SILVER FERNS FARMS – FINEGAND
MEAT PROCESSING EFFLUENT TREATMENT PLANT UPGRADE

Azam Khan **MIPENZ CPEng IntPE(NZ)**
Pattle Delamore Partners Ltd, Auckland

Silver Ferns Farms Limited upgraded its Finegand meat processing effluent treatment plant in 2007 at a cost of $12M in response to resource consent conditions requiring improvement in discharged wastewater quality. The key issue was to ensure that the effect of the final discharge was such that contact recreation quality was still maintained in the Koau Branch of the Clutha River / Mata-Au.

A greenfield physico-chemical treatment plant using an innovative process patented by Pattle Delamore Partners Ltd was constructed to treat up to 15,000 m^3/d effluent generated from the integrated sheep/lamb and beef meat works and rendering plant. In October's NZWWA annual conference, a paper by the author was presented that discussed the resource consenting programme and the engineering design. The following is a modified version of that paper detailing the upgrade aspects.

INTRODUCTION

Silver Fern Farms Limited is the largest meat export company in New Zealand with processing sites located from Dargaville to Invercargill. Silver Fern Farms employs about 8,000 workers at the peak of the season. Silver Fern Farms owns and operates its largest integrated meat processing plant at their Finegand plant near Balclutha and employs over 800 employees. The meat processing plant processes up to 12,000 sheep/lamb and 500 cattle, with additional meat rendering operations at the site. The Finegand plant is responsible for about 15% of the company's production throughput.

The resource consent for the discharge of wastewater into the Koau Branch of Clutha River/Mata-Au required renewal. The Finegand meat processing plant had been discharging up to 22,000 m^3/d primary treated meat processing wastewater to the Koau Branch of the Clutha River for many years.

From the outset, Silver Fern Farms made a decision that the wastewater treatment system at the Finegand site would be upgraded to secondary and tertiary treatment level, to meet the requirements of the Water Plan of Otago Regional Council and also demonstrate continual improvement in environmental performance. Silver Fern Farms accepted that increased levels of wastewater treatment were the norm in New Zealand for discharges to surface water.

During the start of the environmental investigations, Silver Fern Farms undertook a preliminary engineering costing for the likely treatment options and determined that three possible treatment technologies could fit with the likely tightening discharge limits that may be imposed for the site. The technologies involved conventional anaerobic/aerobic biological treatment plant and acid assisted chemical treatment plant. For the resource consents process, Silver Fern Farms presented the outcomes of the likely treatment options and indicated the typical treated wastewater characteristics that could be predicted in terms of treatment effectiveness. One of the problems of presenting the "three likely treatment technologies" was that the disparity in the level of treatment from each treatment technology. The anticipated tightening of the discharge limits for the key contaminants, namely biochemical oxygen demand, total suspended solids, fats, oil & grease and ammoniacal nitrogen, allowed Silver Fern Farms to select one of the treatment options that had been proposed so long as adequate microbial disinfection of the treated wastewater could be achieved.

The resource consent conditions focussed on employing some prescriptive limits as well as addressing in-stream effects, with a stricter microbial contaminant discharge limit in order to meet

the ORC Water Plan policy of moving the Koau Branch of Clutha River/Mata-Au towards contact recreation guideline levels. Silver Fern Farms was granted new resource consent for a term of 15 years in May 2006 following the Environment Court Order after mediation between Silver Fern Farms and ORC. The key discharge compliance limits that have evolved over the last two resource consents are given in Table 1.

Table 1: Summary of Compliance Limits	
Compliance Parameter	**Discharge Limit**
Flow (m^3/d)	20,000
pH (pH units)	6.5 – 9.7
E.coli (cfu/100mL)	15,000 [2,000]
5-day soluble BOD	210
Total suspended solids	70
Oil & Grease	26
Dissolved Reactive Phosphorus	15
Ammoniacal Nitrogen	63
Formaldehyde	6
Notes: *1. All compliance limits in mg/L unless otherwise stated.* *2. BOD = Biochemical oxygen demand* *3. The E.coli limit is set as 90-percentile limit as well as [median limit]. All other parameters except pH are set as 90-percentile limits. pH is set as a range.*	

The key compliance limits were for the microbial contaminants, enumerated as *E. coli* as an indicator organism, biochemical oxygen demand (BOD_5), total suspended solids (TSS) and oil & grease (O&G). The compliance levels were based on the treatment technology that was proposed by Silver Fern Farms and therefore reflects slightly higher levels for BOD_5 and dissolved reactive phosphorus (DRP). The ammoniacal nitrogen limit had been set at a slightly higher level because the proposed treatment technology resulted in the removal of a substantial amount of total Kjeldahl nitrogen (TKN) a precursor to ammoniacal nitrogen, and the resultant discharge of ammoniacal nitrogen would not have resulted in adverse effects. A tighter limit for formaldehyde was set as it was determined that the higher formaldehyde concentrations may have been contributing to fish tainting in the river.

During the resource consents process, the discharge limits recommended by Otago Regional Council and then subsequently agreed by Silver Fern Farms leaned towards a modified form of the chemical treatment option proposed by Silver Fern Farms.

INVESTIGATED TREATMENT OPTIONS

Silver Fern Farms had considered three options for secondary treatment and two options for tertiary treatment. The treatment options included:

1. Option 1 - A biological wastewater treatment plant consisting of anaerobic lagoons (3.5 ha, 6 m deep), lamella plate separator, aerated lagoon (1.1 ha, 5 m deep) and secondary clarifier if tertiary treatment using ultraviolet (UV) disinfection; or

2. Option 2 - A biological wastewater treatment plant consisting of anaerobic contact lagoon (0.5 ha, 6 m deep) and lamella plate separator if tertiary treatment using facultative pond (24 ha) and maturation ponds (10.5 ha); or

3. Option 3 - A physico-chemical treatment plant using Meat Industry Research Institute of NZ (now part of AgResearch) [MIRINZ] double pH-adjustment method and using dissolved air flotation (DAF) unit, with flow equalisation basins upstream and downstream of the DAF unit, and tertiary treatment using UV disinfection.

During in initial engineering options analysis, Silver Fern Farms determined the expected treatment efficiencies for various contaminants of the proposed options as outlined in Table 2.

Table 2: Treatment Options and Predicted Treated Wastewater Quality

Compliance Parameter	**Treatment Options Proposed**		
	Option 1	**Option 2**	**Option 3**
pH (pH units)	7.0 – 8.5	7.0 – 8.5	8.5 – 9.1
E.coli (cfu/100mL)	15,000 [2,000]	15,000 [2,000]	33,000 [6,300]
Temperature (°C)	30	20	30
5-day soluble BOD	30	25	240
Total suspended solids	80	120	109
Oil & Grease	30	25	26
Total phosphorus	15	15	3
Dissolved Reactive Phosphorus	13	13	< 1
Total nitrogen	174	174	79
Ammoniacal Nitrogen	160	160	63
Total Sulphide	< 1	< 0.5	1.3
Formaldehyde	undetected	undetected	7.8

Notes:

1. *All compliance limits in mg/L unless otherwise stated.*
2. *BOD = Biochemical oxygen demand*
3. *Option 1 – Anaerobic Lagoon and UV disinfection.*
4. *Option 2 – Anaerobic Contact Lagoon and Facultative/Maturation Ponds.*
5. *Option 3 – Physico-Chemical DAF and UV disinfection.*
6. *All predicted discharge compliance limits are shown for 90-percentile values, except for E. coli also shown as [median] and for pH shown as a range.*

Pattle Delamore Partners Ltd (PDP) was engaged by the ORC to peer review the proposal that Silver Fern Farms had put forward for consenting purposes. During the peer review, it was determined that a modified layout for Option 3 (physico-chemical DAF and UV disinfection) was able to provide a better wastewater quality, especially in relation to further reduce *E. coli* as the clarity of the discharge was considerably improved. This modified process was a patented system (NZ Patent 539117) developed by Pattle Delamore Partners Ltd and had been employed at another large meat processing plant in Southland for the removal of contaminants from high phosphorus laden waste streams.

While still working through the resource consents process, Silver Fern Farms approached ORC to engage PDP to assist Silver Fern Farms to further investigate the merit in the use of modified Option 3. The Environment Court and ORC agreed that Silver Fern Farms could engage PDP to provide technical advice to develop modified Option 3 as a viable solution.

INVESTIGATION CONCEPT TO TRIAL

The use of chemically assisted dissolved air flotation (DAF) to remove contaminants from meat processing plants is a well established practice in New Zealand and generally uses pH adjustment to precipitate the proteins out of meat processing wastewater in order to assist nitrogen removal before the proteins are mineralised. The dissolved air in the DAF unit is then utilised to separate the solids from the effluent and generally a clear subnatant is discharged.

The MIRINZ double step pH adjustment process utilises an acid phase step and an alkali phase step to precipitate various dissolved contaminants prior to utilising a DAF plant for the separation of the solids from the liquid. The initial acid step allows the precipitation of dissolved proteins and the subsequent alkali step allows the precipitation of haemoglobin resulting in further removal of biochemical oxygen demand. A generalised block diagram of the treatment process is given in Figure 1.

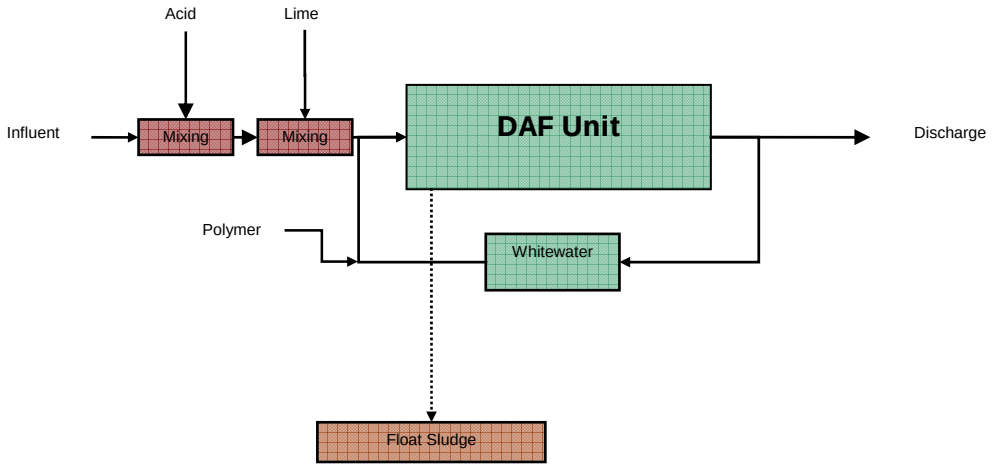

Figure 1: MIRINZ Double step pH Adjustment Process

An innovative modification of the MIRINZ double step pH adjustment process is the separation of the pH adjustment steps with intermediate solids separation, using the DAF-in-Series principle. This results in the reduced chemical requirements, especially in the alkali phase and the significant improvement of water clarity in the final chemically treated wastewater. A generalised block diagram of the treatment process is given in Figure 2.

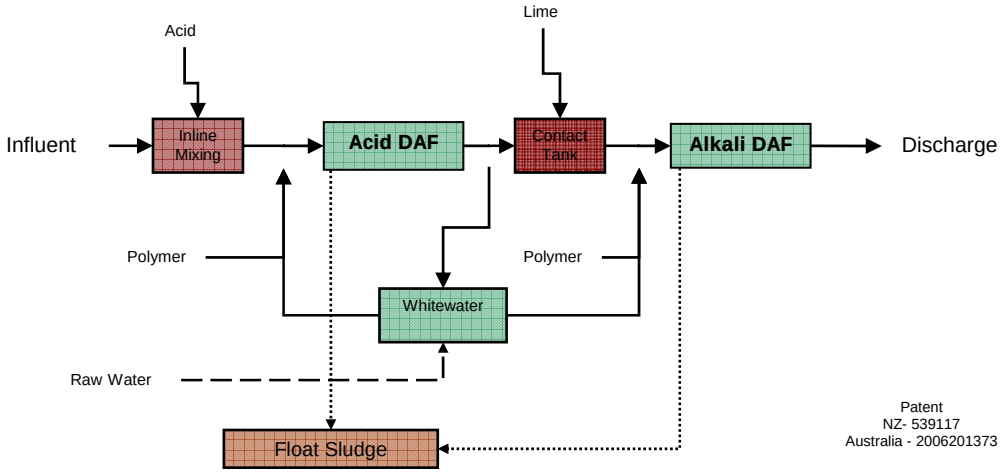

Figure 2: PDP DAF-in-Series Patented System

The typical efficacy in terms of contaminant removal in the use of the DAF-in-Series system can be shown in Figure 3. The lighter bar shows the typical contaminant removal in the acid phase and the darker bar shows the additional removal in the alkali phase. Apart from phosphorus, which is substantially removed in the alkali phase, a significant increase in contaminant removal is observed for BOD, soluble BOD and nitrogen species.

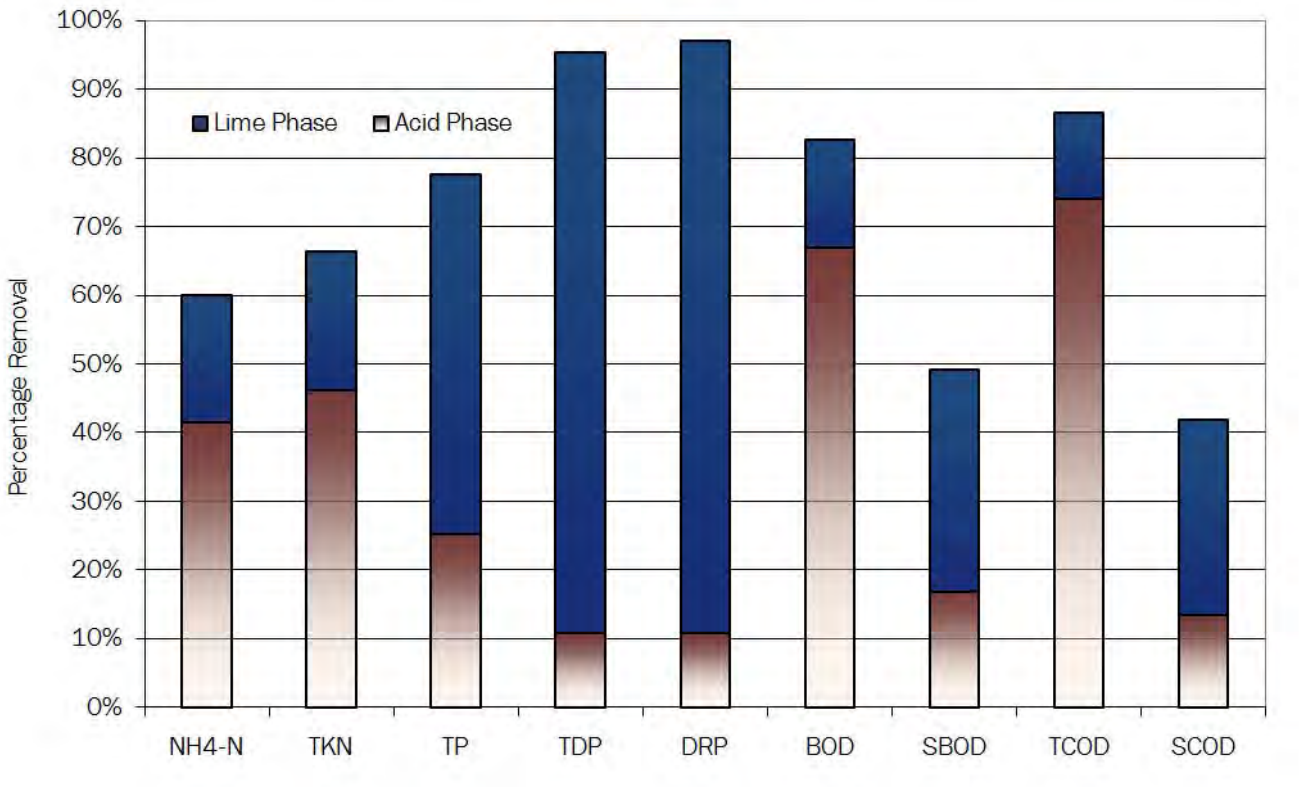

Figure 3: Typical Contaminant Removal in DAF-in-Series Patented System

Silver Fern Farms commissioned a DAF-in-Series trial on meat processing wastewater from the combined sheep/beef processing plant at Belfast, Christchurch. The units were operated at 10 m^3/hr, having the ability to treat up to 200 m^3/d (20-hour operation). This allowed the trial system to run at around 1% flow ratio to the proposed consented full-scale system at Finegand. Silver Fern Farms ran the trial for a period of 3 – 4 months, under various operating regimes.

The influent and treated wastewater characteristics monitored during the trial is given in Table 3. A list of the key discharge limits that were recommended by ORC is also given for comparison.

Table 3: DAF-in-Series Trial Performance Data

Monitored Parameter	**Influent**	**Pilot Scale Trial**	**Consent Limit**
E.coli (cfu/100mL)	3.5E+06 [2.0E+06]	6,900 [1,000]	15,000 [2,000]
5-day soluble BOD	477	169	210
Total suspended solids	1,655	36	70
Oil & Grease	857	< 20	26
DRP	13.2	< 0.6	15
TKN	153	54	-
Ammoniacal Nitrogen	58	38	63

Notes:

1. *All parameter concentrations in mg/L unless otherwise stated.*
2. *BOD = Biochemical oxygen demand; DRP = Dissolved reactive phosphorus; TKN = Total Kjeldahl nitrogen.*
3. *All data is based on 90-percentile values. For E. coli the [median] values are also given.*

The results obtained during the pilot scale trial provided a considerable amount of confidence to Silver Fern Farms that the modified Option 3, using the innovative process of DAF-in-Series, would satisfy the treatment objectives that were set by Silver Fern Farms and also meet the discharge limits.

ENGINEERING DESIGN AND CONSTRUCTION

In order to ensure that the new wastewater treatment plant was built on time, Silver Fern Farms explored outsourcing the capital project as a possible design & build project from a third party. This resulted in Silver Fern Farms requesting for proposals from various design/build teams. The advantage in having an approach of this manner was that it still allowed further exploration of alternative options than what Silver Fern Farms had initially proposed for the consents process. Treatment options other than DAF-in-Series would also be allowed to be explored to design a new treatment plant to meet the consent limits. However, all proposals received by Silver Fern Farms recommended DAF-in-Series option.

In order to allow the DAF-in-Series option to be taken further, the front end engineering design (FEED) was contracted to a third party construction company who had exclusive arrangements with the patent owners. The FEED documents were prepared within two months and submitted to Silver Fern Farms for project execution. Silver Fern Farms decided that progress to construction could be undertaken internally by Silver Fern Farms engineering teams and internalised the detailed design programme.

The FEED documents were prepared to a level that much of the detailed engineering could be avoided and the construction of the new treatment plant could be undertaken based on the process and instrumentation diagram layouts. The long lead mechanical items identified during the FEED were pre-ordered while the civil design and electrical design was completed in-house by Silver Fern Farms. Specialist engineering advice on various civil, electrical and mechanical design was outsourced from various local specialist engineering organisations.

Primary treatment that was already at the site consisted of an influent flow lifting station using an Archimedes screw supported by submersible centrifugal pumps, rotating milliscreens and a primary clarifier.

The **secondary treatment** process is a chemically assisted DAF-in-Series plant consisting of flow equalisation basin (FEB) prior to chemical treatment, acid dosing system including contact tank, solids separation using first stage dissolved air flotation, lime dosing and second stage dissolved air flotation. The FEB is utilised as the production wastewater is generated over a 10-hour day shift, and the treatment is undertaken over 24 hours. The influent is pumped into 2 flow trains of parallel DAF-in-Series plant, each flow train pumping controlled by variable speed drives so ensure equal flow into the DAF tanks. The acid is forced into the main flow stream and assisted with in-line mixing together with additional contact tank mixing to promote coagulation. A treated effluent recycle stream is utilised as a polymer carrier as well as for carrying dissolved air. For the alkali phase, a lime slurry made from hydrated lime is directly added into the acid phase discharge stream and allowed to mature in the alkali phase contact tank. The polymer and dissolved air is supplied in the same manner as the acid phase stream. The DAF tanks are operated on the counter-current float sludge recovery to avoid sludge carry-over near the discharge end of each tank. Any grit and other fine settleables are removed periodically from a series of bottom hoppers in the DAF tanks. Nearly all the pipe work and tank construction including DAF tanks and mixing tanks are constructed of stainless steel.

The **tertiary treatment** system provides for clarified subnatant from the alkali phase DAF to pass through a series of in-line fully enclosed low pressure high output UV disinfection lamps before discharge into the Koau Branch of the Clutha River/Mata-Au via a 2 port diffuser on the river bed.

The construction programme was generally over the winter months when the processing plant was in shutdown season. The construction of the $12M capital works project was completed within 10 months after the FEED documents were prepared and Silver Fern Farms commissioned the new wastewater treatment plant at the start of the processing season in November 2007 in time for the new discharge limit that came into effect on 1 December 2007.

During the first processing season (2007 – 08) of operation, Silver Fern Farms has been making process improvements to reduce chemical usage for treatment. Additional up the pipe remedial works are being undertaken to reduce the amount of contaminant discharge, especially oil & grease, into the treatment plant so that there would be progressive treatment efficiency gains.

The general layout and overall view of the upgraded treatment plant is shown Photograph 1. The layout shows the existing primary screening facilities and the primary clarifier in the far right, the newly constructed flow equalisation basin at the left and the DAF-in-Series system in the centre of the photograph with the ancillary chemical facilities, UV disinfection units and control room. The processing plant facilities are shown on the top left of the photograph.

Photograph 1: Overall layout of the Finegand Upgraded Wastewater Treatment Plant

SOLIDS MANAGEMENT STRATEGY

In parallel to the use of innovative wastewater treatment process upgrade at the Finegand site, Silver Fern Farms also undertook an innovative process to manage the solids generated from the wastewater treatment facilities. The solids are generated from the primary treatments processes and the DAF-in-Series system. All the wastewater treatment solids except the stockyard wastes are collected and combined with the DAF float sludge. The mixed sludge is then heated using steam and then centrifuged. The dry solids from the centrifuge is then fed to purpose built boiler that incinerates the wastewater sludge together with wood waste for the meat processing plant's hot water and steam generation. The boiler can also handle a proportion of coal fines as supplementary fuel. The waste liquid from the centrifuge is fed back to the wastewater treatment plant. Silver Fern Farms considers that the incineration of the wastewater solids eliminates the need for landfilling of sludge and reduces the need for composting of the sludge which requires a large amount of bulking material with limited disposal options. Silver Fern Farms Finegand, however, undertakes some composting as a parallel option to handle primary screen solids unsuitable for centrifuging and as a backup to the boiler operation.

SUMMARY

Silver Fern Farms Finegand plant has upgraded its wastewater treatment plant to meet the tightening environmental limits imposed on the site as a result of implementation of the ORC Regional Policy Statement and the Regional Water Plan.

During the resource consents process, Silver Fern Farms had recognised that a modified layout of a physico-chemical treatment plant using DAF would achieve the compliance limits imposed on the site by ORC. Silver Fern Farms Finegand confirmed the use of an innovative process prior to the upgrade by commissioning a pilot scale DAF-in-Series (NZ Patent) at their Belfast meat processing plant. The upgrade of the facilities resulted in maintaining a very small footprint against the other alternatives available.

The design, construction and commissioning was completed within 12 months of granting the resource consent with an estimated capital cost of $12M.

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ABOUT THE AUTHOR

Azam Khan is a senior environmental engineer with more than 17 years of experience. His specialist areas include wastewater treatment and disposal, solid wastes and resource consenting. He developed the patented DAF-in-Series system.