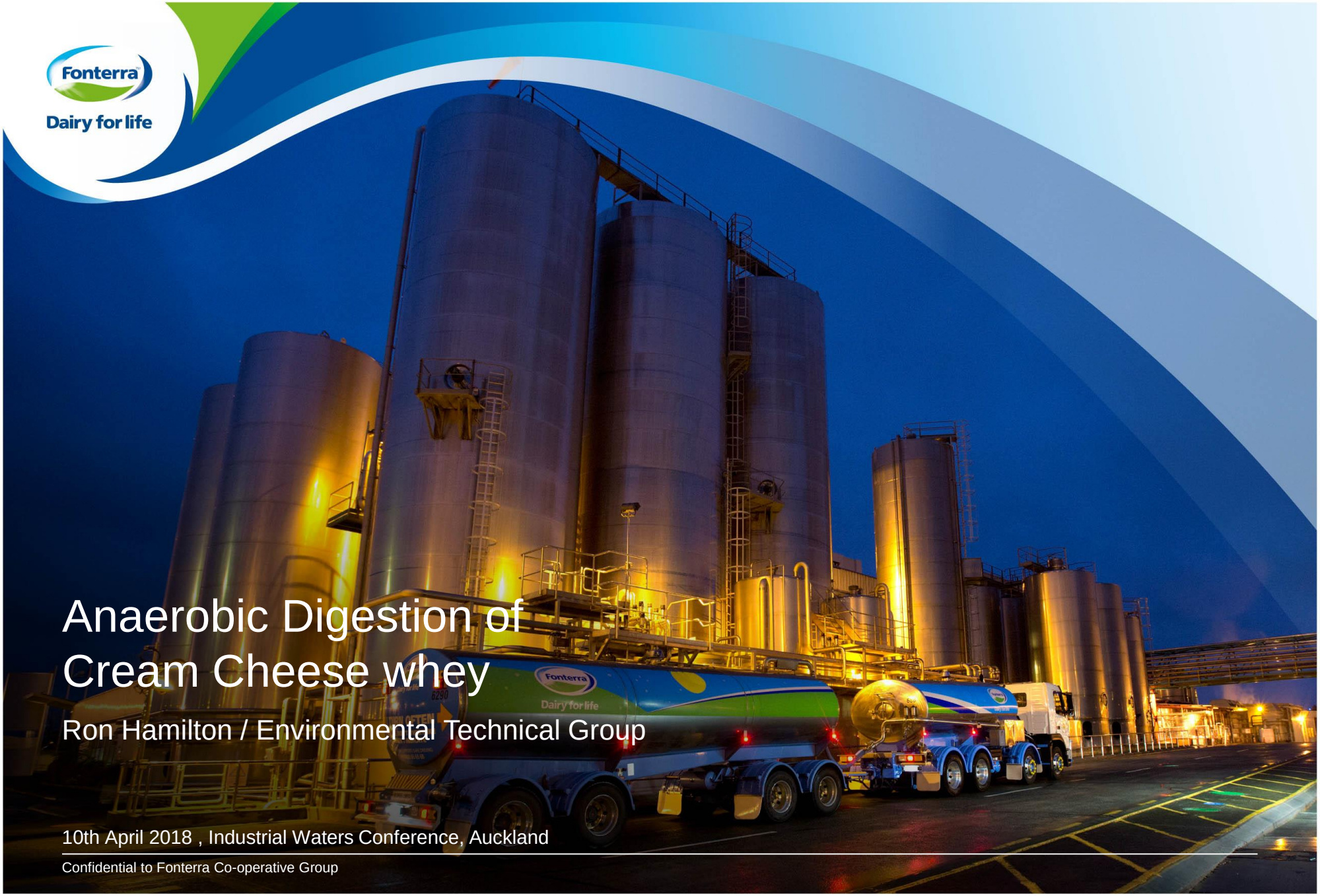

Anaerobic Digestion of Cream Cheese whey

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What was the need?

- Cream Cheese is a high demand consumer foodservice product,
- It is used to make cheesecakes and Tea Macchiato- a tea drink taking China by storm- 200 million serves each year.
- Most product is sold in frozen form to China
- Te Rapa has two cream cheese plants but due to market demand it has been decided to expand production to the Darfield site
- Construction of the Cream Cheese plant at Darfield is well under way with the first product expected in August.
- Cream cheese production generates what we term a High Strength Waste (HSW) being “Cream Cheese Whey” (CCW)

Tea Macchiato- very little phase mixing

Cream Cheese Whey composition (typical)

Component	% or concentration
COD (Chemical Oxygen Demand)	89,000mg/litre +
Total nitrogen	943 mg/litre
Total phosphorus	756 mg/litre (90%)
Fat	0.55% (but up to 2%)
Total sulphur	145 mg/litre
pH	4.3

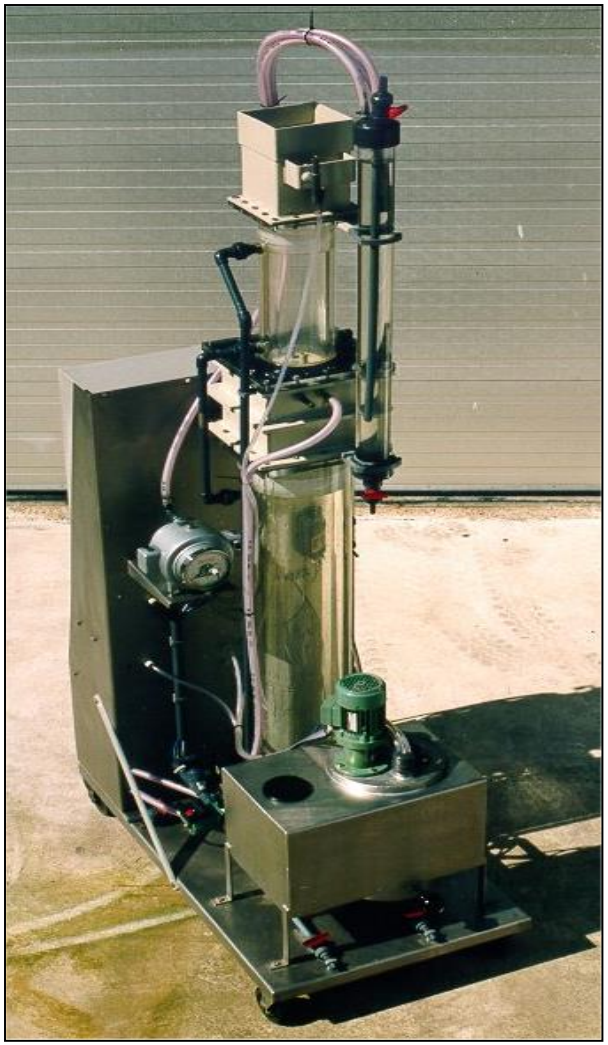
Fonterra Darfield site

- The Darfield site is ~40 km to the West of Christchurch
- It is exclusively a land based wastewater disposal site with very tight limits on nitrogen
- The Darfield farms are close to being fully committed in terms of their nitrogen assimilation capacity
- The nutrients contained in the whey (nitrogen and phosphorus) could possibly be applied to the Darfield irrigation area but Fonterra was looking for a sustainable longer term option

Anaerobic digestion option

- Quotes for the supply of two pilot scale anaerobic digesters were sought, Fonterra opted to operate these in parallel- both plants were fed from a common container (1000 litre pod) of CCW
- ADI (now a part of BPO) provided one unit (nominal volume of 1200 litres)- described as an Anaerobic Contact Process (ACP) digester.
- Paques (Netherlands) supplied a 60 litre ICX digester.

Paques ICX digester



ADI (BPO) ACP digester

Anaerobic digestion

- CCW could be treated in either a contact type reactor or an ICX type digester, the key in terms of capital cost is to keep process volume as small as possible.
- To achieve this objective, the solids content of the digester needed to be maintained as high as possible- target volumetric loading rate was ~5 kg of COD applied per m^3day. By way of comparison, the maximum loading rate achieved in the Tirau existing digester is ~2 kg of COD/m^3/day.
- The existing Tirau process was an ideal source of inoculum for both digesters, the Tirau sludge was concentrated as much as possible (gravity) prior to transfer to the pilot digestion processes.
- CCW was collected in 1000 litre pods from the Te Rapa CC plant; for the ADI system a pump was installed in the IBC and this served as a mixer prior to product transfer to the digester.
- Feeding the Paques process was via a series of pumps but the volume being fed was much less, a set of scales was used to accurately measure feed volume and this provided information for the COD loading rate to be determined.

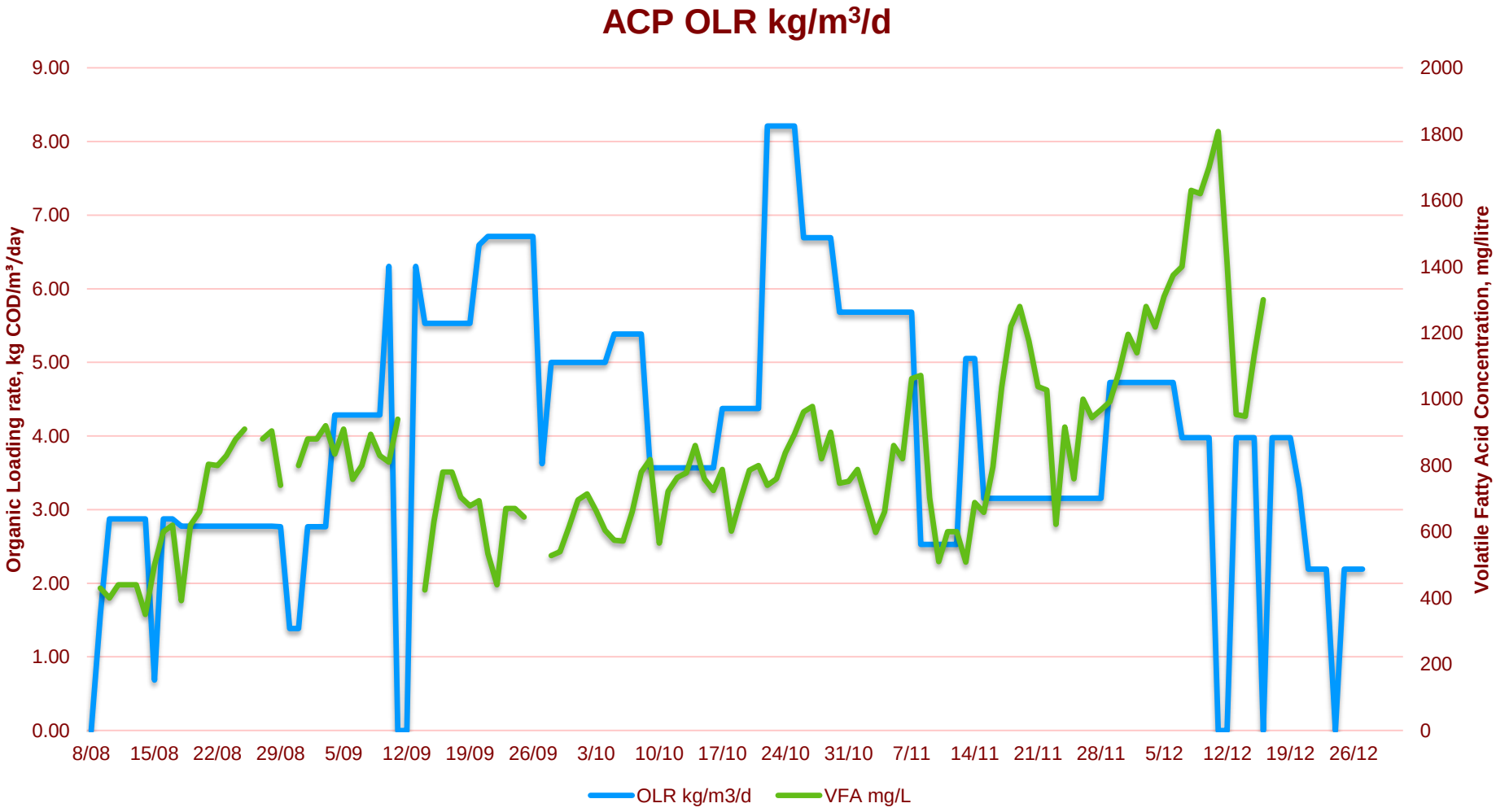
Paques ICX

- A very tall installation requiring a ladder to secure samples from the top three phase clarifier
- Two three phase clarifiers, this enabled some (most) gas to be removed from the fermentation half way up the column reducing turbulence in the top section- and reducing solids loss. It also helps with the growth of a concentration gradient (biomass) within the digester.
- The CCW was fed (very slowly given its strength) into a pre-acidification (PA) tank to one side of the column and the acidified wastewater was fed into the base of the lower section.
- A small amount of treated wastewater was recycled through the PA tank (alkalinity recovery) and the balance (volume associated with CCW feed) overflowed to the waste container.
- It was not found necessary to feed either trace metal nutrients or additional alkalinity into the process during the trial.
- A gas meter was supplied with the unit, but this didn't seem to work- however gas production rates are well known from a given mass of COD.

ADI (BPO) contact digester

- A pump was run continuously to keep the process contents well mixed.
- The process was fed every three hours using a large peristaltic pump
- While the process was being fed, a second peristaltic pump transferred settled sludge from a clarifier back to the process. The returning sludge was thickened using polymer to ensure that as few solids were lost from the clarifier (system) as possible
- Gas production was measured continuously using a small meter- production was ~0.32 m^3/kg of COD applied.
- A number of parameters (volatile fatty acids- VFA) were measured daily and nutrients in the digestate less frequently
- Feed volume was adjusted to keep the VFA concentration in the required range- by changing the run time on the peristaltic pump
- No trace metal nutrients or alkalinity were required to be dosed during the trial

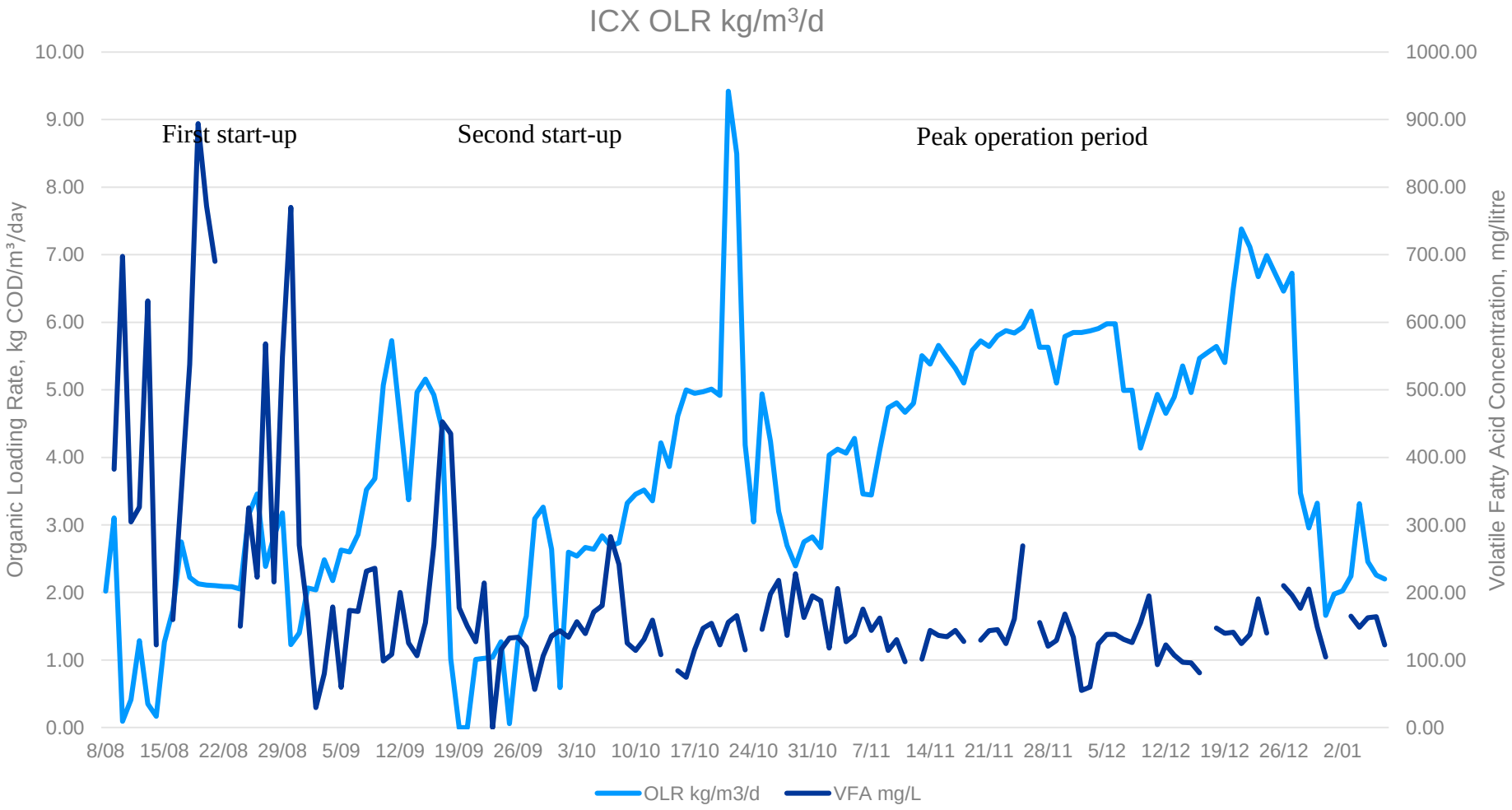
Loading rate results for the ADI (BPO) digester- Anaerobic Contact Process (ACP) reactor



ADI- BPO comments/observations.

- The process was able to maintain a loading rate of ~5 kg of COD/m^3 for extended periods.
- At small scale it is very hard to mimic the sludge concentration technology that would be used in a full scale plant (rotary vacuum filter, screw press etc.)- this issue resulted in excessive sludge loss at times.

Paques ICX Organic Loading Rate (OLR)



Comments on the Paques IXC reactor

- The Paques similarly maintained an OLR of around 5 kg COD/m³/day
- As a trial, polymer was added to the process as a way of accelerating the achievement of steady state conditions- reduced solids loss. Unfortunately the polymer stopped the ready release of gas from the sludge and caused significant loss of solids from the top three phase separator- requiring a re-start.
- CCW composition varied significantly from batch to batch, the COD of the feed was not measured daily resulting in high OLR after a change in pod.
- The ICX digester feed system produces a sludge gradient from the bottom to the top- fed from the bottom. The lower digester solids content were very hard to measure (and resulted in a significant biomass loss if undertaken too frequently). When measured they were between 27-29 kg/m³- similar to the BPO digester using a different concentration technology.

Nutrient composition of the treated CCW

- Suspended solids were lost from each digester more or less continuously at a low rate. In addition to the solids lost- which contained nitrogen and phosphorus, soluble nitrogen (as ammonia) and soluble phosphorus (as Dissolved Reactive Phosphorus (DRP)) were also lost.
- The real issue with the AD of CCW was that through the process very few nutrients were actually lost. This meant that Fonterra also had to build an aerobic treatment process that could nitrify and denitrify (to remove nitrogen) and to precipitate soluble phosphorus in an insoluble form- adding considerably to the solution.

Composition of anaerobically treated CCW effluent

Component	Cream Cheese Whey (CCW)	ADI treated effluent	Paques treated effluent
Total COD	67300-126300 mg/litre	2300	2250 mg/litre
Soluble COD	64700 (on 67700 total sample)	240 mg/litre	410 mg/litre
TKN	943 mg/litre (protein plus ammonia)	-	-
Ammonia-N	(300mg/litre- at times)	622 mg/litre (and up to 770 mg/litre)	572 mg/litre
Total Phosphorus	756 mg/litre (90%)	-	93.76 mg/litre
Dissolved phosphorus	677 mg/litre	44.5 mg/litre	62.4 mg/litre
Fat content	0.18%- 2.0 % (FT 120)		

% removal of main constituents

Component	Paques	BPO
COD	96.7%	96.6%
Nitrogen	39.3%	35%
Phosphorus (DRP)	~91%	~93%
Phosphorus (Total)	93.4%	n.d.
Fat	unknown	unknown

A few notes on nutrient measurement

- It was difficult to balance the flows in the Paques system; some water was added at times which resulted in the observed reduced concentrations of nutrients.
- Biomass yields were high in both digesters and due to the extreme difficulty of obtaining a representative sample actual yield was not estimated. The phosphorus concentration was high in both digester sludge's as was the nitrogen content. Calcium phosphate precipitates in the sludge since the AD process operates at neutral pH.

Conclusion and epilogue….

- The use of anaerobic digestion can greatly reduce the COD of the CCW.
- Nitrogen contained in the CCW is not destroyed, some is assimilated into the biomass and the rest ends up as ammonia in the treated wastewater.
- Most of the phosphorus in the whey ends up in the sludge (biomass- around 94%), the balance as DRP in the treated wastewater.
- Due to the need to (also) build an aerobic treatment plant to deal with the nitrogen (nitrification/denitrification) Fonterra has decided to convert the whey into a stockfood in a purpose built drier.
- The whey is a food grade product and while the anaerobic digestion option was attractive it did not address the Darfield site nutrient issues. Fonterra has adopted a Phosphorus application to land target to a maintenance rate only. In terms of AD sludge utilisation, the site doesn't have enough land to which to apply the phosphorus to at maintenance application rates. This made the stockfood option more attractive

Questions….?