Secondary treatment – solid waste

Thickening, digestion, dewatering and disposal

Wastewater information sheet 5

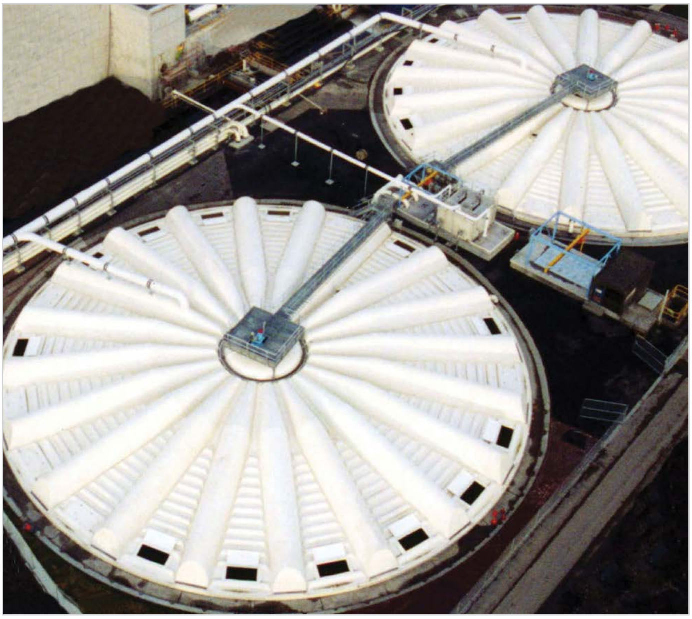
After primary treatment the waste stream is separated into two components – liquid and solid waste. The liquid stream is conveyed to the reactor/clarifiers for secondary treatment (see the information sheet *Secondary treatment – liquid*). The solid waste stream (primary sludge) is passed through gravity thickeners to gravity belt thickeners, and then to anaerobic digesters. Here it is processed before being dewatered and limed to become biosolids – ready for landfill disposal or possible productive re-use.

Pre-secondary treatment

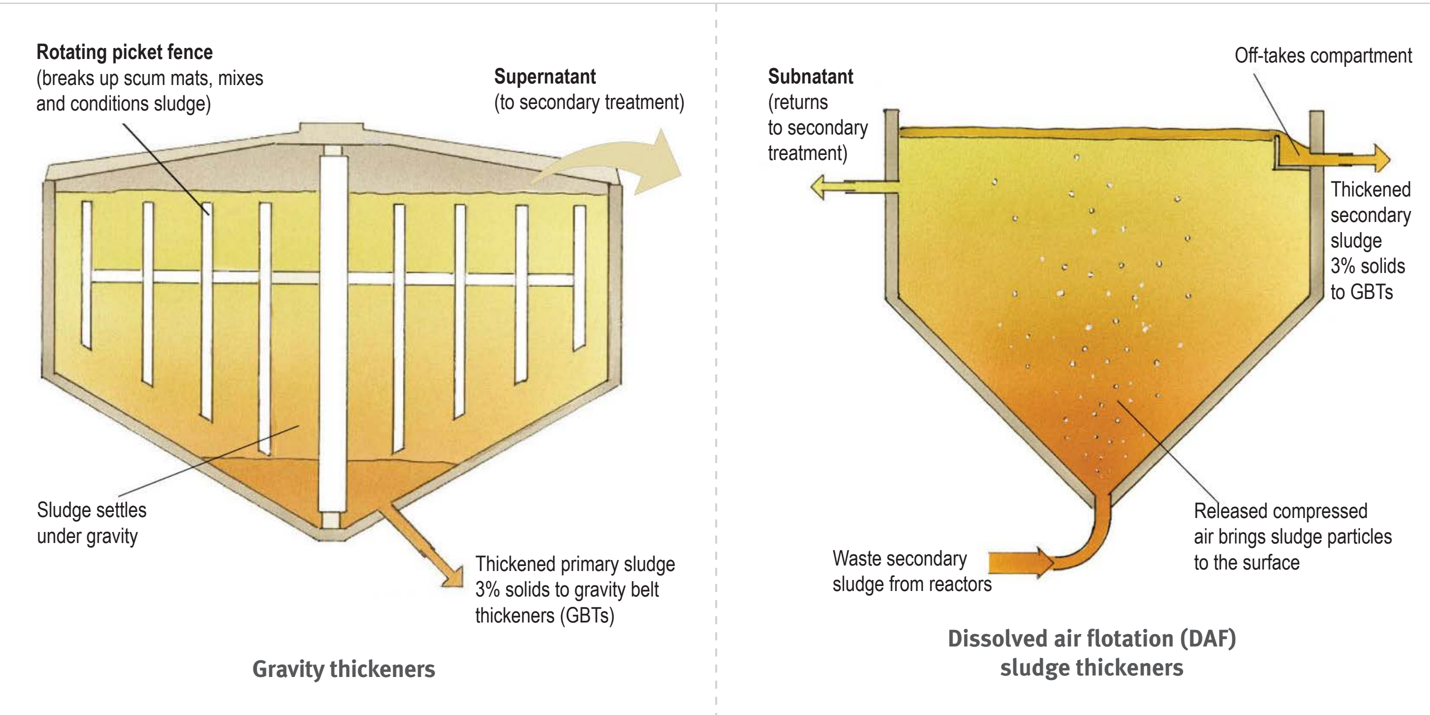
Gravity thickeners

As the sludge extracted from the primary sedimentation tanks is still in very liquid form (approximately one and a half per cent solids), it is required to be thickened to prepare it for digestion. The two gravity thickeners have been built using the concrete structures of two of the former secondary sedimentation tanks. The circular tanks are 37 metres in diameter and three and a half metres deep at the sides, sloping away to a depth of five metres in the centre.

The thickeners are fitted with a picket fence-like mechanism which slowly rotates, breaking up scum mats and releasing entrapped gas. As primary sludge enters the thickener tank, the heavier sludge gravitates to the bottom (hence 'gravity thickeners'). As more sludge enters the thickeners, it settles on the bottom of the tank forming a sludge blanket. As the blanket thickness increases, the weight of the sludge squeezes more water out of the sludge increasing the sludge thickness. The liquid fraction (supernatant) is decanted over a weir and conveyed via the interstage pumping station to the reactor/clarifiers. The remaining settled sludge is sent to the gravity belt thickeners for further thickening before being conveyed to the anaerobic digesters.



The two gravity thickeners along with the gravity belt thickeners, thicken primary sludge from one and a half percent to three percent solids prior to anaerobic digestion.



Secondary sludge

The solid waste known as waste activated sludge discharged from the reactor/clarifiers constitutes a second stream of solid waste. Of the approximately 17,000 cubic metres per day of liquid effluent treated in the reactor clarifiers, about seven per cent (1250 cubic metres) is collected and discharged as solid waste. The waste activated sludge is piped to the dissolved air flotation (DAF) plant for thickening.

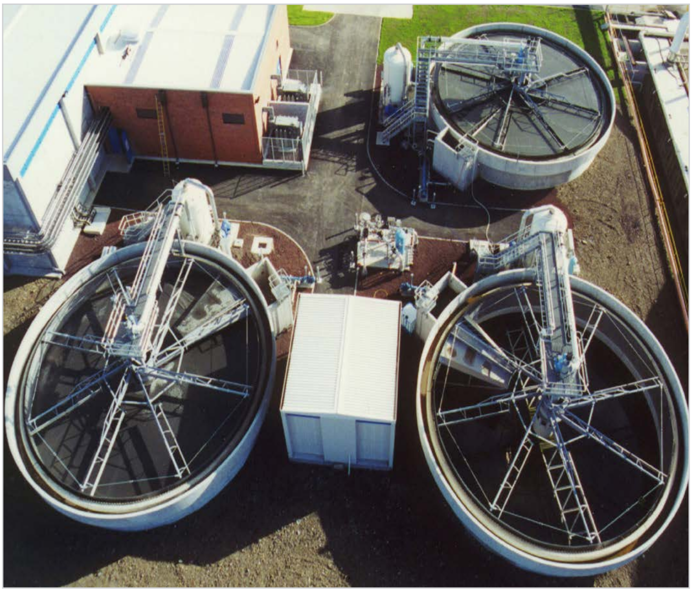
Dissolved air flotation (DAF) thickeners

There are three DAF tanks which are designed to process the waste activated sludge discharged from the nine reactor/clarifiers.

In separating out solids from liquids, the DAF system works on the opposite principle to the primary gravity thickeners. In the gravity thickeners suspended solids are designed to settle to the bottom under the influence of gravity. In the DAF system, thickening works the opposite way round. Waste activated sludge, still in highly liquid form (with a solids content of only 0.2 percent) enters the DAF saturation tanks where it is mixed with compressed air.

The liquid sludge saturated with dissolved air is piped under pressure to the floor of the DAF tank where it is released. The sudden release of pressure causes the air to come out of the solution, forming microscopic bubbles. The microscopic bubbles adhere to the sludge particles which are then transported to the surface to form a floating blanket. Here a slowly rotating arm skims the top layer of thickened sludge into a trough.

The trough is a narrow segment which extends from the outside to the centre of the circular DAF tank. The DAF thickening process increases the solids contents to three percent – a factor of 15. The thickened sludge is sent to the gravity belt thickeners, then piped to anaerobic digesters, while the liquid effluent is passed back to the reactor/clarifiers.



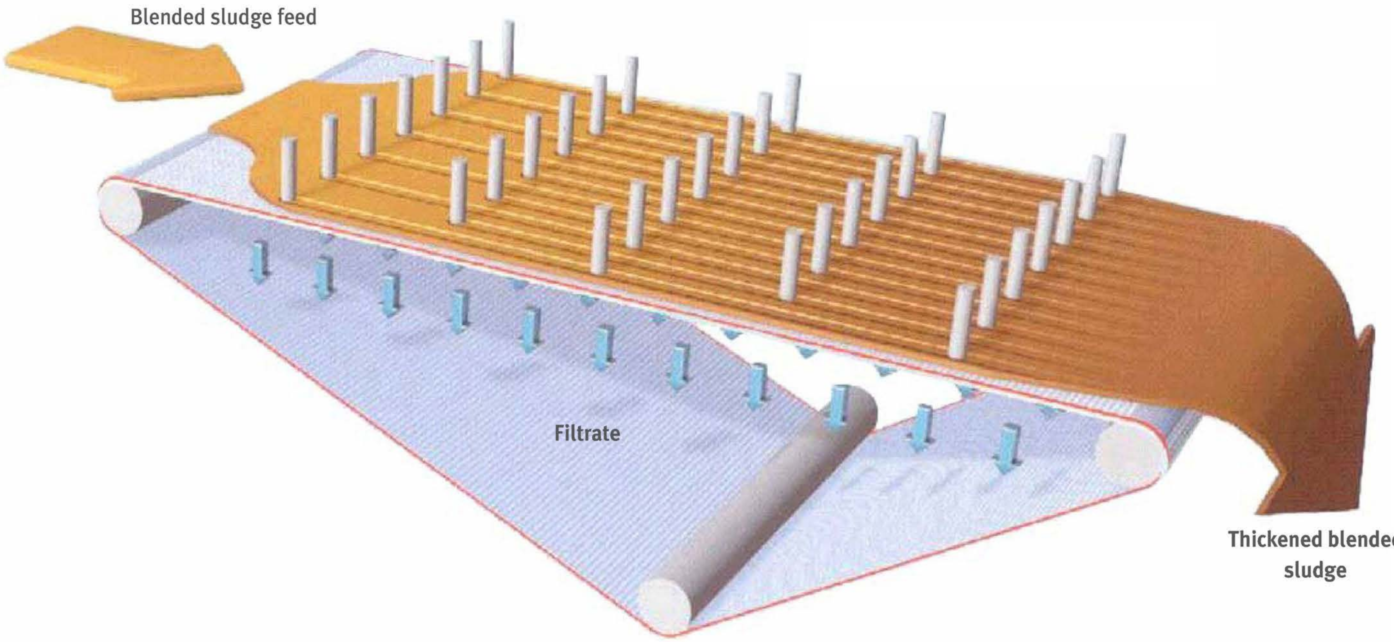
Processing (thickening the solid waste from the reactor/clarifiers) – the DAF system.

Gravity belt thickeners (GBTs)

The two streams are sent to the gravity belt thickeners where it is first blended together in the gravity belt thickener feed tank. The combined streams are approximately three percent solids.

4500m^3 of three percent sludge is thickened over the gravity belt thickeners to produce 2250m^3 of six percent sludge that is fed to the digesters.

How the gravity belt thickeners work



Gravity belt thickener.

The gravity belt with thickened blended sludge.

Secondary treatment

Anaerobic digestion

The seven anaerobic digesters are circular, brick-faced structures with floating concrete covers. Each tank is 30.5 metres in diameter, with an average depth of 10.2 metres and an effective volume of 7,450 cubic metres. The distinctive structures are original process elements retained and progressively upgraded as engineers consider them still the most effective means of treating primary solid waste.

The sludge is fed batchwise to each digester and heated to 37.0 degrees celsius. Digestion at this temperature is called mesophilic digestion.

Sludge digestion is a complex biological process. Acid forming bacteria break down the organic materials, eg sugars and protein, into organic acids which are converted into methane and carbon dioxide gases by methane-forming bacteria.

At the centre of the digester process is the mixing system. A new version mixing system has been installed in all the digesters. The new system employs a large centrifugal pump which continually recycles the sludge, macerates it and passes it back under pressure through jet nozzles in pipes arranged on the digester floor. The nozzle system is configured to set up a toroidal flow (a circular motion in the horizontal and vertical planes) of the sludge around the tank. This ensures the sludge is kept in perpetual motion and is thoroughly mixed – thus ensuring even consistency and optimal conditions for bacterial treatment and sludge conditioning. Mixing also optimises the digesters' capacity by preventing the build up of sludge mats, grit deposits and lumpy 'dead areas' in the tanks.

The sludge remains in the digesters for approximately 20 days. Digested sludge (reduced in dry-weight by about 50 percent) is decanted from the top of the digesters by gravity and passed to the dewatering plant.

During the digestion process, approximately 50 percent of the volatile material such as fats and carbonaceous material is consumed by anaerobic bacteria. An important by-product of the process is gas, mainly methane. Gas production is about 500 cubic metres for each tonne of solids. Each digester produces some 500 cubic metres per day (60,000 cubic metres per day in total) which is recycled to the co-generation plant.

The sludge digesters deal with two streams of 'solids' – sludge from the primary tanks and waste sludge from the reactor/clarifiers (secondary sludge).

Co-generation plant

Four Jenbacher JMS 616 turbo-charged gas engine/generators (rated at 1.7MW per set) have been designed to run on biogas produced by the anaerobic digesters. Each generator has the capacity to produce enough electrical power to supply the equivalent of 200 households. The gas engine/generators contribute to the treatment plant's electricity demands during normal operation and also provide all the heat required for the treatment process. Heat from the engines and boilers, which also run on biogas, is used to heat the digesters and buildings. The engines are also capable of running on natural gas as a back-up and for this purpose a natural gas line has been laid to the plant.

One of the four Jenbacher JMS 616 turbo-charged gas engine/generators.

Tertiary treatment

Dewatering plant

After 20 days in the digesters, the sludge is reduced in dry weight by about 50 percent and the solids content reduced to approximately three percent. The digested sludge is piped to the dewatering plant.

The dewatering plant complex consists of two sludge tanks, a gallery of progressive cavity pumps, a polymer dosing plant, six centrifuges (including one stand-by), a conveyor and load-out system.

To help thicken the sludge and aid its dewatering, a polymer solution is added which encourages the solids to flocculate or stick together in the centrifuges. The sludge and the polymer additive is 'spun dry' in the centrifuges to produce what is termed 'process biosolids'.

Centrifuges in the dewatering plant complex.

The surplus liquid (centrate) from the centrifuge process is returned to the front end of the plant via the Western Interceptor. The biosolids, now approximately 22 percent solids, are discharged from the centrifuges onto a system of screw and belt conveyors to one of two lime mixing units where lime is added to a level of 25 percent. The limed process biosolids are then discharged onto a conveyor and taken to the adjacent biosolids storage building.

Biosolids storage building

The biosolids building is a large concrete structure which has a capacity to hold up to 96 hours of biosolids production (1200 tonnes) in specially designed concrete bunkers.

Disposal of biosolids

Mangere Wastewater Treatment Plant produces approximately 300 tonnes of dewatered biosolids* each day.

Once stabilised with lime, the biosolids (at approximately 27 percent (22 refers to, prior to, before lime) dry solids) are disposed of at a rehabilitation site, Pond 2, a 44 hectare area of former seabed that contains oxidation pond sludge. Pond 2 is divided into a series of cells, where biosolids are placed in layers of approximately 600 to 800 millimetres deep.

The pond is lined with a high density polyethylene liner, an environmental protection measure designed to contain leachate. A network of perforated PVC pipes within the heart of Pond 2 intercepts leachates and conveys it back to the treatment plant.

Watercare continually monitors the aquifier via a number of groundwater bores surrounding Pond 2.

At the end of each placement day, a layer of dried aged oxidation pond sludge is used to cover the biosolids to control odour. In addition, a biosolids odour management protocol was formulated by Watercare in consultation with the Project Manukau Audit Group and the Auckland Regional Council to prevent further nuisance to the local community.

** Biosolids, a byproduct of the treatment plant, is defined in the current guidelines for the safe application of biosolids to land in New Zealand (NZWWA Guidelines 2003) as 'sewage sludge or sewage sludges mixed with other materials that have been treated and / or stabilised to the extent that they are able to safely and beneficially applied to land'.*

In the foreground, Pond 2, a 44 hectare area of former seabed that contains oxidation pond sludge. Pond 2 is divided into a series of cells, where biosolids are placed in layers of approximately 600 to 800 millimetres deep.