The Results of a Water and Effluent Audit carried out at Youngs (Annan) Limited in October 1998

Confidential Report No. CR 154

October 1999

Sea Fish Industry Authority

Seafish Technology

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Summary

In the near future new environmental legislation will add greatly to the cost and difficulty of disposing of waste water. This will present a significant problem to the fish industry. Seafish has commissioned a number of water audits in fish processing companies, looking at water use and effluent production with a view to reducing both. This report is concerned with the audit of Youngs (Annan) Ltd.

Water is used throughout the factory in a number of different applications. The total volume of water used during the 3 days of monitoring during the audit was 2099.7m^3. A significant amount of water was wasted through a combination of practices and inefficient/ineffective equipment. By far the largest water usage was in the Torry freezers.

Using the composite effluent samples obtained from the sump containing the flow monitoring equipment, the daytime (production) effluent strength for the overall site had a sCOD of 750mg/l and SS of 249 mg/l. This would result in a future trade effluent charge of about £0.36/m^3 when calculated using the full Mogden formula. The night-time (cleaning) effluent strength was a sCOD of 1632mg/l and SS of 640mg/l which would result in a charge of about £0.67/m^3. On this basis, the annual trade effluent discharge bill would increase from £30,941.26 to about £50,997. The main effluent problems were the high strength effluent produced by the *Nephrops* processing machines and the enrobing process and waste material such as shell ending up down the drain.

A number of opportunities for minimising water use and effluent strength have been identified.

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1. Introduction

In the near future new environmental legislation will add greatly to the cost and difficulty of disposing of waste water, which will present a significant problem to the fish industry. Fish processing requires large volumes of water and similarly produces large volumes of effluent, which can have a high level of organic contamination. Traditionally, the effluent in UK coastal regions, where the fish processing industry largely remains, has been pumped out to sea at negligible cost but this will change as the Urban Waste Water Treatment Directive (91/271/EEC) demands that by the end of 2001 effluent must be treated before release into the sea.

In the future, coastal businesses will be charged on the strength of their effluent; the greater the quantity and the stronger the effluent, the higher the treatment costs. These new trade effluent charges will be calculated using the full Mogden formula which includes charges for the biological effluent treatment required to meet the strict standards set by the Directive. This will bring coastal companies into line with charges already faced by inland businesses.

In some areas the fish industry causes contamination far in excess of the human population and will, inevitably, pay the bulk of the sewerage costs in those areas. This may involve financing the construction of new treatment plants/pipelines. Alternatively the water industry may set very low consents to discharge to the public sewers and so the fish industry would have to take on responsibility for treating its own effluent. These unavoidable increases in costs will ensure that waste management becomes an issue of major commercial importance to all and a survival issue for many.

To find solutions to these water and effluent problems, Seafish has been working with a number of companies throughout the UK, representing different sectors of industry. Detailed water and effluent audits have been carried out in these companies. The results have been used to develop comprehensive guidance documentation for industry, which provides detailed advice on carrying out a water and effluent audit and how to minimise water use and reduce effluent strength.

This report is concerned with the audit of Youngs (Annan) Ltd. Water use and the effluent produced were investigated and monitored within the factory. Areas for reducing water consumption and effluent strength are identified.

2. The Company

Youngs (Annan) Ltd. is part of the United Biscuits group. It is a large-scale business, primarily processing shellfish. At the audited site, the main species processed is *Nephrops norvegicus*. Although no structured waste minimisation programme had been carried out, the company had recently made efforts to reduce both the volume and strength of effluent, with good results (water use reduced by 39%, sCOD and suspended solids by 18% and 35% respectively).

2.1 Site Description

The audited site consists of a large production building with ancillary office and storage buildings. The production building comprises five areas: a grading, nitrogen freezing and glazing area; a main production area housing mechanised peeling machines and manual peeling (blowing) lines and defrosting equipment; a smaller manual peeling area; an air blast freezing area; and an enrobing area. The layout of the production building is shown in Figure 1.

Nephrops tails are brought into the production building through the grading, freezing and glazing area. This area houses a wash tank, grading equipment, a nitrogen tunnel freezer and a glazing machine. After glazing, the frozen *Nephrops* tails are packed into bags and placed in the cold store.

The main production hall houses a Cabinplant continuous belt steam defroster, seven Offshell Press peeling machines and two manual peeling lines. Equipment for mixing polyphosphate with peeled *Nephrops* tails and a Baader meat extraction/deboning unit is also located in this area. The second, smaller peeling area houses three manual peeling lines.

Two Torry type tunnel freezers are located in the main freezing area. The separate enrobing area houses enrobing and packaging equipment.

2.2 Factory Water Points and Drainage

The factory drainage system and water points are also shown in Figure 1.

The production building is supplied with water from one metered point. Mains water is first supplied to a storage tank which provides storage for twelve hours use. The water from the storage tank then flows into the boiler room. Water for general use, domestic use and batter production is supplied to the various water points when required. Water used for manual peeling is treated with hypochlorite. This water can also be heated to 14°C if necessary. A proportion of the water (approximately 1 tonne/hour) is heated and used in steam production for defrosting, and also for central heating and hot water. A number of power washing points used in cleaning are located throughout the factory.

Water (cold, hot, treated or untreated) is supplied to wall or ceiling mounted taps via main water lines which run through the ceiling space of the factory or around the internal walls.

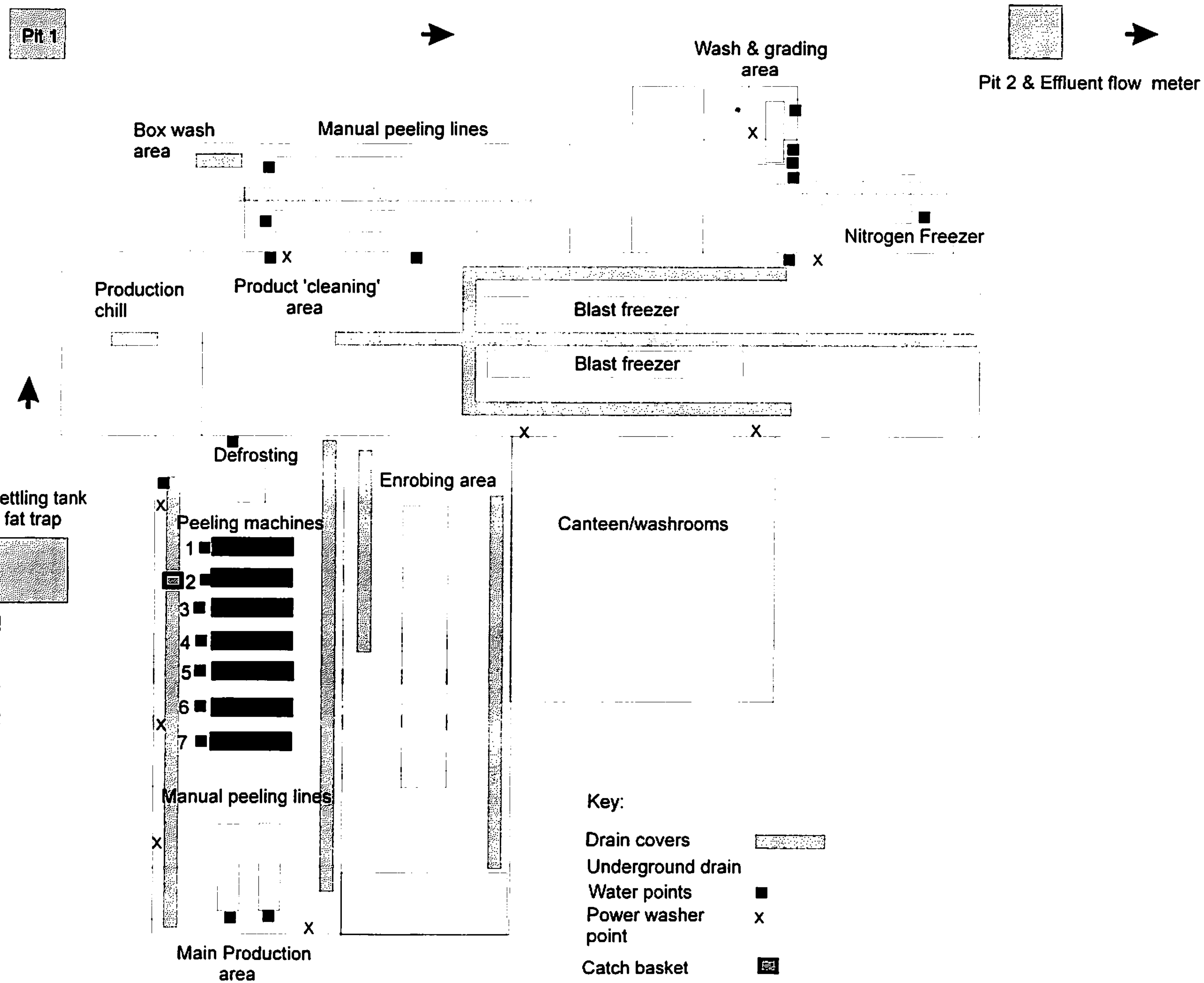

Figure 1 - Simplified factory plan

A number of variously sized drainage channels, ranging from 100 mm wide x 100 mm deep to 300 mm wide x 100 mm deep, collect effluent from the production areas. The drainage channels use various types of drain covers, ranging from 20 mm x 20 mm aperture cast iron, to 10 mm x 19 mm aperture fabricated stainless steel.

Effluent from the main production area passes through a large catch basket before leaving the area. This effluent stream then enters a series of flotation and settling tanks before entering the main drain. The other effluent streams generated in other parts of the factory are thought to enter this treatment system at different points.

An effluent flow meter, situated in Pit 2, is used to monitor the volume of effluent leaving the factory.

2.3 Factory Operation

The operation of the factory is complex, in terms of the hours worked and production flows.

The factory is in continuous operation throughout the five-day week, working to a defined production schedule. Primary processing operations are carried out daily, between the hours of 6am and 10pm, with some processes finishing at 3pm. Basic cleaning duties are carried out throughout the day, however the primary production areas are thoroughly cleaned overnight between 10pm and 6am. The secondary processing area is in continuous operation for a forty-hour period from Monday morning (6am) until Tuesday evening (10pm). The process is then stopped and the area thoroughly cleaned. This cycle is repeated over the Wednesday and Thursday with a shorter processing shift on Friday.

When supplies are available, iced *Nephrops* tails are delivered to the factory each day. These are washed, size graded, frozen and packed before being held in cold storage. *Nephrops* tails required for further processing are taken out of the cold store from pre-frozen stocks. Larger *Nephrops* tails tend to be peeled manually and are incorporated into a premium product whereas smaller *Nephrops* tails are usually peeled mechanically and are incorporated into re-formed product. After peeling, product may be held in a chill store or frozen straight away. Frozen product is put back into cold storage or continues through the enrobing process as dictated by production demand. Due to such complex production flows, it was not possible to track the overall weight of product going through all the processes.

3. The Audit Methodology

In order to investigate water use and effluent production within the company, four working days were spent on site (5th to 8th October 1998) observing the process and (during the final 3 days) monitoring water use and effluent production.

3.1 Measurement of Water Use

Due to the large number of water points it was impossible to individually meter each point. A representative number of water points in each main process were measured and the results used to estimate the total volume of water used in that process.

In-line totaliser meters were installed in various water points around the production building including: three Offshell Press peeling machines, the water supply for making polyphosphate solution, a water point used in the tail meat 'cleaning' area (removal of small pieces of shell or viscera from the peeled product) and a water point to the nitrogen tunnel freezer. Readings were taken at the start and end of each working shift. Readings from the main site meter were also taken at these times.

The manual peeling lines, defrosting unit and water supply to the enrobing equipment were monitored using a Micronics Portaflow 300, ultrasonic non-invasive flow meter, which recorded the flow rate at six minute intervals over half a typical production day.

The flow rates to the other water points in the building were measured using either an in-line spot check flow meter or the Portaflow 300. The information from the spot checks was used to estimate the water use at each point based on the period of use each day.

3.2 Effluent Sampling and Analysis

The strength of the effluent produced by the different processes was determined by taking one litre samples. Spot samples were taken directly from equipment whilst an Epic automated effluent sampler was used to obtain further composite samples. The composite samples (100 ml every 10 minutes) were taken over a twelve hour period from the last effluent discharge point i.e. the external sump containing the 'V' notch effluent flow meter. The samples were analysed by West of Scotland Water Laboratory, Dumfries.

The samples of effluent were analysed for settled chemical oxygen demand (sCOD) and suspended solids (SS).

3.3 Calculating Trade Effluent Treatment Charges

The sCOD and SS values of the effluent were used to estimate the future costs when the effluent will have to be fully treated. Costs where calculated using the 1998/99 West of Scotland Water charging rates for trade effluent in the areas where it is already treated.

$$C = R + V + \left[B\frac{Ot}{Os}\right] + \left[S\frac{St}{Ss}\right]$$

C	=	Cost pence/m^3
R	=	Reception charge = 5.97 pence/m^3
V	=	Volumetric & primary settlement charge = 5.31 pence/m^3
B	=	Biological treatment charge = 6.01 pence/m^3
S	=	Suspended solids charge = 3.64 pence/m^3
O_t	=	Mean organic strength of the trade effluent (COD mg/l)
O_s	=	Mean regional organic strength of domestic sewage = 246 mg/l (COD)
S_t	=	Mean suspended solids (SS) of effluent sample (mg/l)
S_s	=	Mean regional strength of settleable solids in domestic sewage = 150 mg/l

4. Overall Water Use and Effluent Production

This section gives an overview of water use and effluent production. The individual processes are discussed in more detail in Section 5.

The weights of *Nephrops* tail meats passing through each process during the audit (6th to 8th October 1998) are shown in Table 1.

Table 1 - The weight of *Nephrops* tail meats passing through each process

	Initial washing, grading & freezing	Defrosting	Mechanised peeling	Manual peeling	Enrobing
Weight (Tonnes)	10.84*	17.42*	15.16	5.07	25.88

Key:
* converted from unpeeled tail weight to meat weight using an approximate yield of 57% (Ref [1]).

4.1 Water Use

Water is used throughout the site in a number of different processes. The water consumption of a representative part of each main process was measured. Using this and the main site meter readings as a basis, the total volume of water used during the operation of each main process was estimated (Table 2).

Table 2 - The estimated water use in each main process/activity during the 3-day audit

Process/Activity	Estimated Water Consumption (m^3)
Tunnel freezers - belt rinse	611.16
Main cleaning operation	363.68
Peeling - manual	243.24
Box washing	207.36
Enrobing	143.00
Initial *Nephrops* washing	81.00
Hot water boiler*	72.00
Glazing	70.20
Domestic**	29.25
Nitrogen freezer	28.01
Polyphosphate solution	18.97
Peeling - mechanised	17.30
Peeled meat cleaning	17.27
Boot washers	5.76
Initial *Nephrops* grading	--
Defrosting	--
Total (except grading & defrosting)	**1908.20**

Key:
* based on rating

** based on the volume of water used (per person per day) in a company providing toilet, handwashing and canteen facilities (water industry figures).

-- unable to meter

[1] Measures, Stowage Rates and Yields of Fishery Products, Torry Advisory Note No. 77, Torry Research Station

The total volume of water used during the audit according to the main site meter, was 2099.7m^3. Therefore approximately 9% (191.5m^3) was unaccounted for, which was used in initial *Nephrops* grading, defrosting, secondary cleaning, cooling water, two water points in the box wash area which supply chemically dosed water, and wastage by having water on when the processes were not being operated.

Using the total volume of water used and weight of *Nephrops* tails processed, it was estimated that approximately 57m^3 of water was used to produce 1 tonne of product. This can only be an approximate calculation due to the complex product flows throughout the site. It would be beneficial to identify water use per tonne of product in each process but this would require further information that could not be gathered during the audit.

4.2 Effluent Production

The composite samples obtained from the sump containing the effluent flow monitoring equipment were used to determine the effluent strength and the associated full Mogden calculated trade effluent treatment charges (Table 3).

Table 3 -The average effluent strength and full Mogden calculated trade effluent charges for the composite effluent samples

Time of Sampling	Average effluent strength (mg/l)		Current charge (£/m^3)	Future full Mogden calculated charge (£/m^3) 98/99
	sCOD	SS		
Daytime (processing)	750	249	£0.17	£0.36
Night-time (cleaning)	1632	640	£0.27	£0.67

Based on data obtained from West of Scotland Water, water consumption (July 1997 to end June 1998) was 110,864m^3, costing £30,941.26 to dispose of. The company is currently paying trade effluent charges based on the Mogden formula but excluding the biological treatment charge (B). If full Mogden calculated charges were applied to this volume, and allowing for the different levels of water use and effluent strength in day and night operations, it would cost approximately £50,997.

5. The Main Operations

5.1 Washing

Nephrops tails are washed before grading (Figure 2). The boxes of iced *Nephrops* tails are tipped into a stainless steel hopper (approximate volume 350 litres) before being elevated out of the hopper by a wire conveyor (10 mm^2 aperture holes). This conveyor passes under a perforated spray bar, designed to rinse the *Nephrops* tails before they fall onto a second conveyor which transports them to the grader.

A single water supply feeds the spraybar and the hopper. In use the water is left running and the hopper continually overflows.

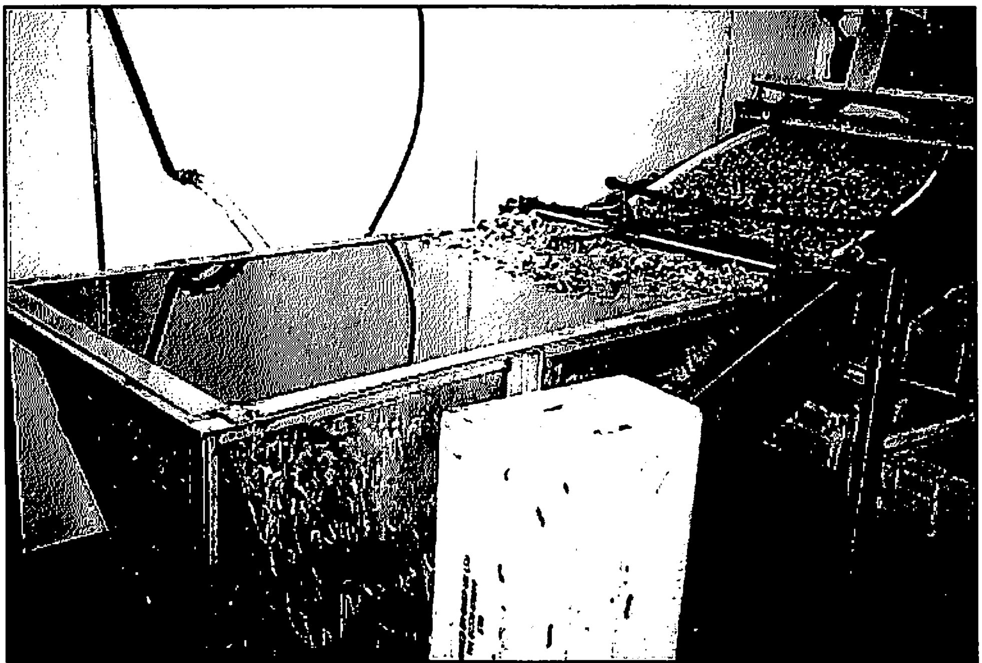

Figure 2 - Washing *Nephrops* tails

5.1.1 Water Use

The washing unit used 60 l/m, however the *Nephrops* tails did not appear to be washed effectively.

To improve the effectiveness of washing, the product could be agitated in the hopper, either mechanically or by using water or air movement. To reduce water consumption and improve rinsing, the spray bar could be replaced by a bar with proper spray nozzles rather than holes which would provide a spray pattern which covers the full width of the belt. The water supply could be taken from the pressure washing circuit, and would run back into the hopper.

The water supply should be switched off when the unit is not in use. This could be achieved by fitting an automatic solenoid valve linked to the conveyor motor.

5.1.2 Effluent Production
The effluent from this area drains to an external catch basket which is poorly fitting and has a cracked housing, resulting in solids bypassing the basket. The basket and housing should be repaired or replaced with a more effective 'separator' catch basket design (see Seafish Guidelines).

On cleaning out the hopper, the solid waste at the base should be shovelled into a waste container rather than being washed down the drain.

5.1.3 Conclusions
The efficiency of washing *Nephrops* tails could be improved by simple modifications to the equipment. This would also reduce the amount of waste produced by the grading equipment. Alternative types of washing equipment, that provide a more 'active' wash, could also be considered.

5.2 Grading
The washed *Nephrops* tails are conveyed from the washer into a vibrating grader (no manufacturers name plate). The grader uses a series of diverging vibrating bars to size the *Nephrops* tails into 9 size categories. Water is sprayed onto the waste chutes of the machine to keep them clear. Waste and graded *Nephrops* tails are collected in separate boxes.

5.2.1 Water Use
The ultrasonic flow meter could not determine the water used by the grader. However, the amount of water used by the sprays usually appeared to be modest. The use of smaller and more efficient nozzles could be investigated.

5.2.2 Effluent Production
A significant amount of waste collects beneath the machine when in use, particularly around the feed hoppers as a result of overflowing. The feed hopper should be enlarged to prevent overspill and the alignment of the conveyor belt/guards should be checked. Alternatively, a level sensor wired into the supply conveyor belt motor could be fitted.

5.2.3 Conclusions
Simple technical modifications could be carried out which should reduce water consumption and will prevent a significant amount of waste ending up on the floor.

5.3 Defrosting
Frozen *Nephrops* tails are defrosted using a Cabinplant International, warm air defrosting system. Bags of frozen tails are tipped into a feed hopper, then elevated onto a shaker/ conveyor which transports them onto the main defrosting conveyor running through the defrost chamber. Steam and water are injected into the chamber to achieve defrosting. The defrosted tails then fall onto a third conveyor, before falling into plastic boxes.

5.3.1 Water Use
The small volume of water and steam used by the defroster could not be measured with the equipment available.

5.3.2 Effluent Production

The waste simply falls from the machine. Due to the lack of an identifiable effluent stream, the effluent produced by defrosting could not be sampled. However, a significant amount of solid waste (whole and small pieces of *Nephrops* tail meats/ shell) ended up on the floor around the feed hopper, shaker/conveyors and the box filling chute (Figure 3). Boxes are often used in an attempt to collect the waste.

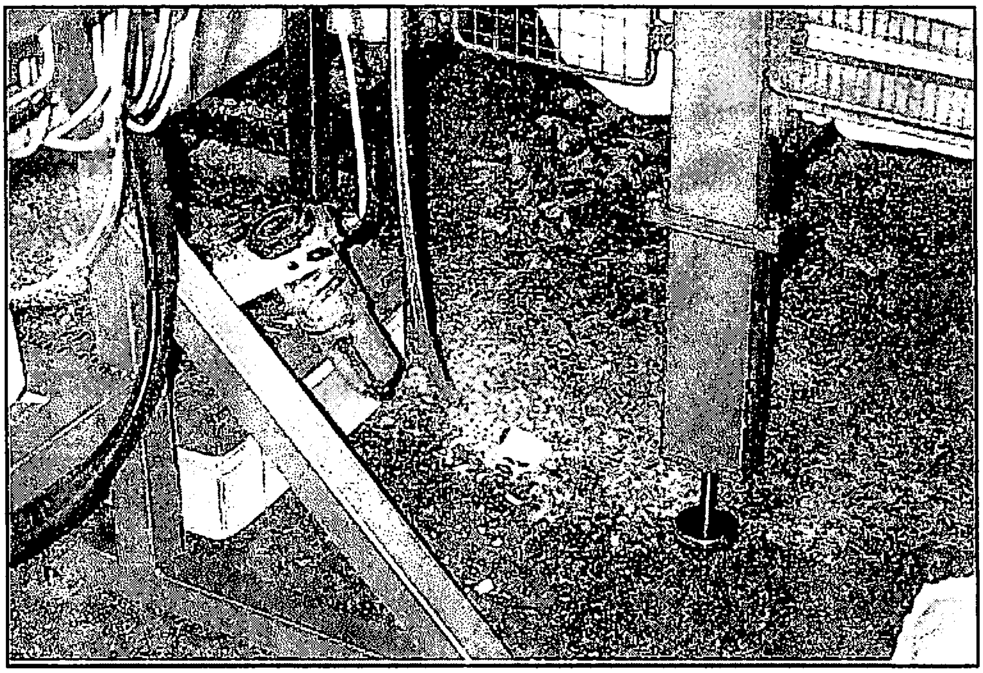

Figure 3 - Waste on the floor from defrosting

The alignment of conveyor guards and catch trays should be checked. Purpose built catch trays and box guides should be fitted to hold the product boxes in place and prevent spillage onto the floor.

5.3.3 Conclusions

From other studies, warm air defrosting appears to be a relatively cost-effective method of defrosting in terms of water use and effluent production. However, the simple and inexpensive methods identified could be applied to keep waste out of the drain and hence minimise future Mogden calculated trade effluent charges.

5.4 Hand Peeling

Nephrops tails destined for use in whole tail or premium products are manually peeled with the use of high pressure water jets (blowing). There are two manual peeling areas: the main dedicated area which houses a total of 47 blowing stations in two lines, and a smaller area in the main production hall which houses two blowing lines comprising 20 stations.

A blowing line consists of a series of blowing stations arranged in opposite pairs. Each station is supplied with water from a main supply running along the central section of each line of stations. Individual pipes (¼") branch off this main supply to each station, where a manually operated tap is used to control the water supply. A waste water flume runs along the lower central section of each blowing line, receiving waste water from the blowing stations and discharging it to the drainage channel.

Each blowing station consists of a 'sink' type arrangement. Inside each sink is a metal pipe (2-3 mm) over which the *Nephrops* tails are placed by the operator. Water flows through the pipe at high pressure, 'blowing' the *Nephrops* tail meat away from the shell. After peeling, the shells are discarded down a waste chute. This waste chute is hinged so that when it is extended the shells fall into the central flume but when folded back, they fall into a waste container. The peeled tail meats and water are dropped down a separate curved chute which enables the tail meats to drop into a container underneath the sink, whereas the water is ducted away into a punch plate catch tray designed to catch any small pieces of waste (2 mm aperture). The water then drains into the central waste flume before passing through plastic trays used as catch baskets and into the drain. Figure 4 shows one of the blowing stations.

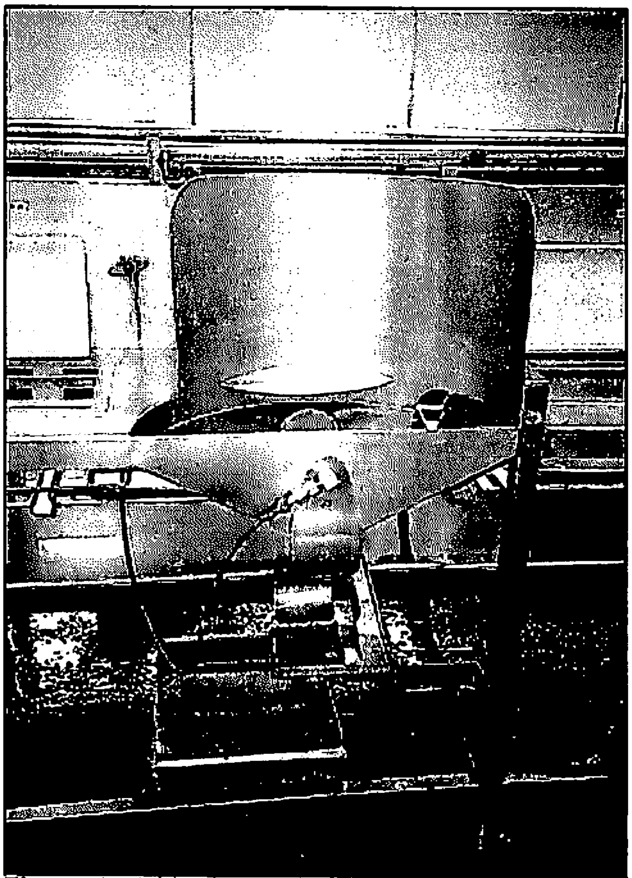

Figure 4 - A blowing station

5.4.1 Water Use

During the audit the number of blowing stations in use varied daily. Based on the flow rates and time spent processing, it is estimated that approximately 243.24m^3 of water was used in manual peeling during the audit.

The flow rate is individually controlled by the operating staff and usually set to the maximum. A large amount of water is wasted by the water supplies being left on when not in use, particularly when the operators take the boxes of tail meats away to be weighed, and at the end of the shift when the water supply is often left running until the start of the cleaning shift (7 hours later). As an example, over 2 days of the audit the water supplies to a number of the blowing lines in the main area were observed to have been left running unnecessarily for about 7 hours each day after processing. Based on the measured flow rates, this results in a wastage of approximately 10.5m^3 of water each day.

To prevent this wastage, the existing taps could be replaced with taps which supply water intermittently, for example installing a thumb operated control adjacent to the nozzle would turn off the water supply when the operator was no longer working. A timer and solenoid valve could also be installed to ensure the water supply was turned off at predetermined times, such as during breaks and at the end of the shift.

5.4.2 Effluent Production

The samples of effluent taken from the drain in the main blowing area had a sCOD of 285 mg/l and SS of 105 mg/l giving a full Mogden calculated trade effluent charge of £0.21/m^3.

With the current station design there is a significant degree of contact between water and both the product and shell waste, which increases effluent strength. Ideally, each station 'sink' should be modified to enable the water to run away from the product and shell waste, to the central flume.

A significant amount of shell waste ends up on the floor underneath the blowing lines or in the waste water flume as a result of missing or mis-aligned catch trays. A large amount of shell waste also ends up on the floor when the catch trays are emptied. Trays must be positioned correctly underneath each station. The equipment should be modified to include a guard to ensure the catch trays remain in position. Trays should be emptied regularly. To prevent shell waste on the floor being trampled underfoot, the floor should be cleaned regularly with the use of a squeegee and/or a shovel.

A number of the blowing stations have bent water/product chutes so that this mis-alignment results in the water washing through the product tray, instead of being ducted to the smaller 2 mm punch plate catch tray. This water washes through any product contained in the product tray, washing out additional organic material which will increase the strength of effluent. The ducts should be aligned properly so that all the water washes through the catch tray before entering the waste water flume.

The punch plate catch trays are all permanently fixed in place so cannot be emptied for cleaning. Instead, all the debris is hosed out onto the floor and into the drain. These catch trays should be separate to enable cleaning and would require a positive location to ensure they can only be placed in the correct position.

The waste water flume passes through plastic catch trays (aperture size >5 mm) before emptying to the central drainage channel (Figure 5). Any large pieces of shell or other debris are caught in the plastic trays, however, smaller pieces pass straight into the drain increasing the strength of the effluent. As the catch trays are rarely emptied during the day water continuously washes over the waste, which increases the strength of the effluent. Wherever possible, shells and waste should not enter the waste water flume. Improving the catch trays underneath each blowing station should improve this, however, if waste still enters the flume, a separator screen and catch basket could be used at the end of the channel to catch any stray waste. The catch tray at the end of the flume should have smaller apertures to prevent shells/waste ending up in the drain. This should also be emptied regularly.

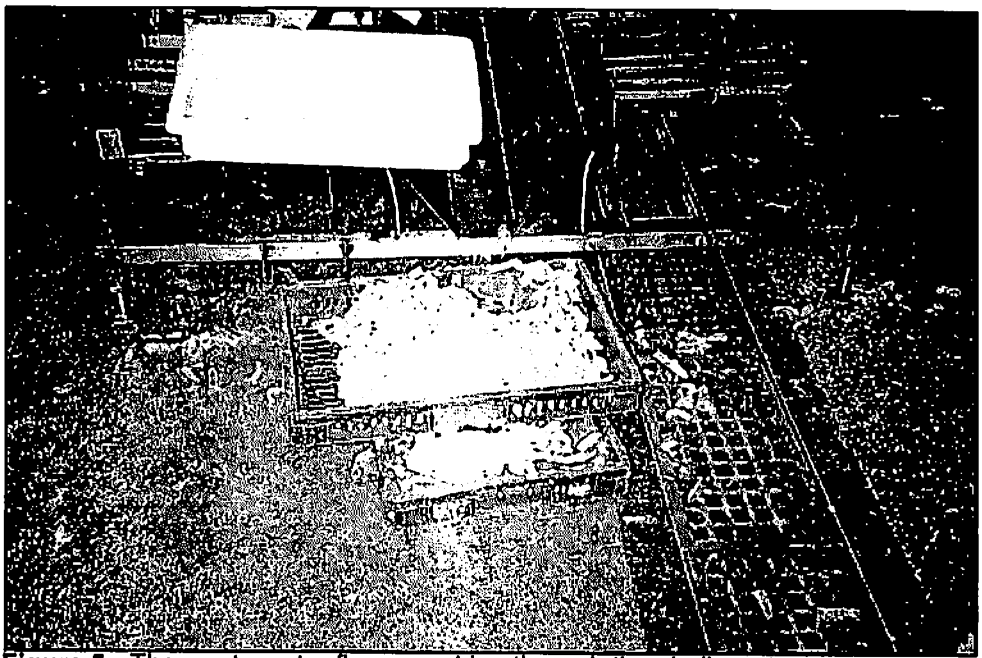

Figure 5 - The waste water flume washing through the shell waste

5.4.3 Conclusion

A large volume of weak effluent is produced during manual peeling. Reducing wastage of water would significantly reduce the volume of water used. The strength of effluent produced could be reduced by improving product and waste collection.

5.5 Mechanised Peeling

A proportion of the enrobed product produced on-site uses small pieces of *Nephrops* tail meat, bound together with a polyphosphate solution (re-formed product). *Nephrops* tails destined for use in this re-formed product are mechanically peeled.

There are seven independent peeling machines (Offshell Press machines) located in the main production area (six used during the audit). Defrosted *Nephrops* tails are mechanically fed onto the conveyor belt of each machine. Operators correctly align the tails on the conveyors as they travel to the mechanism which removes the shell from the meat. The tail meat is conveyed out of the machine into a box where it is hand 'cleaned' for removal of pieces of viscera and shell before weighing. The waste shell is deposited in a bin located at the end of each machine.

5.5.1 Water Use

Water is used for lubricating the mechanism inside the machine. Based on the meter readings to three of the machines, approximately 17.3m^3 of water was used in mechanised peeling during the audit.

The water supply to the peeling machines is drawn by machine no. 7 first and machine no. 1 last (the number of each machine corresponds to Figure 1). The internal sprays in each machine have to be modified periodically to compensate for fluctuations in pressure, to ensure that sufficient water gets to the shell removal mechanism. It is recommended that the lowest flow rate whereby the equipment operates satisfactorily should be determined and flow regulators fitted to the water supply to each machine to standardise and regulate flow rates. Depending on the size required, flow regulators cost approximately £10 each excluding installation. The positioning of existing nozzles and the use of more water efficient nozzles could be investigated.

5.5.2 Effluent Production

Samples of effluent were taken from directly underneath the processing equipment and had a sCOD and SS of 28,200 mg/l and 38,500 mg/l respectively. This gives a full Mogden calculated trade effluent treatment charge of £16.35/m^3. This high strength effluent is a result of the large amount of organic material and waste which is generated during this process (Figure 6).

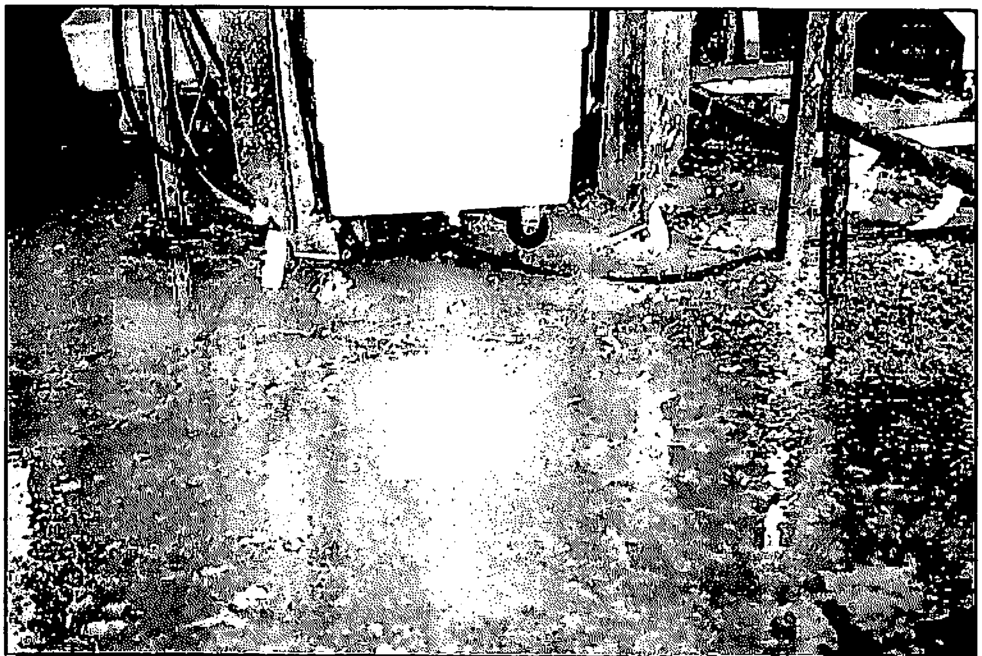

Figure 6 - Waste on the floor from mechanised peeling

During processing a large amount of *Nephrops* tails and shell waste ends up on the floor, particularly under the feeder section and the shell collection basket of each machine. Once on the floor, this waste is further broken up as it is trampled underfoot which will increase the strength of the effluent. To prevent this the equipment should be properly aligned, in conjunction with guides/guards and effective catch trays, where necessary.

The floor of the processing area is cleaned periodically throughout the day, usually by using a squeegee. The majority of this waste ends up down the drain. At the end of each shift and during break-times, the machines are briefly rinsed with water. Waste, comprising shells and small pieces of tail meat, are washed onto the floor and into the drain. Although it is good practice to clean waste off the machines, measures should be taken to try to prevent waste from falling onto the floor. Any material which ends up on the floor should be shovelled up into a waste container.

5.5.3 Conclusion

Mechanised peeling produces a small volume of extremely high strength effluent. The installation of flow regulators and finer nozzles should reduce water use. By preventing waste ending up on the floor with the use of effective catch trays, and keeping waste out of the drain, the effluent strength could also be reduced.

5.6 Cleaning of Peeled *Nephrops* Tails

After peeling, the tail meats are manually 'cleaned' which involves the removal of viscera and small pieces of shell. There is a main area where cleaning is carried out, but some cleaning is carried out in other areas e.g. the main production hall. The staff work independently, each cleaning one box of tail meats at a time.

5.6.1 Water Use

Typically, boxes filled with water from a large tub are used at each work station for washing away waste material from hands. The tub is filled with water from a wall mounted tap and hosepipe. Approximately 17.27m^3 of water was used during the audit. Occasionally the water supply to the tub was left running when not in use. Wastage could be avoided by using a trigger spray on the end of the hosepipe or improved management of personnel. Where cleaning of tail meat is carried out in other areas e.g the main production area, no water is used.

5.6.2 Effluent Production

Waste material which is washed off hands ends up in the boxes of water which are emptied down the drain. The remaining waste ends up on the table top work area and this is also washed onto the floor and down the drain. Samples of the effluent draining off the work tables were taken. The sCOD was 13,950 mg/l and the SS was 5,860 mg/l giving a full Mogden calculated trade effluent treatment charge of £4.94/m^3. To reduce this charge, the effluent should be screened before it ends up down the drain. This could be achieved by modifying the existing tables to incorporate a simple drainage system which enables the effluent to run to a central discharge point where it can be screened before falling onto the floor.

Where product cleaning is carried out in other areas, the debris is usually flicked onto the floor. At the end of the day this is hosed down the drain and will increase the strength of the effluent. Wherever possible, waste material should not end up on the floor. Instead it should be put into waste containers.

5.6.3 Conclusion

Cleaning peeled *Nephrops* tails produces a small volume of high strength effluent. By modifying the water hose arrangements and preventing waste material from ending up on the floor and down the drain, the strength and volume of the effluent and hence the future trade effluent charge for this process could be reduced.

5.7 Polyphosphate Solution

Polyphosphate solution is added to the batches of tail meats used in making re-formed products. A batch of tail meat is pumped into mixing equipment and a measured volume of polyphosphate solution added. This is mixed for 12 minutes before it is dispensed into boxes or bins. The product is then held in the production chill store before freezing.

5.7.1 Water Use

Water is used in making the polyphosphate solution. It is taken from a wall mounted tap in the production hall and emptied into a container, from where it is input, by bucket, to the mixing equipment. Approximately 18.97m^3 of water was used during the audit. Wastage of water was not evident.

5.7.2 Effluent Production

As the polyphosphate solution is added to the product there is no direct effluent discharge from this process.

5.7.3 Conclusion

Although wastage of water and high strength effluent production in this process were not an apparent problem during the audit, it is worth monitoring the operation in the longer term to determine that excess solution is not produced and dumped down the drain on completion of work.

5.8 Freezing (Air Blast Freezers)

There are two Torry type tunnel freezers situated parallel to each other in the central area of the factory. One of the freezers is used for producing frozen whole tail/premium product which is individually placed, by hand, onto the freezing belt. After freezing the product is packed into boxes and placed in the cold store. The second freezer is used for freezing the re-formed product which is mechanically dispensed onto the freezing belt. After freezing, the re-formed tail meats are either packed into boxes and placed in cold storage or conveyed directly from the freezer to the enrobing area.

5.8.1 Water Use

The majority of the water used by the freezers is for lubricating the conveyor belt rollers and washing waste off the freezer belts before additional product is added. Water, supplied from ceiling mounted pipes, is continuously sprayed over the lower return section of the freezer belt. The flow rates to both freezers were measured. The whole tail/premium product freezer was supplied with water at 31.5 l/m and the re-formed product freezer at 110 l/m. Using these flow rates and the time spent in operation (reportedly 24 hours per day), the total volume of water used during the three days of the audit was 611.28 m^3.

It is unclear why there is such a large difference in water consumption between the two freezers. Perhaps the polyphosphated product is more difficult to clean from the belt. It should be determined whether both can operate effectively at the lower flow rate (31.5 l/m) and possibly reduced further. The installation of flow regulators would control the flow rate effectively.

It is also worth considering whether there are alternatives to using such large quantities of water, particularly as the water is left running all the time even when no product is being frozen (clearly the flow to the reformed product freezer could be reduced when not freezing product). By modifying the cleaning system to possibly include a scraper and high pressure low volume spray nozzles, the water consumption could be reduced. It is advisable to contact the freezer manufacturers to determine whether they have developed any modifications. It is also worth considering any modifications which could reduce the water flow to a minimum when there is no product on the freezer belts, providing only enough water to lubricate the rollers. This could be either manual or sensor operated.

5.8.2 Effluent Production

Effluent is produced as the water washes waste off the freezer belts. A sample was taken and the sCOD and SS were 41 mg/l and 2 mg/l respectively. This results in full Mogden calculated trade effluent treatment charges of £0.12/m^3, reflecting the very weak nature of this effluent stream.

5.8.3 Conclusion

By far the largest water usage during the audit was by the tunnel freezers. It should be determined whether it is necessary to use this amount of water and wherever possible, reduce it to the minimum required without affecting the operation of the equipment.

5.9 Enrobing

After re-forming and freezing, *Nephrops* tail meats are enrobed. Re-formed tail meats are conveyed into a Stein (APV) enrobing line where they are dipped in batter then coated in breadcrumbs, then dipped again before receiving the outer coating of coarse crumb. The enrobed product is then conveyed through a flash fryer before being blast frozen and packed.

5.9.1 Water Use

Water is used for making the batter mixture and for rinsing the floor and flushing the equipment prior to cleaning.

To reduce the amount of water wasted through flushing, the equipment could be power washed to remove the majority of solid material before flushing .

5.9.2 Effluent Production

During the enrobing process a significant amount of crumbs, batter and oil end up on the floor (Figure 7). During cleaning, the remaining crumb and batter including the contents of the catch trays is washed onto the floor and into the drain (Figures 8 and 9). This produced very high strength effluent with a sCOD and SS of 15,900 mg/l and 20,100 mg/l respectively, giving a Mogden calculated charge of £8.87/m^3.

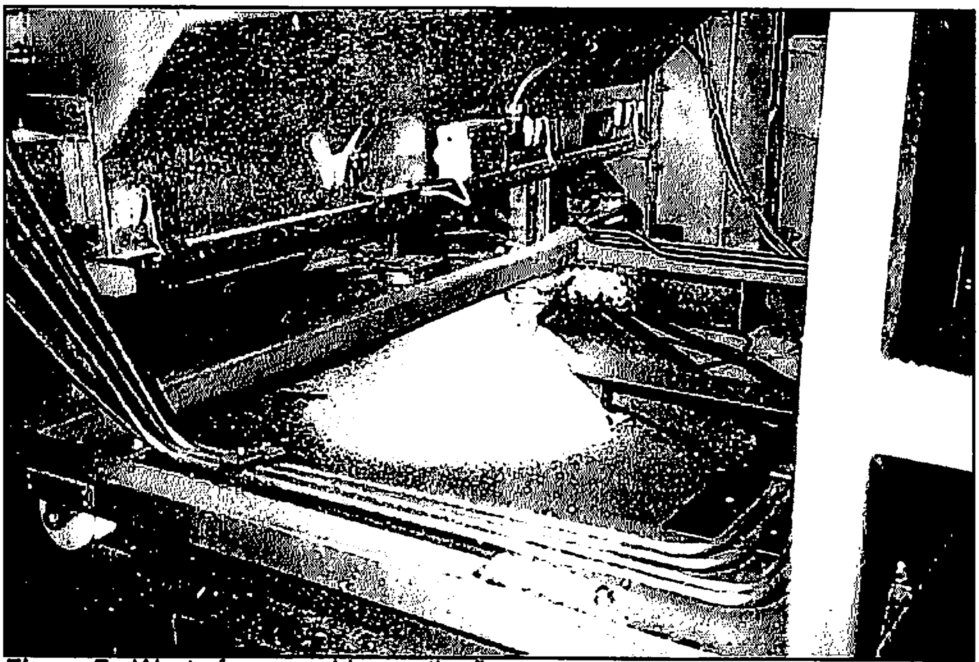

Figure 7 - Waste from enrobing on the floor

Figure 8 - Catch tray waste on the floor and down the drain

Figure 9 - Waste batter down the drain

The strength of this effluent could be significantly reduced by checking the alignment of conveyors and catch trays and modifying/fitting catch trays where necessary. The frying oil leak (from a seal underneath the equipment) should also be rectified (Figure 10).

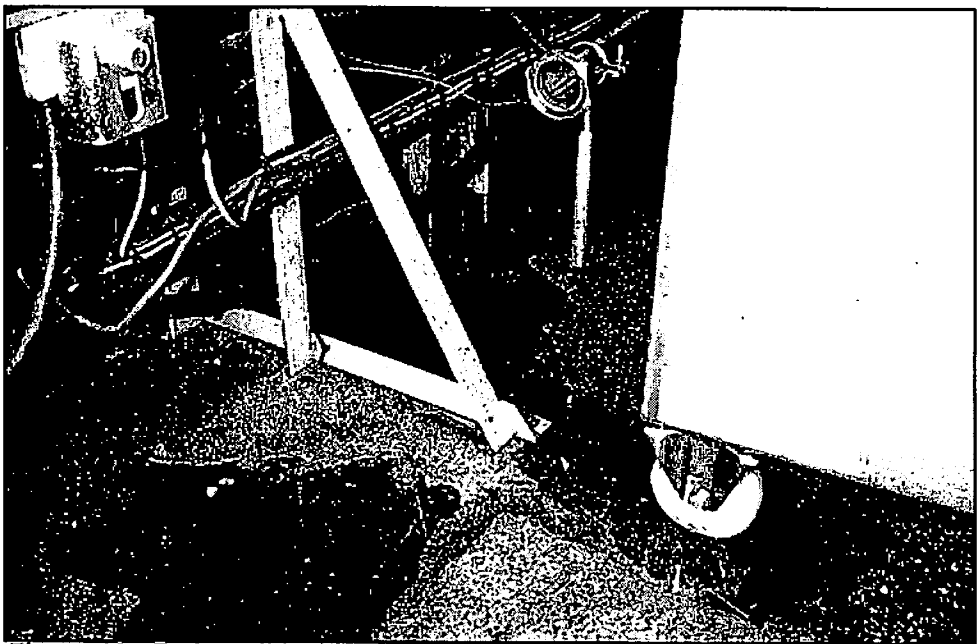

Figure 10 - Frying oil leak

During cleaning the remaining batter should be emptied into a container, either for re-use, or alternative disposal. Solid waste on the floor should be shovelled up and the waste in catch trays disposed of in the similar manner.

5.9.3 Conclusions

The enrobing process currently produces a significant amount of very high strength effluent. The Mogden calculated charge for disposal of pure batter is approximately £165/m^3, therefore the waste associated with this process must be prevented from entering the drainage system.

5.10 Box Washing

The boxes are initially rinsed either by a power washer or an open ended hosepipe (which supplies water treated with either detergent or sanitiser). The rinsed boxes are then placed in the box washer, manufactured by Industrial Washing Machines Ltd. and washed with hot water, which is sprayed over the boxes as they pass along the machine. The hot water is supplied from the mains and stored in a tank below the washing mechanism (approximate volume 1.3m^3). This water is recirculated from the tank to the sprays and back to the tank. However, mains water is supplied through a ballcock arrangement to maintain the water level in the tank. As the boxes exit the washer they are stacked in preparation for re-use. Some heavily soiled boxes are placed in a tank of water, labelled as containing hypochlorite solution, for an additional wash.

5.10.1 Water Use

The flow rate to the box washer storage tank was measured at 48 l/m. Approximately 207m^3 of water was used during the audit. It is not known whether the flow rate of water into the box washer is excessive. This should be checked against the manufacturers recommended flow rate and any necessary adjustments made.

A large volume of water is wasted by the use of open ended hosepipes to initially rinse the boxes. These hosepipes are often left running when not in use. By wasting this treated water, chemicals are also wasted. Used boxes could be initially rinsed in a tank of treated water instead of using continuously running hoses, or trigger sprays attached to the hoses to prevent water wastage.

5.10.2 Effluent Production

A sample of effluent was taken from this area and had a sCOD and SS of 525 mg/l and 262 mg/l respectively, giving a Mogden calculated trade effluent charge of £0.30/m^3. As a result of rinsing the used boxes, a large amount of waste material ends up on the floor and down the drain. The drain in this area has no means of filtration.

By preventing material ending up on the floor and down the drain the strength of effluent produced will be reduced. When the boxes are initially emptied, as much product as possible should be taken out instead of it ending up as waste down the drain. If boxes were rinsed in a tank of treated water, a much smaller volume of higher strength effluent would be produced but the pressure cleaning effect would be lost. An effective catch basket in the drain would help to reduce effluent strength, providing it was emptied and cleaned regularly.

5.10.3 Conclusion

By standardising the current box washing procedure between different members of staff, the volume of water used could be reduced. Preventing waste from ending up on the floor and down the drain would also reduce the strength of effluent produced.

5.11 Cleaning

During the day, some cleaning of equipment and floors is carried out by using a squeegee and shovel to pick waste up off the floor. Equipment is sometimes hosed down using an open ended hosepipe. At the end of each day the process areas and equipment are thoroughly cleaned, with the exception of the enrobing area which is only cleaned at the end of a continuous 40 hour operation.

A team of personnel clean the factory during the night. The majority of the solid waste material on the floor is scraped up using a squeegee and shovel and emptied into a waste container. Any liquid waste e.g. batter, is left on the floor. Equipment is then dismantled and cleaned with a power washer with detergent feed, before all floors and walls are power washed. During those evenings when all the factory including the enrobing area is cleaned the process takes 8 hours to complete.

5.11.1 Water Use

During the audit, the water consumption in the main cleaning operation was approximately 363.68m^3 (this excluding daytime cleaning). Wastage of water was not apparent, however, there was a large variation in water use between different evenings, indicating possible differences in practices which should be investigated.

5.11.2 Effluent Production

Although cleaning is carried out during the day using a squeegee and shovel, a large amount of waste is left on the floor being broken up underfoot which increases the strength of the effluent. This material, particularly shell waste, is often left on the floor for hours until the start of the evening cleaning shift.

A composite sample of the effluent produced during overnight cleaning was taken from the main effluent discharge point. The sCOD was 1632 mg/l and the SS was 640 mg/l resulting in Mogden calculated trade effluent charges of £0.67/m^3.

During the main cleaning shift, the majority of the solid waste on the floor is picked up using a squeegee and shovel and emptied into a waste container. However, all liquid waste, such as batter and the liquid produced during mechanised processing, is released on to the floor and hosed down the drain. After waste is picked up off the floor the equipment is cleaned using the pressure washing system. This washes additional waste on to the floor which is then washed down the drain as the walls and floor are cleaned. The design of the drain covers allows shells and pieces of tail meat to enter the drainage channels. Sometimes the drain covers were lifted to enable waste to be easily washed or squeegeed down the drain.

Once incorporated into effluent, waste is very difficult to separate and will add considerably to the effluent strength and future trade effluent disposal costs. To keep future costs low, waste should not be allowed to enter the drainage system. An effective cleaning schedule, incorporating education of all personnel, should help to reduce the amount of waste getting into the drain. Lockable drain covers with smaller aperture holes would also help. All waste on the floor, including liquid waste and waste which is rinsed off processing equipment, should be scraped up using a squeegee and put into a waste container.

5.11.3 Conclusion

The effluent produced during cleaning is significantly stronger than the effluent produced during processing, reflecting the effect of the amount of waste/debris entering the drainage system during the cleaning shift. By preventing this waste material from entering the drain the associated Mogden calculated trade effluent charge will be reduced.

5.12 Drainage and Effluent Treatment

The effluent from the main production area runs through a 420 mm x 280 mm x 600 mm deep stainless steel catch basket made with 2 mm aperture punch plate. This drain, along with the drains from the enrobing area, enter a recently installed flotation tank (fat trap). This tank consists of an approximately 5 m x 5 m x 5 m brick sump with three internal baffle plates to direct the flow to aid flotation. A fat digesting chemical (none available on site for inspection) is added periodically to the tank to reduce the fat layer, reducing the frequency of pumping out. The effluent from the flotation tank is then pumped into two secondary settling tanks (pits) situated to the side and rear of the factory, from which the effluent is pumped again to a metering station at the front of the factory (Pit 2). The metering station consisted of a sump, out of which the effluent is pumped through an ultrasonic 'V' notch flow meter which records the volume and flow rate of the effluent passing into the main sewer. It is thought that drains from the other main processing areas run into the secondary sumps.

Drains in the washing and glazing areas consisted of a simple hole in the wall which allowed the effluent to drain into an outside drain consisting of poorly fitting 200 mm diameter and 250 mm deep cylindrical catch basket with 10 mm holes. These drains were thought to carry effluent directly into the metering station sump.

5.12.1 Problem Areas

The catch basket in the main production area is of a poor design. The small aperture holes were blocked resulting in the effluent overflowing between the poorly fitting basket and the damaged concrete housing (Figure 11 overleaf).

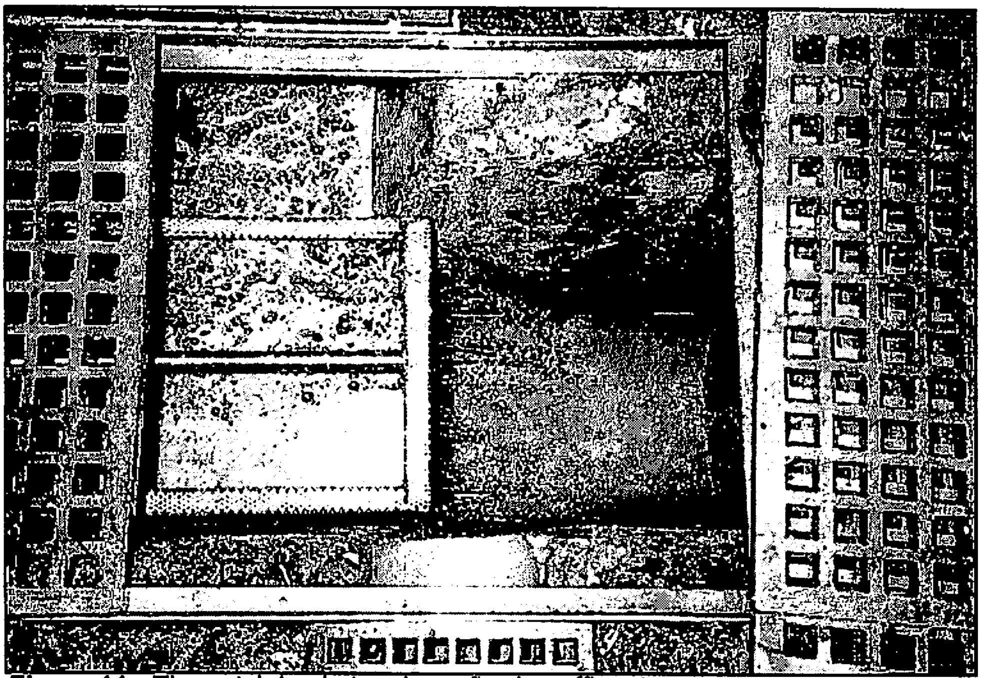
Figure 11 - The catch basket and overflowing effluent

The housing should be repaired as soon as possible. However this design of catch basket allows the water to wash through the solid material, increasing the effluent strength. A separator catch basket should be used instead (see Seafish Guidelines).

The nature of the fat digesting chemical should be identified. If it has an emulsifying effect, it will dramatically increase the strength of the effluent by solubilising the oils/grease.

The section behind the 'V' notch flow meter was full of small solids and small pieces of shell (Figure 12) which will affect the accuracy of the meter. The unit should be cleaned and its accuracy checked regularly.

Figure 12 - Waste behind the 'V' notch effluent flow meter

The housings around the external drains in the washing and glazing areas are damaged (Figure 13). These should be repaired/modified to stop waste by-passing the catch basket. More importantly the drains should be covered to prevent rain water running into the drain and increasing the volume of effluent measured by the flow meter. Both these drains should be screened to prevent vermin entering the factory.

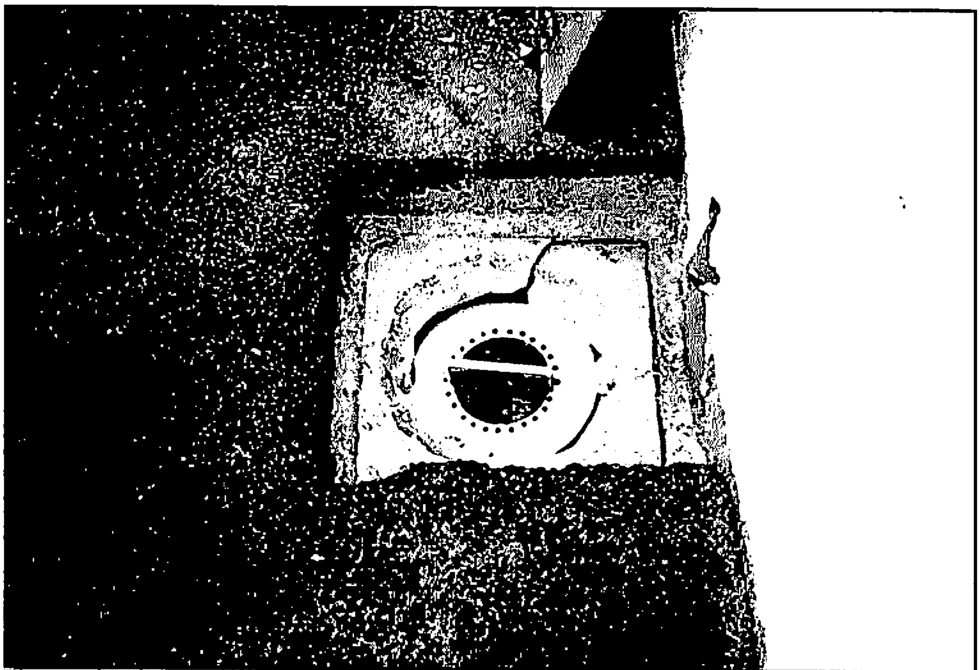

Figure 13 - Damaged housing of an external catch basket

5.12.2 Conclusions

The current effluent treatment system appears to be fairly complex but fails to prevent small solids entering the sewerage system. The amount of soaking and pumping carried out should be minimised to limit the maceration of solids.

As in many premises, the layout of the current drainage system is far from ideal and it would be very costly to rectify this. However, small aperture wedge wire screens/separator catch baskets could be used to reduce the effluent strength. These screens/separator catch baskets should best be located at the outlets from the processing areas before the effluent enters the various sumps.

If the effluent flow meter is to be used by the Water Authority to provide the volumetric figure for charging, it is essential to prevent rainwater entering the system and to carry out regular maintenance and flowmeter checks to prevent overcharging.

6. Conclusions

When the full Mogden calculated trade effluent charges are introduced, the company will face a significant increase in trade effluent disposal costs. From the daytime composite effluent samples taken from the outlet sump (Pit 2) during processing operations, the sCOD was 750 mg/l and the SS was 249 mg/l. This would result in Mogden calculated trade effluent treatment charge of £0.36/m^3, using 1998/1999 West of Scotland Water charging coefficients taken during cleaning operations. From the night-time samples, the sCOD was 1632 mg/l and the SS was 640 mg/l, which would result in a charge of £0.67/m^3. Based on the annual water consumption of 110,864m^3, and allowing for the differences in day and night operations, the annual water bill would increase from £30,941.26 (1997/1998) to £50,997 (1998/1999 coefficients). However, as a result of the Water Authority having to make substantial investment in treatment facilities in order to comply with the Urban Waste Water Treatment Directive, the coefficients they use in the Mogden formula may well increase in the future causing yet further increase in the effluent discharge cost.

Changes to equipment and working practices to reduce effluent volume and strength can reduce these costs.

Reducing water use is equally as important as reducing effluent strength, as diluting strong effluent increases the volume of effluent produced and, in addition, the separate water supply charge is also reduced. Based on the audit data, it is estimated that approximately 57m of water is used to produce one tonne of product.

Water use:

- Large amounts of water are used and wasted. Freezing and cleaning are the largest uses of water. Introducing changes to equipment and regulating flows could considerably reduce the water consumption.

- Wastage by personnel leaving water points running when not in use is also a significant problem. Increased management and training staff in why and how to make savings could reduce this wastage.

Effluent strength:

- Currently a large amount of waste including batter, shell and product ends up on the floor, particularly from processing equipment in the enrobing and mechanised peeling processes. Practices should be changed and equipment modified to keep waste off the floor and out of the drain.

- Although some waste on the floor is picked up during cleaning, a significant amount is washed or brushed into the drain. As much waste as possible should be scraped together, using a squeegee, and shovelled into a waste container.

- The existing drain channel covers allow waste to easily enter the drain. Effective covers should be used wherever possible and existing covers redesigned and replaced to prevent large solids entering the drainage system. The covers could also incorporate a simple locking device to prevent lifting by unauthorised personnel.

- The existing drainage and effluent treatment system is complex but ineffective in preventing solid waste from entering the public sewer and may well exacerbate the problem of that waste soaking in the effluent. Fitting wedge wire screens/separator catch baskets in the drains exiting the production areas could reduce effluent strength.

Water use and effluent production should be continually monitored. It is advisable to involve staff in identifying further opportunities for making reductions in water use and effluent production. Any measures, which change working practices, must be properly managed to ensure staff do not revert back to old ways.

The West of Scotland Water Authority will begin applying the full Mogden formula to trade effluent bills, from the end of 2000. In preparation for this, it is recommended that the company continues to introduce cost-effective changes, with regards to reducing water use and effluent production.