The Results of a Water and Effluent Study carried out at G. W. Latus Limited in September 1997

Consultancy Report No. CR131

December 1997

The 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, which will present a significant problem to the fish industry. Seafish has commissioned a number of water audits in fish processing companies, to look at water usage and effluent production, with a view to minimising both. This report is concerned with the audit of G. W. Latus Limited.

Water is used throughout the factory, in a number of different processes but primarily in defrosting and filleting. The total volume of water used over the five day period of the audit was $180m^3$, generating approximately $165m^3$ of trade effluent.

Composite samples indicate that the effluent strength for the overall site has a COD of 1960 mg/l and SS of 138 mg/l. This would increase the trade effluent charge from the current cost of £0.29/m^3 to £0.85/m^3, when calculated using the Mogden formula.

Opportunities for minimising water use and effluent strength were identified, many of which may be carried out at little or no cost.

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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 volume and 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 a component 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 Yorkshire Enterprise Limited and technical consultants to carry out an ERDF funded project in the Humber region. With assistance from the Hull and Grimsby Fish Merchants' Associations, 40 small to medium sized fish companies agreed to have a preliminary waste audit carried out in their premises. From the findings of these audits seven fish processing companies, representative of the diverse range of industry practices, were chosen. More detailed water audits have been carried out in these companies. The results will be used to develop comprehensive guidance documentation for industry, which will provide detailed advice on carrying out a water audit and how to minimise water use and reduce effluent strength.

This report is concerned with the audit of G. W. Latus Limited. Water usage and the effluent produced were investigated and monitored within the factory. Areas for reducing water consumption and effluent strength are identified.

2. The Preliminary Review

The preliminary waste audit which was undertaken on April 30th 1997, identified that the main water usage areas are defrosting and filleting. It was felt that a large volume of water is unnecessarily used in filleting by hoses running continuously throughout the day. It was also observed that taps set in the water lines to the filleting benches are always set to the maximum by the filleters.

It was identified that effluent is mainly produced in the process area and, despite the use of catch baskets, solid material is discharged to the main drain.

It was concluded that a water audit should be undertaken at the site in order to raise awareness of the current usage of water and that changes in current practices should be made to effect a reduction in water usage and effluent production.

3. The Company

G. W. Latus was first established as a fish and chip retailer in 1888 and then started in the fish merchanting trade in 1925. The company was originally based on Hull Fish Docks but moved to its current premises approximately five years ago. It now has an annual turnover of about £1 million and employs 14 personnel. The main fish processed are frozen at sea haddock with some fresh fish used when available. The company primarily processes fish for sale to the fish frying industry.

3.1 Site Description

The audited site comprises; a process area where fish are filleted and packed, a defrosting room where fish are defrosted overnight and a large freezer store. Storage and despatch areas make up the rest of the site. Figure No. 1 shows the layout of the site.

The main process area houses five filleting benches (numbered 1 to 5) with at least three in use every day (1,2 and 3). A Baader 51 skinning machine and a small chill store are also located in the main process area.

3.2 Factory Water Points and Drainage

The factory water points and drainage system are also shown in Figure No. 1. Wall mounted taps are positioned around the factory, whilst taps and hoses suspended from the roof supply water to the individual filleting benches.

The majority of the site is supplied with water directly from the mains, with the exception of the skinning machine which is fed from a water storage tank located on the roof. The tank was installed due to the lack of water to the skinning machine when all the filleting benches are in use. The tank usually fills up during the evening.

In the main filleting area two 130 mm wide x 130 mm deep 'V' section drainage channels collect effluent from the factory floor. Large solids are prevented from entering the channel by cast iron drain covers with 100 mm x 20 mm wide slots. The channels run towards the rear of the building where each empties into its own catch basket before the effluent enters the main drain leaving the factory.

The catch baskets are constructed from stainless steel plate on four sides, with one end made of 5 mm diameter punch plate. This allows effluent to pass whilst retaining large solids. Each catch basket is housed in a concrete holder. Gaps up to 40 mm in size, between the basket and holder, allow solids to escape into the drain if the basket overflows.

The defrosting room has four, 50 mm diameter drainage holes in the floor, each covered by a fine stainless steel mesh. These channels drain outside into the adjacent yard area where the effluent runs down a nearby drain.

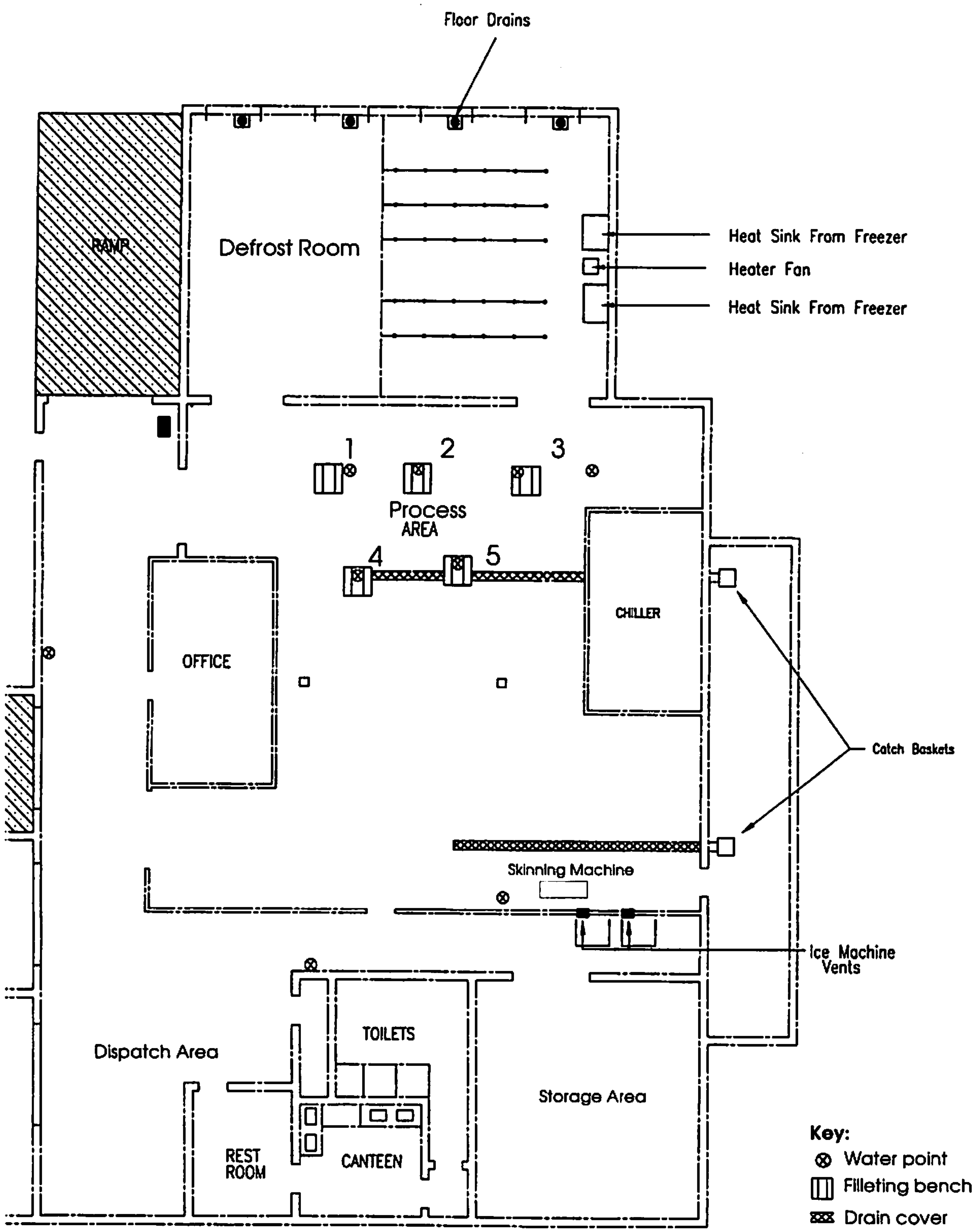

Figure No. 1 - Plan of the factory

4. The Audit Methodology

In order to investigate the use and contamination of water within the company six working days were spent on-site, observing the process and determining where water was used and effluent produced.

4.1 Measurement of Water Usage

The volume of water used in each main process was measured.

Three in-line flow meters, with a 4-20mA output, were installed in the water supplies to the three filleting benches in daily use. The same type of meter was installed in the water supply to the skinning machine. A Squirrel data logger was used to record the flow rates, at two minute intervals, over a five day period.

In-line totaliser meters were installed in the water supplies to the remaining two filleting benches and in the water supplies to the ice machines and power washer. Readings were taken every hour, from the start of the working day through to the end. The main site meter reading was also taken every hour.

The water supply to the spray system used in defrosting was monitored using a Micronics Portaflow 300, ultrasonic non-invasive flow meter, which recorded the flow rate at six minute intervals each evening.

4.2 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 i.e. the filleting benches and the skinning machine, whilst an Epic automated effluent sampler was used to obtain composite samples. Samples (100 ml every 10 minutes) were taken over an eight hour period, from the two internal drains and the external main drain. The effluent produced during defrosting was sampled overnight. The samples were analysed by Alcontrol UK (Analytical Services), Rotherham.

The samples of effluent were analysed for chemical oxygen demand (COD) and settleable solids (SS).

4.3 Calculating Trade Effluent Treatment Charges

The COD and SS values of the effluent were used to estimate the future costs when the effluent will have to be treated. Costs were calculated by the Mogden formula using the 1997 Yorkshire Water charging rates for treating trade effluent.

Mogden formula:

$$C = R + P + [B\frac{O_t}{O_s}] + [S\frac{S_t}{S_s}]$$

C	=	Cost pence/m^3
R	=	Reception charge = 17.46 pence/m^3
P	=	Preliminary treatment charge = 20.06 pence/m^3
B	=	Biological treatment charge = 20.27 pence/m^3
S	=	Treatment / disposal of foul sewage sludge = 12.46 pence/m^3
O_t	=	Mean organic strength of the trade effluent (COD mg/l)
O_s	=	Mean regional organic strength of domestic sewage = 931 mg/l (COD)
S_t	=	Mean settleable solids (SS) of effluent sample (mg/l)
S_s	=	Mean regional strength of settleable solids in domestic sewage = 336 mg/l Sts

5. Overall Water Usage and Effluent Production

This section gives an overview of water usage and effluent production. Over the five day period of the audit, 7.3 tonnes of whitefish fillets were produced. The individual processes are discussed in detail in Section 6.

5.1 Water Usage

Water is used throughout the site in a number of different processes. The water consumption during the audit for each process was measured separately, see Table No. 1.

Table No. 1 - The water usage in each main process/activity over the five day period of the audit

Process/Activity	Water usage during the audit (m^3)
Defrosting	87.3
Filleting	65.7
Skinning	9.2
Cleaning - power washer	6.1
Ice production	5.1
Total	173.4

The total volume of water used during the audit was 180m^3, according to the main site meter. Approximately 4% of this was unmetered during the audit, which was primarily used in non-processing areas such as the kitchen and toilets.

Using the total volume of water used and the weight of fish processed during the audit, it was calculated that approximately 24m^3 of water is used to produce 1 tonne of fillets (includes defrosting, filleting, skinning, ice production and cleaning).

5.2 Effluent Production

It was impossible to obtain an overall effluent sample for the site as a number of drainage points do not appear to run into the main drain which receives effluent from the process area. The source, strength and estimated future costs of the main effluent streams, from which composite samples were taken, are shown in Table No. 2. The future trade effluent charges can be compared to the current charge of £0.29/m^3.

Table No. 2 - The source, strength and estimated future costs of the composite samples taken from the main effluent streams at the factory

Source	Strength		Mogden calculated trade effluent charges (per m³)	Volume produced during the audit (m³)	Mogden calculated trade effluent charges for the five days of the audit
	COD (mg/l)	SS (mg/l)			
Composite - filleting drain	2200	288	£0.96	65.7	£63.07
Composite - skinning drain	1960	152	£0.86	9.2	£7.91
Composite - defrosting	515	32	£0.50	74.9	£43.65

A composite effluent sample was taken from the main drain where both filleting and skinning effluent discharge. It is likely that Yorkshire Water will use this as the main sampling point to determine the overall strength of the effluent sample for the site. The sample obtained during the audit had a COD of 1960 mg/l and SS of 138 mg/l, this would increase the trade effluent charge from the current cost of £0.29/m³ to £0.85/m³, when calculated using the Mogden formula.

6. The Main Operations

6.1 Defrosting

During the audit between 1,800 kg and 3,500 kg of fish were defrosted each night to provide the raw material for the following days processing.

The required amount of fish (frozen in 25 kg blocks) is removed from the freezer, usually around 6 am, and stored in the defrosting room on pallets. The defrost room consists of an insulated room with two sliding doors at each end. Three fan heaters, predominantly used in winter, are situated on the end wall of the room. Two of the heaters use the waste heat from the main refrigeration system to assist defrosting, whilst the third is a standard 6 kw electric heater. At the end of the day's processing (typically 2 - 4 pm) the frozen blocks of fish are laid out on aluminium bars laid across fish boxes. A sprinkler system on the ceiling is used to spray water onto the frozen blocks to defrost the fish. The effluent from defrosting runs through 50 mm diameter holes in the floor which are covered by a fine stainless steel mesh, into an external drain. The mesh quickly blocks and the floor of the defrosting room floods, effluent escapes into the processing area and down the nearest drain. The ultrasonic flow meter was used to record the amount of water used during defrosting, whilst a Squirrel data logger was used to record fish temperatures every ten minutes. To investigate the efficiency of spray defrosting, the temperature of fish laid out and defrosted without water and fish stacked on a pallet was also recorded.

6.1.1 Water usage

The water supply to the sprinklers is switched on after the fish are laid out. The water is left running from about 3pm until 4.30am the following day. An electrically operated valve can be used in conjunction with a timer to control the flow of defrost water but was not used during the audit. Each defrost used between 20.4m^3 and 23.4m^3 of water. During defrosting the water temperature and ambient temperature inside the room ranged from 14° C to 15° C and 12° C to 17° C respectively.

Frozen blocks were laid out having a temperature of between -3° C and - 10° C.

Typical defrosting results are shown in Figure No. 2. Frozen blocks of fish laid out at - 8° C took five hours to defrost (reach 0° C) whilst fish which laid out but not sprayed with water took 8 hours to defrost. Fish left to defrost on the pallet warmed up at a much slower rate.

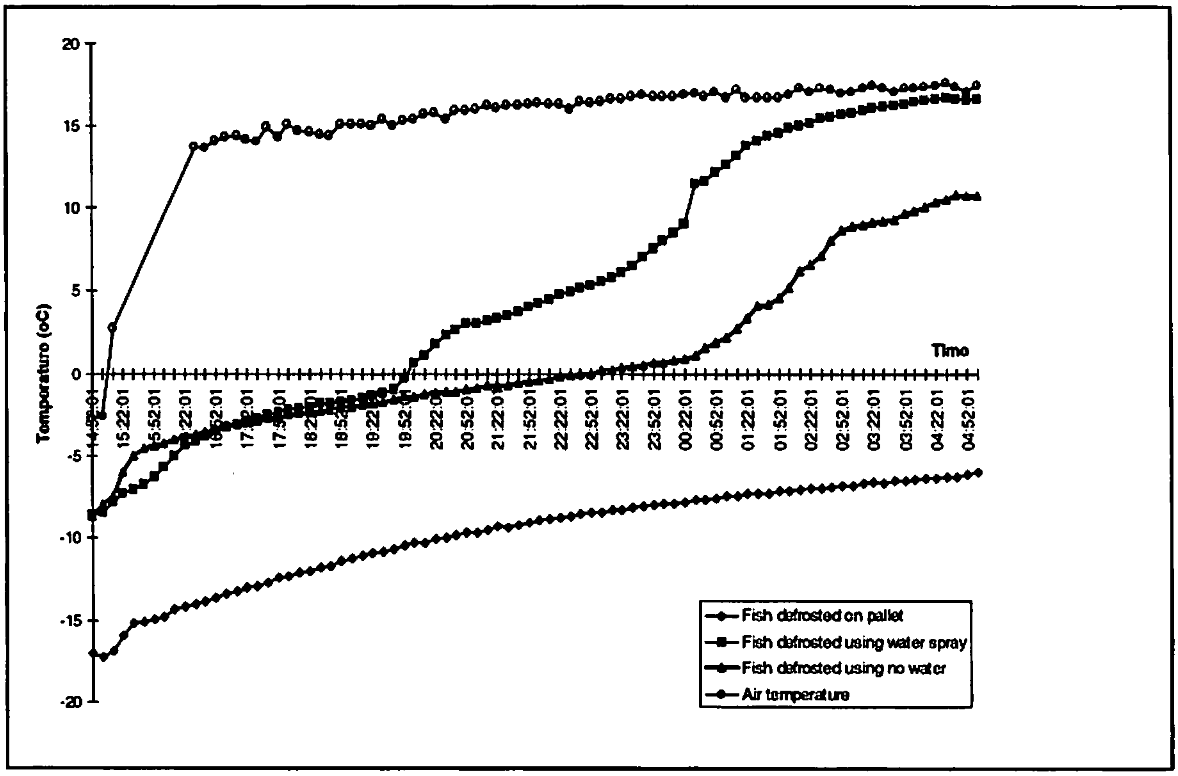

Figure No. 2 - Thawing time of frozen fish using different defrosting methods

6.1.2 Effluent production

An effluent sampler was used to take composite samples of defrosting effluent entering the external drain. The COD of the sample was 515 mg/l and SS of the sample was 32 mg/l.

6.1.3 Conclusions and recommendations

Care must taken when defrosting fish during the warmer months of the year, to prevent water being wasted and the temperature of the fish rising above that of melting ice. Using the water spray, it took between 2 to 6 hours for the fish to defrost. If the fish defrosted after 2 hours this would result in about 17m^3 of water being wasted, with a estimated future cost of £20.36 taking into account water and trade effluent charges. In addition, the temperature of the fish rises to an unacceptable level where quality will quickly deteriorate.

During the warmer months of the year, blocks of fish could be laid out and defrosted without the use of water. In winter a water heater or the waste heat from the refrigeration system could be used to heat the defrosting water (recommended maximum 15° C). This should reduce the time taken for defrosting, the amount of water used and effluent produced. To control the process, temperature probes inserted into the fish, could be used to switch off the water supply when the fish have defrosted.

There are a range of other options available which could reduce both water consumption and costs, whilst effectively defrosting all the frozen supplies, but these would involve major capital expenditure i.e. specialist defrosting equipment. It is, however, worth considering the long-term cost effectiveness of the purchase of such equipment, against the current and future use of such large volumes of water, particularly when future disposal costs apply.

The flooding of part of the processing area overnight when the drains block in the defrosting room is clearly undesirable.

6.2 Filleting

Whitefish filleting is the only type of filleting operation carried out. The fish are primarily frozen at sea, headed and gutted haddock.

The large filleting benches are all made to traditional design, with a central tub separating two cutting boards, enabling a pair of filleters to work facing each other. Each tub has a maximum capacity of 220 litres. An overflow pipe is located near the top of one end of each tub. There is a catch basket (aperture 10 mm) located underneath each drain plug to catch pieces of fish when the tubs are emptied. When the bench is in use, the tub drains are blocked with tight fitting plugs.

6.2.1 Water usage

Each filleting bench is individually supplied with water. Typically, a continuous supply of water is maintained to each bench in use, throughout the day. As such, water continually overflows from the benches, onto the floor and into the drain. This overflow water does not pass through the bench catch basket.

A timer system is installed into the water supply, to turn the water off at break times and lunchtime. However, it was observed that if a filleter remains filleting during these times it is demanded that the water supply be switched on again.

The water supply to the filleting benches is drawn by bench 1 first. The number of the filleting bench corresponds to the numbering system shown in Figure No. 1. When benches 1 to 3 have their water supply on fully, benches 4 and 5 receive very little water. This necessitates a member of management turning down the water supply to benches 1 to 3, in order to ensure water is supplied more equally to all five benches. It was observed that the filleters working at benches 1 to 3 will eventually turn the water flow up again, which reduces the water flow to the two benches at the end of the water supply.

The variability in water use and flow rates between the different benches is shown in Table No. 3.

Table No. 3 - The water usage of the filleting benches

Filleting Bench	Water Usage during the audit (m^3)	Range of flow rates (l/m)	Average flow rate (l/m)
1	25.8	8 to 15	9.0
2	11.8*	8 to 15	5.8
3	17.5	5 to 10	6.2
4	8.2	3 to 7	5.0
5	2.4**	2 to 4	2.8

* unused for one day of the audit
** unused for 3 days of the audit

6.2.2 Effluent production

During filleting, small pieces of fish and trimmings remain in the water in the tub. As the tubs are generally not emptied, or only half emptied, during the day a significant amount of material accumulates at the bottom of each.

Samples of effluent were taken directly from the overflowing water from a filleting bench over a period of a day, to determine if the increasing amount of material at the bottom of the tub has an effect on effluent strength. The results are shown in Table No. 4 below.

Table No. 4 - The strength of effluent samples taken at intervals throughout the day

Time Interval	Strength COD mg/l	Strength SS mg/l
After 1 hour	191	8
After 3.5 hours	1040	28
After 6 hours	802	68
After 7.5 hours	1250	108

During filleting, small pieces of fish are trimmed off the fillets and are usually thrown into an offal container or flicked into the water. A significant amount of material misses the containers and ends up on the floor where it is broken up underfoot, see Figure No. 3. At the end of the day the material on the floor is collected and shovelled into the offal bin. Any pieces of fish which are left on the floor are then hosed into the drain.

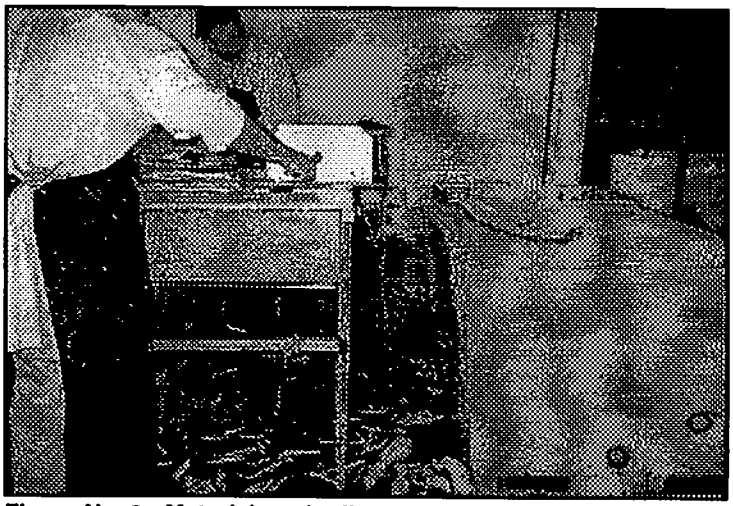

Figure No. 3 - Material on the floor

When the tubs are emptied at the end of the day the catch baskets retain large solid material. Samples of the effluent were taken after passing through the catch basket. The COD and SS of the effluent was 5990 mg/l and 892 mg/l respectively.

A composite sample was obtained from the drain which receives water from the filleting benches. The COD was 2200 mg/l and the SS was 288 mg/l.

6.2.3 Conclusions and recommendations

The volume of water used in filleting is considerable. The water flow and consumption to the different filleting benches varies significantly and it is important to control this. In order to standardise the flow rates to each bench, flow regulators could be fitted to the individual bench water supply. Flow regulators will maintain a set maximum water flow, automatically compensating for changes in water pressure, (approximate cost £10 each, excluding installation). If a regulated flow rate of 8 l/m had applied over the five days of the audit this could have saved approximately 7m^3 of water from the three filleting benches (1 to 3) which are, generally, in daily use. Alternatively a more regimented approach to the management of water usage could be introduced.

Clean water supply to a filleting bench is essential to maintain hygiene but the traditional tub type benches are often wasteful in water usage. It is undesirable to leave fish soaking in the water and particularly to wash fillets in that same water. Alternative systems are available in which the fish is washed/de-iced separately if required prior to filleting and a controllable water spray is used on the filleting bench to lubricate the knife, maintain cleanliness and wash the fillets.

The use of the timer system could be made more effective by ensuring that the water supply is fully turned off and that the timings coincide with actual break times. It is advisable to ensure that all the filleters have their break at the same time.

The current cost of disposing of trade effluent is £0.29/m^3. Based on the strength of the composite effluent sample taken from the drain which receives effluent from the filleting benches, the future Mogden calculated disposal charges would be £0.96/m^3. To keep future Mogden calculated trade effluent charges to a minimum it will be important to try and prevent material from entering the drainage system, and to introduce practices which will minimise any increase in the strength of effluent.

As the amount of solid material (trimmings etc) in the water in the tubs slowly increases throughout the day this causes an increase in the strength of the effluent. The Mogden calculated trade effluent costs of disposing of filleting effluent, based on the sample taken after one hour of filleting would be £0.42/m^3, whereas the cost of disposing of the effluent taken after 7.5 hours would be £0.69/m^3. It is advisable to empty tubs regularly throughout the day to prevent a build up of this material, which will assist in minimising costs. Additionally, a wire mesh (recommended aperture 3 mm) should be incorporated onto the bench end of the overflow pipe. Filleting benches should also be modified to incorporate a simple catch tray underneath the cutting board, see Figure No. 4 overleaf. Trimmings should be scraped into the tray, which can be emptied into the main offal bin at the end of each day.

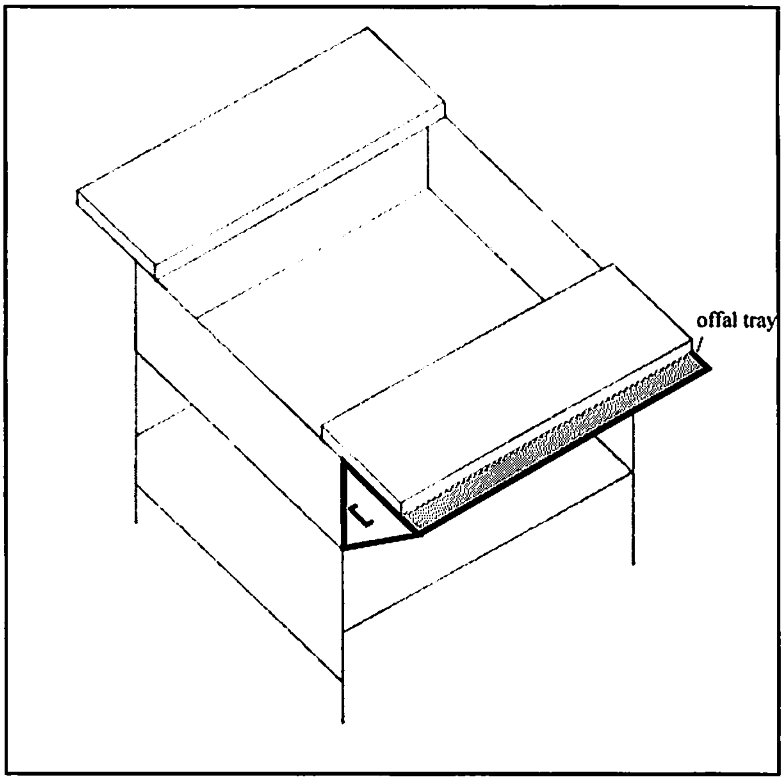

Figure No. 4 - Possible filleting bench modification

The sample of effluent taken immediately after passing through the catch basket is particularly high strength. The Mogden calculated trade effluent charge would be £2.01/m^3. To minimise this cost, pieces of fish should not be allowed to accumulate in the water in the tubs throughout the day. Catch baskets should be emptied and cleaned before the bench is emptied and thoroughly cleaned at the end of each day.

A significant amount of material which falls onto the floor is washed into the drain, which will increase the strength of the effluent. In order to prevent this, changes in practices i.e. ensuring material is put into the offal bin, will be necessary. The change in bench design, to incorporate a catch tray, would also assist in preventing material from ending up on the floor. Any material which falls onto the floor should be swept up and put into the offal bin rather than going down the drain.

6.3 Cleaning

The floor of the filleting area is cleaned down at the end of the day. Overnight the effluent from defrosting quickly blocks the mesh covering the drains in the defrosting area, which results in effluent running out of the defrost room and into the filleting area. After the defrosted fish has been removed, a pressure washer is used to wash the floor of the defrost room and the filleting area for a second time.

At the end of the day when all the fish have been filleted, a significant amount of small pieces of fish end up on the floor around the filleting benches (Figure No. 5). The waste is scraped into the centre of the floor and shovelled into the fishmeal bin. The floor is then powerwashed and remaining pieces of fish are brushed and washed down the drain. No detergents were used in conjunction with the powerwasher during the audit.

Figure No. 5 - Waste being swept down the drain

The slot design of the drain covers allowed large pieces of fish to enter the drainage channel. The catch baskets filled very quickly, but were only emptied once per week (Figure No. 6). Weighing the catch basket determined that approximately 30 kg of waste was collected per day. Once full, the baskets overflowed resulting in high strength effluent escaping into the drain and solids building up in the bottom of the catch basket housing. Effluent samples were taken to determine the amount of organic material picked up by tap water washing through a catch basket. Initially the tap water had a COD of <15 mg/l, and SS of < 3 mg/l. After washing through the catch basket the COD of the effluent increased to 2,900 mg/l with a SS of 780 mg/l.

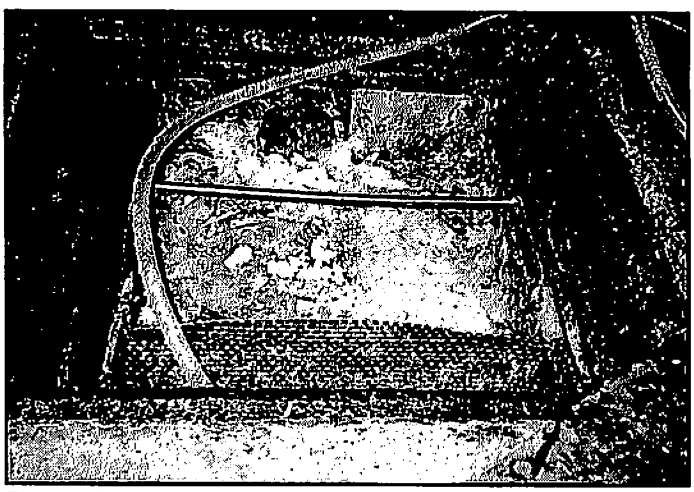

Figure No. 6 - Full catch basket

Unpleasant spoilage odours were associated with the catch baskets and also the chill, used to store defrosted fish, the floor of which was covered with spoiled fish slime.

6.3.1 Conclusions and recommendations

Drainage in the defrost room could be improved by using larger aperture mesh grilles; this should prevent the drains blocking and the defrost effluent flowing into the filleting area. In turn this should significantly reduce the amount of morning cleaning required.

After changes in working practices or filleting bench design, all the pieces of fish which still end up on the floor should be shovelled into the fishmeal bin, rather than being brushed down the drain which increases the strength of the effluent. Drain covers could be changed to 6 mm punch plate or small aperture wedge wire to prevent large solids entering the drain. Catch baskets should also be redesigned to fit the housing with all five sides made from screening material. This will increase the surface area for filtration, reducing blocking. A smaller aperture catch basket could be effectively used in conjunction with smaller aperture drain covers to reduce the strength of effluent leaving the factory.

Catch baskets must be emptied frequently, at least once per day as even clean tap water washing through a full catch basket can pick up additional organic material, dramatically increasing the disposal cost from £0.38/m^3 to £1.30/m^3. A longer term solution would be to redesign the catch baskets to prevent the water washing over the solid material.

An effective cleaning and hygiene schedule must be carried out to prevent hygiene and odour problems. This would involve cleaning using a neutral or mildly alkaline detergent to cut dirt and grease, followed by rinsing and disinfection using a 150 mg/l solution of sodium hypochlorite to kill bacteria. Disinfection should then be followed by a thorough rinse of any surface which may come into contact with fish.

6.4 Skinning

A Baader 51 skinning machine is used to skin fillets when required. Prior to skinning, fillets are dipped in a solution of sodium polyphosphate.

The machine is connected to a water point by a flexible hose. The water supply is turned on and off when required, by either a manually operated valve on the main supply or on the machine itself.

When the machine is in operation, the waste water and fish skins exit from a waste chute located underneath the skinning mechanism. The skins are collected in a catch basket (aperture 10mm).

6.4.1 Water usage

During the audit, 9.2m^3 of water was used in the skinning process. A proportion of this was used to make up the sodium polyphosphate solution. The flow rate of water into the machine varies between 8 l/m to 12 l/m, but is typically maintained at 10 l/m.

Water was seen to be wasted in the skinning process, by personnel leaving the water supply turned on when the machine was not in use.

To determine whether skinning could be carried out using less water, without affecting the efficiency (yield), a basic trial was undertaken.

Fish were skinned using a fixed flow rate of 10 l/m and then at reduced flow rates of 9 l/m and 7 l/m. At each flow rate, boxes of fillets were weighed before and after skinning to estimate the yield, in order to determine the relative success of the reductions in flow rates. The average yield at 10 l/m is 92%. At both flow rates of 7 l/m and 9 l/m the yield averaged 91%.

6.4.2 Effluent production

Effluent is produced as a result of the skinning process. As the effluent washes through the skins in the catch basket, small pieces of solid material are washed out and either deposited on the floor or flow into the drain. Effluent samples from the initial waste water and after it washes through the catch basket were taken. The COD and SS of the initial effluent without skins was 607 mg/l and 640 mg/l respectively. After passing through the catch basket the COD increased to 2210 mg/l and the SS to 828 mg/l.

To determine the effect of water washing through the catch basket, fresh water was washed through the catch basket containing the fish skins. After passing through the fish skins, the COD was 3180 mg/l and the SS was 290 mg/l.

A composite sample was obtained from the drain which receives effluent from the skinning machine. The COD was 1960 mg/l and the SS was 152 mg/l.

6.4.3 Conclusions and recommendations

Due to the low flow rate of water to the skinning machine there is not much scope for further reducing water consumption from the skinning process. The variable flow rate to the machine should be restricted to 10 l/m, with the installation of a flow regulator. It may not be advisable to reduce the flow rate to less than 10 l/m.

Operators of this equipment should ensure that the water supply is switched off immediately after use, to reduce water use and minimise effluent production. Alternatively, an automatic valve to cut off the flow of water when the machine is not in use would be effective.

There appears to be more scope for reducing effluent production. Calculations indicate that future effluent charges associated with skinning could increase from the current cost of £0.29/m^3 to £0.86/m^3 based on the composite sample taken from the drain which receives effluent from the skinning machine.

The current practice of allowing water to wash over the skins in the catch basket significantly adds to the effluent load. As the water washes through the skins additional pieces of solid material are washed out with the water. This will have a significant effect on future effluent charges, which will be based on the actual strength of the effluent. Calculations indicate that if the effluent could be prevented from washing through the skins, the future effluent treatment charge could be reduced from £1.16/m^3 to £0.74/m^3.

This highlights the need to switch off the water supply to the machine when not in use. While the water is running effluent costing £1.18/m^3 is being produced.

By modifying the waste chute underneath the skinning machine water can be diverted away from the catch basket. This could be achieved by incorporating a section of wedge wire in to the existing chute. The majority of the water would pass through the wedge wire, behind the catch basket whereas the skins would fall into the basket.

In addition, the following simple measures could minimise the future costs associated with skinning effluent. Catch baskets should be emptied more frequently, if possible after each use of the machine. A catch basket, with small drainage holes should be used to assist in preventing a large proportion of solid material from washing out of the basket. It is also important to ensure that the catch basket is positioned correctly in order to catch all the solid waste material.

6.5 Ice Production

Two flake ice machines are used to supply ice for the site. They work independently so that one or both can be used at any time. The ice is fed into insulated containers in the process area.

6.5.1 Water usage

Over the five day week of the audit the water consumption was 5.1m^3.

6.5.2 Conclusions and recommendations

The ice produced on-site is generally packed and sent out with the fish. As it does not go down the drain, trade effluent charges should not be paid for the volume of water used in ice production.

Based on the amount of water used during the audit, it is calculated that this would save approximately £72 per year at current charges.

As ice consumption varies weekly, a totaliser water meter should be fitted to the water input to the ice machines. The amount of water used over a longer period could then be determined accurately and the information used to try and claim an allowance from Yorkshire Water. It will become particularly important to claim an allowance when future charges apply, as the increased costs of disposal will apply to the total volume of water used on-site.

7. Overall Conclusions and Recommendations

When the Mogden calculated trade effluent charges are introduced, the company is likely to face a significant increase in trade effluent disposal costs. The effluent samples obtained during the audit indicate that the effluent leaving the site has a COD of 1960 mg/l and an SS of 138 mg/l. This would result in trade effluent treatment charges increasing from the current rate of £0.29/m^3 to £0.85/m^3. Fortunately, some low cost or no cost changes in practices or equipment can be implemented to reduce this cost.

- The current method of whitefish processing results in a large volume of effluent finding its way into the drains. Waste must be prevented from entering the tubs or falling on the floor. This can be achieved by educating staff and/or modifying benches to include an offal tray.

- Drain channel covers and catch baskets were found to be ineffective, allowing waste to easily enter the drain. Drain channel covers should be redesigned and replaced to prevent this problem. Catch baskets should be emptied more frequently and cleaned thoroughly. In the longer term it will be beneficial to redesign the catch baskets.

- The high strength effluent stream produced by the skinning machine could be significantly reduced by incorporating a section of wedge wire in to the waste chute, to divert water away from washing over the skins collected in the catch basket.

Reducing water use will be as important as reducing effluent strength, as diluting strong effluent increases the volume which results in similarly increased effluent charges.

It is calculated that approximately 24m^3 of water is used to produce one tonne of fillets (includes defrosting, filleting, ice production, skinning and cleaning). As a result of the observations there appears to be a lot of scope for reducing water usage.

- Currently all the water used for defrosting is being wasted as during the warmer months fish can be defrosted without using any water at all. In winter, heated water and a simple control system should be used to switch the water off when the fish have defrosted.

- It is likely that the volume of water used in filleting can be significantly reduced by installing flow regulators and by major changes to current practices. More stringent management should also be applied.

- Water is wasted in other areas, such as leaving water on unnecessarily in skinning and by 'double' cleaning. Changes in practices should be introduced.

It is advisable to inform and educate staff about the future costs associated with effluent and water use. Water usage should be continually monitored. Staff should be involved and encouraged to identify 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.

Yorkshire Water will begin applying the revised Mogden formula to trade effluent bills from April 2000. In preparation for this, staggered price increases have been applied for the interim years. With this in mind it is recommended that the company starts to introduce changes, with regards to reducing water usage and effluent production, as soon as possible in preparation for these increases in costs.

The Results of a Water and Effluent Study carried out at T. Chapman & Sons Limited in September 1997

Confidential Report No. CR134

January 1998

The Sea Fish Industry Authority

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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 usage and effluent production with a view to minimising both. This report is concerned with the audit of T. Chapman & Sons Ltd.

Water is used throughout the factory in a number of different processes but primarily in defrosting and filleting. The total volume of water used during 5 days of the audit was 181m^3, generating approximately 163m^3 of trade effluent.

Sampling of the main drain leaving the factory was not possible. Using the composite samples obtained from the drains which receive effluent from the filleting and enrobing processes, the effluent strength for the overall site was calculated to be a COD of 15,396 mg/l and TSS of 10,518 mg/l. This would result in an increase in the future trade effluent charge from the current cost of £0.18/m^3 to £8.57/m^3, when calculated using the Mogden formula.

The main problem found was the amount of very high strength effluent generated by the enrobing process ending up in the drain. This occurred as a result of inadequate catch trays, excess batter production and bad practice. Opportunities for minimising water use and effluent strength were identified, many of which may be carried out at little or no cost.

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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 volume and 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 a component 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 Yorkshire Enterprise Limited and technical consultants to carry out an ERDF funded project in the Humber region. With assistance from the Hull and Grimsby Fish Merchants' Associations, 40 small to medium sized fish companies agreed to have a preliminary waste audit carried out in their premises. From the findings of these audits 7 fish processing companies, representative of the diverse range of industry practices, were chosen. Detailed water audits have been carried out in these companies. The results will be used to develop comprehensive guidance documentation for industry, which will provide detailed advice on carrying out a water audit and how to minimise water use and reduce effluent strength.

This report is concerned with the audit of T.Chapman & Sons Limited. Water usage and the effluent produced were investigated and monitored within the factory. Areas for reducing water consumption and effluent strength are identified.

2. The Preliminary Waste Audit

A preliminary waste audit, carried out at the premises on April 24th 1997, highlighted some general problems with water usage. In particular, it was felt that water was being wasted in the filleting process by the use of continuously running hoses. It was also felt that the company would face a large increase in trade effluent charges, due to the volume and nature of the effluent e.g. batter and oil.

At the time of the waste audit it was noted that the volume of water used in ice production, glazing and in the batter mixture could be used to claim an allowance from ABP, which would reduce the overall volume of water classed as trade effluent.

3. The Company

T. Chapman & Sons has been a family owned and managed company since it was first established. It currently has an annual turnover of £3.5 million and employs about 50 personnel. The company primarily fillets, breads and batters fish for sale to the catering industry. The main species of fish processed is cod.

3.1 Site Description

The audited site is situated on the North Quay of Grimsby and consists of two main areas; a wet side and a dry side. The wet side is where fish are filleted, either by hand or machine. The fillets are then glazed, frozen and mechanically size graded before being packed. The dry side is where the enrobing process takes place. After freezing, the enrobed fillets are stored in the cold store. A plan of the site is shown in Figure No. 1.

The wet side comprises three separate areas. The filleting area houses five filleting benches, a Baader 188 filleting machine and a Nitrogen tunnel freezer. Grading and glazing equipment are housed in adjacent areas.

The dry side is located in one main area which houses a conveyor system for enrobing the fillets, a Torry tunnel blast freezer and grading and packing equipment.

During the audit the company was undergoing building work and moving equipment to different areas. The site may have changed further since the audit.

3.2 Factory Water Points and Drainage

A plan of the factory water points and drainage system is also shown in Figure No. 1.

A combination of wall mounted taps and hose pipes suspended from the ceiling supply water for the individual processes. Drainage channels in each of the main process areas collect effluent and duct it into the main drains leaving the factory.

Large solids are prevented from entering the 300 mm wide by 200 mm deep drainage channels in the filleting area by cast iron covers with 25 mm x 25 mm holes. The drainage channel in the batter and breading area has a cover with 15 mm wide and 100 mm long slots. No catch baskets are used.

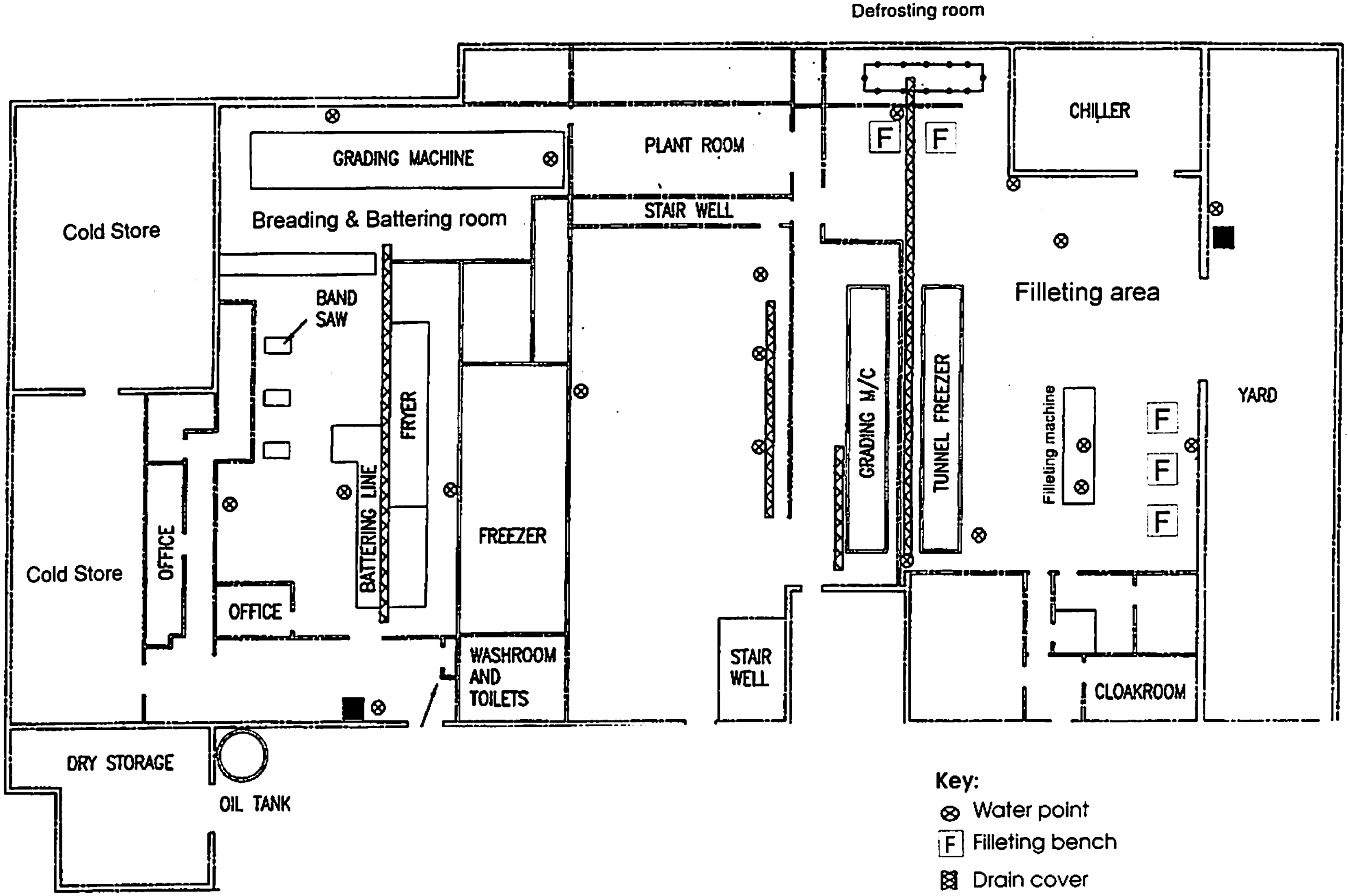

Figure No. 1 - Plan of the factory

4. The Audit Methodology

In order to investigate the use and contamination of water within the company six working days were spent on-site from, observing the process and determining where water was used and effluent produced.

4.1 Measurement of Water Usage

The volume of water used in each main process was measured.

During the audit, the five filleting benches were supplied with water from two separate water points. An in-line flow meter, with a 4.20 mA output, was installed into each water supply. The same type of meter was installed in the water supply to the filleting machine. A Squirrel data logger was used to record the flow rates, at two minute intervals, over a five day period.

In-line totaliser meters were installed in the water supplies in the enrobing area, to the power washers and in a water supply specifically used for defrosting. Readings were taken every hour, from the start of the working day through to the end. The two main site meters were also read every hour.

The water supply to the ice machine was monitored using a Micronics Portaflow 300, ultrasonic non-invasive meter, which recorded the flow rate at 6 minute intervals each day.

It was not possible to meter the water supply to the spray system used in defrosting. The difference between the evening and morning readings of the main site meter was used to estimate the volume of water used in defrosting.

4.2 Effluent Sampling and Analysis

The strength of the effluent produced by the different processes was determined by taking 1 litre samples. Spot samples were taken directly from equipment i.e. the filleting benches and the filleting machine, whilst an Epic automated effluent sampler was used to obtain composite samples. Samples (100ml every 10 minutes) were taken over an 8 hour period, from the internal drains. The samples were analysed by Alcontrol UK (Analytical Services), Rotherham.

The samples of effluent were analysed for chemical oxygen demand (COD) and total suspended solids (TSS).

4.3 Calculating Trade Effluent Treatment Charges

The COD and TSS values of the effluent were used to estimate the future costs when the effluent will have to be treated. Costs were calculated by the Mogden formula using the 1997 Anglian Water charging rates for treating trade effluent.

Mogden formula:

$$C = R + V + [B\frac{O_t}{O_s}] + [S\frac{S_t}{S_s}]$$

Charges

C	=	Cost pence/m^3
R	=	Reception charge = 11.42 pence/m^3
V	=	Preliminary treatment charge = 21.23 pence/m^3
B	=	Biological treatment charge = 17.63 pence/m^3
S	=	Suspended solids charge = 8.38 pence/m^3
O_t	=	Mean organic strength of the trade effluent (COD mg/l)
O_s	=	Mean regional organic strength of domestic sewage = 456 mg/l (BOD)
S_t	=	Total suspended solids (TSS) of effluent sample (mg/l)
S_s	=	Mean regional strength of settleable solids in domestic sewage = 383 mg/l

5. Overall Water Usage and Effluent Production

This section gives an overview of water usage and effluent production. Over the five days of the audit, 6.7 tonnes of fillets were produced and 18.6 tonnes of battered product. The individual processes are discussed in detail in Section 6.

5.1 Water Usage

Water is used throughout the site in a number of different processes. The water consumption during the audit for each process was measured separately, see Table No. 1.

Table No. 1 -The water usage in each main process/activity during the audit

Process/Activity	Water usage during the audit (m^3)
Filleting (hand and machine)	70.5
Defrosting	42.3
Breading / battering area	25.9
Glazing	15.7
Cleaning - power washers	15.7
Ice production	5.0
Total	**175.1**

The total volume of water used during the audit was $181m^3$, according to the two main site meters. Approximately 20% of this was used in the dry side and 80% used in the wet side. In total 3% of the total volume of water used was unaccounted for during the audit, which was primarily used in non-processing areas such as the toilets and canteen.

Using the total volume of water used and the weight of fish processed in the week it is calculated that approximately $22m^3$ of water is used to produce 1 tonne of fillets (includes defrosting, filleting, glazing, ice production and cleaning). Approximately $1.4m^3$ is used to produce 1 tonne of battered fillets (excludes primary processing).

5.2 Effluent Production

It was impossible to obtain an overall effluent sample for the site as more than one drain exits the factory. Composite samples from the main internal drains were used to estimate the strength of effluent leaving the site. The source, strength and estimated future costs of the two main effluent streams are shown in Table No. 2. The future trade effluent charges can be compared to the current charge of £0.18/m^3.

Table 2 - The source, strength and estimated future costs of the composite samples taken from the main effluent streams

Source	Strength		Mogden calculated trade effluent charges (m^3)	Volume produced during the audit (m^3)	Mogden calculated trade effluent charges for the 5 day period of the audit
	COD (mg/l)	TSS (mg/l)			
Composite - filleting area	1270	248	£0.87	130.4	£113.44
Composite - enrobing area	71,900	51,600	£39.42	32.6	£1,285.09

The overall effluent sample for the site is calculated to have a COD of 15,396 mg/l and TSS of 10,518 mg/l. This would increase the trade effluent charge from the current cost of £0.18/m^3 to £8.57/m^3, when calculated using the Mogden formula. With approximately 163m^3 of trade effluent generated in the week of the audit, the future cost of disposal would be about £1,396 based on the calculated strength of effluent taken at this time.

6. The Main Operations

6.1The Enrobing Process

A proportion of the fish fillets which are produced on-site are enrobed. Individual frozen fillets are fed into a battering machine where the first coating of batter is applied. The fillets then travel along a conveyor into a breadcrumbing machine, where they are coated on both sides. A final batter coating is then applied. The enrobed fish pass through a flash fryer before being frozen in a blast freezer. The frozen, enrobed fillets are then packed.

6.1.1 Water Usage

Water is used for making batter mixture and for rinsing down the floors after batter and scrap (small pieces of fried batter) spills.

During the audit, 25.9m^3 of water was used in the enrobing area. Approximately half of this volume of water was used for cleaning down the floors to wash batter and scraps into the drain.

6.1.2 Effluent Production

During the coating process a significant amount of batter mixture and scraps fall onto the floor, see Figure 2. The absence of drip trays for specific sections of the battering line means that a significant amount of batter drips onto the floor. This is then washed into the drain. Over a period of five hours monitoring, approximately 40 litres of batter mixture passed down the drain.

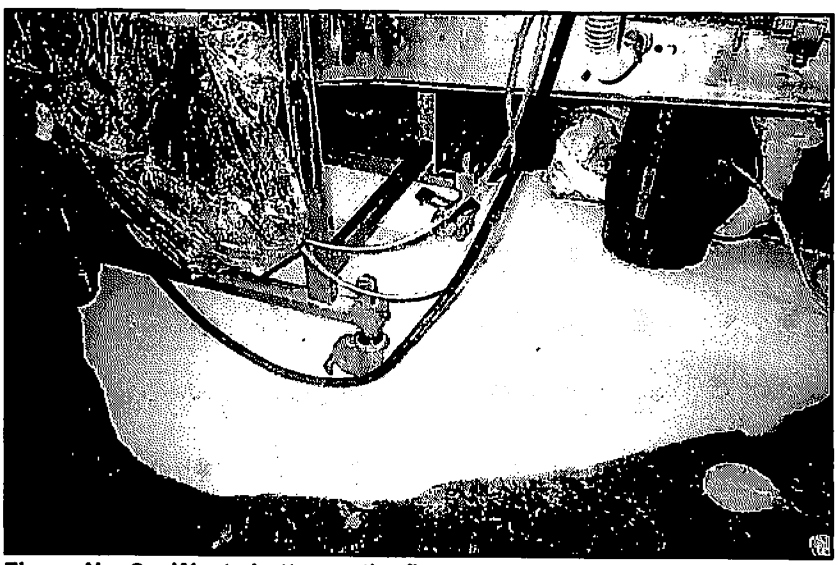

Figure No. 2 - Waste batter on the floor

As the enrobed fillets pass from the fryer into the freezer, a significant amount of scraps fall from the conveyor onto the floor. The majority of scraps are caught in boxes placed underneath the conveyor. These are emptied at the end of the day for sale to a local farmer. The scraps which do not fall into the boxes find their way into the drain. After two hours of continuous processing approximately 7.3kg of solid material had fallen onto the floor. Using this as a basis, over a typical 9 hour day of continuous processing, approximately 34 kg of this material would finish up on the floor. This would all be washed into the drain.

Composite effluent samples were taken from the drain in the enrobing area. The COD and TSS were calculated to be 71,900 mg/l and 51,600 mg/l respectively. A sample of the batter mix was also analysed. The COD was 375,000 mg/l and the TSS was 398,000 mg/l.

6.1.3 Conclusions and Recommendations

The current method of enrobing fish produces a significant amount of very high strength effluent. Calculations indicate that future trade effluent charges associated with this process could increase from the current cost of £0.18/m^3 to £39.42/m^3, based on the current strength of the effluent stream taken from the drain in this area. The future Mogden calculated charge for disposing of pure batter is calculated to be £232.50/m^3. To keep future Mogden calculated trade effluent charges to a minimum, this effluent must be prevented from entering the drainage system.

Any batter which gets onto the floor runs into the drain, significantly increasing the strength of the effluent. The current system of catching dripping batter should be improved, with additional drip trays underneath the first battering machine and any other areas where batter drips occur.

The means of catching scraps should be improved in order to prevent the material getting onto the floor and into the drain as this significantly increases the strength of the effluent. Any material which does get onto the floor should be collected and put into the scrap bin.

The water used in batter production is incorporated into the product which leaves the factory. As this water, generally, does not go down the drain, trade effluent charges should not be paid for the volume of water used in batter production. Based on the amount of water used during the audit, it is calculated that approximately £110 per year could be saved by this means at current charges.

As batter production varies daily, a totaliser water meter should be fitted to the water input to the batter equipment. The amount of water used over a longer period could then be determined accurately and the information used to try and claim an allowance from the landlord ABP, who in turn deal with Anglian Water. It will become particularly important to claim an allowance when future charges apply, as the increased costs of disposal will apply to the total volume of water used on-site.

6.2 Filleting

The main operation carried out is the manual filleting of headed and gutted frozen at sea fish. The Baader 188 filleting machine was also used for the first three days of the audit.

All five filleting benches are of a traditional design with a central tub separating two cutting boards enabling a pair of filleters to work facing each other. Two shallow 120 litre tubs are used whilst the rest are deeper 130 litre units. Each tub has a solid bung and has no overflow arrangement. A catch basket (aperture 10 mm) is placed underneath the drain plug to catch pieces of fish when the tub is emptied. Fish boxes are positioned under the Baader 188 to catch falling waste.

6.2.1 Water usage

During the audit, the five filleting benches were supplied with water from two separate points. The supply from the first water point was split using a 'Y' fitting to allow a hose pipe to be placed into each of two filleting benches. The second water point had a single hose which was shared between the three adjacent benches. Occasionally during the audit continually running hoses were observed. However, water was normally only used when required.

At the start of filleting two or three boxes of fish are put in the tub which is then filled up with water. This process of adding fish and topping up with water is repeated until the water in the tub is considered by the filleters to be 'dirty'. The tub is then emptied and refilled. It was calculated that the total volume of water used in filleting during the audit was 70.5m^3. The average flow rate to each filleting bench was 15 l/min. A total of 53m^3 was used by all the benches over the five days of the audit.

The average flow rate to the Baader was 30 l/min. A total of 17.5m^3 was used by the machine over the three days it was in use.

It was calculated that the machine filleting and hand filleting used approximately 947 litres and 667 litres respectively to process one tonne of whole fish.

6.2.2 Effluent Production

During hand filleting, the frames and lugs are thrown or flicked into the fishmeal bin or a fish box. A significant amount of waste misses the containers and ends up on the floor (Figure No. 3). Smaller pieces of fish are flicked into the filleting tub. At the end of filleting most of the pieces of fish on the floor are shovelled up. The remaining waste is hosed down the drain.

Composite effluent samples were taken from the drain in the filleting area and spot effluent samples were taken from the Baader filleting machine. The effluent from the drain had a COD of 1270 mg/l and TSS of 248 mg/l. The effluent sample from the Baader filleting machine had a COD of 5346 mg/l and a TSS of 4231 mg/l.

Figure No. 3 - Filleting waste on the floor

6.2.3 Conclusions and Recommendations

The volume of water used in filleting is considerable. If continuous water supply to the filleting benches remains a problem then water usage could be reduced and controlled by fitting flow regulators to the supply of each bench (approximate cost £10 excluding installation). More controlled management over water use should be introduced.

Calculations indicate that future trade effluent charges associated with filleting could increase from the present cost of £0.18/m^3 to £0.87/m^3 based on the strength of the effluent from the drain in the filleting area. The strength of effluent taken from the filleting machine would cost £3.32/m^3 when future trade effluent disposal charges apply. To keep future trade effluent treatment charges to a minimum, solid material must be kept out of the drain.

A limited comparison of the efficiency of hand filleting and the Baader filleting machine can be made (Technical data for the Baader 188 is taken as being the same as for the Baader 190).

It would require approximately 13 filleting benches to process the same weight of (40 cm long) fish per hour as a Baader 190. Assuming the fillets do not use continually running hose pipes, it was calculated that the benches would use water and produce effluent with an estimated future cost of £2.58 per hour, in comparison to the Baader which would cost £5.97. A detailed specific study would be required to produce an accurate comparison.

To prevent filleting waste ending up on the floor, benches could be modified to include a simple offal tray (Figure No. 4). Small pieces of fish could be flicked into the offal tray which would reduce the effluent strength in the filleting bench. Education is also required to ensure filleters accurately throw offal into appropriate containers to prevent it ending up on the floor.

A clean supply of water to a filleting bench is essential to maintain hygiene but the traditional tub type benches can be wasteful in water. It is undesirable to leave fish soaking in water and particularly to wash fillets in that same water. Alternative systems are available in which the fish is washed/de-iced separately (if required) prior to filleting and a controllable water spray is used on the filleting bench to maintain cleanliness and wash the fillets.

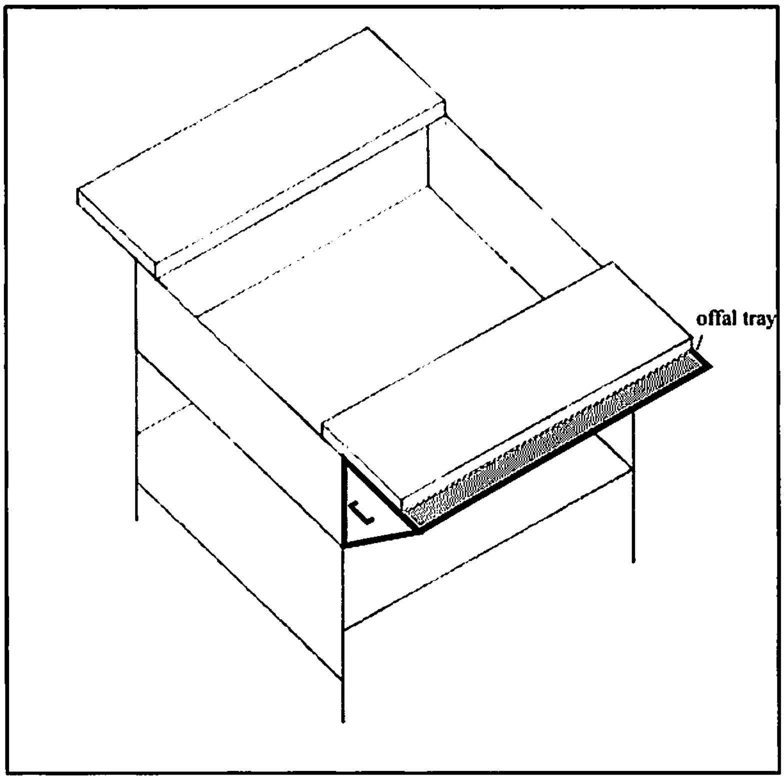

Figure No. 4 - Possible filleting bench modification

6.3 Defrosting

Frozen blocks of fish are defrosted in stages. Firstly, they are placed on racks outside the factory, uncovered at ambient temperatures (Figure No. 5). At the end of processing for the day, the racks are brought inside and placed into the defrosting room, which has an overhead water spray system. Water is then sprayed over the racks of fish throughout the night. As the fish thaw, they fall away from the blocks onto the floor (Figure No. 6).

Figure No. 5 - Fish placed outside the factory

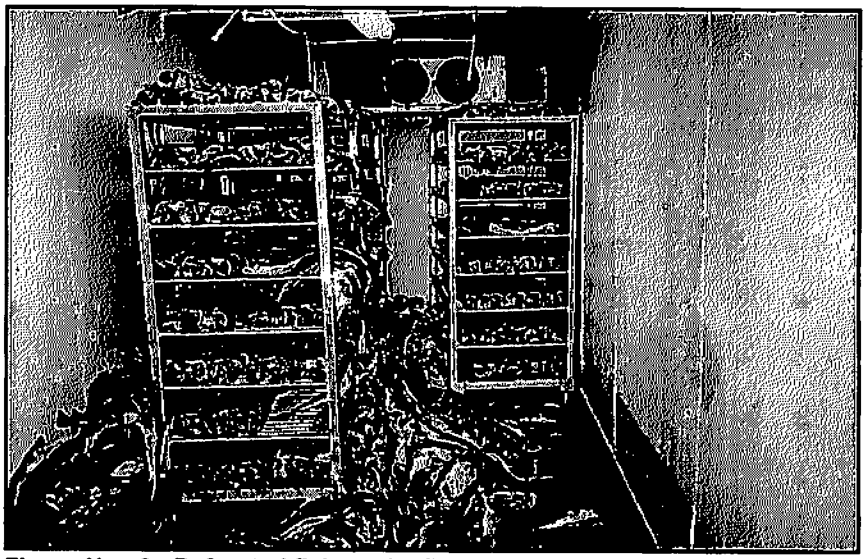

Figure No. 6 - Defrosted fish on the floor

At the start of the following day the fish are removed from the defrosting room. Fish which are not defrosted are put into containers or a stack of fish boxes. The container/ stack of boxes is placed underneath a water point and the water supply turned on to run continuously until the fish defrost. As the water runs into containers it overflows onto the floor. With a stack of fish boxes the water is unable to reach the lower boxes in the stack (Figure 7).

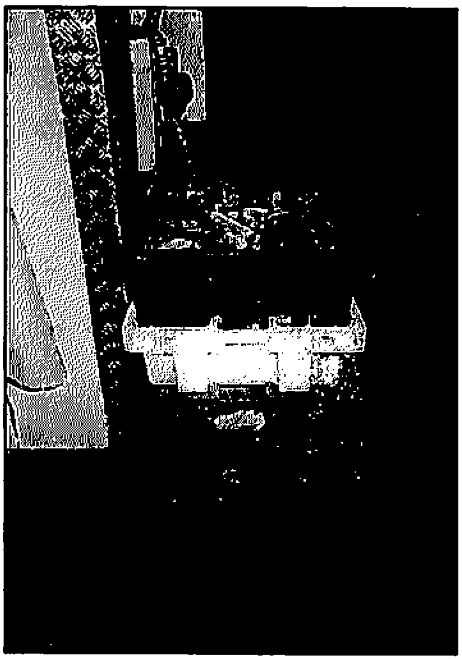

Figure No. 7 - Water unable to reach the lower boxes in the stack

6.3.1 Water Usage

Approximately $42m^3$ of water was used during overnight defrosting and by a dedicated defrost water point over the five days of the audit. During the audit, a number of water points were used to defrost the fish in containers and stacks of boxes throughout the day i.e. from the filleting machine and from the filleting benches. It is impossible to determine how much water was used during these times.

6.3.2 Effluent Production

It was not possible to obtain a sample of the effluent produced during defrosting. Insread, effluent samples obtained from other comparable defrosting operations can be used to estimate the effluent strength.

Typically defrost effluent has a COD and TSS of 5,115 mg/l and 32 mg/l respectively.

6.3.3 Recommendations and Conclusions

The current cost of disposing of trade effluent is £0.18/m^3. From the effluent samples obtained from other comparable defrosting opeations, the future charges associated with defrost effluent are likely to be about £0.53/m^3. To keep these charges as low as possible, it will be important to reduce the volume of water used and prevent waste material from entering the drainage system.

It is not acceptable to defrost unprotected fish in the open air, or directly on the floor. This exposes the fish to possible contamination from a number of sources. Both defrosting fish on a rack and in stacked fish boxes is not effective as the water does not come into contact with all the fish. The current method of defrosting wastes a large volume of water.

To improve rack defrosting, water should be sprayed onto each level of the rack by mounting the nozzles on the walls of the room. Alternatively, fish should be laid out in a single layer. Frozen blocks can be balanced on fish boxes to keep them off the floor. The defrosted fish fall into the boxes which assists handling.

During warmer months of the year fish can be laid out and defrosted in air, without the use of water. The frozen blocks must be removed from the cold store in sufficient time to allow the fish to defrost. In winter, a water heater or waste heat from the refrigeration system could be used to heat the defrost water or the defrosting room itself. However, it is recommended that temperatures should not be allowed to exceed 15°C. This should reduce the time taken for defrosting, the volume of water used and the effluent produced. To control the process, temperature probes inserted into the fish could be used to switch off the water/heat supply when the fish have defrosted (reached an internal temperature of above 0° C). The fish should then be kept in chill after defrosting.

There are a range of other options available which could reduce both water consumption and costs, whilst effectively defrosting all the frozen supplies, but these would involve major capital expenditure i.e. specialist defrosting equipment. It is, however, worth considering the long-term cost effectiveness of the purchase of such equipment, against the current and future use of such large volumes of water, particularly when future disposal costs apply.

6.4 Cleaning

The main source of organic material on the floors comes from the enrobing process and from filleting.

The floor in the enrobing area is cleaned down as necessary during the day. At the end of processing, any batter, oil and scraps which are on the floor are washed into the drain. The drain covers are usually lifted up by personnel to make this task easier (Figure 8).

Figure No. 8 - Waste being washed down the drain

At the end of the day when the enrobing equipment is cleaned, large volumes of excess batter are emptied directly down the drain (Figure 9).

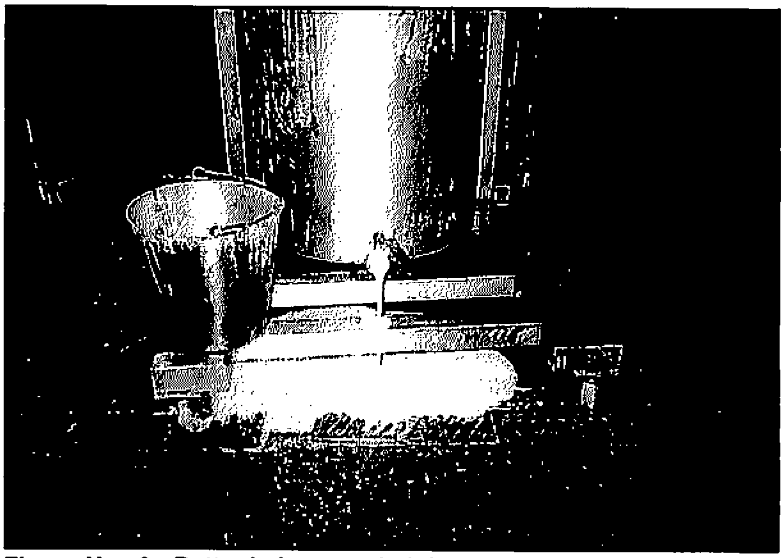

Figure No. 9 - Batter being emptied down the drain

The floor around the filleting benches is also cleaned down as necessary during the day. At the end of filleting, the majority of pieces of fish on the floor are shovelled up into a fishmeal bin or into a box for sale to a fishcake manufacturer. The remaining waste is then washed into the drain. The large aperture drain cover allows large pieces of fish to enter the drain.

Overnight cleaners wash down and sanitize the factory equipment, floor and drains. Although the operation was not observed it was calculated that approximately 3m^3 of water was used per night.

6.4.1 Conclusions and Recommendations

All solid material should be prevented from finding its way on to the floor and into the drains. The drainage channel covers should be replaced with 6mm stainless steel punch plate or smaller aperture wedge wire, to prevent large solids entering the drain. Covers should incorporate a simple locking device to prevent lifting by unauthorised personnel.

The use of catch baskets should be considered. Catch baskets should also be made from punch plate or wedge wire with an aperture smaller than that of the drain covers. The design should ensure a high surface area for effective filtration and be a good fit in its holder. Baskets should be emptied frequently as effluent washing through a full catch basket can pick up additional organic material, which can significantly add to the strength of the effluent.

Excess batter should not be poured down the drain, as this will dramatically increase the strength of the effluent. If possible, the production of excess batter should be avoided as this not only causes a disposal problem but is a waste of resources. The volume of batter made should be more carefully tailored to actual production, particularly towards the end of the day. This will help to avoid the current levels of wastage and high trade effluent charges. An alternative disposal route for excess batter should be found.

Any pieces of fish which have been in direct contact with the floor may be contaminated and must not be sold for use in the manufacture of fishcakes.

6.5 Glazing

Fillets were glazed by placing in an 'L' shaped 150 litre water bath which received a continuous supply of water. Holes in the bottom of the bath allow water to escape. A purpose built glazing machine was available but was not in use.

6.5.1 Water Usage

During the audit, 15.7m^3 of water was used in the glazing process.

6.5.2 Effluent Production

An effluent sample was taken from the glazing bath and found to have COD of 3410 mg/l and TSS 476 mg/l.

6.5.3 Conclusions and Recommendations

A large volume of water is wasted in the glazing process with the use of a continuous supply of water. The flow rate of water should be reduced to decrease the overall water consumption.

It is likely that the glazing machine would use less water and produce less effluent, as it uses a recirculated water bath. The current method of glazing could be modified to incorporate a similar recirculation system.

The future trade effluent treatment charges for the sample of effluent taken from the glazing process would increase from the current £0.18/m^3 to £1.75/m^3.

The water used in glazing is incorporated into the product which leaves the factory. As this water, generally, does not go down the drain, trade effluent charges should not be paid for the volume of water used in the glazing process. Based on the amount of water used during the audit, it is calculated that approximately £139 per year could be saved by this means at current charges.

As the water consumption in the glazing process varies daily, a totaliser water meter should be fitted to the water input to the glazing unit and the dip-glazing tank. The amount of water used over a longer period could then be determined accurately and the information used to try and claim an allowance from the landlord ABP, who in turn deal with Anglian Water. It will become particularly important to claim an allowance when future charges apply, as the increased costs of disposal will apply to the total volume of water used on-site.

6.6 Ice Production

A flake ice machine is used to supply ice for the site.

6.6.1 Water Usage

The average rate of water consumption was approximately 0.11m^3 per hour. During a 9 hour working day, the water consumption was typically 1m^3.

The ice machine is usually switched off overnight, which limits water consumption to working hours only.

6.6.2 Conclusions and Recommendations

The ice produced on-site is generally packed and sent out with the fish. As it does not go down the drain, trade effluent charges should not be paid for the volume of water used in ice production.

Based on the amount of water used over the 24-hour period, it is calculated that approximately £40 per year could be saved by this means at current charges.

As ice consumption patterns may vary daily, a totaliser water meter should be fitted to the water input to the ice machine. The amount of water used over a longer period could then be determined accurately and the information used to try and claim an allowance from the landlord ABP, who in turn deal with Anglian Water. It will become particularly important to claim an allowance when future charges apply, as the increased costs of disposal will apply to the total volume of water used on-site.

7. Overall Conclusions and Recommendations

When Mogden calculated trade effluent charges are introduced the company is likely to face a significant increase in effluent disposal costs. From the effluent samples taken within the factory the overall strength of effluent produced by the factory was estimated to have a COD of about 15,396mg/l and TSS of 10,518mg/l. This would result in effluent treatment charges increasing from the current £0.18/m^3 to £8.57/m^3. Fortunately many low cost or no cost changes in working practices can be implemented to reduce this cost.

- The enrobing process results in a large volume of high strength effluent finding its way into the drains. The enrobing equipment should be modified to prevent batter from falling onto the floor. The production of excess batter should also be avoided.

- Filleting also results in a large volume of effluent entering the drains. The filleting benches could be modified to incorporate an offal tray to prevent waste falling onto the floor.

- Drain channel covers were found to be ineffective, allowing waste to easily enter the drain. They should be redesigned and replaced to prevent this problem. The covers should also incorporate a simple locking device to prevent lifting by unauthorised personnel.

- The installation of well designed catch baskets which are regularly emptied can reduce the strength of effluent leaving the site.

Reducing water use is equally as important as reducing effluent strength, as diluting strong effluent increases the volume of water used which will result in increased effluent charges.

Using the total volume of water used and the weight of fish processed in the week it is calculated that approximately 22m^3 of water is used to produce 1 tonne of fillets (includes defrosting, filleting, glazing, ice production and cleaning). Approximately 1.4m^3 is used to produce 1 tonne of enrobed fillets (excludes primary processing). As a result of the observations there appears to be scope for improvement.

- The use of continually running hoses during filleting should be prevented. Changes to current practices and more stringent management over water usage can help to save water.

- During warmer months fish can be defrosted without using any water at all. The current method of defrosting should be modified to improve efficiency and hygiene.

- A relatively large volume of water is used during glazing. It would be beneficial to reduce the water flow to the current glazing process.

It is advisable to inform and educate staff about the future costs associated with effluent and water use. Water usage figures should be continually monitored. Staff should be involved and encouraged to identify 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. It is advisable to monitor any changes in water consumption to ensure that they do not cause the strength of the effluent to increase.

Anglian Water have not formalised their plans regarding to a date for introducing the new trade effluent charges. However, they suggest that the latest date would be sometime in the year 2000. With this in mind it is recommended that the company starts to introduce changes, with regards to reducing water usage and effluent production, as soon as possible in preparation for the inevitable increases in costs.