The Results of a Water and Effluent Study carried out at A. Darnell Limited in November 1997

Confidential Report No. CR136

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. 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 A. Darnell Limited.

Water is used throughout the factory, in a number of different processes but primarily in filleting. The total volume of water used during the four days of the audit was $144m^3$, generating approximately $131m^3$ of trade effluent for 20 tonnes of fish product.

Using the composite samples obtained from the main external drain the effluent strength for the overall site has a COD of 1600 mg/l and TSS of 272 mg/l. This would result in an increase of the future trade effluent charge from the current cost of £0.18/m^3 to £1.01/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.

Table of Contents

Page No.

Summary

1. Introduction 1

2. The Preliminary Waste Audit 2

3. The Company 3
3.1 Site Description 3
3.2 Factory Water Points and Drainage 3

4. The Audit Methodology 5
4.1 Measurement of Water Usage 5
4.2 Effluent Sampling and Analysis 5
4.3 Calculating Trade Effluent Treatment Charges 6

5. Overall Water Usage and Effluent Production 7
5.1 Water Usage 7
5.2 Effluent Production 7

6. The Main Operations 8
6.1 Filleting 8
6.1.1 Water usage 8
6.1.2 Effluent production 8
6.1.3 Conclusions and recommendations 9
6.2 Skinning 10
6.2.1 Water usage 10
6.2.2 Effluent production 11
6.2.3 Conclusions and recommendations 11
6.3 Cleaning 12
6.3.1 Conclusions and recommendations 12
6.4 Ice Production 13
6.4.1 Water usage 13
6.4.2 Conclusions and recommendations 13

7. Overall Conclusions and Recommendations 14

Figures
Figure No. 1 Plan of the factory
Figure No. 2 Waste on the floor around a filleting bench
Figure No. 3 Filleting bench with offal tray
Figure No. 4 Poorly designed catch basket

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

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 most 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. 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 A. Darnell 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 company on 21st April 1997, highlighted some general problems with water usage and effluent production in the process areas. It was noted that water is predominantly used in the filleting process, with skinning and ice production being the other main areas. It was identified that a large amount of waste material accumulates on the floor and that a significant amount of this would eventually get into the drainage system.

3. The Company

A. Darnell Limited has been situated on the North Quay of Grimsby since 1981. The company currently employs 34 personnel. Only whitefish is processed, with cod being the predominant species.

3.1 Site Description

A plan of the factory is shown in Figure 1.

The site consists of three areas; a packing area, the main process area where the fish are filleted and skinned, and a dispatch area.

The majority of the water usage and effluent production occurs in the main process area which houses seven filleting benches and a Baader 51 skinning machine. Offal is transported along a conveyor to a skip, which is located outside.

3.2 Factory Water Points and Drainage

A plan of the factory water points and drainage system is included in Figure 1. A combination of wall and ceiling mounted hoses are positioned around the factory and used to supply water for the individual processes.

The drainage system consists of 225 mm x 225 mm drain covers, (stainless steel grids with 20 mm x 20 mm aperture holes) covering well fitting 150 mm diameter x 300 mm deep catch baskets with only a few 10mm holes drilled into the upper surface. The effluent runs to the rear of the factory before entering the main sewer.

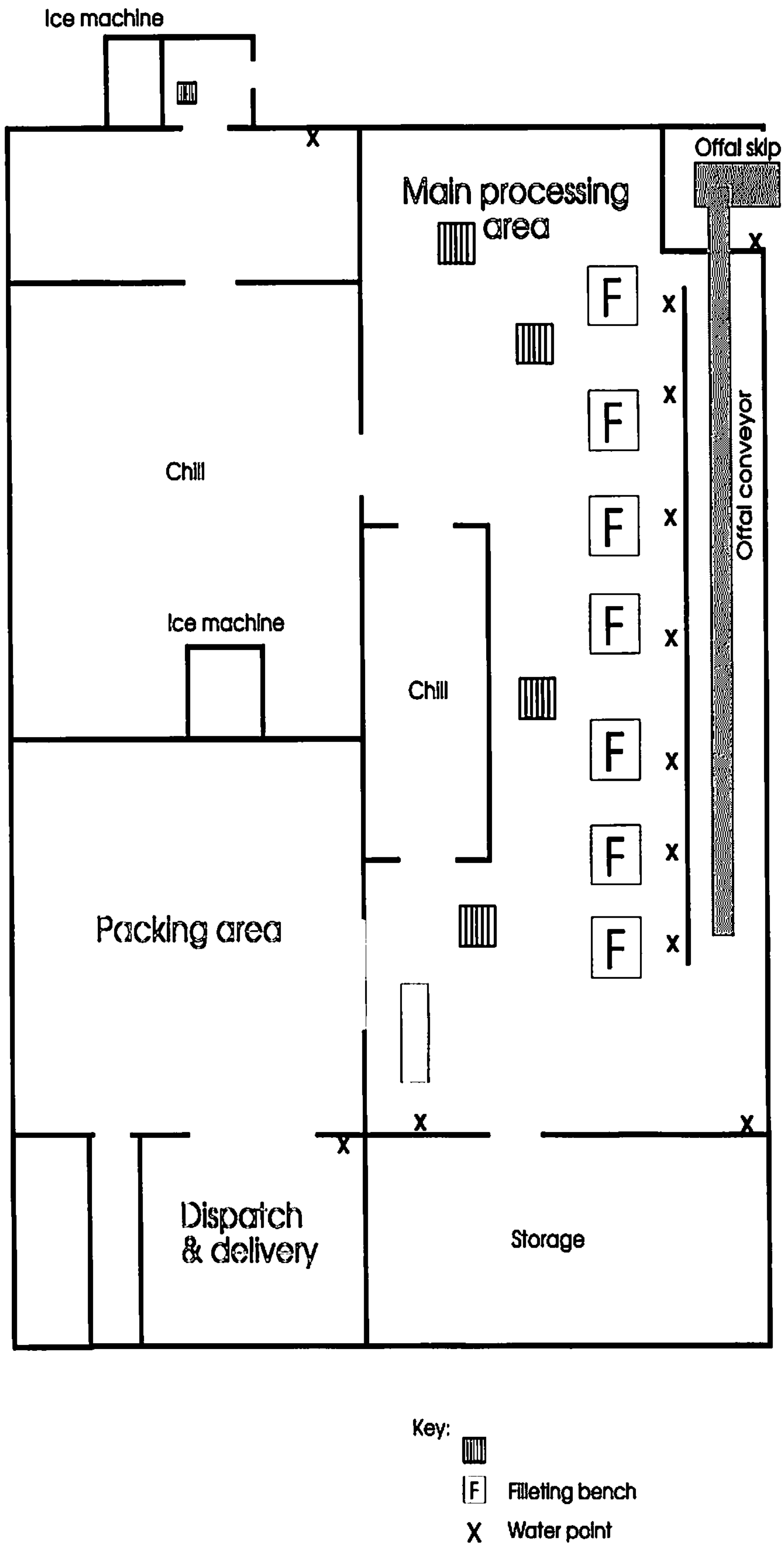

Figure 1 - A plan of the factory

4. The Audit Methodology

In order to investigate the use and contamination of water within the company, five working days (7th-13th November 1997) 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.

Four in-line flow meters, with a 4-20mA output, were installed in the water supplies to four of the filleting benches. A Squirrel data logger was used to record the flow rates, at two minute intervals, over four days.

In-line totaliser meters were installed into the water supplies to the remaining three filleting benches and to the skinning machine. It was not possible to meter the ice machines, a water line used for cleaning and two external water points. Meter readings, including the main site meter, were taken at the start of each working day.

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. filleting tubs and the skinning machines, whilst an Epic automated effluent sampler was used to obtain composite samples. Samples (100 ml every 10 minutes) were taken over a 6 hour period from the external drain. The samples of effluent were analysed by ALControl (Analytical Services), Rotherham.

Samples 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 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. During the audit, 19.9 tonnes of 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 four days of the audit was measured separately for each process, see Table 1. As the amount of water used in ice production could not be measured directly, an estimation was calculated based on use and equipment ratings.

Table 1 - The water usage in each main process/activity during the audit

Process/Activity	Water usage during the audit (m^3)
Filleting	82.1
Skinning	11.3
Ice production	10.0*
Total	103.4

* based on equipment ratings

The total volume of water used during the four days of the audit was 144m^3 according to the main site meter. Approximately 28% of this was unaccounted for during the audit, which was likely to be by the three unmetered water points used for cleaning and external use. A proportion of this would also be used in domestic areas, such as kitchens and toilets. As a significant volume of water is unaccounted for it would be worth carrying out a check for leaks over a weekend.

Using the total volume of water used and the weight of fish processed during the audit it is calculated that approximately 6.6m^3 of water is used to produce one tonne of fillets.

5.2 Effluent Production

The composite samples obtained from the external drain which receives trade effluent from the site were used to determine the effluent strength. The COD was 1600mg/l and the TSS 272mg/l. This would result in an increase of the future trade effluent charge from the current cost of £0.18/m^3 to £1.01/m^3 when calculated using the Mogden formula.

Approximately 131m^3 of trade effluent was generated during the four days of the audit. At current trade effluent charges this would cost £22.93 to dispose of. When calculated using the Mogden formula, this increases to £144.10.

6. The Main Operations

6.1 Filleting

The main operation carried out is the filleting of fresh cod. All seven filleting benches are of a traditional design with a central tub separating two cutting boards, allowing a pair of filleters to work facing each other. Two different tub sizes and designs are currently in use. Two of the benches have 226 litre, round bottomed, stainless steel tubs, whilst the remainder have flat bottomed, 200 litre tubs. Each tub has a simple bung to block the drain plug, but no overflow pipe. As the fish are filleted, the fillet, head and lugs are thrown into boxes, whilst the frame is thrown onto the offal conveyor. Small pieces of fish and gut lining are flicked into the tub.

6.1.1 Water usage

The way water is used varies with individual filleters. Typically the tub is half filled with water before adding 2 to 3 boxes of fish. The water is changed or topped up when a new batch of fish are added or when it is considered by the filleters to be 'dirty'. Occasionally water was observed to be left running.

The average flow rate to the benches varied from 20 l/min to 40 l/min. The benches used between $2.2m^3$ and $7m^3$ per day resulting in a total of $82.1m^3$ of water used during the audit.

6.1.2 Effluent production

A significant amount of waste ends up on the floor around the filleting bench as a result of careless throwing (Figure 2).

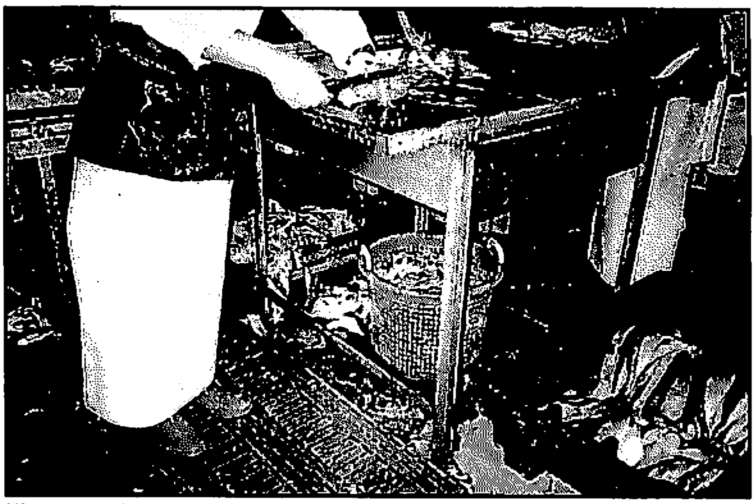

Figure 2 - Waste on the floor around a filleting bench

Much of this material is then broken up underfoot which can significantly add to the effluent loading. When the bench drain plug is removed, the water and pieces of fish empty into a catch basket (aperture size 5mm). Small pieces of fish are washed through the catch basket onto the floor.

Samples of filleting effluent were taken. The COD and TSS of the effluent was 1500 mg/l and 228 mg/l respectively.

6.1.3 Conclusions and recommendations

The volume of water used in filleting is considerable. The water consumption and flow rates to the different benches vary significantly and it is important to try and control them. A change in management practices, such as a more structured policy on water usage should be introduced and enforced. Particular attention should be given to preventing the use of continuously running water. If continually flowing water remains a problem, flow regulators can be fitted (approximate cost £10 excluding installation) to control the flow of water to each bench.

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.

To keep future trade effluent charges low, waste material must be kept off the floor and out of the drains. Calculations indicate that the future disposal charges associated with effluent produced during filleting could increase from the current £0.18/m^3 to £0.95/m^3. The filleting benches could be modified to include a simple offal tray (Figure 3). Small pieces of fish could be flicked into this tray to keep fish out of the central tub and off the floor. Filleting tubs and catch baskets should be emptied and cleaned regularly.

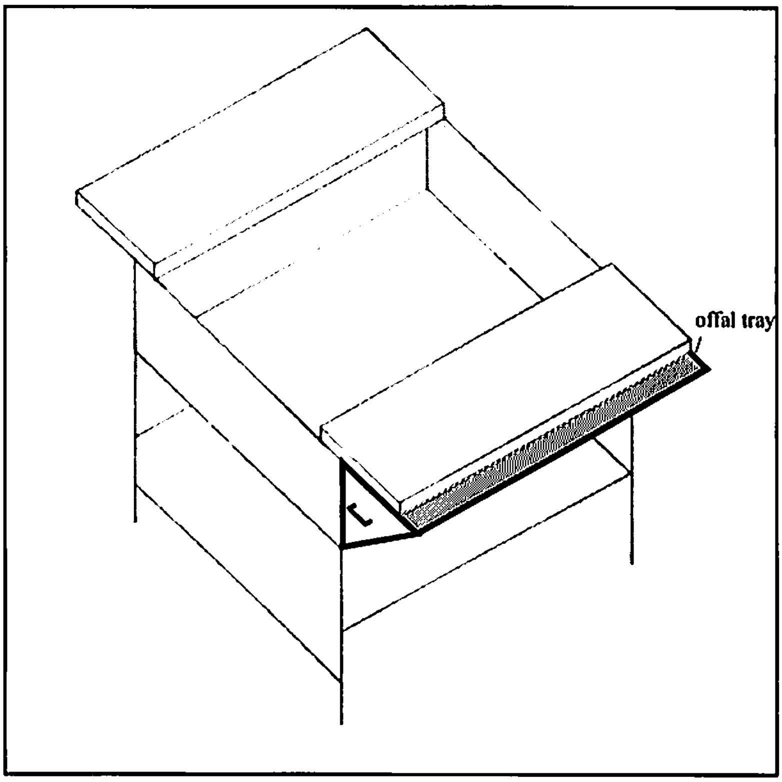

Figure No. 3 - Possible filleting bench modification

6.2 Skinning

A Baader 51 skinning machine is used to skin fillets when required. The machine is connected to a water point by a flexible hose. The water supply is turned on and off, 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).

6.2.1 Water usage

During the audit, 11.3m^3 of water was used in the skinning process. The flow rate of water into the machine is typically maintained at 28 l/m. The manufacturers recommended flow rate is 25 l/m.

Water was 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 effectively using less water, a basic trial was undertaken.

Fish were skinned at a flow rate of 28 l/m and then at reduced flow rates of 15 l/m and 10 l/m. The effectiveness of skinning was determined by observing the operation of the machine and comparing the fillets after skinning. No change in the appearance of the fillets was apparent when skinning at the different flow rates.

6.2.2 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 TSS of the initial effluent without skins was 538 mg/l and 218 mg/l respectively. After passing through the catch basket the COD increased to 1490 mg/l and the TSS to 220 mg/l.

6.2.3 Conclusions and recommendations

The flow rate of water to this machine is high, exceeding the manufacturers recommended flow rate of 25 l/m. Based on the results of skinning at lower flow rates it is apparent that there is scope to reduce water consumption in the skinning process without affecting the product. The installation of a flow regulator will help to manage and control the water flow.

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

The different strengths of the effluent samples indicate that the current practice of allowing water to wash over the skins in the catch basket adds to the effluent load, as the strength is significantly higher than the water which initially falls from the machine. 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 the future disposal costs of the effluent produced during skinning will increase from £0.18 per m^3 to £0.95 per m^3, based on skinning fish at 28 l/m.

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.

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 fall into the basket.

6.3 Cleaning

The main source of organic material on the floor comes from the filleting process. After filleting the majority of waste is shovelled up. The floor is then cleaned and a significant amount of waste is washed down the drain. Occasionally drain covers were lifted and catch baskets removed to make this task easier. The design of the catch baskets (Figure 4) caused them to block by the end of the day's filleting, when they are emptied. A night cleaner washes down and sanitises the equipment, floor and drains. This operation was not observed.

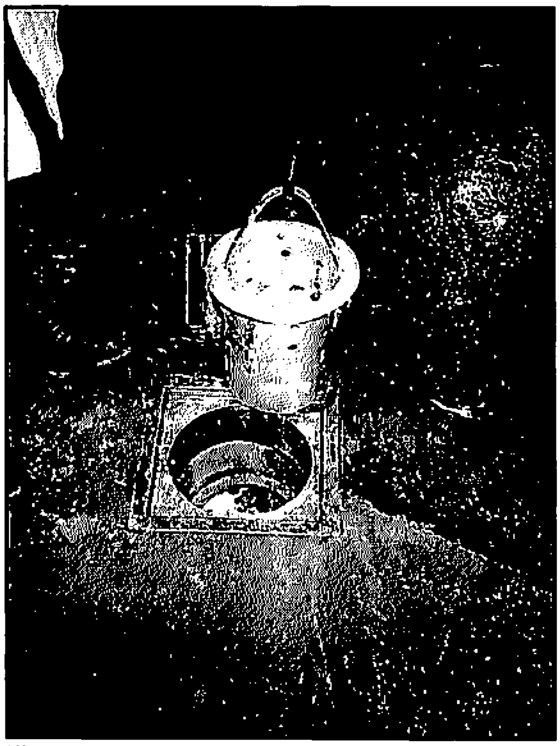

Figure 4 - Poorly designed catch basket

6.3.1 Conclusions and recommendations

Any solids ending up on the floor after changes in working practices or filleting bench design, must be collected and sent for fishmeal, rather than being brushed down the drain which will add considerably to the cost of future effluent treatment charges.

The drain covers should be redesigned using 6mm punch plate or small aperture wedge wire to prevent large solids entering the drains. The covers should incorporate a simple locking device to prevent them being lifted by general staff. The design of the catch baskets is ineffective. The location of the holes drilled into the side of the catch basket allows the bottom half of the basket to fill with solid material and the size of the holes allows large solids to escape into the drain. Catch baskets should also be re-designed from punch plate or wedge wire to maximise the surface area for filtration. Catch baskets should be emptied frequently as effluent washing through a full catch basket picks up additional material which can add significantly to the strength of the effluent.

6.4 Ice Production

Two flake ice machines are used to supply ice for the site. One of the ice machines was installed on the second day of the audit.

6.4.1 Water usage

It was impossible to individually meter the ice machines due to difficulties in gaining access to the water supplies. The water usage is estimated based on the capacity of each machine.

The older ice machine has a capacity of 1 tonne of ice per day. This machine was operating for one day of the audit and is estimated to have used $1m^3$ of water. The newly installed ice machine has a capacity of 3 tonnes of ice per day. This was operating for three days of the audit and is estimated to have used $9m^3$ of water in this period.

During the audit the total water consumption in ice production is estimated to be $10m^3$.

6.4.2 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 four day period of the audit, it is calculated that approximately £133 per year could be saved 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 the landlord Associated British Ports who in turn will approach 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 trade effluent disposal costs. The effluent samples obtained during the audit indicate that the effluent leaving the site has a COD of 1600 mg/l and a TSS of 272 mg/l. This would result in trade effluent treatment charges increasing from the current rate of £0.18/m^3 to £1.01/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. The filleting benches should be modified to incorporate a catch tray, to prevent waste entering the tubs or falling on to the floor.

- Drain covers and catch baskets were found to be ineffective, allowing waste to easily enter the drain. Drain covers and catch baskets must be redesigned and replaced to prevent this problem. Catch baskets should be emptied more frequently.

- 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 the skins in the catch basket.

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

It is calculated that approximately 6.6m^3 of water is used to produce 1 tonne of fillets (includes filleting, ice production, skinning and cleaning). As a result of the observations there appears to be scope for further reducing water usage.

- 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 excessive flow rates and leaving water on unnecessarily in skinning. Changes in practices should be introduced and a flow regulator should be installed to help control and manage water usage.

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.

Anglian Water have not formalised their plans, with regards 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 in that year.