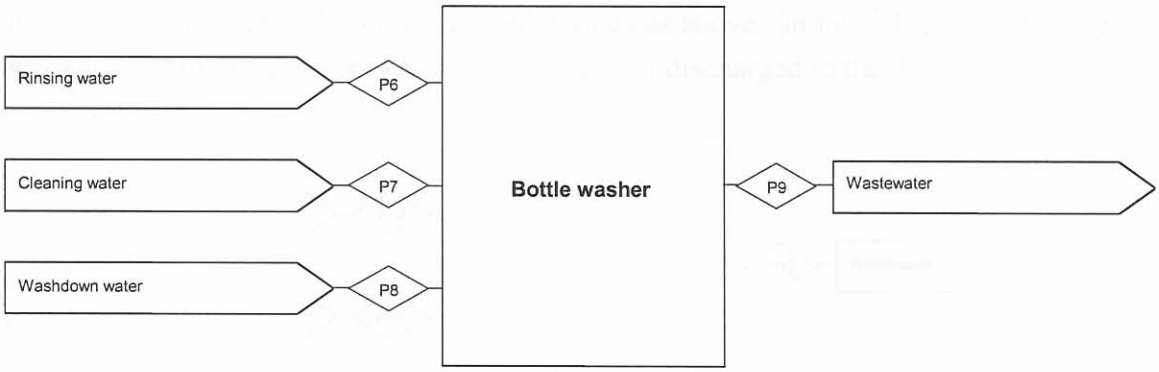
⊕ Sources, other than streams, are presented at the end of each chapter.

Figure 5.3 Water balance for the crate washer (quart line).

Bottle washer

The water balance over the bottle washer is shown in Figure 5.4. A continuous flow of water is used to rinse the bottles in the last compartment of the bottle washer and to maintain the levels in the bottle washer. The average flowrate of water to the final rinse compartment of the bottle washer is 210 hl/h (SAB, 2001) and if the machine is in operation for 19 hours per day, 3 990 hl of water is discharged to the drains per day.

A predetermined volume of water is used on a daily (42 hl) and on a weekly (304 hl) basis for cleaning purposes (Volmer, 2000). Therefore 514 hl of water is discharged to the drains per week to ensure that the water within the compartments remains within acceptable standards. The bottle washer is also washed for an average of 6 hours per week with high pressure hoses and if the flowrate through a hose is assumed to be 5 000 l/h, then 300 hl of water is used to washdown the bottle washer.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P6	3 990	per day	19 950	S10
P7	514	per week	514	S11
P8	300	per week	300	S4
P9	-	-	20 764	P6 + P7 + P8

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

Figure 5.4 Water balance over the bottle washer (quart line).

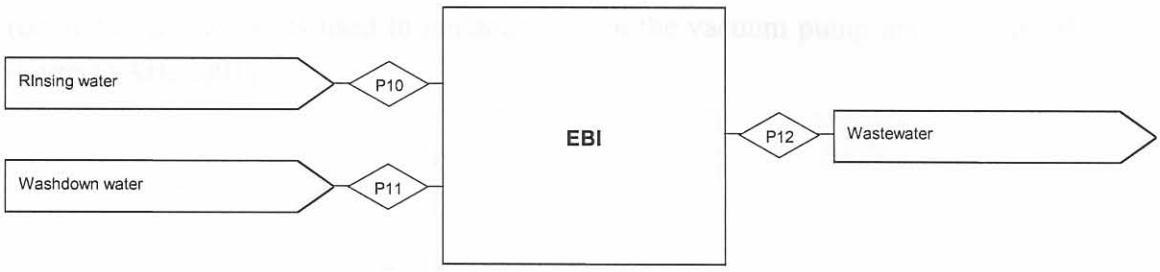
Empty bottle inspector

The water balance over the empty bottle inspector (EBI) is shown in Figure 5.5. The flowrates of unmeasured streams were determined from plant trials conducted during November 2000 to approximate water volumes used in the EBI (Van der Merwe, 2000). From these trials the average flowrate through the water sprays of the EBI was found to be 0,18 hl/h. Therefore, assuming the line is operated for 19 hours per day, 3 hl of rinsing water is discharged to the drains per day. The EBI is washed, on average, once a week for approximately 30 minutes with high pressure hoses and if the flowrate through a high pressure hose is assumed to be 5 000 l/h, 25 hl of water per week is used for washdown purposes.

Filler

The water balance over the filler is shown in Figure 5.6. 24 725 hl of beer per week (4 945 hl/day) is transferred from the BBTs to the filler per line. Before the transfer of beer from the BBTs to the filler, deaerated water is used to displace air in the filler lines at a rate of 370 hl/h for 10 minutes (SAB, 2001). This practice occurs, on average, twice a day and the resultant 617 hl per week of deaerated water is discharged to the drains. On completion of the beer transfer, deaerated water is used to transfer any beer remaining in

the lines to the filler at the same rate and periods as above. In total, 1 234 hl of water per week is used in the transfer of beer to the filler and discharged to the drains.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P10	3	per day	15	S12
P11	25	per week	25	S4
P12	-	-	40	P10 + P11

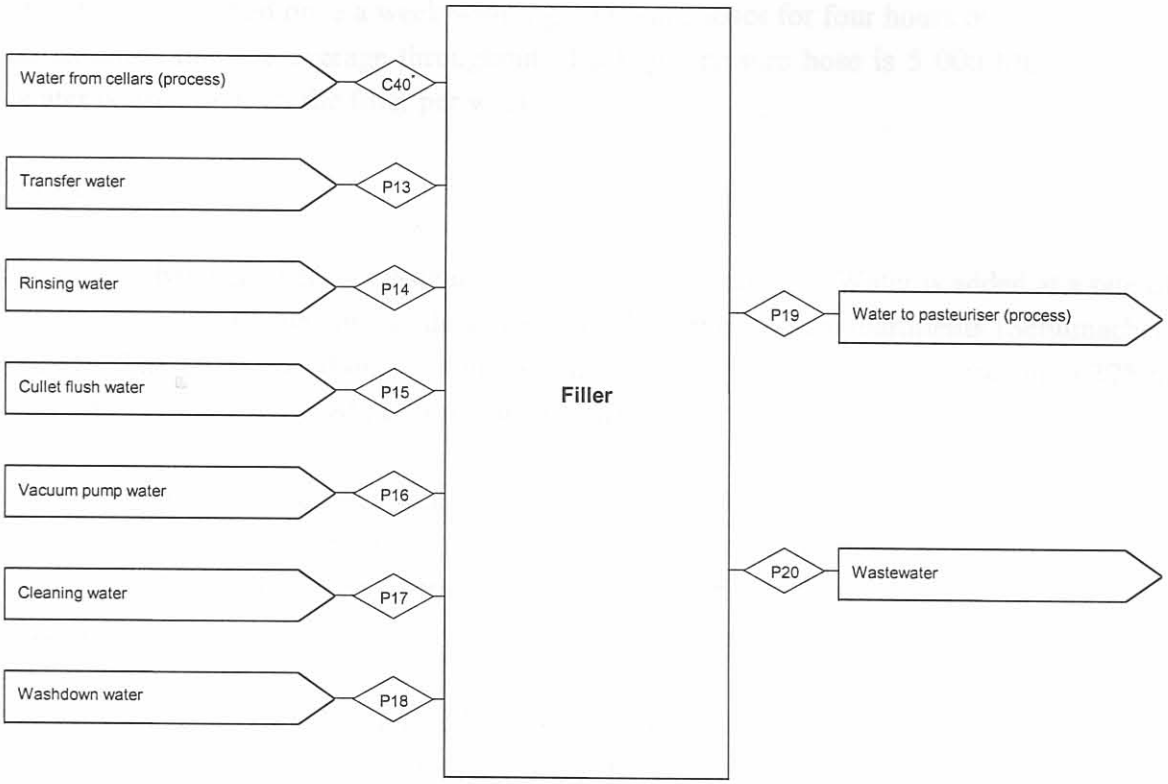
⊕ Sources, other than streams, are presented at the end of each chapter.

Figure 5.5 Water balance over the EBI (quart line).

After the bottles have been filled with beer, a fine jet of water is sprayed into the bottles to displace air from the headspace of the bottle. During the plant trials of November 2000, the flowrate of this water was found to be 0,08 hl/hour on average and subsequently 7,6 hl of water per week per line is discharged to the drains. This volume is an order of magnitude lower than that of the other water volumes calculated in this thesis and is therefore assumed to be negligible. After the bottles have been filled and crowned, they are rinsed by five water sprays with an average flowrate, calculated from plant trials, of 2,85 hl/h per spray. Therefore, assuming that the sprays are in operation for 19 hours per day, the volume of water lost due to rinsing is 1 354 hl per week and discharged to the drains.

Should a bottle burst during filling, a set of sprays is activated which flushes the area in which the bottle burst. The average amount of cullet (broken bottles) generated during filling per week per line is 189,2 kg, which equates to 376 bottles (SAB, 2001). The average flowrate through the water sprays is 250 hl/h and the sprays are activated for approximately 5 seconds per bottle breakage (Schumacher, 2000). Therefore the average volume of water used per week to flush the filler due to broken bottles is 131 hl.

To remove any air residing in the bottles, a vacuum is applied through a vacuum pump. Water is used to create the vacuum and once the temperature of the water becomes too high, the hot water is replaced and discharged to the drains. An average of 62 hl per day (or 310 hl per week) is used to replace water in the vacuum pump and discharged to the drains (SAB, 2001).



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
C40*	24 725	per week	24 725	Section 4.3
P13	1 234	per week	1 234	S4
P14	1 354	per week	1 354	S12
P15	131	per week	131	S13
P16	310	per week	310	S10
P17	56	per week	56	S14
P18	200	per week	200	S4
P19	24 725	per week	24 725	C40
P20	3 285	per week	3 285	P13 + P14 + P15 + P16 + P17 + P18

⊕ Sources, other than streams, are presented at the end of each chapter. * part of C40.

Figure 5.6 Water balance over the filler (quart line).

The beer lines undergo a CIP clean once every second week at a rate of 450 hl/h. The CIP cycle continues for approximately 40 minutes, of which 15 minutes of flow is expected to discharge to the drains (Myoli, 2000). Therefore the average volume of water used to CIP the lines for a week is 56 hl.

The filler is washed once a week with high pressure hoses for four hours on average. If it is assumed that the average throughput of a high-pressure hose is 5 000 l/h, 200 hl of water is used to wash the filler per week.

Pasteuriser

The water balance over the pasteuriser is shown in Figure 5.7. Water is added at a rate of 35 hl/h to compensate for the decreasing levels within the compartments (Schumacher, 2000). Therefore, based on 19 hours per day and five days per week operation, 3 325 hl of make-up water is added per week and discharged to the drains.

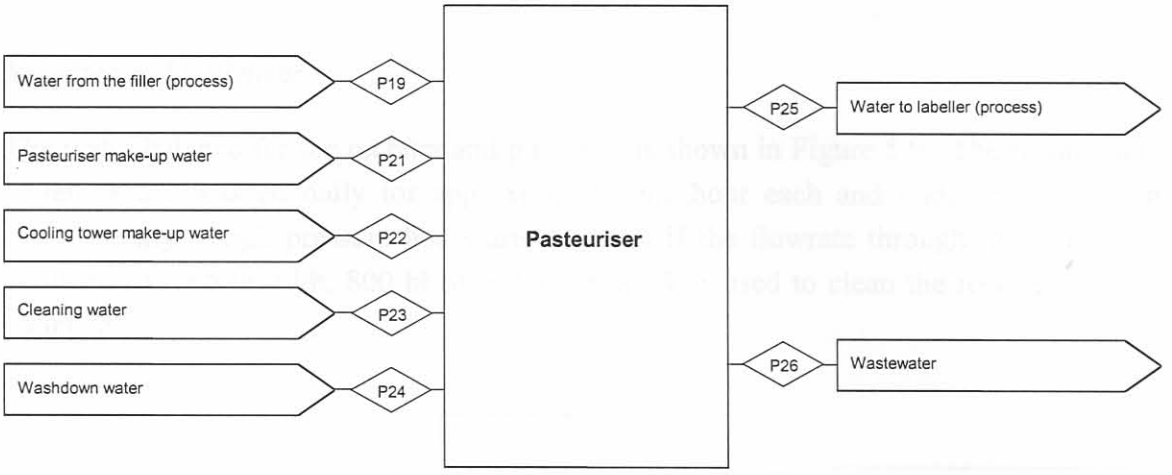
Water is also circulated between the cooling towers and the pasteuriser. On average, a flow of 24 hl/h is expected to make-up for losses incurred (SAB, 2001). Therefore, assuming that the line is in operation for 19 hours per day, the average volume of water required to make-up the volumes in the cooling towers is 2 280 hl per week.

When the quality of the water within the pasteuriser compartments deteriorates below a certain level, it is discharged to the drains. The average volume of cleaning water added per week is 128 hl (SAB, 2001).

The pasteuriser is washed daily for two hours and undergoes a thorough clean once a week for an average of five hours. High-pressure hoses are used to clean the pasteuriser and if it is assumed that the average throughput of a hose is 5 000 l/h, then the average volume of water used to clean the pasteuriser is 750 hl per week.

Labeller

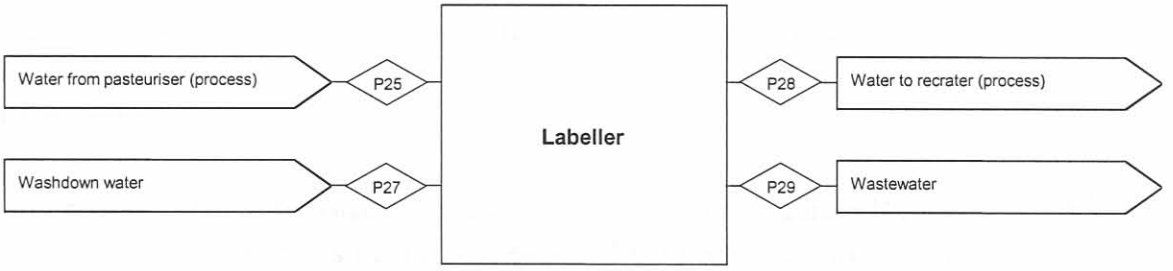
The water balance over the labeller is shown in Figure 5.8. The labeller is washed daily for approximately one hour and undergoes a thorough clean weekly for approximately two hours. High-pressure hoses are used to clean the labeller and if the flowrate through these hoses is assumed to be 5 000 l/h, 350 hl of water is used per week.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P19	24 725	per week	24 725	-
P21	3 325	per week	3 325	S13
P22	2 280	per week	2 280	S10
P23	128	per week	128	S10
P24	750	per week	750	S4
P25	24 725	per week	24 725	P19
P26	6 483	per week	6 483	P21 + P22 + P23 + P24

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

Figure 5.7 Water balance over the pasteuriser (quart line).



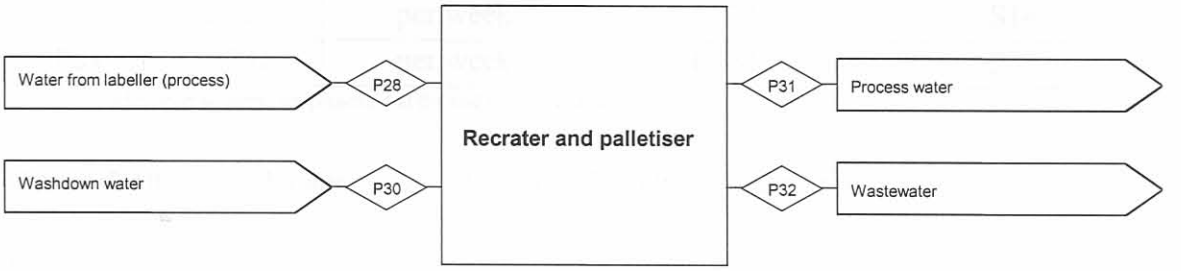
Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P25	24 725	per week	24 725	-
P27	350	per week	350	S4
P28	24 725	per week	24 725	P25
P29	350	per week	350	P27

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

Figure 5.8 Water balance over the labeller (quart line).

Recrater and palletiser

The water balance for the recrater and palletiser is shown in Figure 5.9. The recrater and palletiser are washed daily for approximately one hour each and undergo a thorough clean weekly. High pressure hoses are used and if the flowrate through these hoses is assumed to be 5 000 l/h, 800 hl of water per week is used to clean the recrater and the palletiser.



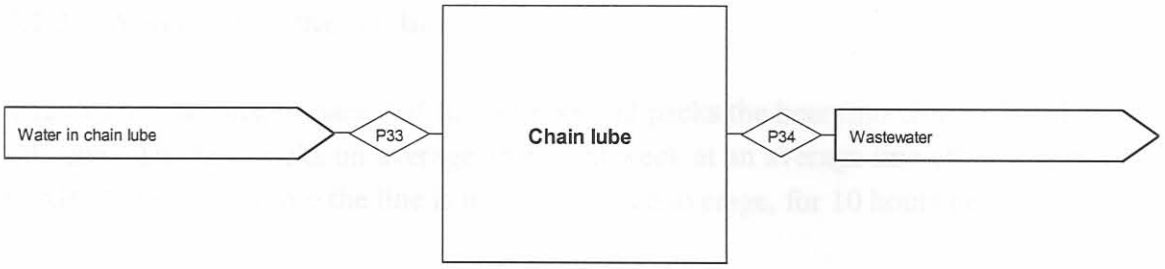
Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P28	24 725	per week	24 725	-
P30	800	per week	800	S4
P31	24 725	per week	24 725	P28
P32	800	per week	800	P30

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

Figure 5.9 Water balance over the recrater and the palletiser (quart line).

Chain lube

The water balance associated with chain lube is shown in Figure 5.10. To reduce friction between the moving parts of the conveyor and between the conveyor and the bottles, a chain lube mixture is added. The volume of water used for lubrication is 1 731 hl, based on 7 litre of water per hl of beer packed (see Section 5.1.1).



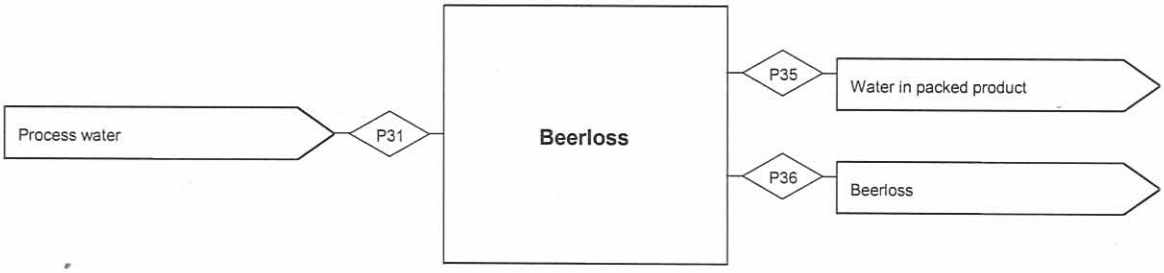
Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P33	1 731	per week	1 731	S14
P34	1 731	per week	1 731	P33

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

Figure 5.10 Water balance associated with chain lube (quart line).

Beerloss

The water balance associated with the beer lost to the drains on the returnable bottle line is shown in Figure 5.11. During the packing process, beerlosses are inevitable and these losses are discharged to the drains. It is expected that, on average, 1,25 % of the beer packed is lost to the drains (Davis, 2000). Therefore, if one packaging line packs 24 725 hl of beer per week, 309 hl of beer is lost to the drains per week per line.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P31	24 725	per week	24 725	-
P35	24 416	per week	24 416	P31 - P36
P36	309	per week	309	S14

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

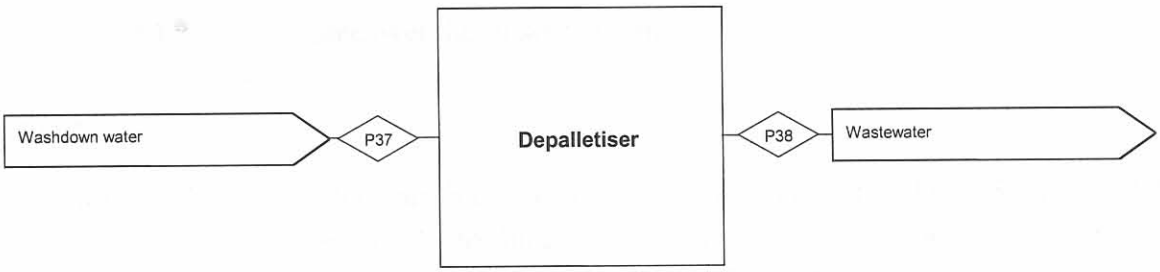
Figure 5.11 Water balance associated with beer lost to the drains (quart line).

5.2.2 Water use on the can line

The can line is rated to pack 408 hl/h of beer and packs the beer into either 450 ml or 340 ml cans. The line packs on average 15 839 hl/week at an average line efficiency of 80% (SAB, 2001). Therefore the line is in operation, on average, for 10 hours per day.

Depalletiser

The water balance over the depalletiser is shown in Figure 5.12. The depalletiser is washed daily with high-pressure hoses for approximately one hour and undergoes a thorough clean on a weekly basis for approximately two hours. The average flowrate of water through these hoses is assumed to be 5 000 l/h and therefore 350 hl of water is used per week and discharged to the drains (SAB, 2001).



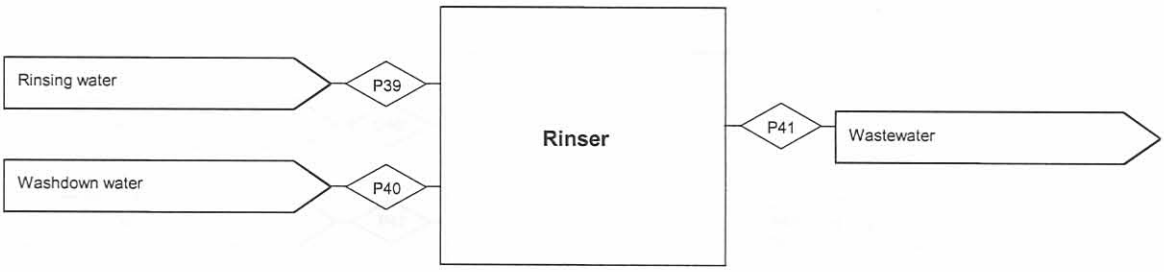
Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P37	350	per week	350	S4
P38	350	per week	350	P37

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

Figure 5.12 Water balance over the depalletiser (can line).

Rinser

The water balance over the rinser is shown in Figure 5.13. The rinser sprays water into the cans at a rate of 24 hl per hour (Myoli, 2000) and this water is discharged to the drains. Assuming the line is active for 10 hours per day, the volume of water used to rinse the cans is 1 200 hl per week. The rinser is washed for approximately five hours per week with high-pressure hoses. Since the flowrate through these hoses is assumed to be 5 000 l/h, 250 hl of water is used to wash the rinser per week.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P39	1 200	per week	1 200	S14
P40	250	per week	250	S4
P41	1 450	per week	1 450	P39 + P40

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

Figure 5.13 Water balance over the rinser (can line).

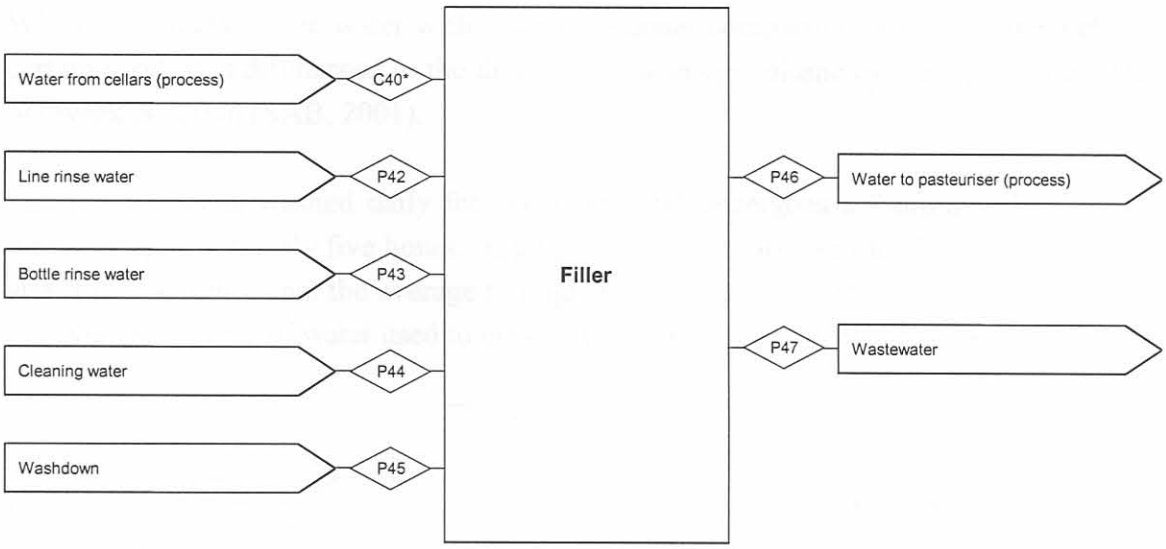
Filler

The water balance over the can line filler is shown in Figure 5.14. From Section 5.2.2 15 839 hl of beer per week (3 168 hl/day) is transferred to the filler on the can line. Before the transfer of beer from the BBT's to the filler, deaerated water is used to displace air in the filler lines at a rate of 408 hl/h for 10 minutes. This practice occurs, on average, once per day and the resultant 340 hl per week of deaerated water is discharged to the drains. On completion of the beer transfer, deaerated water is used to transfer any beer remaining in the lines to the filler, at the same rate and periods as above. In total, 680 hl of water per week is used in the transfer of beer to the filler and discharged to the drains.

After the cans have been filled and seamed, they are rinsed at an average rate of 5 hl/h (Myoli, 2000). Therefore, if the line is in operation for 10 hours per day, 250 hl of water is used per week to rinse the cans.

The beer lines undergo a CIP once every second week at a rate of 165 hl/h. The CIP cycle continues for approximately 40 minutes, of which 15 minutes of flow is expected to discharge to the drains (Myoli, 2000). Therefore the average volume of water used to CIP the lines per week is 21 hl.

The filler is washed once a week with high-pressure hoses for four hours on average. If it is assumed that the average throughput of a high-pressure hose is 5 000 l/h, 200 hl of water is used to wash the filler per week.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
C40*	15 839	per week	15 839	-
P42	680	per week	680	S4
P43	250	per week	250	S14
P44	21	per week	21	S14
P45	200	per week	200	S4
P46	15 839	per week	15 839	C40
P47	1 151	per week	1 151	P42 + P43 + P44 + P45

⊕ Sources, other than streams, are presented at the end of each chapter. * part of C40.

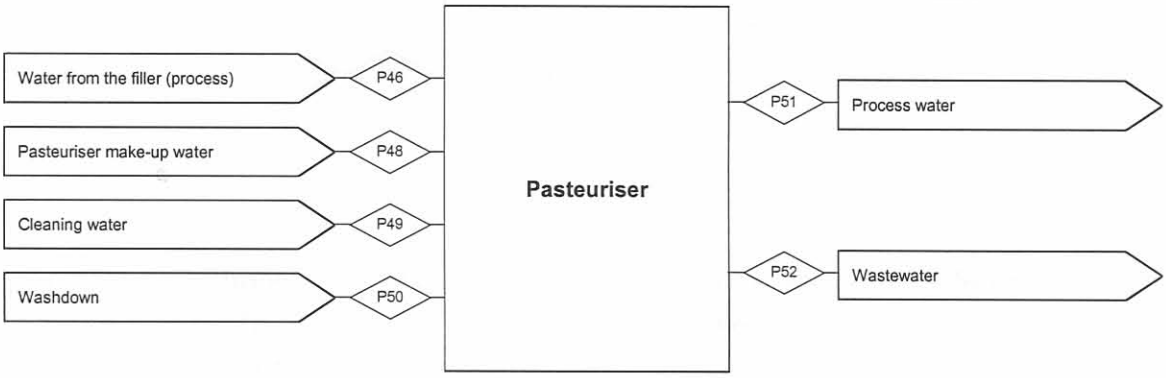
Figure 5.14 Water balance over the filler (can line).

Pasteuriser

The water balance over the pasteuriser on the can line is shown in Figure 5.15. Unlike the pasteurisers used on the bottle lines, the pasteuriser used on the can line does not recycle water back to the cooling towers. Water is transferred to the final compartment of the pasteuriser at a rate of 294 hl/h (SAB, 2001), resulting in 14 700 hl of water discharged to the drains per week. In addition, water is also added to the pasteuriser at a rate of 40 hl per hour (or 2 000 hl per week) to compensate for the carry over of water by the cans (Schumacher, 2000). In total, 16 700 hl of pasteuriser make-up water is added to the pasteuriser per week and discharged to the drains.

When the quality of the water within the pasteuriser compartments deteriorates below a certain level, it is discharged to the drains. The average volume of cleaning water added per week is 230 hl (SAB, 2001).

The pasteuriser is washed daily for two hours and undergoes a thorough clean once a week for approximately five hours. High-pressure hoses are used to clean the pasteuriser and if it is assumed that the average throughput of a high-pressure hose is 5 000 l/h, then the average volume of water used to clean the pasteuriser is 750 hl per week.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P46	15 839	per week	15 839	-
P48	16 700	per week	16 700	S9
P49	230	per week	230	S9
P50	750	per week	750	S4
P51	15 839	per week	15 839	P48
P52	17 680	per week	17 680	P48 + P49 + P50

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

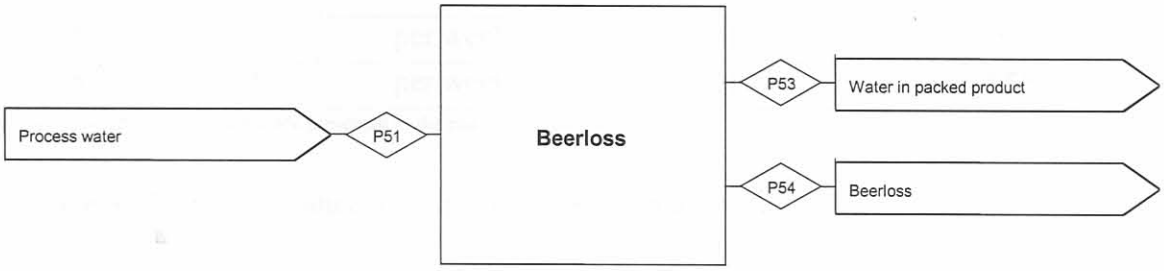
Figure 5.15 Water balance over the pasteuriser (can line).

Shrinkwrapper, traypacker and palletiser

The shrinkwrapper, traypacker and palletiser are washed by an operator, on average, for one hour per week. The volumes of water used to clean these machines are of an order of magnitude less than what is used by the other equipment on the line and the volumes will therefore be ignored (Van der Merwe, 2000). (Since plastic belts are used to transport the cans between equipment, chain lube is not used on a can line.)

Beerloss

The water balance associated with the beer lost to the drains on the can line is shown in Figure 5.16. During the packing process, beerlosses are inevitable and these losses are discharged to the drains. It is expected that, on average, 1,25% of the beer packed is lost to the drains (Davis, 2000). Therefore, if the line packs on average 15 839 hl of beer per week, 198 hl of beer is lost to the drains per week.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P51	15 839	per week	15 839	Section 4.3
P53	15 641	per week	15 641	P51– P54
P54	198	per week	198	S13

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

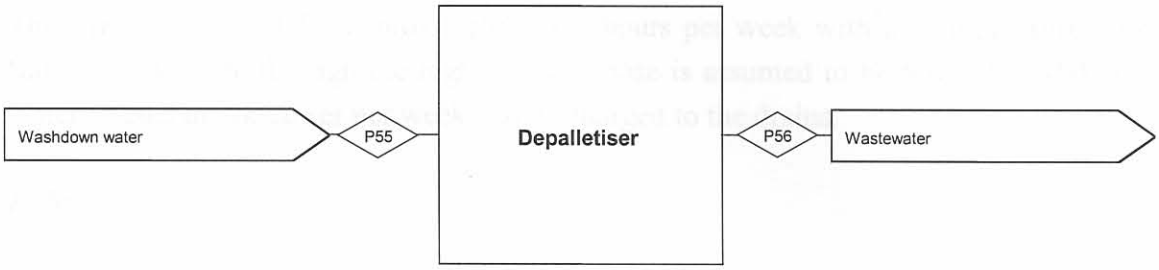
Figure 5.16 Water balance associated with beer lost to the drains (can line).

5.2.3 Water use on the nonreturnable bottle line

The nonreturnable bottle line is rated to pack 170 hl/h of beer into 340 ml bottles. The line packs on average 2 010 hl/day at an average line efficiency of 80% (SAB, 2001). Therefore the line is in operation, on average 15 hours per day.

Depalletiser

The water balance over the depalletiser is shown in Figure 5.17. The depalletiser is washed daily with high-pressure hoses for approximately one hour and undergoes a thorough clean on a weekly basis for approximately two hours. Since the average flowrate through a high pressure hose is assumed to be 5 000 l/h, 350 hl of water is used per week and discharged to the drains (SAB, 2001).



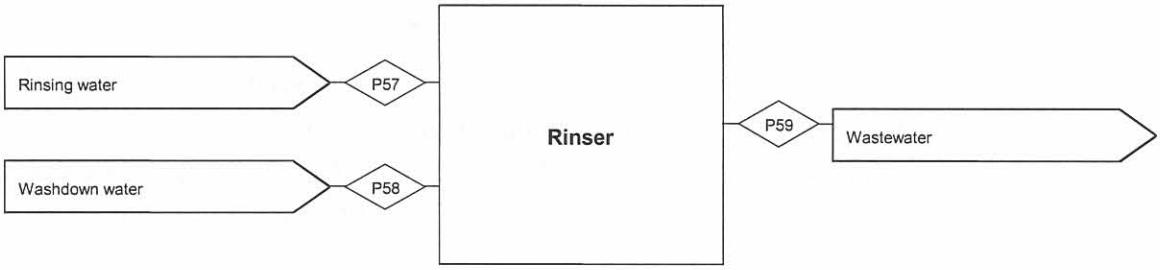
Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P55	350	per week	350	S4
P56	350	per week	350	P55

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

Figure 5.17 Water balance over the depalletiser (handy line).

Rinser

The water balance over the rinser is shown in Figure 5.18. The rinser sprays water into the bottles at a rate of 35 hl per hour (Myoli, 2000) and this water is discharged to the drains. Assuming the line is active for 15 hours per day, the volume of water used to rinse the bottles per week, is 2 625 hl.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P57	2 625	per week	2 625	S14
P58	250	per week	250	S4
P59	2 875	per week	2 875	P57+ P58

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

Figure 5.18 Water balance over the rinser (handy line).

The rinser is washed for approximately five hours per week with a high-pressure hose. Since the flowrate through the high-pressure hose is assumed to be 5 000 l/h, 250 hl of water is used on the rinser per week and discharged to the drains.

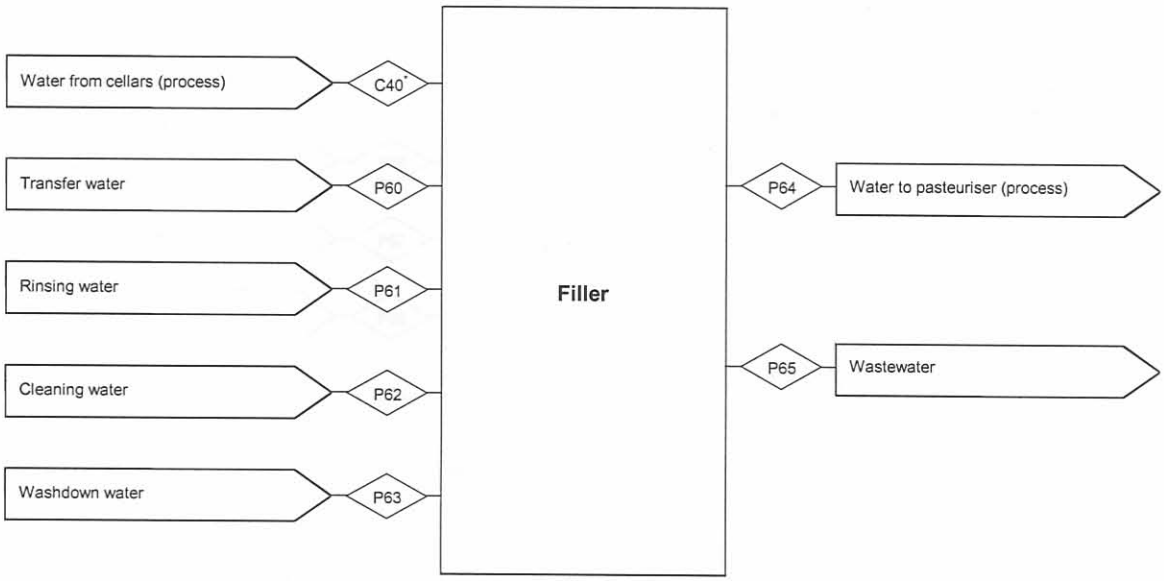
Filler

The water balance over the nonreturnable bottle line filler is shown in Figure 5.19. 10 050 hl of beer per week (2 010 hl/day) is transferred to the filler on the nonreturnable bottle line. Before the transfer of beer from the BBT's to the filler, deaerated water is used to displace air in the filler lines at a rate of 170 hl/h for 10 minutes. This practice occurs, on average, once a day and the resultant 142 hl per week of deaerated water is discharged to the drains. On completion of the beer transfer, deaerated water is used to transfer any beer remaining in the lines to the filler at the same rate and periods as above. In total, 284 hl of water per week is used in the transfer of beer to the filler and discharged to the drains.

As with the quart line, after the bottle has been filled, jetting occurs. However, the volume of water used for jetting is of an order of magnitude lower than the volumes generated from the other unit processes and is assumed negligible (Van der Merwe, 2000). After the bottles have been filled and crowned, they are rinsed at an average rate of 10 hl/h, as established by the plant trials of November 2000 (Van der Merwe, 2000). Therefore, the average volume of water used per week to rinse the cans is 750 hl.

The beer lines undergo a CIP once every second week at a rate of 231 hl/h. The CIP cycle continues for approximately 40 minutes, of which 15 minutes of flow is expected to discharge to the drains (Myoli, 2000). Therefore the average volume of water used to CIP the lines per week is 29 hl.

The filler is washed on average once a week with high pressure hoses for approximately 4 hours. If it is assumed that the average throughput of a high-pressure hose is 5 000 l/h, then the average volume of water used to clean the line is 200 hl/week.



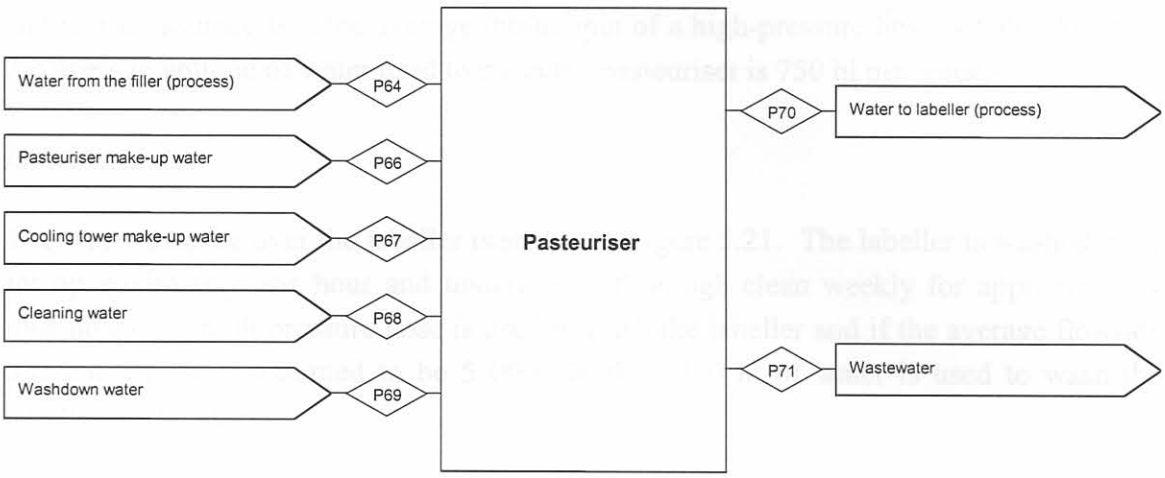
Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
C40*	10 050	per week	10 050	Section 4.3
P60	284	per week	284	S4
P61	750	per week	750	S14
P62	29	per week	29	S14
P63	200	per week	200	S4
P64	10 050	per week	10 050	C39
P65	1 263	per week	1 263	P60+ P61+ P62+ P63

⊕ Sources, other than streams, are presented at the end of each chapter. * part of C40.

Figure 5.19 Water balance over the filler (handy line).

Pasteuriser

The water balance over the pasteuriser on the nonreturnable bottle line is shown in Figure 5.20. Water is added at a rate of 40 hl per hour to compensate for the carry over of water by the bottles (Schumacher, 2000) and the resultant 3000 hl/week discharged to the drains. Spray bars are cleaned once a year for 10 minutes with the assistance of high-pressure hoses. This volume of water is assumed to be negligible.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P64	10 050	per week	10 050	Section 4.3
P66	3 000	per week	3 000	S12
P67	1 800	per week	1 800	S9
P68	240	per week	240	S9
P69	750	per week	750	S4
P70	10 050	per week	10 050	P64
P71	5 790	per week	5 790	P66+ P67+ P68 + P69

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

Figure 5.20 Water balance over the pasteuriser (handy line).

Water supplied to the final compartment of the pasteuriser is circulated between the cooling towers and the pasteuriser. On average, a flow of 24 hl/h is expected to make-up for losses incurred (SAB, 2001). Therefore, assuming that the line is in operation for 15 hours per day, the average volume of water required to make-up the volumes in the cooling towers is 1 800 hl per week.

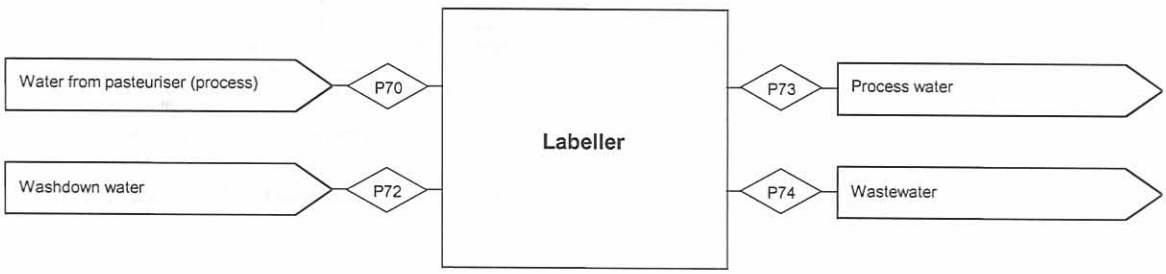
When the quality of the water within the pasteuriser compartments deteriorates below a certain level, it is discharged to the drains. The average volume of cleaning water added per week is 240 hl (SAB, 2001).

The pasteuriser is washed daily for two hours and undergoes a thorough clean once a week for an average of five hours. High-pressure hoses are used to clean the pasteuriser

and if it is assumed that the average throughput of a high-pressure hose is 5 000 l/h, then the average volume of water used to clean the pasteuriser is 750 hl per week.

Labeller

The water balance over the labeller is shown in Figure 5.21. The labeller is washed daily for approximately one hour and undergoes a thorough clean weekly for approximately four hours. A high-pressure hose is used to wash the labeller and if the average flowrate through a hose is assumed to be 5 000 l/h, then 450 hl of water is used to wash the labeller per week.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P70	10 050	per week	10 050	Section 4.3
P72	450	per week	450	S4
P73	10 050	per week	10 050	P70
P74	450	per week	450	P72

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

Figure 5.21 Water balance over the labeller (handy line).

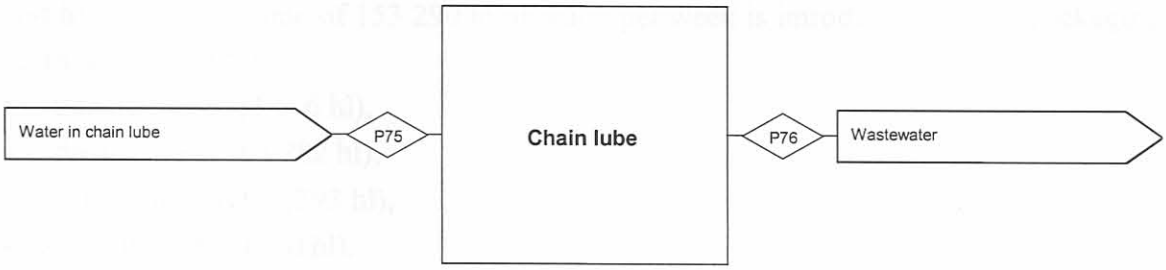
Shrinkwrapper, traypacker and palletiser

The shrinkwrapper, traypacker and palletiser are washed for one hour per week on average. The volumes of water used to wash these machines are of an order of magnitude lower than the volumes generated from the other unit processes and is therefore assumed to be negligible (Van der Merwe, 2000).

Chain lube

The water balance associated with chain lube on the nonreturnable bottle line is shown in Figure 5.22. To reduce friction between the moving parts of the conveyor and between

the conveyor and the bottles, a chain lube mixture is added. The volume of water used for lubrication is 704 hl, based on 7 litre of water per hl of beer packed (see Section 5.1.1).



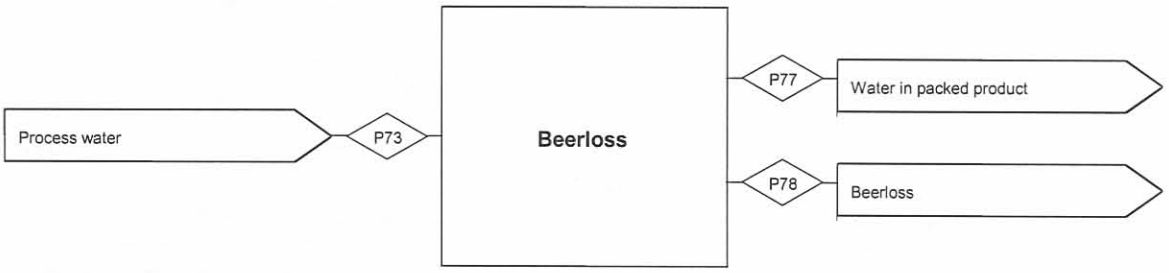
Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P75	704	per week	704	S13
P76	704	per week	704	P75

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

Figure 5.22 Water balance associated with chain lube (handy line).

Beerloss

The water balance associated with the beer lost to the drains is shown in Figure 5.23. During the packing process, beerlosses are inevitable and these losses are discharged to the drains. It is expected that, on average, 1,25% of the beer packed is lost to the drains (Davis, 2000). Therefore, if the line packs, on average, 10 050 hl of beer per week, 126 hl of beer is lost to the drain per week.



Stream	Volume [hl]	Frequency	Ave volume/week [hl/week]	Source ⊕
P73	10 050	per week	10 050	Section 4.3
P77	9 924	per week	9 924	P73 – P78
P78	126	per week	126	S13

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

Figure 5.23 Water balance associated with beer lost to the drains (handy line).

5.3 OVERALL WATER BALANCE IN PACKAGING

The overall water balance over the entire packaging section is shown in Figure 5.24 (a and b). A total volume of 153 290 hl of water per week is introduced into the packaging section and used for

- transfer water (4 666 hl),
- rinsing water (68 782 hl),
- cullet flush water (393 hl),
- vacuum pump (930 hl),
- pasteuriser make-up water (29 675 hl),
- cooling tower make-up water (8 640 hl),
- water within chain lube (5 897 hl),
- cleaning water (19 432 hl), and
- washdown water (14 875 hl).

Since 98 813 hl of beer is packed into the required containers, the water ratio can be calculated as

$$\text{Water ratio for the packaging section} = \frac{153290}{98813} = 1{,}55$$

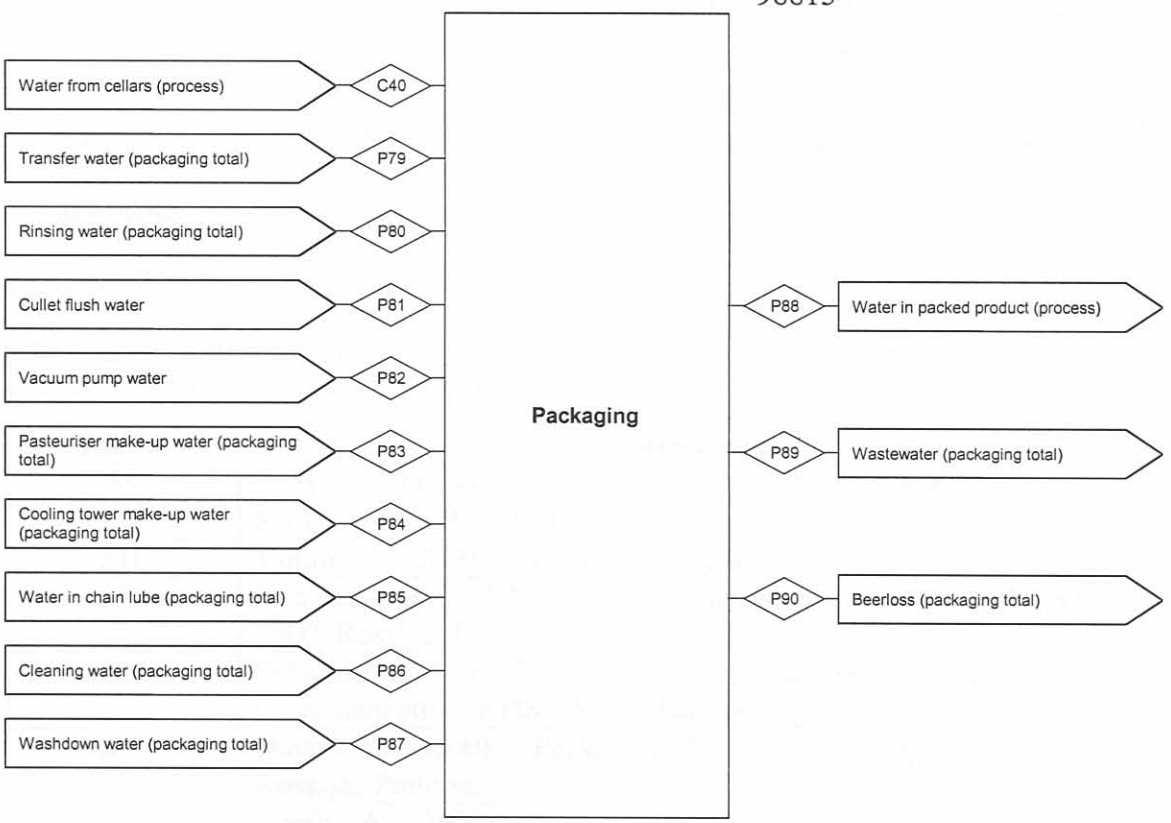


Figure 5.24a The overall water balance for the packaging section at the Rosslyn plant.

Stream	Volume per week (hl/week)	Source
C40	100 064	Section 4.3
P79	4 666	3 x P13 + P42 + P60
P80	68 782	3 x P6 +3 x P10 +3 x P14 + P39 + P43 + P57 + P61
P81	393	3 x P15
P82	930	3 x P16
P83	29 675	3 x P21 + P48 + P66
P84	8 640	3 x P22 + P67
P85	5 897	3 x P33 + P75
P86	19 432	3 x P3 +3 x P7 +3 x P17 + 3 x P23 + P44 + P49 + P62 + P68
P87	14 875	3 x P1 +3 x P4 +3 x P8 + 3 x P11 + 3 x P18 + 3 x P24 + 3 x P27 + 3 x P30 + P37 + P40 + P45 + P50 + P55 + P58 + P63 + P69 + P72
P88	98 813	3 x P35 + P53 + P77
P89	153 290	3 x P2 + 3 x P5 + 3 x P9 + 3 x P12 + 3 x P20 + 3 x P26 + 3 x P29 + 3 x P32 + 3 x P34 + P38 + P41 + P47 + P52 + P56 + P59 + P65 + P71 + P74+ P76
P90	1 251	3 x P36 + P54 + P78

Figure 5.24b The overall water balance for the entire packaging section.

5.4 SOURCES

The sources used within this chapter for calculating the different water balances over the packaging section are presented below.

Source	Reference
S9	SAB, (2001), Activity Reports for the Rosslyn Packaging Section, SA Breweries Rosslyn plant, Pretoria.
S10	Volmer, P. (2000) Washer Cleaning Schedules, Rosslyn, Pretoria.
S11	Van der Merwe, A.I. (2000) Plant trials conducted during November 2000, Rosslyn, Pretoria.
S12	Schumacher, P. (2000), "Water Use at the Rosslyn Plant", Personal Communication, KHS – SA, Johannesburg.
S13	Davis, T. (2000), "Packaging Water", Personal Communication, Rosslyn, Pretoria.
S14	Myoli, A. (2000), "Packaging Water", Personal Communication, Rosslyn, Pretoria.