States of Jersey

Liquid Waste Strategy

Treatment Process Review

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1 INTRODUCTION

1.1 Present Arrangements – Collection, Treatment and Disposal of Foul Sewage

The original public sewerage system in St. Helier was constructed in the latter part of the 19th century. The sewers were built of brick and carried both foul and surface water. This is referred to as a combined system as opposed to a separate one, in which surface water and foul sewage are conveyed in different pipes. To reduce the amount of surface water in the system, a 1.8m diameter sewer was constructed in 1956 from Town Mills to the Weighbridge to intercept flows from the brooks in Vallee des Vaux and Grands Vaux. This sewer discharges to sea through the old granite outfall at Albert Pier.

Prior to 1959, raw sewage in Jersey was discharged direct to the sea by way of a number of short outfalls. The sewage treatment works at Bellozanne became operational at that time and was designed to treat effluent from a population of 57,000. In addition to the treatment works, a large pumping station at First Tower and a number of interceptor sewers were constructed to convey flows to the works. The foul sewerage system has since been extended into many parts of the island, which has required construction of a large number of smaller pumping stations. Further separation of foul and surface water flows has also been carried out in St. Helier.

The treatment works has also been improved and upgraded over time to take account of increased flows, tighter environmental standards and modern process technologies. For example, the secondary treatment process was upgraded in 1999 to reduce the amount of nitrogen in the final effluent. The works presently fully treats flows up to 600l/s from a resident population of 89,000, which increases to 104,000 during the peak summer months. Currently, flows to full treatment receive the following stages of treatment: -

- Preliminary, comprising screening and grit removal. There are two mechanically raked bar screens (duty/assist) and grit and grease are removed in an aerated tank
- Primary, comprising four circular settlement tanks
- Secondary, comprising an activated sludge process (ASP) which has been retrofitted to from a high rate process, including 12 circular final settlement tanks.

Flows in the range 600 to 1100l/s receive preliminary and primary treatment.

All flows up to 1100l/s receive tertiary treatment in the form of ultraviolet disinfection by a proprietary system, prior to discharge to St. Aubin’s Bay. The outfall discharges some 500m from the sea wall and is exposed at mid tide.

The surplus sewage sludge produced by the works is thickened and pumped to anaerobic digesters. The methane gas which is generated is used as an energy source for other purposes at the works. To permit the sludge to be applied to agricultural land, lime dosing is undertaken. The cake is generally disposed of to land, depending on the season and weather conditions. If the land route is not available, the sludge is incinerated in a mixture with municipal solid waste, in the Energy from Waste (EfW) plant.

There is a small packaged treatment plant at Bonne Nuit on the north east coast, which deals with foul flows from a small catchment. To date, the works has performed satisfactorily although some issues are evident. Hence, it is not proposed to deal with this treatment works as part of this report.

1.2 Issues

Only some 86% of the population is connected to the sewerage system; foul flows from the remainder discharge to private treatment works, septic tanks or tight tanks. Some of the pumping stations are hydraulically overloaded and a significant amount the mechanical and electrical equipment is in poor condition.

There are major concerns associated with the treatment works. It struggles to achieve the current temporary 20mg/l nitrogen standard agreed with the Regulator. The European Union 1991 Urban Wastewater Directive (UWWTD) requires different levels of treatment, depending on whether effluent is discharged to “sensitive” or “non-sensitive” waters. St Aubin’s Bay is likely to be classed as sensitive water; studies to determine this are in progress. Hence, any discharge into the bay would need to meet a total nitrogen limit of 10mg/l. Alternatively, the effluent would need to be treated to a level acceptable for discharge to non-sensitive (“deep”) waters via a long sea outfall. Hence, there is a link between the level of treatment to be provided at the works and the length of the outfall which would be required.

A satisfactory population of organisms in the ASP has not been re-established following the modifications made in 1999. As a result, the ASP is prone to problems of poor final tank settlement and banks of biological foam form on the surface of the aeration tanks. The latter is unsightly and a Health & Safety risk, and requires a significant operational input to remove it. Work is in hand to address the issues. Works are also in hand to upgrade the sludge treatment and disposal facilities. In addition, there are complaints about odours emanating from the works and some 50% of its assets are in poor condition.

The works would not comply with the bacteriological standards required by the revised EU Bathing Water Directive; the compliance date is the end of the 2015 bathing season. This is directly linked to the solids carry over from the final tanks due to poor settling sludge and foam. By current standards, the outfall into St. Aubins Bay is too short.

This report deals with the selection of the preferred treatment processes. The report outlines the alternative processes that are available, the reasons for carrying forward some and substantiation of the choice. Whilst it deals with all stages in the treatment process, it focuses on secondary treatment because this is where the principal choices exist and this stage will be the deciding factor in shaping the works. It considers both the conventional treatment processes and the emerging alternative technologies.

2 PRELIMINARY AND PRIMARY TREATMENT

2.1 Preliminary Treatment

The objective of preliminary treatment is to remove the inorganic solid material from the influent. This can be readily removed and disposed of in order to protect the downstream processes. Such preliminary treatment is likely to include: -

- removal of debris and rags by screens;
- removal of fats, oils and grease using dissolved air flotation;
- removal of grit, sand and stones by controlled settlement/ separation.

Such processes are housed in an Inlet Works, which would also include equipment to facilitate the transfer, treatment and disposal of the removed material. Flow control, balancing and measurement facilities can also be included.

Regardless of the choice of site for the treatment works, there will be a need to provide a new Inlet Works; the existing one at Bellozanne suffers from operational problems and would need to be replaced. The preferred layout has not been finalised but screening and grit removal will be provided.

2.2 Primary Treatment

Primary treatment is required to remove readily settleable solids and floating material, and thus reduce the suspended solids content. The incoming sewage flows through tanks which are sized to allow solids to settle on the bottom and any remaining floating material, such as grease and oils, to rise to the surface and be skimmed off. Scum boards are provided to separate the grease and oils from the primary tank effluent, which overflows the top of the tank and continues to secondary treatment. Sludge is removed from the bottom of the tank and separately treated or processed.

Primary settlement tanks are usually equipped with mechanically driven scrapers that continually drive the sludge towards a hopper in the base of the tank, from where it can be pumped for further treatment. Tanks on large treatment works were traditionally rectangular with a sloping floor. However, fitting auto de-sludging equipment to them is more expensive because the scrapers tend to crab on the rails. There can be problems with short circuiting in the tanks which disturbs the settled solids.

Radial flow tanks, such as at Bellozanne, are more common in modern wastewater treatment works. These typically have minimum side wall depths of 2.5m with a floor slope of 7.5 to 10 degrees. The continuously operating scraper bridge and automated sludge withdrawal system ensure that there is not an excessive sludge blanket. Hence, there is a low risk of solids rising in the tank due to biological activity and being lost over the weirs.

Upward flow tanks are traditionally square pyramidal in shape and are very deep with a base slope of 60 degrees. There is no scraper mechanism and there is a high risk of solids rising in them. Their form and depth of construction lead to relatively high construction costs and they now tend to be fabricated in GRP or stainless steel for package plants. Consequently, their use is now limited to smaller works up to a population of 5000.

Regardless of the choice of site for the treatment works, there will be a need to provide new primary tanks; the existing ones at Bellozanne suffer from operational problems and would need to be replaced. At this stage, the preference is to use radial flow tanks, similar to the existing ones at Bellozanne. This decision will be reviewed at a later stage but it is not a significant factor in site selection or the choice of processes. As noted previously, it is the secondary treatment that will most influence these.

3 SECONDARY TREATMENT

3.1 Introduction

Secondary treatment is designed to substantially reduce the biological content of the wastewater. All municipal treatment plants treat either screened crude sewage or primary tank effluent using aerobic biological processes.

Biological treatment is based on the principle that where enough air is present, cultures of bacteria will form. Millions of bacteria and other tiny creatures live on a substrate, the organic material in the sewage, and convert it from complex carbohydrates, proteins and fats into carbon dioxide, water and nitrates. They literally 'eat' the sewage and remove harmful waste. Secondary treatment systems are classified as either: -

- fixed-film
- suspended-growth

Fixed-film, such as a trickling filter, allows the biomass to grow on the media and the sewage passes over its surface. Aeration is provided by natural ventilation. In suspended-growth systems, such as activated sludge, the biomass is mixed with the sewage and air is forced into the process by means of blowers or mechanical aerators. Hence, their footprints are relatively smaller. However, fixed-film systems are more able to cope with drastic changes in loading. Both systems can provide high removal rates for organic material and suspended solids, and meet stringent discharge consents.

3.2 Trickling Filters

Trickling filters have been used to provide biological wastewater treatment for nearly 100 years. Modern trickling filters have a bed of media (mineral or plastic) over which the wastewater is continuously distributed. Air is provided by ventilation at the base of the filters and percolates naturally through the bed. Most filters are of the low rate type and are around 1.8m deep. The media grows a natural culture of bacteria which breaks down the Biological Oxygen Demand (BOD) with higher organisms e.g. protozoa, worms and fly larvae grazing on the film formed on the media. The grazing organisms ensure that the sludge production is less than other secondary processes. Nitrification of ammonia to nitrate takes place in the lower part of the filter and is carried out by autotrophic organisms which are slow growing.

The effluent produced by filters has to be settled in tanks of a similar construction to primary tanks. Most humus tanks, as they are termed, are of radial or upward flow type. Upward flow tanks are favoured on small works because the maximum size of prefabricated tank is 6m in diameter. The sludge is removed at regular intervals from the bottom of the tanks and the overflow passes forward. The sludge is usually pumped to the primary tank feed to be co-settled with the primary sludge because on its own it is thin and difficult to thicken.

Trickling filters are classified by their hydraulic or organic loading rates. Classifications are low or standard, intermediate, high, super high and roughing. Frequently, two-stage filters are used, in which two trickling filters are connected in series. More detailed information on these systems and variations is contained in Appendix A.

3.3 Rotating Biological Contactors

A Rotating Biological Contactor (RBC) is another fixed film secondary treatment. It consists of a series of closely spaced parallel discs mounted on a rotating shaft within a tank. The fixed film grows on the discs which are rotated through the wastewater allowing exposure to the air and degradation of the biological content of the wastewater. A clarifier or settlement zone is required to allow sludge to settle out and be removed. Many RBCs are provided as package plants with primary and secondary settlement zones, in addition to a biological treatment zone containing the rotating discs.

Failure of a RBC plant can be caused by loss of rotation of the rotor as a result of either loss of power or mechanical failure. Loss of rotation will eventually cause the biological process to cease but gravity flow through the plant will continue. Prolonged plant or power failure could result in a breach of the discharge consent and, where pumping is required, a premature storm discharge may occur.

RBCs are only used for populations up to approximately 2000.

3.4 Activated sludge

In general, activated sludge plants encompass a variety of mechanisms and processes that use dissolved oxygen to promote the growth of biological floc. This is termed mixed liquor and it substantially removes organic material. The process traps particulate material and can, under the correct conditions, convert ammonia to nitrite and nitrate and ultimately to nitrogen gas; this is refereed to as denitrification. The requirements of an activated sludge plant (ASP) is good mixing in the aeration lanes, a DO concentration of 1 to 2mg/l in the aeration lanes and good settlement of the activated sludge in final tanks, which are always of a radial flow type. The thickened activated sludge formed in the final tanks must be returned to the front of the ASP to provide an inoculation of organisms to ensure that the process can be maintained. A portion of this returned activated sludge is removed from the process at regular intervals to ensure that the mixed liquor solids are retained within the operating range of 2000 to 3000mg/l.

The two principal control measures are Food/Activated Sludge Mass (F/M ratio) and sludge age.

F/M ratios are dependent on the incoming load, mixed liquor solids concentration and aeration tank volume. An F/M of 0.2 to 0.3 is required for good carbonaceous treatment to achieve a consent of 20mg/l BOD. However, if full nitrification is required, an F/M of 0.08 to 0.1 will be required.

The sludge age is the length of time sludge spends in the ASP system before being removed. It is measured in days and needs to be 10 days as a minimum to ensure full nitrification throughout the year. This is because the nitrifying organisms (autotrophies) have a lower reproductive rate than the carbonaceous organisms and are washed out of the system at lower sludge ages.

The three principal configurations of ASP can be classified according to their hydraulic flow characteristics as: -

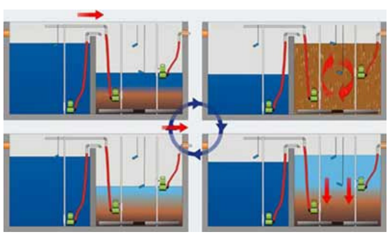
- Batch (SBR)
- Plug flow
- Completely mixed

More detailed information on these systems and variations is contained in Appendix A and for the purposes of this report we have included SBRs under proprietary treatment processes; refer to Section 3.6.

3.5 Secondary Sedimentation

The final step in the secondary treatment stage is to settle out the biological floc or filter material and produce an effluent containing very v7low levels of organic material and suspended matter. The sludge produced is constantly withdrawn from the tanks and returned to the inlet to the aeration tanks.

3.6 Proprietary Treatment Processes



Sequential Batch Reactors are a common variant of the activated sludge process. They are, in principle, an automated version of the original Arden and Lockett fill and draw system devised at Davyhulme, Manchester in 1914. There are usually four tanks which operate in sequence namely fill/aerate/settle/decant. Their primary advantage is that the standard process requires no separate settlement tanks. The main disadvantage is that if influent is to be treated continuously, more than one treatment stream is required.

For an SBR to de-nitrify, there must be a phase where very low or no available oxygen levels are present for de-nitrification to occur. In a conventional SBR system, this is achieved by retaining more of the clarified effluent in the reactor in the final phase. As this effluent has undergone nitrification, all of the ammonia will have been converted to nitrate which requires de-nitrification to reduce the total nitrogen levels. The clarified effluent, which is rich in nitrate, is treated in the first phase by only mixing during this period. In this way, anoxic or anaerobic conditions are encouraged and de-nitrification occurs.

Research of the available literature has revealed that there are three potential options for de-nitrifying in SBRs. Two of these are widely available namely, the Surge Anoxic Mix (SAM) from Severn Trent Services/Fluidyne and the Hybrid Twin Tank System from Eimco Water Technologies. The third has been studied at a pilot plant scale only and at this stage cannot be considered as a viable option. In the SAM process, the incoming sewage is mixed with recycled activated sludge in a separate tank prior to the four cell SBR, in the absence of aeration. The recycled sludge is de-nitrified in the SAM tank, the carbon source being provided by the incoming sewage. The Hybrid Twin Tank system is a continuous flow process. The first is an aerobic/anoxic tank which acts in a variable aeration/non-aeration operating mode, and creates cyclical aeration and anoxic zones. This provides periods of carbonaceous treatment and nitrification, and periods of de-nitrification. Flows then pass to the second tank, an intermittently operated clarifier, which acts as a standard SBR with fill, aerate, settle and decant stages.

A Submerged Aerated Filter (SAF) package treatment plant incorporates primary settlement and sludge storage, biological treatment and secondary settlement. The air blower will operate continuously to provide aeration for the biological process. The process is a hybrid between activated sludge and filters in that the aeration zone contains flooded plastic rigid form media which is aerated by a duty/standby blower. The process is generally used in prefabricated units for populations up to 1000, although it is possible to build the units in concrete tanks for populations up to 20000.

The settlement zones require regular de-sludging, although the period will vary from site to site depending on the characteristics of the sewage. De-sludging of the secondary zones is carried out automatically via air lift pumps and the sludge is transferred into the primary zone. Failure of the SAF plant can be caused by power failure or mechanical failure of the compressor.

Biological aerated filters (BAFs) are groups of tanks which provide self-contained aeration and, to a varying degree, solid separation treatment of sewage. Depending on the supplier of the proprietary process, the process may be upward or downward flow. The media is about 6mm in diameter and tends to be ignited shales or natural pumice type material.

Good performance from a BAF unit requires good upstream process performance, to provide a good influent. The BAF process is particularly suitable for providing tertiary polishing treatment, for discharge consents with tight ammonia limits. BAF discharge characteristics may not be acceptable as a result of surges after backwash, which may also affect downstream processes, particularly UV disinfection. Some BAF manufacturers have a maturation cycle after backwash to limit these effects. Flow smoothing by attenuation downstream is permissible. BAFs can also be operated for denitrification with an additional carbon source, namely glycerol.

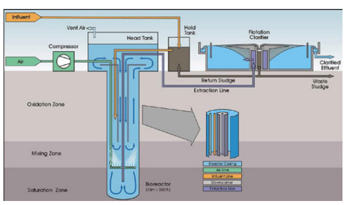
An **aerated lagoon** is a basin in which wastewater is treated either on a flow-through basis or with solids recycle. The essential function of this process is waste conversion. Oxygen is usually supplied by means of surface aerators or diffused as units. As with suspended-growth systems, the turbulence created by the aeration devices is used to maintain the contents of the basin in suspension.

Depending on the detention time, the effluent from an aerated lagoon contains about one-third to one-half the value of the incoming BOD in the form of cell tissue. Most of these solids must be removed by settlement prior to discharge; a settling tank or basin is normal component of most lagoon systems. If the solids are returned to the lagoon, there is no difference between this and a modified activated sludge process. However, a much larger surface area /population served is required.

Membrane Bioreactors (MBRs) combine activated sludge treatment with a membrane liquid-solid separation process. The membrane component uses low pressure micro-filtration or ultra filtration membranes and eliminates the need for clarification and tertiary filtration. The membranes are typically immersed in the aeration tank although some applications have a separate membrane tank. One of the key benefits of a membrane bioreactor system is that it effectively overcomes the limitations associated with poor settling of sludge in conventional ASP processes. The technology permits bioreactor operation with considerably higher MLSS concentrations than conventional ASP systems, which are limited by sludge settling. The process is typically operated at MLSS in the range of 8000 to 12000mg/l, whereas conventional ASPs are operated in the range of 2000 to 3000mg/l. The elevated biomass concentration in the membrane bioreactor process allows for the very effective removal of both soluble and particulate biodegradable materials at higher loading rates. Thus, increased sludge retention times, usually exceeding 15 days, ensure complete nitrification even in extremely cold weather.

The cost of building and operating a MBR is higher than conventional wastewater treatment, however, as the technology has become increasingly popular and has gained wider acceptance, the life-cycle costs have steadily decreased. The small footprint of MBR systems, and the high quality effluent, makes them particularly useful for water reuse applications.

There are numerous examples of industrial effluent treatment of high strength waste low volume effluents using the MBR approach. However, although examples of municipal wastewater treatment by MBR exist, these are mostly small. The largest MBR plant in the UK is Buxton (Severn Trent Water) with a population of 32000. Generally it has only been used where a small footprint plant is required or where a massive and rapid increase in load has to be accommodated to maintain consent.



The **DeepShaft™** activated sludge system was invented by ICI as a spin-off from the manufacture of Pruteen, which is a microbial protein grown on methanol. It is a high rate activated sludge system which is able to run at higher mixed liquor concentrations and at loading rates 5 to 10 times greater than conventional systems. The aeration requirement is also reduced by the nature of the process because it has a greater efficiency of oxygen transfer into solution.

The system works by drilling a shaft typically 40 to 100m deep, using techniques from the oil industry. Raw sewage enters a holding tank where it is mixed with return activated sludge. This mixture of raw sewage and return activated sludge is passed down the centre of the shaft and re-circulates back up the outside with the aid of compressed air. This typically takes between 2 to 6 minutes and the sewage is circulated around 20 to 40 times prior to discharge. After treatment the effluent is clarified by flotation or sedimentation.

The principal advantages are that no primary settlement stage is required and its footprint is relatively small. An additional process would be required for nitrification/denitrification. Its use in the UK has been limited to two works, which primarily treat industrial effluents, and one where space is severely restricted.

Other high rate systems The Kraus process is a variation of step aeration and is used to treat wastewater with low nitrogen levels. Digester supernatant is added as nutrient source aeration to a portion of the return sludge in a separate aeration tank, which is designed to nitrify. The resulting mixed liquor is added to the main plug-flow aeration system.

Claims have been made that increased loads can be treated by installing fixed film media within the aeration zones. The Kaldnes process does this, but course bubble aeration is required to develop a film on the fixed film media and this is less efficient than fine bubble diffusion in terms of oxygen transfer.

The Pegasor process has been employed in Japan and in Jersey. Pegasor pellets are placed in the aeration zones and are impregnated with immobilised nitrifying organisms and thus a high degree of nitrification can be achieved even at an F/M of 0.2. Unfortunately, a high DO concentration of 3 to 6mg/l is required in the aeration lanes and this encourages the growth of a particular filamentous organisms, namely Nocardia, which cause banks of foam up to 1m deep in the aeration lanes at Bellozanne.

3.7 Comparison of Options

A comparison of the above processes, together with reasons for discounting or carrying them forward for further consideration, is presented in Table 1.

Process	No of years in use	Comments	Suitability for Jersey	Consider further?
Trickling filters	**80**	**Low rate** filters have low energy requirements and are excellent for small works with populations up to 5000. Mechanically driven rectangular filters have historically been used for populations up to 500,000 but they require a large area of land. This tends to rule them out for new builds at larger works.	Long established process. Robust and will achieve BOD and ammonia standards. Not suitable for total nitrogen standard. Footprint too large for Jersey.	n
	40	**High rate** filters will not produce a suitable effluent and must be followed by another process.	Well established process, but would not achieve required standard.	n
	40	**Super high rate** filters - Most are in the form of packed towers and are used as a pre-treatment for strong industrial discharges	Not suitable for municipal treatment	n
	40	**Roughing** filters are intended to treat particularly strong or variable organic loads, typically industrial, to allow them to then be treated by conventional secondary treatment processes.	Not suitable for municipal treatment	n
	60	**Two stage** filters - nitrification is not possible with alternating double filtration operation.	Long established process but footprint too great	n

Rotating Biological Contactors	**30**	RBCs are only used for populations up to approximately 2000.	Only used on small works	n
Activated Sludge	**15**	**Sequential Batch Reactor** – These are generally used on populations in excess of 80,000. The works at Dublin, with a population of 1.8m, is one of the largest. Compact plants do not require final tanks and can be housed in a building under negative pressure to avoid odour release. With robust operation it is possible to achieve carbonaceous treatment and nitrification, but whilst denitrification has been reported, this is not routinely used with this process. There are a number of such (small) plants in Northern Ireland.	Small footprint and worth further consideration for carbonaceous treatment and nitrification.	y
	80	**Plug Flow/Completely Mixed** – This is a conventional activated sludge plant which promotes good settling sludge. They can be carbonaceous, nitrifying or nitrifying/denitrifying. Completely Mixed is not suitable for nitrification because of the high Food/Mass ratio. Refer to Appendix A for more information.	Conventional process has been in use since 1920s. There are several examples of nitrifying /denitrifying plants in the UK. This variant originates from South Africa in the 1980s. Worth further consideration.	y
	15	**Submerged Aerated Filters** - The process is generally used for small works, up to a population of 1,000, in prefabricated units. It is possible to build concrete tanks for populations up to 20,000.	No SAFs in the UK for populations greater than 2000. Not suitable for Jersey.	n
	10 to 15	**Biological Aerated Filters** – This is a hybrid between a sand filter and a low rate percolating filter. The organic load is removed onto ignited shale media 6mm in diameter. The solids are retained in the media and removed by periodic backwash, like a sand	Suitable as a tertiary stage for nitrification/ denitrification. Small footprint would be advantageous.	y

		filter. No final tanks are required and, hence, the footprint is relatively small. Operating costs (energy) can be high. Problems have occurred when they are operated as carbonaceous treatment with fouling of the aeration membranes with biological film. They are much better operated as a tertiary nitrifying/denitrifying stage, after a carbonaceous ASP.		
	3	**Aerated Lagoons** require a relatively much larger surface area than the above options. Only been used on small works, such as Tobermory with a 2000 population	Too large a footprint	n
	10	**Membrane Bioreactors** - The largest plant in the UK is at Buxton (Severn Trent Water) with a population of 32,000. Generally, they have only been used where a small footprint plant is required or where a massive and rapid increase in loading has to be accommodated. Operating costs are high and there have been problems with blinding of the membranes with a biological slime.	Would be the largest MBR ever built.	n
	30	**Deepshaft^{TM}** – small footprint but high capital cost of drilling and lining the shaft. Generally used in the UK to treat high strength industrial effluents. The efficiencies and cost savings of the system are only realised where the influent BOD strength is greater than 500mg/l. No nitrification/denitrification.	Presence of rock would increase capital costs. The strength of the sewage at Bellozanne is not high, which means that the operational cost savings are unlikely to materialise. The lack of a significant track record in the UK means that there would be increased operational risks.	n

Other High Rate Proprietary Systems	**2 to 5**	There are a number of these on the market, including the upgrade that was undertaken at Bellozanne. These are relatively complex, difficult to operate and high risk.	May be used as a retrofit to the existing plants to attempt to get them to perform better, but not recommended for Jersey	n

Table 1 – Comparison of Secondary Treatment Processes

3.8 Conclusions

There are a number of pivotal factors in the choice of a secondary process. These are: -

- The majority of wastewater treatment plants in the UK are either low rate filters or conventional plug flow ASPs.
- Due to limitations on the available space, it would not be feasible to use low rate trickling filters. The footprint would be of the order of 32000m^2 compared with 3000m^2 for a nitrifying activated sludge plant. The figures do not include the area required for final the settlement tanks, which would be similar for both.
- Because of the large footprint and the reasons given in Table 1, the variations on low rate trickling filters are also not practical.
- Conventional ASPs are robust and relatively easy to operate. They have been in use in the UK for over 70 years and the technology is well established.
- Nitrifying ASPs are easy to operate but the addition of nitrification/denitrification leads to a larger plant, which is more complex and more difficult to operate.
- There are a lot of SBR plants in the UK and it is an option for carbonaceous treatment and nitrification. They are cheaper than conventional ASPs and have a smaller footprint, but there can be operational problems. SBRs are not ideal for an island site because of their inherent complexity in operation and the large range of flows to be treated. They are not generally employed to achieve a total nitrogen limit, including denitrification. The Hybrid Twin Tank SBR can be utilised for this and has some advantages but to date its use has been limited to 3 small works, including 1 in Northern Ireland.
- The BAF option is expensive in capital and running costs. Technically, it is difficult to get a carbonaceous plus nitrifying BAF to operate long term because of the maintenance problems associated with fouling of the membranes. Yorkshire Water has had to dose caustic soda to clean their two plants.
- A nitrifying only BAF following, say, a carbonaceous ASP is a practical option and United Utilities have several large nitrifying plants, including Davyhulme in Manchester. However, the whole life costs are much higher than a nitrifying ASP.

Given the above, the preferred option is some form of ASP and the final choice will be dependent on the length of the outfall in St. Aubins Bay. For example, a conventional treatment process would require an outfall length of some 4.25km from the sea wall whereas some form of enhanced treatment could reduce the length to 1.5 to 3.5km. We will keep SBRs under review but a major consideration will be the client's view on the operational risks, particularly if they are to be used for nitrification/de-nitrification.

4 TERTIARY TREATMENT

4.1 Introduction

Tertiary treatment is required where there is a need to substantially reduce the number of microorganisms in the final effluent or meet a stringent discharge consent. The former is undertaken by disinfecting with ozone, chlorine or ultraviolet, and full details of these are included in Appendix B. Ozone is very expensive in both capital and operating costs. The use of chlorine is not permitted in the UK by the regulators due to the production of chlorine by products which can be toxic to aquatic life. Thus, UV disinfection is the preferred option in the UK and the EU.

Bellozanne was the first plant in the UK to adopt UV disinfection. The system was completely refurbished in 2003. There have been problems with its performance in terms of reduction in total coliforms and E Coli, which was caused by high solids in the effluent to be treated. The UV light could penetrate the solids and the overall performance was poor. However if a good quality final effluent is treated by UV, a very good kill rate can be achieved.

Tertiary treatment processes to meet stringent discharge consents include sand filters and nitrifying filters, and details of these are included in Appendix B. Although phosphorus removal is not strictly a tertiary process, we have included details of it in Appendix B.

4.2 Conclusions

Whilst it may not be necessary to disinfect the effluent with some of the proposed options, there is likely to be a concern from the public that the removal UV disinfection would be a retrograde step. At this stage, we have assumed that this practice would continue under any new arrangements. The final decision needs to be taken by the client when the site, treatment processes and length of outfall are being finalised.

None of the other tertiary treatment processes would be required for Jersey.

5 OTHER TECHNOLOGIES

Section 3 deals with conventional secondary processes to treat sewage at a works. There are an increasing number of alternative wastewater treatment technologies, the common feature of which is their localised nature. They do not rely on wastewater being conveyed via a sewerage system to a centralised treatment facility.

5.1 Small scale technologies

Some of the small scale technologies, such as composting toilets and septic tanks, are not alternatives to a centralised works; they would reduce the flows and loads to the works.

Composting toilets are dry, waterless toilets treat human waste through natural biological processes and turn it into an organic compost material that can be used on soil. The decomposition occurs through the aerobic conditions that worms, bacteria and other macro and micro-organisms utilise to breakdown the waste. As such, it is necessary that the compost remains relatively dry. Because of this, some composting toilets separate urine from faeces, and the urine passes through a nitrification process that results in an odourless liquid which is suitable as a fertilizer. Other types simply incorporate a carbon material, such as sawdust, to soak up the liquid.

Although typically viewed as a solution for developing countries, there has been significant progress in the development of commercial models suitable for more developed countries with colder climates. Such features include electric fan ventilation, oxygen injection systems, along with mechanical mixing and heating systems. However, common features of most systems are that the toilets require regular hygienic management and the compost to be removed regularly. As such, maintenance operations can be time consuming and there must be ample training for those overseeing the collection and application of composted waste. Toilets must also be built at a household scale and, as such, they are not suitable for dense urban areas without ample garden space.

A **septic tank** has anaerobic bacteria that decompose or mineralize waste. Periodic maintenance is required to remove the irreducible solids that gradually accumulate in the tank and reduce its efficiency. Septic tanks generally have two chambers; the first allows the solids to settle and the scum to float. The solids are anaerobically digested and the solid waste volume reduced. Further settlement takes place in the second chamber and finally a clear liquid is drained from the outlet into a Leachfield; see below**.** The remaining impurities are broken down in the soil matrix, through a combination of evaporation, percolation, microbial activity and plant transpiration.

As noted previously, septic and tight tanks are used on the island where properties are not connected to the sewerage system. They are only suitable for small communities (< 200 population). Their use alone in Jersey, where there is little dilution in the receiving watercourses, is not recommended. It would be better to provide a package secondary treatment plant to provide further treatment after the septic tank.

5.2 Localised treatment plants

A number of the technologies, such as Solar Aquatics, wetlands, reed beds and leachfield, lend themselves to treating effluent from small scale communities or developments.

The **solar aquatic system (SAS)** treats effluent to advanced standards through a series of aerated translucent tanks, which contain host plant communities and aerobic micro-organisms. This system effectively replicates and optimises the natural water purification processes present in a freshwater wetland. Wastewater is circulated through a series of clear tanks, each with its own aquatic ecosystem. Aeration and mixing takes place within the tanks to ensure settling does not take place. This enhances degradation of solids over conventional systems. Treated water is suitable for irrigation, toilet flushing and groundwater recharge.

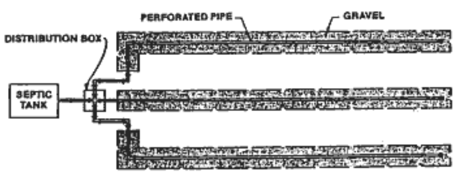
Whilst SAS is an alternative to a conventional works, it requires a significant input to set up the complex system and achieve a high quality treated effluent. This means that set up costs are invariably high and they also require a skilled technician to visit regularly to ensure their effective operation and maintenance.

A **wetland system** has become a popular form of 'green' technology to simultaneously treat wastewater through natural processes and provide an ecosystem suitable for a range of species. These are complex systems that are based on natural processes in which water, plants, micro-organisms, sun, substrate and air interact to improve water quality. Many wastewater treatment facilities use them for tertiary treatment prior to discharge to a local watercourse but with proper design they are able to provide secondary and tertiary treatment.

When properly designed and built, wetlands can remove pollutants from residential, municipal and commercial wastewater. They can be especially effective in removing contaminants such as BOD, suspended solids, nitrogen and heavy metals. Thin aerobic films around the root hairs of semi aquatic plants facilitate the decomposition of organic matter by aerobic micro-organisms along with nitrification. Phosphorus is co-precipitated with iron, aluminium and calcium compounds in the root-bed medium. Suspended solids are filtered out as they settle or are physically filtered by the vegetation. Harmful bacteria are reduced through filtration and adsorption by biological films on the sand media.

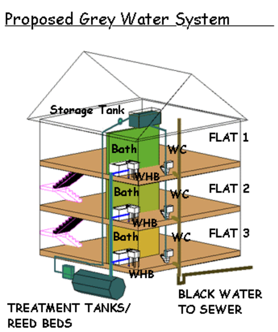
The processes involved in wetland wastewater systems take a significant amount of time to develop in comparison to conventional systems. They do not have anything like the capacity of conventional systems and require a significant amount of space. Thus, such systems are only suitable for small scale decentralised treatment, where there is sufficient space, such as a cluster of rural housing, a farm or other type of small holding. The sheer density and lack of space in urban areas mean such systems are inappropriate. Thus they would not obviate the need to make significant improvements to the wastewater treatment facilities.

Vertical and horizontal reed beds are a secondary treatment method. It is suitable for the discharges from a septic tank, although there could be odour problems in the summer. It works by percolating the effluent by way of a tank containing layers of sand and gravel with planted reeds. Horizontal flow beds can then be used to further treat the sewage to a tertiary level. It utilizes the fundamentals of the wetland and solar aquatic systems, but is only a very small scale method that takes significant treatment time. A large land area is required ($5m^2$/PE). Horizontal reed beds do not nitrify and whilst vertical reed beds can, they are difficult to operate.



Leachfield is a secondary treatment system of perforated pipes laid in underground gravel trenches. Flows percolate through gravel, where the solids are removed and digested by micro-organisms, leaving a liquid suitable for percolation into the groundwater. The relative size of a Leachfield is proportional to the volume of the wastewater and inversely proportional to the porosity of the ground. These are an updated version of the sewage farms of the late 19th/early 20th century and may operate poorly in the long term if they are overloaded. The land eventually becomes full of solids and fails to provide effective treatment.

5.3 Others



Greywater recycling - wastewater from all domestic sources, except toilets, is referred to as greywater. Most greywater recycling systems collect this water, treat it to a desired level and use it on site for a range of things, from toilet flushing to watering. This system is usually applied at a household scale and significantly reduces the quantity of wastewater a household generates. Such systems are gaining popularity and acceptance especially in drought prone areas, where reductions in the water demand and increased water use efficiency are vital in maintaining water resources.

Greywater recycling is not an alternative to a treatment works. It would reduce the flows to a works, and in widespread use it could reduce the footprint of a work

5.4 Conclusions

There is an interest in the above technologies and their use will become more widespread particularly in cases where it would be expensive to connect to the sewerage system. They tend to lend themselves to new and smaller developments rather than retrofitting to large urban areas. Therefore, whilst they may reduce the flows and loads to a treatment works in the future, this is unlikely to be significant. Hence, they would not obviate the need to make significant improvements to the wastewater treatment facilities and we do not consider that they will influence the choice of treatment processes.

6 CONCLUSIONS

Regardless of the choice of site for the treatment works, there will be a need to provide new preliminary and primary treatment stages; the existing ones at Bellozanne suffer from operational problems.

Due to limitations on the available space, it would not be feasible to use low rate trickling filters for the secondary stage. For this and the reasons given in Table 1, the variations on this process are also not practical. The preferred conventional option is some form of ASP and the final choice will be dependent on the length of the outfall in St. Aubins Bay. For example, a conventional treatment process would require an outfall length of some 4.25km from the sea wall whereas some form of enhanced treatment could reduce the length to 1.5 to 3.5km. The enhanced treatment could take the form of a nitrifying/denitrifying plant. This would be of a more conventional design than the 1999 upgrade at Bellozanne.

The requirement to continue to disinfect the final effluent with UV should be taken at a later date.

Whilst the take up of alternative technologies is likely to increase, this would not obviate the need to make significant improvements to the wastewater treatment facilities. Hence, we do not consider that they are a factor in the choice of treatment processes, and they are not appropriate for wide scale adoption in the urban areas.

APPENDIX A – SECONDARY TREATMENT PROCESSES

1 Trickling Filters

1.1 Low Rate

A low-rate filter is relatively simple and highly dependable, and produces an effluent of consistent quality with an influent of varying strength. The filters may be circular or rectangular in shape. On small to medium size works (500 to 30000 populations) the filters are usually circular with the distributors hydraulically driven. On large works, the filters are rectangular and mechanically driven with a siphon from a central channel supplying the feed to the distributor arms. Generally, a constant hydraulic loading is maintained, not by recirculation, but by suction level controlled by pumps or a dosing siphon. Dosing tanks are small, usually with only a 2 minute detention time, based on twice the average design flow.

In most low-rate filters, only the top 0.6 to 1.2m of the medium will have appreciable biological slime. As a result, the lower portions of the filter will be populated by autotrophic nitrifying bacteria that oxidize ammonia nitrogen to nitrate. If the nitrifying population is sufficiently well-established and the climatic conditions and wastewater characteristics are favourable, a well-operated low rate filter can provide good BOD removal and a highly nitrified effluent. Where possible, gravity flow is a distinct advantage, but pumping may be required if the site is flat.

Low rate filters have low power requirements but need a large land area. Although an excellent choice for small works, more intensive power hungry processes have had to be developed for larger sites because of the lack of available land.

1.2 Intermediate and High Rate

In intermediate and high rate filters, recirculation of the effluent permits higher organism loadings. Intermediate-rate filters are similar to low rate ones and may be circular or rectangular. The flow to the filter is usually continuous, although intermittent wetting of the filter medium is permissible.

High rate filters are designed for substantially higher loadings. Recirculation of effluent from the trickling filter clarifier permits the high rate filter to achieve similar removal efficiencies as the low rate or intermediate one. Recirculation of effluent around the filter results in the return of viable organisms and often improves treatment efficiency. Recirculation also helps to prevent ponding in the filter and reduces the nuisance from odours and flies. High-rate filters use either a rock or a plastic packing medium. The filters are usually circular and the flow is continuous. The depth of media may be increased to 3 to 4m. High rate filters will not produce an effluent suitable for discharge to a river and must be followed by another process.

1.3 Super High-Rate

Super high-rate trickling filters are loaded at high hydraulic and organic rates. The major differences between super high-rate and high-rate filters are the greater hydraulic loadings and greater filter depth. Greater depths are possible because lighter, plastic media are used. Most of these types of filters are in the form of packed towers up to 6m in depth.

1.4 Roughing

Roughing filters are high-rate type filters that treat an organic load of more than (1.6kg/m^3/d) and hydraulic loadings up to (187m^3/m^2/d). They are intended to treat particularly strong or variable organic loads, typically industrial discharges, to allow them to then be treated by conventional secondary treatment processes. Characteristics include typically tall, circular filters filled with open synthetic filter media to which wastewater is applied at a relatively high rate. They are designed to allow high hydraulic loading and a high flow-through of air. On larger installations, air is forced through the media using blowers. The resulting wastewater is usually within the normal range for conventional treatment processes. Most roughing filters are designed to use plastic media.

1.5 Two-Stage

A two-stage filter system, with an intermediate clarifier to remove solids generated by the first filter, is most often used with high-strength wastewater where nitrification is required. The first-stage filter and intermediate clarifier reduce carbonaceous BOD, and nitrification takes place in the second stage. Problems can be encountered with excessive film growth on the first stage filters which then will not permit the effluent to pass through the filter easily. This effect known as “ponding” can be overcome by using alternating double recirculation in which the duty of each filter is rotated fortnightly. In this way, film is not developed enough to cause ponding problems since the filter then becomes the secondary filter for a time and the excessive film is broken up. Nitrification is not possible with ADF operation.

Filter type	**Loading rate (kg BOD/m^3/d)**	**Effluent Quality**	
		BOD	**Ammonia**
Low rate	0.07	15	5
Intermediate rate	0.12	20	20
High Rate(plastic media)	0.3	20	25
Super High rate (plastic media)	0.4	40	30
Roughing Filter (Plastic)	1.0	60	no removal

2 Activated Sludge

2.1 Sequencing Batch Reactor

The batch reactor is characterised by the fact that flow does not enter or leave on a continuous basis. The extent of reaction or degree of purification is purely a function of time. The sequencing batch reactor system involving a single complete mix reactor in which all steps of the activated sludge process occur. Mixed liquor remains in the reactor during all cycles, thereby eliminating the need for separate secondary sedimentation tanks. There are usually four tanks which operate in sequence namely fill/aerate/settle/decant. At any point in time, each lane will be in each stage of the process. If incoming flows increase, the time spent on fill and aerate is reduced to permit satisfactory treatment of the feed.

2.2 Plug Flow

In plug-flow, flows pass through the reactor and are discharged in the same sequence in which they enter. The particles retain their identity and remain in the tank for a time equal to the theoretical detention time. This type of flow is approximated in long tanks with a high length-to-breadth ratio in which longitudinal dispersion is absent. Settled wastewater and recycled activated sludge enter at the head end of the aeration tank and are mixed by diffused-air or mechanical aeration. Air application is generally uniform throughout the length of the tank. During the aeration period, adsorption, flocculation and oxidation of organic matter occur. Activated-sludge solids are separated in a secondary settling tank.

The extended aeration process is similar to the conventional plug-flow, except that it operates in the endogenous respiration phase of the growth curve, which requires a low organic loading and long aeration time. This process is used extensively for prefabricated package plants for small communities. It has the advantage that less sludge is produced.

Tapered aeration is a modification of the conventional plug-flow process. Varying aeration rates are applied over the length of the tank, depending on the oxygen demand. Greater amounts of air are supplied to the head of the aeration tank, and the amounts diminish as the mixed liquor approaches the other end. Tapered aeration is usually achieved by using different spacing of the air diffusers over the tank length.

Step feed is another modification of the conventional plug-flow process in which the settled wastewater is introduced at several points in the aeration tank to equalise the F/M ratio, thus lowering the peak oxygen demand. Generally, three or more parallel channels are used. Flexibility of operation is one of the important features of this process.

Modified aeration is similar to the conventional plug-flow process except that shorter aeration times and higher F/M ratios are used. BOD removal efficiency is lower than other activated sludge processes.

The Kraus process is a variation of step aeration and is used to treat wastewater with low nitrogen levels. Digester supernatant is added as nutrient source aeration to a portion of the return sludge in a separate aeration tank, which is designed to nitrify. The resulting mixed liquor is added to the main plug-flow aeration system.

Plants designed to nitrify are provided with anoxic zones at the front of the aeration lanes in which the mixed liquor is kept in solution by mixers but no aeration is applied. In these zones of low or no dissolved oxygen, nitrate in the RAS is reduced to nitrogen gas by facultative anaerobes in the presence of a carbon source, which is usually settled sewage. In this way, 25% of the nitrate can be removed and solids flotation in the final tanks is avoided. If a total nitrogen limit is set, these anoxic zones have to be larger and recycling of mixed liquor (up to 4 x the incoming flow in dry weather) is required to achieve the standard of 10mg/l total N.

If an anaerobic zone or zones are incorporated into the process, it is possible to encourage a type of organism which will exhibit the property of luxury uptake of phosphorus in the aeration zone and phosphorus removal can be achieved. These nutrient removal plants have a larger overall volume and are more expensive to operate than a conventional plant.

Conventional plug flow ASPs are provided with a selector in which the RAS and incoming settled sewage are brought together with a high floc loading to promote good settling sludge. This is critical to good performance of the ASP.

Claims have been made that increased loads can be treated by installing fixed film media within the aeration zones. The Kaldnes process does this, but course bubble aeration is required to develop a film on the fixed film media and this is less efficient than fine bubble diffusion in terms of oxygen transfer.

The Pegasor process has been employed in Japan and in Jersey. Pegasor pellets are placed in the aeration zones and are impregnated with immobilised nitrifying organisms and thus a high degree of nitrification can be achieved even at an F/M of 0.2. Unfortunately, a high DO concentration of 3 to 6mg/l is required in the aeration lanes and this encourages the growth of a particular filamentous organisms (Nocardia) which cause banks of foam up to 1m deep in the aeration lanes at Bellozanne.

2.3 Completely-Mixed

Complete-mixing occurs when the particles entering the tank are immediately dispersed throughout the tank. The particles leave the tank in proportion to their statistical population. Complete mixing can be accomplished in round or square tanks with vigorous agitation.

Contact stabilisation uses two separate tanks or compartments for the treatment of the wastewater and stabilisation of the activated sludge. The stabilised activated sludge is mixed with the influent (either raw or settled) in a contact tank. The mixed liquor is settled in a secondary settling tank and return sludge is aerated separately in a re-aeration basin to stabilise the organic matter. Aeration volume requirements are typically 50 percent less than conventional plug flow. The process is an application of the flow regime of a continuous-flow stirred tank reactor. Settled wastewater and recycled activated sludge are introduced typically at several points in the aeration tank. The organic load on the aeration tank and the oxygen demand are uniform throughout the tank length. High-rate aeration is a process modification in which high mixed liquor suspended solids (MLSS) concentrations are combined with high volumetric loadings. This combination allows high F/M ratios and long mean cell-residence times with relatively short hydraulic detention times. Adequate mixing is very important. This form of treatment is not suitable for nitrification because of the high F/Ms.

The oxidation ditch consists of a ring or oval shaped channel and is equipped with mechanical aeration devices. Screened wastewater enters the ditch, is aerated and circulates at about 0.8 to 1.2ft/s (0.25 to 0.35m/s). Oxidation ditches typically operate in an extended aeration mode with long detention and solids retention times. Secondary sedimentation tanks are used for most applications.

High-purity oxygen may be used instead of air in the activated-sludge process. Oxygen is diffused into covered aeration tanks and is recirculated. A portion of the gas is wasted to reduce the concentration of carbon dioxide. PH adjustment may also be required. The amount of oxygen added is about four times greater than the amount possible by conventional aeration systems. Oxygen addition is used generally to treat high loads of readily available BOD and has been applied to treating brewery effluents which have high concentrations of sugars.

APPENDIX B – TERTIARY TREATMENT PROCESSES

1 Disinfection

The purpose of disinfection is to substantially reduce the number of microorganisms in the final effluent. The effectiveness of disinfection depends on the quality of the water being treated (cloudiness, pH, etc), the type of disinfection, the dosage (concentration and time) and other environmental variables. The treatment of cloudy water will be less successful because solid matter can shield the organisms, especially from ultraviolet light, or if contact times are low. Generally, short contact times, low doses and high flows all militate against effective disinfection. Common methods of disinfection include ozone, chlorine or ultraviolet light.

Ozone

Ozone (O_3) is generated by passing oxygen (O_2) through a high voltage potential, resulting in a third oxygen atom becoming attached and forming O_3. Ozone is very unstable and reactive, and oxidizes most organic material it comes in contact with, thereby destroying many pathogenic microorganisms. Ozone is considered to be safer than, say, chlorine which has to be stored on site and is highly poisonous in the event of an accidental release. Ozone is generated on site as required. Ozonation also produces fewer disinfection by-products than chlorination. Disadvantages of ozone are the high cost of the generation equipment, high operating costs and the requirement for special operators. There are no examples in the UK of ozone to disinfect a final effluent.

Chlorination

Chlorination by sodium hypochlorite, or Chloramine, is used quite widely in the USA for disinfection of the final effluent but there are no examples of its use in the UK; the Environment Agency and SEPA do not permit it because of the residual concentrations.

Ultraviolet (UV)

Ultraviolet radiation generally means that with a wavelength in the range of 200 to 390 nanometres (nm). The UV radiation required to achieve the most effective disinfection of sewage effluent is of wavelength 254nm. The success of the UV technique is dependent on the rate of flow, retention of flow, intensity of radiation and transmissivity of the effluent. UV light for sewage treatment is generated by mercury lamps, either low or medium pressure. Low pressure systems have a monochromatic UV output at 254nm, whilst medium pressure systems have a polychromatic UV output between 240 and 310nm.

Factors to be considered are the size and location of the plant, the discharge consent and the capital and operating costs. The UV disinfection channel and unit configuration are designed by a process contractor / specialist manufacturer and are site specific.

2 Other

The following processes would not be required to meet the discharge consent but are included for completeness.

2.1 Solids and Associated BOD Removal by Sand Filters

In most circumstances an inter-stage pumping station will be required to deliver flows to the tertiary sand filters (TSF) plant. There are two types of TSF namely: -

- Deep Bed Sand Filters (DBSFs), which are also known as conventional downward flow filters. They require periodic backwashing and smaller skid mounted modular DBSFs are appropriate for use on small to medium sized works.
- Continuous Operating Upflow Filters (COUFs) also known as moving bed filters.

Prefabricated modular DBSFs are generally appropriate for populations up to approximately 14000 or a maximum flow of 7000m^3/day. Conventional DBSFs, which are constructed in reinforced concrete tanks, are generally appropriate for flows above 7000m^3/day. DBSFs are periodically backwashed with the aid of compressors. Backwashes are initiated on a periodic basis via a timer with high head overrides.

Individual COUFs are generally appropriate for a population up to approximately 5000 or a maximum flow of 2500m^3/day. COUFs are continuously backwashed and the media is continuously recycled with an air lift pump and washer. The backwash is overflowed and returned to the inlet of the treatment works.

Generally COUFs are preferred for populations up to 50,000; above this DBSFs are preferred on price considerations.

As indicated previously, tertiary BAFs can be used for nitrification. They operate similar to rapid gravity sand filters with a daily backwash for each cell. They will, therefore, also effectively remove solids and no final tanks are required.

2.2 Tertiary Nitrifying Filters

Tertiary nitrifying filters are bio-filters which are designed to nitrify or remove ammonia only. They are provided as a tertiary treatment process downstream of an existing secondary treatment plant, where improved ammonia removal is required. These filters usually contain plastic media and can be up to 6m deep. They are not designed to remove BOD and will produce only small quantities of solids, so final settlement is not normally required.

2.3 Phosphorus Removal

This is not strictly a tertiary treatment process but is included in this Section. Chemical dosing for phosphorus (P) removal is generally achieved using a metal coagulant (iron or aluminium salts), to form metal phosphates which settle out and are removed in the sludge. This process is referred to as chemical P removal (CPR). Dosing can be carried out in the primary tank feed usually with a trim dose to the final tank feed. If very tight solids or iron/aluminium standards are required, tertiary sand filters will be required.