1 MGD
Wastewater Treatment Plant

Upflow Sludge Blanket (USBF) Process

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Content

1 Introduction

This generic proposal has been prepared by ECOfluid Systems Inc. (ECOfluid). The proposal contains commercial and technical information that is proprietary and confidential. It is submitted on the understanding that it will not be disclosed in whole or in part to third parties not specifically authorized by, and without express written consent of ECOfluid.

The design utilizes award winning ECOfluid Upflow Sludge Blanket Filtration (USBF™) process technology. In awarding the process the 2006 Technology Leadership Award, Frost & Sullivan included the following in their press release:

"The company's advanced plants based on the USBF™ process, address the constant demand to produce high quality effluents. This single-sludge denitrification process incorporates all the processes required for biological treatment in a single reactor and circulation loop, using very little energy and no chemicals. While conventional processes such as SBR and extended aeration rely on the slow and inefficient sedimentation process, ECOfluid's USBF™ technology utilizes a fluidized bed or 'counter current' movement. This is a dynamic method that continually removes pollutants. In this process, the sewage that enters an anoxic compartment is drawn by gravity into an aeration compartment, and then to the bottom of the upflow sludge blanket filtration clarifier, from where it overflows. The remainder is then recycled from the bottom using airlift pumps, which require no power due to the internal loop configuration. This way, the mixture is exposed to anoxic aeration three or four times a day, resulting in superior biological nutrient removal, even without the use of added chemicals. Phosphorous removal, through a process known as "biological luxury uptake", is another cost-free benefit. "USBF™ does not require primary clarification prior to biological treatment and offers hydraulic flexibility because it easily accommodates high peak flows," says Frost & Sullivan Research Analyst Shilpa Tiku. "In fact, as the flow becomes greater, the sludge blanket rises higher and the filtration area expands simultaneously." ECOfluid's USBF™ technology is, therefore ideal for use in municipal and domestic wastewater treatment, water reclamation, industrial wastewater, and existing plant retrofits. Industrial wastewater is highly organic by nature, and biological packaged wastewater treatment offers an attractive option for treatment plants that are looking at viable and low-cost options. The USBF™ process is a self regulated system and very little, operator attention is required."

In 2002 the University of California, Davis rated the USBF™ technology as the highest ranked biological treatment system out of almost seventy technologies reviewed.

On December 5, 2007 ECOfluid has been selected by the Ottawa Centre for Research and Innovation (OCRI) as one of 2007 winners for Canada's Top Ten Cleantech Companies Competition.

ECOfluid has designed and built over a hundred plants incorporating the USBF technology in Canada and the United States and it currently has a number of long-term operations and maintenance contracts in British Columbia. ECOfluid's cross-reference of design, construction and operating experience provides clients with an enhanced level of comfort and minimizes their risk.

The following is a generic 1 MGD plant budget price proposal for the supply of a system utilizing the USBF technology complemented by pre- and post-treatment equipment and systems that have been packaged and successfully used with the USBF biological treatment in the past. The proposed configuration is one of many. Other, using alternate equipment and sub-systems, if so preferred by the client, can be incorporated and packaged with the USBF.

The proposal includes information based on incomplete data and design. ECOfluid reserves the right to modify the specifications upon completion of detailed design and engineering.

2 Design Criteria

2.1 Influent / Effluent Parameters:

For the purposes of this proposal, 1 MGD plant receiving medium strength (Metcalf & Eddy) concentration has been selected. The influent / effluent parameters are specified in the table below:

3 Process and Plant Description

3.1 Headworks

Raw sewage entering the plant is pumped into the headworks, which consist of integrated mechanical pre-treatment consisting of screening system, screenings wash, conveyance, and dewatering, and sand and grit removal. The systems are installed on an elevated structural steel support platform immediately ahead of the equalization tanks. Washed and dewatered reject materials discharge into a hopper located on the ground level and are hauled to a sanitary transfer station for disposal.


Integrated headworks

From the integrated pre-treatment system, the screened sewage discharges directly into the equalization tanks equipped with submerged mixers and coarse bubble air diffusers. Each equalization tank is provided with two sets of duplex submersible pumps. Controlled by level monitor, each set of pumps transfers screened influent into the common anoxic compartment of a 0.5 MGD bioreactor module.

3.2 Biological Treatment

Biological treatment takes place in a USBF process treatment facility. The facility consists of two 500,000 gpd bioreactors each containing two aerobic compartments, one anoxic compartment and four USBF sludge blanket filters, two each inserted within the aerobic compartments. The influent enters the anoxic compartment where it is mixed with sludge recycled from the bottom of the sludge blanket filters by means of submersible mixers. The sludge recycle is accomplished by RAS airlift pumps provided with the flow measuring boxes. The RAS airlift pumps are driven by independent RAS only dedicated air blowers. From the anoxic tanks the mixed liquor overflows to aerobic compartments equipped with high efficiency fine bubble aeration diffusers. (Both, sock type and disc diffusers have been used in the past).


Sock type fine bubble diffusers

Aerated and moved in a plug flow manner, mixed liquor eventually enters the bottom of the upflow sludge blanket filters.

The mixture of microbial cells and water enters the filter at the bottom and, as it rises, upward velocity decreases until the flocs of cells become stationary and thus form a filtering media. A high degree of filtration efficiency is achieved as colloid and very fine particles are filtered out. As the flocs become large and heavy, they descend to the bottom of the sludge blanket filter and subsequently are recycled back into the anoxic zone.

Upflow sludge blanket filtration eliminates the most commonly encountered problem of the conventional biological treatment plant – gravity separation. It has a substantially higher specific rate of separation than sedimentation, and in addition, it accommodates high peak flows and flow swings in a self-regulating manner. The higher the flow, the higher the sludge flocs rise and the larger the filtration area becomes.

Sludge blanket filter installation within aerobic compartment.

The sludge blanket filters are provided with a gravity surface skimmer system. Walls of the skimmer system are submerged just below the clarifier surface level. If and when required the surface is skimmed by opening the skimmer trough valve and the skimmings are transferred by gravity to the sludge transfer tank.

Clarified treated effluent is collected in a trough on top of the sludge blanket filters before flowing by gravity to post-treatment.

3.3 Nutrient Reduction

3.3.1 Nitrogen Reduction

Nitrogen is removed by nitrification and denitrification processes. Nitrification is autotrophic and all USBF integrated bioreactors deliver complete nitrification of ammonia to nitrate provided that certain minimum temperature is maintained and certain alkalinity is available. [1]

Denitrification is heterotrophic and requires carbon source. The USBF technology "single sludge denitrification" approach uses an endogenous carbon source to maintain the denitrifiers. Influent is combined with nitrified mixed liquor in the anoxic compartment providing the carbon source needed for denitrification. [2]

Increasingly stricter Total Nitrogen parameters are being specified. Where so, high degree of denitrification will be desired and the design will be "enhanced nitrogen reduction" optimized.

3.3.2 Phosphorus Reduction

One of the beneficial features of the USBF technology is increased efficiency of phosphorus removal. This is due to the fact that a significant amount of the influent phosphorus is reduced by biological phosphorus uptake.

The mechanics of biological phosphorus uptake, known as "luxury uptake", is due to exposure of activated sludge to alternating oxide and anoxic/anaerobic conditions. Under the conditions, the cells store more energy in the form of phosphorus than needed for their survival. If strictly oxide conditions are maintained during subsequent clarification, phosphorus is retained by the cells and is eventually removed with excess sludge. Upflow sludge blanket clarifiers maintain oxide conditions in the clarifiers and phosphorus reduction by biological uptake to as low as 1 mg/l has been accomplished.

For further phosphorus reduction phosphorus precipitant chemicals such as aluminum sulfate, ferrous sulfate or other salts are used. In most domestic wastewater phosphorus is present in three forms, orthophosphate, *polyphosphate and organic phosphorus. Polyphosphate* and organic phosphorus cannot be readily precipitated but both are converted to orthophosphate during biological

1 Nitrification consumes 7.1 mg/l of alkalinity as $CaCO_3$ for each mg/l of ammonia oxidized (Denitrification reactions produce 3.57 mg/l as $CaCO_3$)

2 Reduction of 1 gram of nitrogen requires approximately 3 – 6 grams of BOD (or equivalent carbon)

treatment, which can. Since the bulk of phosphorus reduction is accomplished by biological uptake, the small polishing dosages of metal salt precipitant do not significantly increase waste sludge production.

In simultaneous chemical precipitation metal salts are dosed into the anoxic compartment of the USBF bioreactor. Continuous sludge internal circulation and mixing ensure efficient precipitation, coagulation and flocculation within the bioreactor with an added benefit of increased efficiency of the sludge blanket filter.[3]

3.4 Filtration

Effluent filtration is typically achieved by either microfiltration or by membrane filtration.

3.4.1 Microfiltration

Microfiltration takes place in the gravity-flow-through drum microfilters. The filters are equipped with stainless steel filter media having 30-40 microns openings. Biologically treated effluent enters the inside of the microfilter drum and it is filtered as it passes through the filter media. The filters are constructed entirely from stainless steel and they are provided with automatic backwash using filtered effluent from behind the filters. Filtered out mud is collected in a container and periodically pumped to the sludge holding tank.

Channel installed microfilter

3.4.2 Membrane Filtration

Membrane filtration has been widely adopted by the wastewater treatment industry in recent years. To date, predominantly immersed membranes were used. These however, come with significant compromises involving costs, simplicity, flexibility, and other. Costly, 'special requirement influent fine screening' needs to be provided, and steps such as lifting and removing the membranes out of the bioreactor when required for maintenance are disruptive to routine plant operation. Additionally, membranes immersed in the bioreactor make optimization of the biological and the filtration processes difficult.

ECOfluid membrane system gets around the disadvantages of the immersed membranes by employing external membrane filtration (eMBR). The configuration reduces or eliminates many of the immersed membrane compromises. No special pre-treatment is required, the biological treatment can be optimized for biological nutrient removal (and include chemical precipitation if desired), and the membrane energy input is kept low by the membranes design and by the fact that the TSS of the effluent from the USBF™ sludge blanket filter is already less than 10 mg/l. The result is a membrane quality effluent, including giardia and cryptosporidium removal and turbidity reduction to 0.1 NTU, with significantly improved reliability, flexibility and simplicity of operation, and reduced capital and operating costs.[4]

External membrane filtration system (eMBR)

3.5 UV Disinfection

Gravity flow, open channel type system installed within concrete channels is provided. The system consists of two duty and two standby, UV lamp modules banks, installed within two concrete channels.

Concrete channel installed UV disinfection

3.6 Air Management

3 See attached Nitrogen and Phosphorus Reduction Memorandums

4 See attached USBF-eMBR description

Air is required for the biology in the fine bubble aeration diffusers, for RAS airlift pumps, in the equalization tank coarse bubble diffusers and in the sludge holding tanks for sludge post-stabilization.

Air to the biology is supplied by positive displacement blowers provided with variable frequency drives (VFD) and controlled by continuous dissolved oxygen monitors within the aeration tanks. Three air blowers are provided for the 1 MGD plant, two duty each serving 0.5 MGD module, and one common standby. Switching to standby blower requires operator's manual intervention.

Air for RAS airlift pumps and to the equalization and sludge holding tanks is provided by independent blowers.

3.7 Waste Sludge Management

Since the age of activated sludge in the bioreactors is in excess of 25 days, less excess sludge is generated, it is stabilized and its dewatering characteristics significantly improve. The bioreactors are provided with sludge pre-thickeners located in the aeration compartments, which pre-thicken the sludge to approx 1.5-2.5%. Controlled by timers the pre-thickened waste sludge (WAS) is periodically pumped into the sludge transfer tank.

Waste sludge pre-thickener

From the sludge transfer tank, sludge is transferred to sludge post-treatment which may consist of sludge processing to Class A biosolids, centrifuge dewatering, or other.

3.8 Electrical, Instrumentation and Controls

The plant is provided with SCADA systems, which monitor equipment running status and receive data from transmitting instruments. Typically, the entire process and operation control and alarm system consists of the following:

Integrated Headworks	Level switches Motor overload
Equalization Tank	Level monitor Level switch pH monitor Temperature monitor
EQ Tank Pumps	Motor overload Hour meter Leak detector Timer
EQ Tank Mixers	Motor overload Leak detector
Anoxic Mixers	Motor overload Leak detector
RAS Pumps c/w VFD	Motor overload Leak detector
Aeration Tank	DO monitor
Microfilters	Level switches
Mud Pump	Level switch
Membrane Filtration system	Auto-control and report
UV Disinfection	Intensity monitor Temperature monitor Elapsed time meter
Pre-thickener Pumps	Motor Overload 24 hour timer
Air Blowers c/w VFD	Pressure Indicator Pressure Relief Valve Pressure Switch Motor Overload Hour Meter
Sludge Transfer Pump	Motor Overload Hour Meter Moisture detector Leak detector
Emergency Power Genset	
Effluent Flowmeters	
MCC	

4. Plant O & M Considerations

4.1 Reduced Operating Requirements

The entire system is comprised of simple, well proven and tried equipment, systems and modules.

Unlike with immersed membranes, the USBF process does not require "special needs" ultra-fine screening. The proposed 'combi' style pretreatment is totally self-contained, fully enclosed headworks system with low maintenance, optimal throughput and simple, reliable operation.

Equalization tanks together with the USBF inherent hydraulic flexibility accommodate flow variations in a self-regulating manner.

The bioreactors including the sludge blanket filters contain very limited amount of rotating equipment, and that which they do are removable and serviceable 'on the go'.

The USBF sludge blanket filters on their own produce effluent having TSS of less than 10 mg/l.

Drum microscreen filters (if used for post-biology filtration) are fully automatic, simple, reliable and well proven devices requiring minimal operators' attention. The one factor that significantly contributes to operating simplicity and reduces operating and maintenance needs and costs, is the all gravity process flow. Pumped once from the equalization tank into the bioreactors, the entire flow through the process (biology, filtration and UV disinfection) is by gravity.

External membrane filtration (if used for post filtration) is safe, easy and dry. There is no exposure to chemicals and sludge, and no cranes are required. The compact design, minimal amount of moving parts, modularity of construction, high membrane flux rate, reduced power consumption, low fouling and ease of maintenance result in decreased operating and maintenance costs.

The efficiency of the channel type UV disinfection is aided by the reduced effluent suspended solids count, which also reduces the UV lamp cleaning requirements.

4.2 Reduced Power Consumption

Electric power consumption including operation of all equipment of the headworks, the biological treatment, filtration and UV disinfection is calculated to be approximately 2,600 kWh/day, or 850 kWh/foot-acre.

4.3 Pre-Thickened Waste Activated Sludge

At full design load (1 MGD, 220 mg/l BOD and TSS), the waste sludge generation is calculated to be approximately 1,000 lb/day. The sludge will be pre-thickened in the sludge pre-thickeners and in the sludge transfer tank to above 2% d.s. The generated sludge volume at full design loading and at 2% d.s. is estimated to be 800 cuft/day or 6,000 gpd.

4.4 Chemicals

Other than metal salts (aluminum sulfate for example) used for phosphorus precipitation, and cleaning chemicals for UV lamps and external membranes, no chemicals are used in the process.

4.5 SCADA Control

The plant is provided with a SCADA system which monitors and controls the plant operation, and transmits data and information to remote locations.

5. Budget and Costs Considerations

Based on experience and subject to qualifications below, the preliminary 'Order of Magnitude' cost estimate for a complete 1 MGD 'green field' plant installation is summarized in the table below.

(1) Includes excavation, underground piping, drainage etc
(2) Includes MCC and control room, lab, process and air blower rooms
(3) All component cost estimates are 'supply and install' estimates
(4) Alternate equipment and component selection may affect prices and costs estimates
(5) Equivalent Dwelling Unit (EDU) is a unit measure where one unit is equivalent to wastewater effluent from one residence (1 EDU = 250 gallons per day).

LAKE ALFRED WWTP, LAKE ALFRED, FL
CASE STUDY

When the City of Lake Alfred decided to upgrade their existing 1 MGD trickling filters wastewater treatment plant, they looked at a number of technologies and after an evaluation decided on the USBF process.

As part of the upgrade, the plant was provided with a new Fontana Integrated Headworks, which screens the influent, washes and dewaters the screenings, removes sand and grit, and deposits washed screenings and grit into separate bins. From the headworks, the screened influent flows to equalization tank (which is a reconditioned old trickling filters tank – trickling filters removed).

From the equalization tank, the influent is pumped into bioreactor modules. The influent first enters the anoxic tanks (above right in the forefront) and with the slide gate open, it passes into the aeration tanks. The still water in the pictures above and below is the treated effluent surface of the USBF sludge blanket filter, within which fluidized bed filtration (upflow sludge blanket filtration) takes place. The water is crystal clear as can be seen in the pictures below.

The above right picture shows raised sludge filter blanket approx 8-10 inches below clear water surface (the sludge blanket level was intentionally raised by prolonged influent pumping).

LAKE ALFRED WWTP, LAKE ALFRED, FL
CASE STUDY

Filtered clean effluent at the top of the sludge blanket filter overflows into a v-notch overflow trough located under the walkway. There are no moving mechanical parts within the sludge blanket filter/clarifier or the overflow troughs.

From the overflow trough the treated effluent flows by gravity into the Fontana drum microscreen filters. Picture on the right shows filtered effluent in the backwash well of the microfilter (the microfilter uses filtered effluent behind the filter for its automatic backwash).

From the effluent storage tank below the microfilters, the treated, filtered effluent is pumped to the existing chlorination.

	Influent		Effluent		
	BOD	TSS	BOD	TSS	NITRATE
Date	mg/L	mg/L	mg/L	mg/L	mg/L
4-Jun-08	181	192	5.03	3.6	3.80
11-Jun-08			4.76	2.5	3.73
18-Jun-08	219	366	5.09	2.0	3.75
25-Jun-08			5.45	5.0	3.79
Average	200	279	5.08	3.3	3.72

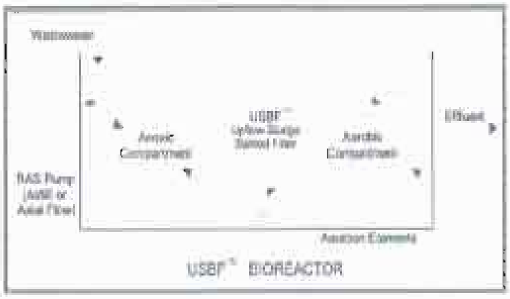
The plant retrofit and upgrade was completed and the plant started up in May 2007. As illustrated by the analysis of samples taken during the month of July 2008, the plant is exceeding its design parameters of <10 mg/l for BOD, TSS and Nitrate.

UPFLOW SLUDGE BLANKET FILTRATION (USBF™)

PROCESS SUMMARY

THE PROCESS

Operation of a USBF™ plant is simple and self-regulating. Wastewater enters the anoxic compartment of the bioreactor where it mixes with activated sludge recycled from the bottom of the sludge blanket filter. Agitated and moved in a plug flow manner, the mixed liquor flows into the bioreactor's aerobic compartment. After aeration, a stream of the mixed liquor enters the bottom of the sludge blanket filter where the sludge flocs and water are separated by upflow sludge blanket filtration. After separation, filtered effluent overflows into a collection trough and is discharged from the system. To complete the internal gravity circulation loop, activated sludge collecting at the bottom of the sludge blanket filter is recycled back into the bioreactor anoxic compartment.



THREE FEATURES THAT INCREASE EFFICIENCY AND REDUCE COSTS

Sludge Blanket Filter

The upflow sludge blanket filter introduces a substantially higher specific rate of separation than other commonly used separation techniques. Unlike conventional clarifiers, influent enters at the bottom and flows upwards. As the cross sectional area increases, the upflow velocity decreases until the activated sludge flocs become stationary and thus form a filtering media for activated sludge flowing through. High filtration efficiency is achieved and even particles with settling velocities too low to be removed by settling alone are filtered out.

High Sludge Concentration

Most traditional plants operate at low or medium sludge concentrations, typically 2,500 – 3,500 mg/l. USBF™ process by contrast operates at higher sludge concentrations, typically 4,000 – 6,000 mg/l resulting in longer sludge age and increased biological efficiency.

All Processes Integrated into One Bioreactor

Most conventional technologies carry out processes of nitrification, denitrification, clarification and sludge stabilization in a number of dedicated vessels. By contrast, USBF™ process incorporates these processes inside a compact bioreactor, reducing equipment size and liquid handling requirements.

Lake Alfred, FL 1 MGD (4,000 m^3/d) WWTP (Four 0.25 MGD modules). Trickling filter plant retrofit.

BENEFITS

High Treatment Efficiency Including Biological Nutrient Removal (BNR)

The USBF™ process features an internal anoxic compartment for biological reduction of nitrogen and phosphorus by nitrification, denitrification and 'luxury uptake' processes respectively.

Alkalinity Recovery & Filamentous Bacteria Control

The integral denitrification process facilitates partial recovery of alkalinity during nitrification. As well, the anoxic selector is used to control filamentous bacteria growth within the system.

No Primary Clarification

USBF™ process does not require primary clarification prior to biological treatment. A proper screening facility and for larger plants, grit removal system is all that is required upstream of the bioreactors.

Hydraulic Flexibility

The sludge blanket filter prism or cone shape not only allows other treatment processes to take place around it, but it also facilitates superior hydraulic flexibility. The process easily accommodates high peak flows and flow swings in a self-regulating manner: the higher the flow, the higher the sludge blanket rises and the larger the filtration area becomes.

Modular expansion of the plant at Sun Peaks Ski Resort. Two original bioreactor modules (left) installed in 1999 supplemented by two additional modules in 2005.

Modular and Flexible Design

Modularity of design allows owners to stage plant development and ensures that plants can be quickly expanded if and when growth demands.

Reduced Operating and Maintenance Requirements

The compact design, minimal amount of moving parts and self- regulating hydrau contributing to lower
operating and maintenance costs.

Reduced Site Requirements

USBF™ process incorporates nitrification, denitrification, clarification and sludge stabilization into a compact bioreactor which reduces equipment size and liquid handling requirements and ultimately leads to a smaller plant footprint.

300 m³/d (80,000 GPD) USBF WWTP built in a residential subdivision between housing attesting to the non-odorous nature of the process.

No Odor

Aerobic conditions throughout the bioreactor and extended sludge age eliminate or dramatically reduce odor. USBF™ plants can be located within populated areas without odor concerns.

Improved Sludge Characteristics

Low microbial loading (extended sludge age of 25-35 days) produces less excess sludge, which is aerobically stabilized, and which is characterized by improved structure and better dewatering capability.

APPLICATIONS

Municipal and Domestic Wastewater

Literally thousands of site constructed and packaged USBF™ treatment plants serving municipalities, communities, subdivisions, ski resorts, shopping centers, summer resorts, golf courses, hotels, restaurants etc. are in operation worldwide.

Water Reclamation

The USBF process alone is capable of removing BOD_5 and TSS to less than 10 mg/l without post-filtration, Total Nitrogen reduction to less than 10 mg/l and Total Phosphorus removal to about 2.5 mg/l. (The reduction of total phosphorus to less than 2.5 mg/l requires additional chemical precipitation). This high efficiency of the continuous flow USBF™ process paves the way to economical 'tertiary' post-treatment. Using the USBF™ process followed by membrane, sand or microscreen filtration, and UV disinfection, ECOfluid designs, builds and operates treatment plants producing Class A (or Title 22), or reclaimed water quality effluent at economical capital and operating costs.

Existing Plant Retrofits

The self-contained nature of the internal circulation loop and structural independence of the sludge blanket filter insert make it possible that virtually any tank can be converted to a wastewater treatment plant. Many existing RBC's, oxidation ditches and other plants have been retrofitted with USBF™ filters to increase treatment efficiency and/or plant capacity.

Industrial Wastewater

Many plants treating high strength industrial wastewater including food processing plants, slaughterhouses and rendering plants, dairy plants and pulp mills have been designed and are in successful operation worldwide.

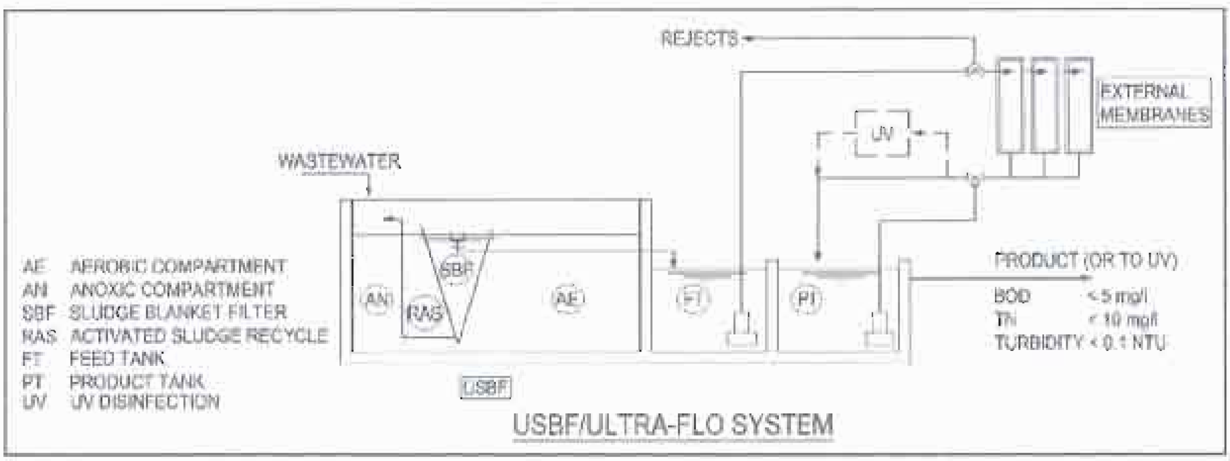
Upflow Sludge Blanket Filtration (USBF™)

AND

External Membrane System (eMBR)

In recent years, membrane filtration has been widely adopted by the wastewater treatment industry predominantly using immersed hollow fiber or panel membranes. The immersed membranes however, come with significant compromises involving costs, simplicity, flexibility, and more. Costly, 'special requirement influent fine screening' needs to be provided, and steps such as lifting and removing the membranes out of the bioreactor when required for maintenance are disruptive to routine plant operation. Additionally, membranes immersed in the bioreactor make optimization of the biological and the filtration processes difficult.

ECOfluid membrane system, which consists of an Upflow Sludge Blanket Filtration bioreactor followed by external membranes, builds on the treatment efficiency of the USBF™ process and utilizes external membranes for final polishing filtration. The configuration reduces or eliminates many of the immersed membrane compromises. No special pre-treatment is required, the biological treatment can be optimized for biological nutrient removal (and include chemical precipitation if desired), and the membrane energy input is kept low by the membranes design and by the fact that the TSS of effluent from the USBF™ sludge blanket filter is already less than 10 mg/l. The result is a membrane quality effluent, including giardia and cryptosporidium removal and turbidity reduction to 0.1 NTU, with significantly improved reliability, flexibility and simplicity of operation, and reduced capital and operating costs.



BRINGING IT TOGETHER:

The system brings together the best of the biological and the membrane processes. The advantages of the ECOfluid membrane system are:

No "Special Needs" Fine Screening

The external membranes do not require "special needs" ultra-fine screening typically required for immersed membranes.

No Primary Clarification

The USBF™ process does not require primary clarification.

Optimized Biological Processes Including Biological Nutrient Removal (BNR), Alkalinity Recovery & Filamentous Bacteria Control

The single sludge denitrification process facilitates total nitrogen reduction and partial recovery of alkalinity lost during nitrification. Total phosphorus is reduced by 'luxury uptake' process, and 'the anoxic selector' controls filamentous bacteria growth.

High Membrane Flux Rate and Reduced Fouling
The low membrane feed solids concentration (~10 mg/l) enables high flux rates and reduced membrane fouling.

Multi-Barrier Two Stage Filtration
Two step filtration - upflow sludge blanket fluidized bed filtration followed by membrane filtration for greater reliability

Easy and Economical Membrane Cleaning and Maintenance
The external membrane maintenance is safe, easy and dry. There is no exposure to chemicals and sludge and no cranes are required.

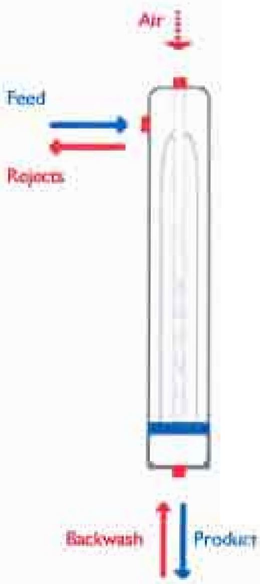
Modular and Flexible Design
The modular nature of the USBF™ process and the external membrane systems ensures that plants can be readily expanded in response to growth in demand.

Reduced Operating and Maintenance Requirements
The compact design, minimal amount of moving parts, modularity of construction, high membrane flux rate, significantly reduced power consumption, low fouling and ease of maintenance result in decreased operating and maintenance costs.

No Odor
Aerobic conditions throughout the process and extended sludge age eliminate or dramatically reduce odor. The plants can be located within populated areas without odor concerns.

Improved Sludge Characteristics
Low microbial loading (extended sludge age of 25-35 days) produces less waste sludge, which is aerobically stabilized, and which is characterized by improved structure and better dewatering capability.

ABOUT THE MEMBRANES



Ultra-Flo® membranes models MU 01 to MU 24 are designed for Cross-Flow and Dead-End (out-to-in) filtration. In dead-end filtration, one end of the hollow fiber is closed ensuring that the feed water permeates through the hollow fiber using less pressure.

The hollow fiber outside diameter is 2 mm and it is fabricated from hydrophilic modified PAN.

Each membrane cartridge is 8" dia x 60" long (200 mm dia x 1500 mm), its total surface area is 450 ft^2 (40 m^2), and the operating pressures are < 8 psig (55 kPa) and < 14 psig (97 kPa) for respectively feed and backwash.

MU 01-8　　MU 04-8　　MU 08-8　　MU 20-8　　MU 24-8

Plant Components and Equipment List

The plant is composed of pre-treatment headworks, two 0.5 MGD bioreactor modules, microfiltration or membrane filtration, and UV disinfection. Without limitation, the following equipment, components and parts is required:

Integrated Headworks IH (1)

Objective:	Screen out debris; remove sand and grit; convey, wash and press screenings.
Design Considerations:	The system is a compact integrated system provided with a coarse bar screen by-pass of the fine mechanical screen to equalization tank should it need to be taken out of service for maintenance.
Make:	TBA
Screen Openings:	3/16"
Capacity:	1,500 gpm peak flow
Material:	Stainless steel / plastic lamellas
Drives:	½ Hp, 115/1/60 screen motor ¼ Hp, 115/1/60 screen brushes motor 3 Hp, 460/3/60 screenings screw 3 Hp, 460/3/60 sand screws (2 of)
Alternative:	Number of other integrated systems are available and can be substituted

Equalization Tank EQT (1)

Objective:	Provide containment for screened influent before pumping to the biology
Capacity:	50,000 gallons
Material:	Concrete

Equalization Tank Pumps EQP (4) (2 for each 0.5 MGD module)

Objective:	Pump the contents of the equalization tank into the anoxic tanks of the bioreactors.
Type:	Submersible, non-clog
Make:	ABS, Meyers, Goulds, Flygt or equal
Capacity:	820 usgpm @ 25 ft TDH
Material:	Cast iron body and impeller
Drive:	10 Hp, 460/3/60
Accessories:	Base elbow c/w carrier and guide rails

Equalization Tank Mixer ETM (2)

Objective:	Mix incoming raw sewage
Design Considerations:	The mixers are provided with thermal and seal leak sensors.
Vendor/Make:	ABS, KSB, ITT Flygt or equal
Material:	Stainless steel propeller and shroud, cast iron body
Drive:	10 Hp, 460/3/60
Accessories:	Guide bars, lifting chain

Fine Bubble Diffusers (Lot)

Objective:	Provide for adequate mixing and oxygen transfer in the aeration compartments of the bioreactors.
Make:	High efficiency sock type or disc diffusers
Material:	EPDM flexible membrane, PVC headers and drops

Anoxic Mixer ANM (4)

Objective:	Mix incoming raw sewage and recycled mixed liquor.
Design Considerations:	The mixers are provided with thermal and seal leak sensors.
Vendor/Make:	ABS, KSB, ITT Flygt or equal
Material:	Stainless steel propeller and shroud, cast iron body
Drive:	10 Hp, 460/3/60
Accessories:	Guide bars, lifting chain

Sludge Blanket Filter SBF (8)

Objective:	Provide conditions for mixed liquor flocculated sludge and effluent separation.
Design Considerations:	The filters accommodate high peak flows and flow swings in a self-regulating manner - the higher the flow, the higher the sludge flocs rise and the larger the filtration area becomes. The filters are provided with adjustable effluent weir troughs and surface skimmer systems. Clarifier skimmings are transferred to sludge transfer tank.
Size:	13' wide x 12 high x 42' long
Material:	The sludge blanket filters are fabricated from steel with all steel surfaces factory sandblasted to SSPC 10 and painted with two coats of polyamide epoxy paint to 12 mils DFT.

Sludge Pre-Thickeners SPT and Pumps SPTP (8)

Objective:	Pre-thicken sludge to 1.5-2.5% d.s. content.
Design Consideration:	Pre-thickener is a large diameter pipe provided with sludge entry/exit openings. Sludge enters at the top and settles to the bottom from where it is periodically drawn out to the sludge transfer tank. The amount of excess sludge depends on the plant organic loading and the pump timer will have to be accordingly adjusted from time to time.
Type:	Submersible, non-clog
Material:	Cast iron body and impeller
Drive:	3 Hp, 460/3/60
Accessories:	Base elbow c/w carrier and guide rails

Microscreen Filters MFB (4) – MICROFILTRATION OPTION ONLY

Objective:	Provide means for residual suspended solids microfiltration.
Design Considerations:	Microfilter is a self-contained unit c/w mud and backwash pumps. Provided with dual air bubble level probes its operation is fully automatic.
Make:	Fontana or equal
Material:	Stainless steel body and filter media
Filter Media:	30 microns, stainless steel
Capacity:	2,200 gpm
Drive:	1 ½ hp, 460/3/60
Accessories:	Backwash pump – 1 ½ Hp, 460/3/60 Mud pump – 1 Hp, 460/3/60, c/w a float switch

External Membrane Filters (eMBR) (5) – MEMBRANE FILTRATION OPTION ONLY

Objective:	Provide means for residual suspended solids filtration.
Design Considerations:	External membrane filters are self-contained unit c/w backwash pumps and air blowers. Provided with dual air bubble level probes their operation is fully automatic.

Make: TBA
Filter Media: 0,1 microns
Capacity: 1,300 gpm
Accessories: Backwash pump – 3 Hp, 460/3/60
Air blower – 1 Hp, 460/3/60
Backwash tank
Feed tank

UV Disinfection (2)
Objective: Effluent disinfection to less than 2.2 MPN/100 ml (fecal coliform)
Design Considerations: Open channel type system installed within concrete channels is provided. The system consists of two UV lamp module banks installed in series within each of the two concrete channels.
Capacity: 1,300 gpm
Fecal Coliform: 2.2 / 100 ml
Accessories: UV intensity monitor, elapsed time meter, ground fault interrupter, cleaning rack

Air Blower AB 1 (3 – Two duty and one standby)
Objective: Provide air for fine bubble aeration.
Design Consideration: Three blowers are provided each capable of serving 0.5 MGD bioreactor. Two blowers are duty blowers the third is a common standby.
Make: Dresser Roots, or equal
Capacity: 1,000 SCFM @ 7.5 psig
Material: All iron
Drive: 50 Hp, 460/3/60
Accessories: Filter/Silencer and Discharge Silencer, Pressure Relief Valve, Belt Drive and guard, Pressure and temperature gauges, VFD drive controlled by DO monitor

Air Blower AB 2 (3 – Two duty and one standby)
Objective: Provide air for RAS airlift pumps, coarse bubble aeration in the equalization basin and sludge aerobic digesters.

Sludge Transfer Tank STPS (1)
Objective: Provide containment for waste sludge and clarifier skimmings before transfer to sludge post treatment
Capacity: 50,000 gallons
Material: Concrete

Sludge Transfer Pump STP (2)
Objective: Pump the contents of the sludge transfer pump station to the sludge post treatment

Alum Storage and Dosing System ADS (1)
Objective: Meter alum into the anoxic compartments of the bioreactors

Decentralized Wastewater Treatment

With the technological advances of small plant performance and reliability, decentralized plants and water re-use have now become eminently feasible and economically and environmentally advantageous. Smaller local treatment plants in place of a large central facility allow for a significant reduction of overall capital cost, phased construction and the possibility of local water re-use in dual plumbing or for irrigation and other non-potable uses.

Traditional centralized solutions require costly collection infrastructure which often represents a major portion of the total capital cost. Moreover, the centralized system does not readily accommodate the treated effluent reuse.

ECOfluid's Upflow Sludge Blanket Filtration (USBF™) process is an innovative technology that is highly suitable for decentralized treatment applications. Economical and easy to operate its features include high secondary treatment efficiency, biological nutrient removal (BNR), self-regulating hydraulics and very importantly NO ODOR. The USBF™ process, followed by sand or membrane filtration and disinfection produces high quality re-usable water at economical capital and operating costs.

No Odor, No Noise, Out of Sight-
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Upflow Sludge Blanket Filtration (USBF)

Nitrogen Reduction Memorandum

Nitrogen is removed by nitrification and denitrification processes. Nitrification is autotrophic and all USBF integrated bioreactors deliver complete nitrification of ammonia to nitrate provided that certain minimum temperature is maintained [1] and alkalinity is available. [2] Denitrification is heterotrophic and requires carbon source. Processes using "separate-sludge denitrification" require that carbon is added. USBF technology "single-sludge denitrification" approach uses an endogenous carbon source to maintain the denitrifiers. Influent is combined with nitrified mixed liquor in the anoxic compartment providing the carbon source needed for denitrification.

The conditions that affect the process of denitrification are (not in the order of priority):

- Volumes or HRTs - The required 'biological' volume is divided into anoxic and oxide volumes. The ratio of the two varies depending on the degree of denitrification desired. The anoxic volume or HRT must allow for DO exertion and for the provision of anoxic conditions needed for fermentation.
- Mixing of the Anoxic Volume - Good mixing and roll of the anoxic compartment is important. Mixing should be 'gentle' so as not to break up the sludge flocs.
- DO Control - DO control throughout the bioreactor is the most important factor. The 'plug' flow of the mixed liquor in the oxide compartment allows for manual adjustment of individual aeration diffuser sections, and the overall air flow is typically controlled by a continuous DO monitor modulating the blower RPM via variable frequency drive (VFD). Anoxic compartment DO is 'controlled' only indirectly by the oxide compartment DO adjustment and control, and by providing sufficient compartment volume (see above).
- RAS Recycle - Mixed liquor containing nitrite/nitrates is recycled from the bottom of the clarifier to the anoxic compartment where the incoming BOD serves as the carbon source or electron donor for the reduction of nitrate to elemental nitrogen. The efficiency of the overall nitrogen reduction has been determined to be a function of the RAS flow multiple (the higher the multiple the higher efficiency). However, the recycle has to be balanced against other factors and based on experience a multiple of 2 to 4 provides a 'safety factor' for typical domestic wastewater while moderating the negative effects. RAS pumps are typically airlift pumps for smaller plants, and low head (low Hp), axial flow pumps provided with VFD drives for larger plants.
- Temperature – Low temperatures and dramatic changes in temperature inhibit or stop the process of denitrification.
- Carbon – Incoming wastewater is the source of carbon. [3] Carbon deficiency is typically not an issue with most municipal or domestic wastewater.

Case Studies

The following USBF plant operating data have been recorded:

Marco Shores, FLA

Effluent	Nitrate as N (mg/l)	Nitrite as N (mg/l)	Ammonia as N (mg/l)	TIN (mg/l)	TKN (mg/l)	TN (mg/l)
August 13, 2003	3.2	0.044U	0.05U	3.29	1.0	4.29
August 27, 2003	2.8	-	0.05U	2.8	0.74	3.54
September 10, 2003	3.1	-	0.05U	3.1	0.7	3.8
Design Parameters						10

Notes: 1. U denotes Under Detectable Limit
2. The plant is not equipped with SCADA, continuous DO monitor and VFD drives
3. Official lab analysis available

[1] Nitrification was observed to function at temperatures as low as ~3 deg C.
[2] Nitrification consumes 7.1 mg/l of alkalinity as $CaCO_3$ for each mg/l of ammonia oxidized.
[3] Reduction of 1 gram of nitrogen requires approximately 3 – 6 grams of BOD (or equivalent carbon)

Kicking Horse Ski Resort, BC

Effluent	Nitrate as N (mg/l)	Nitrite as N (mg/l)	Ammonia as N (mg/l)	TIN (mg/l)
March 15, 2007	4.8	1.9	0.778	7.5
March 22, 2007	3.0	0.07	0.149	3.22
March 29, 2007	3.4	0.0	0.142	3.54
April 2, 2007	5.8	0.67	0.097	6.57
April 9, 2007	3.0	0.2	0.035	3.24

Notes:
1. Nitrogen reduction was not the plant design objective (small anoxic compartment)
2. The plant serves a ski resort where flows, temperatures and biological loadings vary significantly from weekends to weekdays
3. Official lab analysis available

Islamorada, FLA

2005						2006					
April	May	June	July	August	Sept	January	February	March	April	June	July
1.7	3.7	3.1	2.9	3.8	2.8	6.6	3.3	2.1	3.5	2.4	4.7

Notes:
1. The plant is a small plant without any automated controls
2. Due to wide influent flow fluctuations, small plant's denitrification is typically more difficult to manage than with larger plants
3. Official lab analysis available

Snug Cove, BC

	2005				2006		
	March	June	Sep	Dec	March	June	Sep
TN	7.83	4.44	6.54	8.27	2.78	4.41	6.2
TKN	2.2	1.9	5.2	4.7	2.3	3.8	4.3

Notes:
1. This plant is a very basic rendition of the USBF configuration. It was not designed for nitrogen reduction (small anoxic volume), and it is not equipped with continuous DO monitor and VFD drives.
2. Official lab analysis available

Mill Bay, BC

Mill Bay Effluent	Nitrate / Nitrite as N (mg/l)	TKN (mg/l)	TN (mg/l)
April 17, 2007	1.8	0.9	2.7
May 22, 2007	4.0	1.8	5.8
June 25, 2007	5.17	1.5	6.7
July 17, 2007	2.75	1.5	4.2
August 7, 2007	3.38	1.5	4.9
September 11, 2007	7.12	1.4	8.5
October 16, 2007	4.11	1.2	5.3
November 6, 2007	3.9	2.2	6.1
Design Parameters			**10**

Notes:
1. The plant is a water reclamation plant where the permitted effluent Total Nitrogen (TN) is <10 mg/l.
2. The plant is relatively small (150 m^3/d; 40,000 gpd) and experiences high infiltration.
3. Official lab analysis available

UPFLOW SLUDGE BLANKET FILTRATION (USBF)

PHOSPHORUS REDUCTION MEMORANDUM

One of the beneficial features of the USBF technology is increased efficiency of phosphorus removal. This is due to the fact that a significant amount of the influent phosphorus is reduced by biological phosphorus uptake.

The mechanics of biological phosphorus uptake, known as "luxury uptake", is due to exposure of activated sludge to alternating oxide and anoxic conditions. Under the conditions, the cells store more energy in the form of phosphorus than needed for their survival. If strictly oxide conditions are maintained during subsequent clarification, phosphorus will be retained by the cells and it will eventually be removed with excess sludge. Unlike most other methods of clarification, the upflow sludge blanket filtration process maintains oxide conditions in the filter, and phosphorus reduction by biological uptake to as low as 1 mg/l has been achieved as demonstrated in the table below.[1]

The following results were recorded during the 2007 Annual Report filing test period at Kicking Horse Ski Resort, Golden, BC:

	March 15	March 22	March 29	April 2	April 9	Average
Total Phosphorus [mg/l]	1.11	0.78	0.69	0.95	2.2	1.15

Notes:
1. Total Phosphorus reduction was entirely by the biological phosphorus uptake. NO CHEMICALS WERE USED.
2. 24 hour composite samples were analyzed.
3. Official lab analysis available

For further phosphorus reduction phosphorus precipitant chemicals such as aluminum sulfate, ferrous sulfate or other salts are used. In most domestic wastewater phosphorus is present in three forms, orthophosphate, polyphosphate and organic phosphorus. Polyphosphate and organic phosphorus cannot be readily precipitated but both are converted to orthophosphate during biological treatment, which can. Since the bulk of phosphorus reduction is accomplished by biological uptake, the small polish dosages of metal salt precipitant do not significantly increase sludge production.

In simultaneous chemical precipitation metal salts are dosed into the anoxic compartment of the USBF bioreactor. Continuous sludge internal circulation and mixing ensure efficient precipitation, coagulation and flocculation within the bioreactor with an added benefit of increased efficiency of the USBF clarifier.

The following effluent Total Phosphorus parameters were recorded at a 1 MGD (4,000 m^3/d) USBF facility during seven months period from June to December 2002. The facility was provided with aluminum sulfate (alum) dosing system. During the period dual 24-hour composite samples were taken and analyzed and only the higher results were recorded. The following are monthly averages of the daily composite sample analysis.

2002	June	July	August	Sept.	Oct.	Nov.	Dec.	Average
Total Phosphorus	0.4	0.5	0.2	0.3	0.4	0.5	0.3	0.4

Notes:
1. TP design parameter was 1.0 mg/l
2. The facility has not been provided with any post-biology (read post USBF) filtration
3. Since the bulk of the total phosphorus reduction was by biological uptake, the alum consumption and the ballast sludge production were light
4. Two 24-hour composite samples were analyzed. Only the higher results were recorded.
5. Official lab analysis available
6. With added post-biology (post USBF) microscreen filtration, reduction of Total Phosphorus to 0.1- 0.25 mg/l range is believed to be eminently possible

[1] Sludge decant return from storage or dewatering to bioreactors if such is the case must be chemically treated as anoxic conditions during quiescent periods will cause phosphorus release.

At another facility, Islander Resort in Florida, the following results were recorded in 2006:

2006	Jan	Feb	Mar	Apr	May	Jun	Jul	Average
Total Phosphorus	0.1	0.13	0.3	0.4	0.5	0.1	0.2	0.25

Notes:
1. TP design parameter was 1.0 mg/l
2. Islander Resort facility is at 12,000 GPD (45 m^3/d) a relatively small system with highly fluctuating flow and very rudimentary control system only
3. The facility is provided with post-biology (post USBF) microscreen filtration
4. In the original configuration ferric sulfate was used for chemical precipitation, but it was replaced with aluminum sulfate in the last few years
5. Grab samples as mandated by Florida Department of Environmental Protection were analyzed and recorded monthly
6. Official lab analysis available

USBF™ - Membrane Filtration (USBF™MF)

In recent years, membrane filtration has been widely adopted by the wastewater treatment industry predominantly using immersed hollow fiber or panel membranes. The immersed membranes however, come with significant compromises involving costs, simplicity, flexibility, and more. Costly, 'special requirement influent fine screening' needs to be provided, and steps such as lifting and removing the membranes out of the bioreactor when required for maintenance are disruptive to routine plant operation. Additionally, membranes immersed in the bioreactor make optimization of the biological and the filtration processes difficult.

The USBF™MF system, which consists of a USBF™ bioreactor followed by external membranes, builds on the treatment efficiency of the USBF™ process and utilizes external membranes for final polishing filtration. The configuration reduces or eliminates many of the immersed membrane compromises. No special pre-treatment is required, the biological treatment can be optimized for biological nutrient removal (and include chemical precipitation if desired), and the membrane energy input is kept low by the membranes design and by the fact that the TSS of effluent from the USBF™ is already less than 10 mg/l. The result is a membrane quality effluent with significantly improved reliability, flexibility and simplicity of operation, and reduced capital and operating costs.

USBF™MF

merges efficient biological treatment system with compact external membranes

- No "Special Needs" Screening
- Optimized Biology (incl. BNR)
- Multi-barrier, two stage Filtration (USBF/MF)
- High Membrane Flux Rate & Reduced Fouling
- Clean-in-place (CIP)
- Modular & Flexible Design
- No Odor
- Significantly Reduced Power Cost

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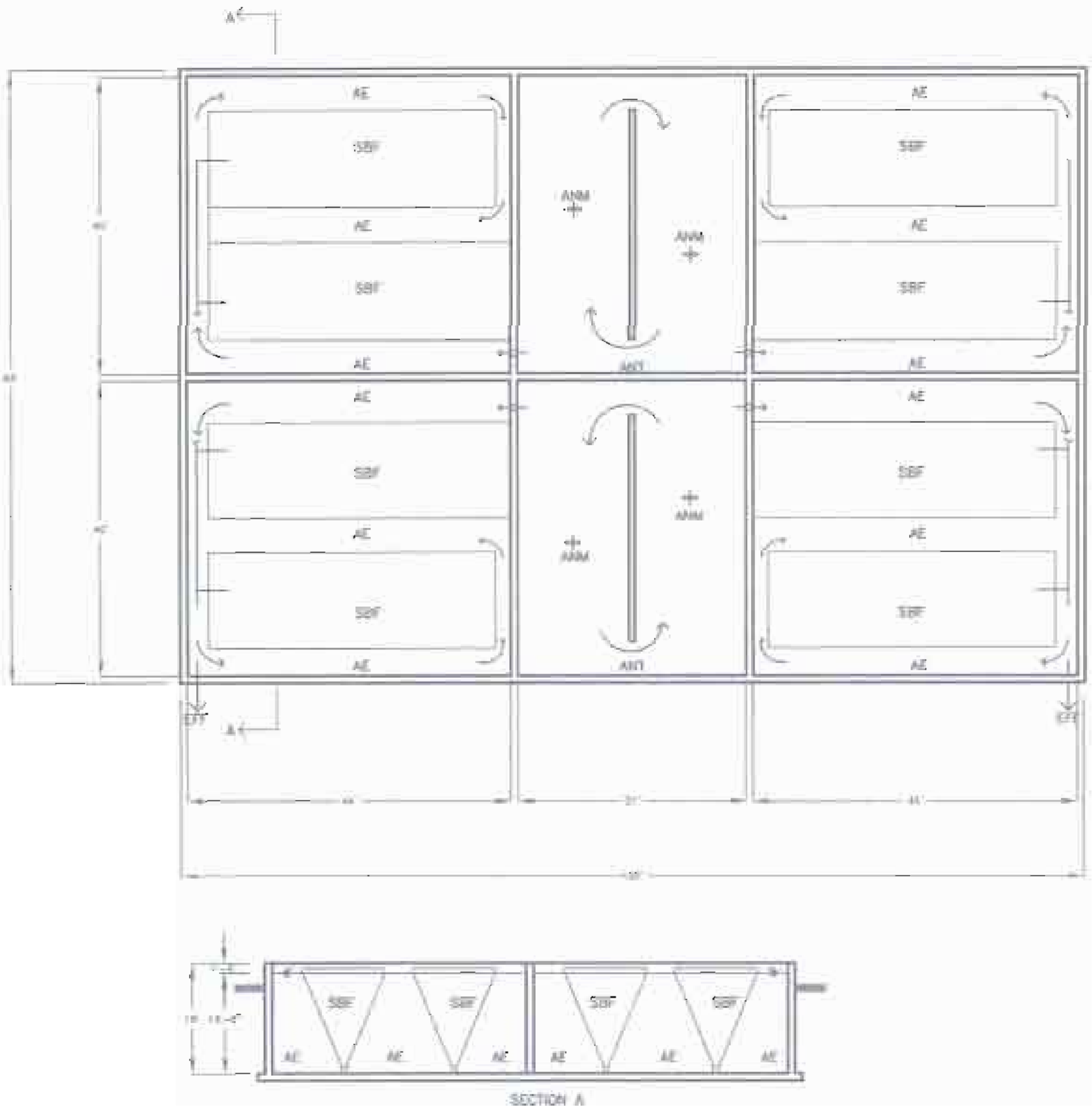


LEGEND

AE — AERATION COMPARTMENT
ANT — ANOXIC COMPARTMENT
ANM — ANOXIC MIXER
SBF — USBF™ SLUDGE BLANKET FILTER

DESIGN BASE

BOD: 220mg/l (METCALF & EDDY MEDIUM INFLUENT PARAMETER)
TSS: 220mg/l (METCALF & EDDY MEDIUM INFLUENT PARAMETER)
PEAKING FACTOR: 3.3

NOTES

1. PLANT CONFIGURATION CAN BE MODIFIED TO SUIT THE SITE REQUIREMENTS.
2. EQUALIZATION TANK, EFFLUENT PUMP TANK, SLUDGE HOLDING TANK, CHLORINE CONTACT TANK, HEADWORKS ROOM, POST TREATMENT PROCESS ROOM AND LAB AND CONTROL ROOM, WHICHEVER REQUIRED, ARE NOT SHOWN.

ECOfluid Systems Inc.

SITE CONSTRUCTED USBF WWTP
1 MGPD (~4,000m³/d)

TYPICAL ARRANGEMENT

ECOFLUID AWARDS & ACCOLADES

- 2007 – Awarded one of Canada's Top Ten Cleantech Companies

- 2006 – Received Frost & Sullivan Award for Technology Leadership

- 2006 – Received the Technology Merit Award from Environmental Business Journal

- 2002 – University of California, Davis – USBF™ technology was the highest ranked biological treatment system out of almost seventy technologies reviewed

"State of the art… an important environmental process revolution."

Lawrence K. Wang, PhD, PE, DEE, CO on the Upflow SludgeBlanket Filtration process

United Nations Industrial Development Organization (UNIDO)
Chief Editor, Humana Press, Albany, NJ
New York City Water Facilities Manager
City of Albany, NJ, Water Dept.

Benefits

High Treatment Efficiency Including Biological Nutrient Removal (BNR)

The USBF™ process features an internal anoxic compartment for biological reduction of nitrogen and phosphorus by nitrification, denitrification and 'luxury uptake' processes respectively.

Alkalinity Recovery & Filamentous Bacteria Control

The integral denitrification process facilitates partial recovery of alkalinity during nitrification. As well, the anoxic selector is used to control filamentous bacteria growth within the system.

No Primary Clarification

USBF™ process does not require primary clarification prior to biological treatment. A proper screening facility and for larger plants, grit removal system is all that is required upstream of the bioreactors.

Hydraulic Flexibility

The sludge blanket filter prism or cone shape not only allows other treatment processes to take place around it, but it also facilitates superior hydraulic flexibility. The process easily accommodates high peak flows and flow swings in a self-regulating manner; the higher the flow, the higher the sludge blanket rises and the larger the filtration area becomes.

Modular expansion of the plant at Sun Peaks Ski Resort. Two original bioreactor modules (left) installed in 1999 supplemented by two additional modules in 2005

Modular and Flexible Design

Modularity of design allows owners to stage plant development and ensures that plants can be quickly expanded if and when growth demands.

Reduced Operating and Maintenance Requirements

The compact design, minimal amount of moving parts and self- regulating hydrau , contributing to lower operating and maintenance costs.

Reduced Site Requirements

USBF™ process incorporates nitrification, denitrification, clarification and sludge stabilization into a compact bioreactor which reduces equipment size and liquid handling requirements and ultimately leads to a smaller plant footprint.

300 m³/d (80,000 GPD) USBF WWTP built in a residential subdivision between housing attesting to the non-odorous nature of the process

No Odor

Aerobic conditions throughout the bioreactor and extended sludge age eliminate or dramatically reduce odor. USBF™ plants can be located within populated areas without odor concerns.

Improved Sludge Characteristics

Low microbial loading (extended sludge age of 25-35 days) produces less excess sludge, which is aerobically stabilized, and which is characterized by improved structure and better dewatering capability.

Applications

Municipal and Domestic Wastewater

Literally thousands of site constructed and packaged USBF™ treatment plants serving municipalities, communities, subdivisions, ski resorts, shopping centers, summer resorts, golf courses, hotels, restaurants etc. are in operation worldwide.

Water Reclamation

The USBF process alone is capable of removing BODs and TSS to less than 10 mg/l without post-filtration, Total Nitrogen reduction to less than 10 mg/l and Total Phosphorus removal to about 2.5 mg/l. (The reduction of total phosphorus to less than 2.5 mg/l requires additional chemical precipitation). This high efficiency of the continuous flow USBF™ process paves the way to economical 'tertiary' post-treatment. Using the USBF™ process followed by membrane, sand or microscreen filtration, and UV disinfection, ECOfluid designs, builds and operates treatment plants producing Class A (or Title 22), or reclaimed water quality effluent at economical capital and operating costs.

Existing Plant Retrofits

The self-contained nature of the internal circulation loop and structural independence of the sludge blanket filter insert make it possible that virtually any tank can be converted to a wastewater treatment plant. Many existing RBC's, oxidation ditches and other plants have been retrofitted with USBF™ filters to increase treatment efficiency and/or plant capacity.

Industrial Wastewater

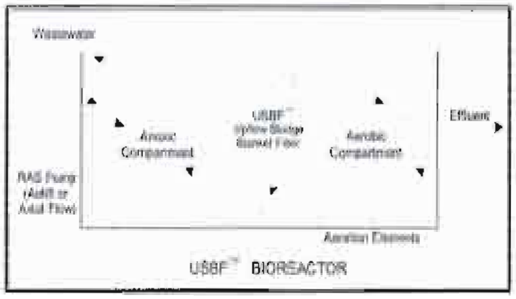
Many plants treating high strength industrial wastewater including food processing plants, slaughterhouses and rendering plants, dairy plants and pulp mills have been designed and are in successful operation worldwide.

Upflow Sludge Blanket Filtration (USBF™)

Process Summary

The Process

Operation of a USBF™ plant is simple and self-regulating. Wastewater enters the anoxic compartment of the bioreactor where it mixes with activated sludge recycled from the bottom of the sludge blanket filter. Agitated and moved in a plug flow manner, the mixed liquor flows into the bioreactor's aerobic compartment. After aeration, a stream of the mixed liquor enters the bottom of the sludge blanket filter where the sludge flocs and water are separated by upflow sludge blanket filtration. After separation, filtered effluent overflows into a collection trough and is discharged from the system. To complete the internal gravity circulation loop, activated sludge collecting at the bottom of the sludge blanket filter is recycled back into the bioreactor anoxic compartment.



Three Features that Increase Efficiency and Reduce Costs

Sludge Blanket Filter

The upflow sludge blanket filter introduces a substantially higher specific rate of separation than other commonly used separation techniques. Unlike conventional clarifiers, influent enters at the bottom and flows upwards. As the cross sectional area increases, the upflow velocity decreases until the activated sludge flocs become stationary and thus form a filtering media for activated sludge flowing through. High filtration efficiency is achieved and even particles with settling velocities too low to be removed by settling alone are filtered out.

High Sludge Concentration

Most traditional plants operate at low or medium sludge concentrations, typically 2,500 – 3,500 mg/l. USBF™ process by contrast operates at higher sludge concentrations, typically 4,000 – 6,000 mg/l resulting in longer sludge age and increased biological efficiency.

All Processes Integrated into One Bioreactor

Most conventional technologies carry out processes of nitrification, denitrification, clarification and sludge stabilization in a number of dedicated vessels. By contrast, USBF™ process incorporates these processes inside a compact bioreactor, reducing equipment size and liquid handling requirements.

Lake Alfred, Fl. 1 MGD (4,000 m^3/d) WWTP (Four 0.25 MGD modules). Trickling filter plant retrofit.

USBF™ - Membrane Filtration (USBF™eMBR)

In recent years, membrane filtration has been widely adopted by the wastewater treatment industry predominantly using immersed hollow fiber or panel membranes. The immersed membranes however, come with significant compromises involving costs, simplicity, flexibility, and more. Costly, 'special requirement influent fine screening' needs to be provided, and steps such as lifting and removing the membranes out of the bioreactor when required for maintenance are disruptive to routine plant operation. Additionally, membranes immersed in the bioreactor make optimization of the biological and the filtration processes difficult.

The USBF™eMBR system, which consists of a USBF ™ bioreactor followed by external membranes, builds on the treatment efficiency of the USBF™ process and utilizes external membranes for final polishing filtration. The configuration reduces or eliminates many of the immersed membrane compromises. No special pre-treatment is required, the biological treatment can be optimized for biological nutrient removal (and include chemical precipitation if desired), and the membrane energy input is kept low by the membranes design and by the fact that the TSS of effluent from the USBF™ is already less than 10 mg/l. The result is a membrane quality effluent with significantly improved reliability, flexibility and simplicity of operation, and reduced capital and operating costs.

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merges efficient biological treatment system with compact external membranes

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Optimized Biology (incl. BNR)

Multi-barrier, two stage Filtration (USBF/eMBR)

High Membrane Flux Rate & Reduced Fouling

Clean-in-place (CIP)

Modular & Flexible Design

No Odor

Significantly Reduced Power Cost

2006

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No Odor, No Noise, Out of Sight-
Two Decentralized Treatment Facilities

2006

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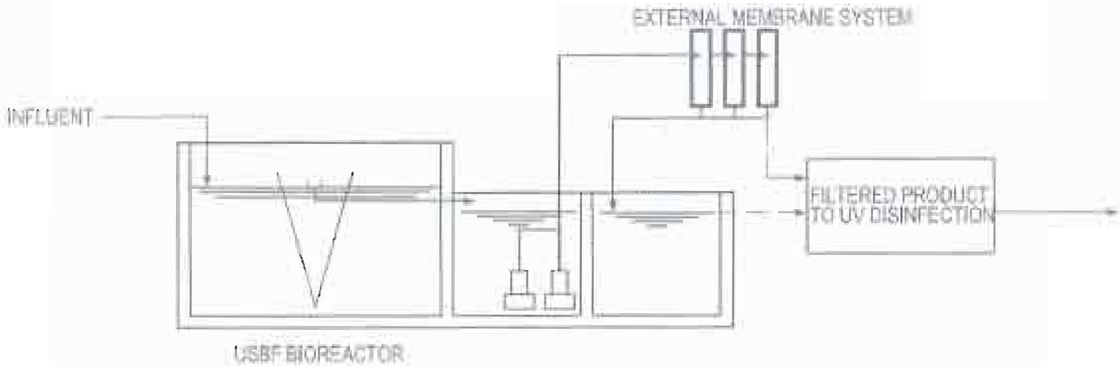
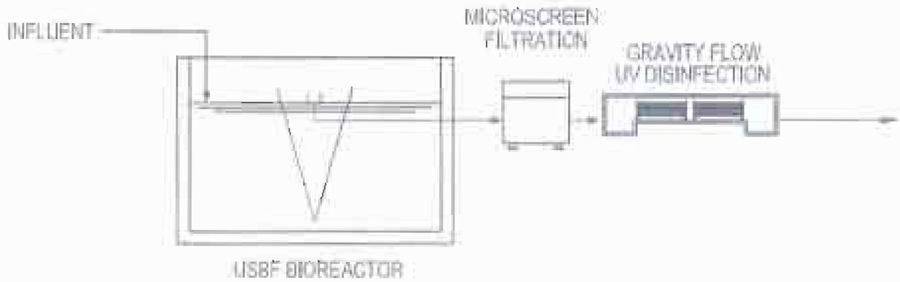
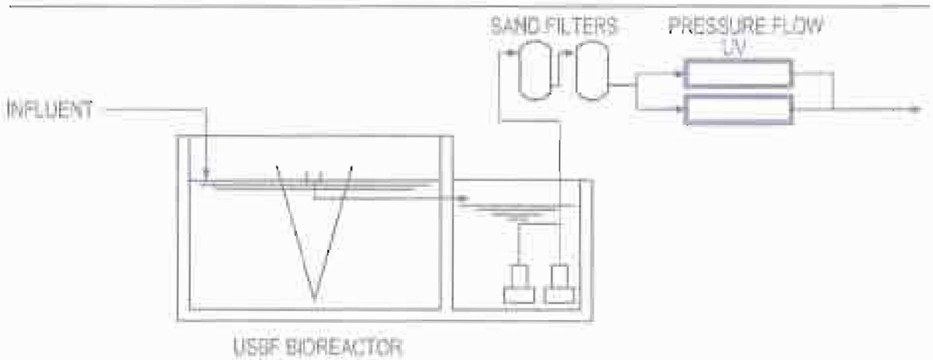


(A1) EXTERNAL MEMBRANE FILTRATION & DISINFECTION



(A2) GRAVITY FLOW FILTRATION & DISINFECTION



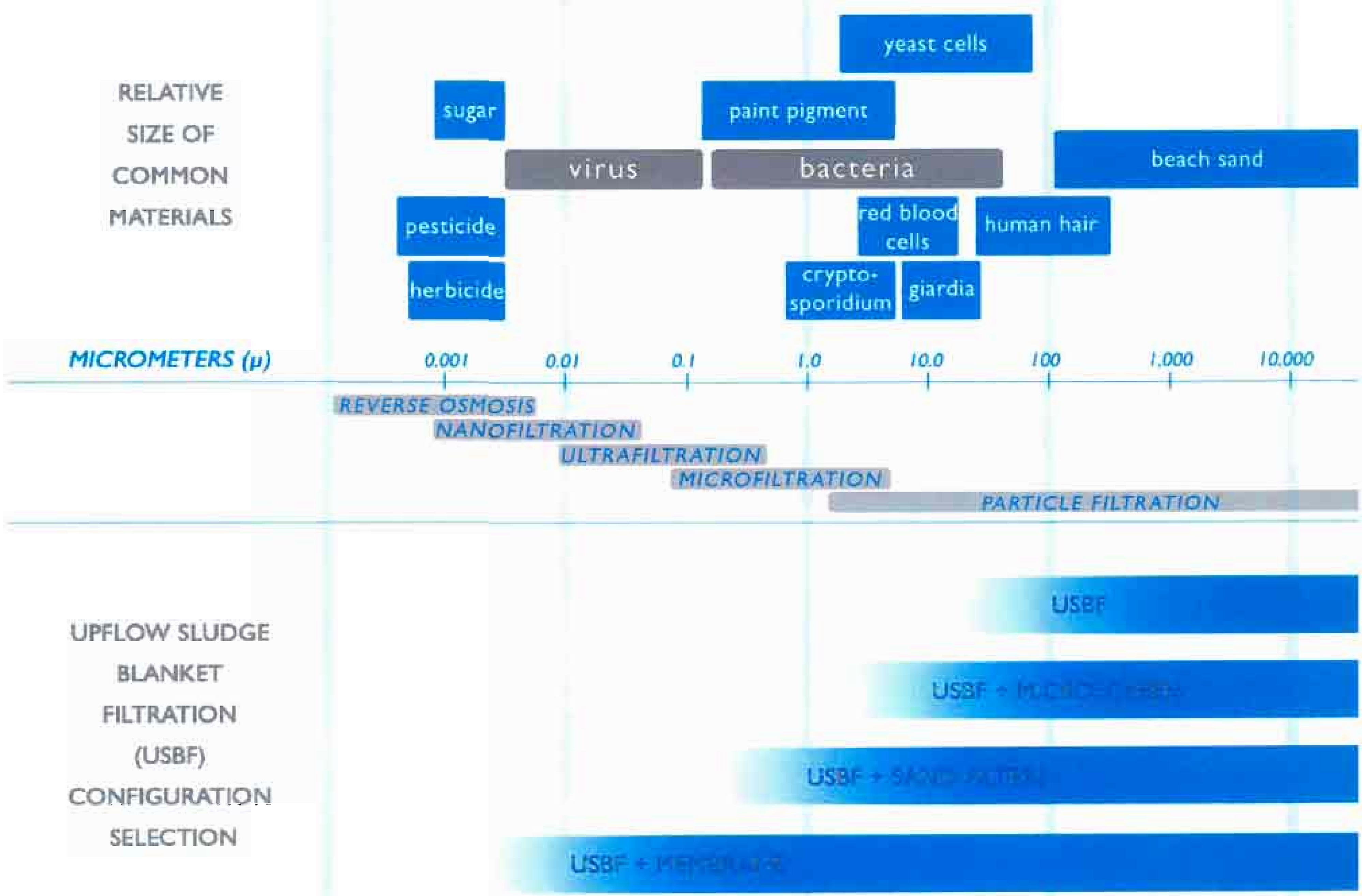
(A3) PRESSURE FLOW FILTRATION & DISINFECTION

USBF WWTP CLASS "A" & RECLAIMED WATER OPTIONS

CLASS "A" PARAMETERS	CLASS "A"	RECLAIMED WATER
BOD, max mg / L	10	10
TSS 10 mg / L	10	5
FC, median, fc / 100 ml	2.2	2.2
FC, any sample, fc / 100ml	14	14
TN, max, mg / L	20	NA
NITRATE - N, max, mg / L	10	NA
TURBIDITY, avg, NTU	2	2
TURBIDITY, any sample, NTU	5	5

ECOfluid

Filtration Selection Chart



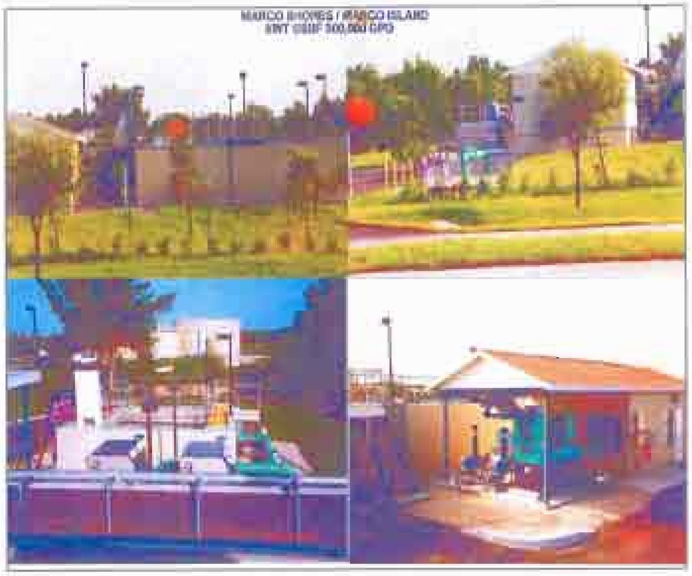
ECOfluid

MARCO SHORES WWTP, MARCO SHORES, FL
CASE STUDY

This 300,000 GPD facility at Marco Shores, FLA employs USBF bioreactors immediately followed by microscreen filtration. No additional filtration is employed.

As illustrated by the operating data tabulated below, the plant designed for 10/10/10 mg/l BOD/ TSS /TN consistently delivers very low BOD, TSS and Total Nitrogen.

Disinfection in this plant is by chlorination.



OPERATING RESULTS

Date	TSS Pre-Filter [mg/l]	TSS Final Effluent [mg/l]	BOD Final Effluent [mg/l]	TN Final Effluent [mg/l]	TP Final Effluent [mg/l]	Fecal Coliform Final Effluent [CFU/100ml]
August 5, 2003	3	0.8				1
August 6, 2003	28	0.8				1
August 7, 2003		1.1				1
August 11, 2003	2.3	2.1				
August 12, 2003	4.0	3.3				1
August 13, 2003		0.6	2.5	4.2	3.1	1
August 14, 2003		0.7				1
August 18, 2003		6.3				1
August 19, 2003		6.9				1
August 20, 2003		0.6				1
August 21, 2003		1.1				1
August 26, 2003		2.2				1
August 27, 2003		1.4	3.6	6.3	2.8	1
August 28, 2003		0.8				1
August 29, 2003		1.6				1
September 8, 2003		2.6				1
September 9, 2003	5.0	0.8				1
September 10, 2003		1.0	2.2	6.8	3.5	
September 11, 2003		0.9				1
Design Parameters		**10**	**10**	**10**		**10**

Total Phosphorus was NOT the plant design parameter

STRATHMORE WWTP
CASE STUDY

OPERATING RESULTS

2002	Bioreactor 1			Bioreactor 2		
	SSV [ml/l]	MLSS [mg/l]	SVI [ml/g]	SSV [ml/l]	MLSS [mg/l]	SVI [ml/g]
June	474	5536	85	374	5236	71
July	820	5131	162	851	5419	159
August	732	4485	167	827	4572	182
September	806	4798	171	758	4620	165
October	780	3797	206	758	3766	201
November	914	5009	185	887	4749	188
December	914	4724	194	917	5065	182

After the plant turn-over to the plant operator in mid-June the operator "experimented" with operating parameters (lower DO, reduced MLSS…). The result was much higher than typical SSV and SVI in the following months.

WASTE ACTIVATED SLUDGE YIELD

2002	WAS [m³/m]	WAS [m³/d]	WAS [% ds]	WAS [kg/d]	WAS Yield [kg WAS / kg BOD and TSS]	WAS Yield [kg WAS / kg BOD]
June	1,684	56.1	0.54	303	0.19	0.37
July	2,954	95.3	0.53	505	0.37	0.75
August	2,978	96.1	0.45	432	0.28	0.56
September	3,347	111.6	0.47	524	0.35	0.69
October	3,908	126.1	0.38	479	0.29	0.58
November	1,969	65.6	0.47	308	0.18	0.38
December	2,465	79.5	0.49	390	0.25	0.49
Average	2,758	90.0	0.48	420	0.27	0.54

Averaged over seven months and including aluminum sulphate ballast sludge Waste Activated Sludge (WAS) yield was 0.27 kg/kg (lb/lb) of combined BOD and TSS or 0.54 kg/kg (lb/lb) of BOD.

ALUM CONSUMPTION

2002	Alum [l/d]	Alum Consumption [l/kg TP]
June	161	11.4
July	145	10.7
August	322	20.8
September	261	16.7
October	230	14.8
November	87	5.6
December	205	13.0
Average	201	13.3

Alum solution consumption was 13.3 litres per kg (1.6 gal/lb) of Total Phosphorus removed. This would indicate that approximately 60% of the Total Phosphorus reduction was by biological "luxury" uptake.

STRATHMORE WWTP
CASE STUDY

The Strathmore WWTP was constructed to replace eight extended aeration lagoons. The plant was designed to process 4,000 m³/day (1 MGPD) Average Day Flow, 10,000 m³/day (2.6 MGPD) Peak Day Flow and the permit stipulated effluent of less than 20 mg/l BOD and TSS, less than 5/10 mg/l N-NH_3 in summer/winter respectively, less than 1 mg/l Total Phosphorus and less than 200 MPN/100 ml fecal coliform. The plant features included headworks, two USBF bioreactors, alum storage and dosing and a UV disinfection system. Alum solution (49%) was dosed into the anoxic compartment of the bioreactors. Phosphorus precipitation and coagulation took place within the bioreactor internal circulation. Filtration was solely by the USBF clarifiers - the process did not include effluent post-filtration.

The plant was operated in May 2002 by ECOfluid and turned over to the Owner's operator in mid June 2002. Seven months of the plant operation and performance in 2002 are summarized in the following summary tables. The results confirm that loaded very close to its design capacity the plant performed well within the design parameters and better.

All data are monthly averages of daily 24 hr composite samples. Daily duplicate 24 hour composite samples were sent to certified lab for analysis (Lab analysis available). Only the higher results were recorded.

INFLUENT DATA

2002	Flow [m³/d]	BOD [mg/l]	BOD [kg/d]	TSS [mg/l]	TSS [kg/d]	TP [mg/l]	TP [kg/d]	NH_3 [mg/l]	NH_3 [kg/d]
June	3,818	213	813	208	794	4.1	15.7	14.4	55.0
July	3,739	179	669	189	707	4.1	15.3	14.5	54.2
August	3,431	226	775	218	748	4.7	16.1	16.0	54.9
September	3,335	229	764	221	737	5.0	16.7	19.8	66.0
October	3,237	255	825	252	816	5.2	16.8	19.9	64.4
November	3,091	266	822	304	940	5.5	17.0	20.3	62.7
December	2,969	269	799	251	745	5.6	16.6	24.5	72.7
Average	3,374	234	781	235	784	4.9	16.3	18	61
Design	**4,000**		**800**		**800**		**30**		**100**

In terms of BOD and TSS the plant seven months average loading was 98% of the design capacity.

EFFLUENT DATA

2002	CBOD [mg/l]	BOD [mg/l]	TSS [mg/l]	TP [mg/l]	NH_3 [mg/l]	Total Coli	Fecal Coli
June	7	12	16	0.4	0.1	14	10
July	5	7	8	0.5	0.1	27	14
August	4	5	7	0.2	0.2	26	14
September	4	6	8	0.3	0.4	117	24
October	4	7	14	0.4	0.1	112	23
November	4	6	9	0.5	0.1	23	13
December	4	6	9	0.3	0.4	19	13
Average	5	7	10	0.4	0.2	48	16
Design		**15**	**15**	**< 1**	**< 5/10**		**200**

- Although not recorded daily effluent Total Nitrogen when analyzed was < 10 mg/l
- Spikes of high pH (11) were experienced by the plant in October.

LAKE ALFRED WWTP, LAKE ALFRED, FL
CASE STUDY

Filtered clean effluent at the top of the sludge blanket filter overflows into a v-notch overflow trough located under the walkway. There are no moving mechanical parts within the sludge blanket filter/clarifier or the overflow troughs.

From the overflow trough the treated effluent flows by gravity into the Fontana drum microscreen filters. Picture on the right shows filtered effluent in the backwash well of the microfilter (the microfilter uses filtered effluent behind the filter for its automatic backwash).

From the effluent storage tank below the microfilters, the treated, filtered effluent is pumped to the existing chlorination.

	Influent		Effluent		
	BOD	TSS	BOD	TSS	NITRATE
Date	mg/L	mg/L	mg/L	mg/L	mg/L
4-Jun-08	181	192	5.03	3.8	3.60
11-Jun-08			4.76	2.5	3.73
18-Jun-08	219	368	5.09	2.0	3.75
25-Jun-08			5.45	5.0	3.79
Average	200	279	5.08	3.3	3.72

The plant retrofit and upgrade was completed and the plant started up in May 2007. As illustrated by the analysis of samples taken during the month of July 2008, the plant is exceeding its design parameters of <10 mg/l for BOD, TSS and Nitrate.

LAKE ALFRED WWTP, LAKE ALFRED, FL
CASE STUDY

When the City of Lake Alfred decided to upgrade their existing 1 MGD trickling filters wastewater treatment plant, they looked at a number of technologies and after an evaluation decided on the USBF process.

As part of the upgrade, the plant was provided with a new Fontana Integrated Headworks, which screens the influent, washes and dewaters the screenings, removes sand and grit, and deposits washed screenings and grit into separate bins. From the headworks, the screened influent flows to equalization tank (which is a reconditioned old trickling filters tank – trickling filters removed).

From the equalization tank, the influent is pumped into bioreactor modules. The influent first enters the anoxic tanks (above right in the forefront) and with the slide gate open, it passes into the aeration tanks. The still water in the pictures above and below is the treated effluent surface of the USBF sludge blanket filter, within which fluidized bed filtration (upflow sludge blanket filtration) takes place. The water is crystal clear as can be seen in the pictures below.

The above right picture shows raised sludge filter blanket approx 8-10 inches below clear water surface (the sludge blanket level was intentionally raised by prolonged influent pumping).

BCWWA 2007 AGM & CONFERENCE, PENTICTON, BC
SUN PEAKS UTILITIES WASTEWATER TREATMENT PLANT
7 YEARS OF OPERATIONS

PAPER PRESENTED BY PAT MILLER, MANAGER OF SUN PEAKS UTILITY CORPORATION

There are now over 12 USBF plants in operation in British Columbia. The facility at the Sun Peaks Resort is today the largest (in BC) and, installed in 1999, one of the earliest. This presentation will outline the plant's operating experiences and operating data, and touch on the resorts' future considerations towards environmental sustainability, including water reuse for golf course irrigation and snow making.

HISTORY

Sun Peaks Resort is situated at the base of Tod Mountain approximately 40 kilometers northeast of Kamloops, British Columbia. Tod Mountain, with a summit elevation of 2,152 meters was originally developed as a ski operation in the early 1960's. In 1972, the former operator decided to develop a few residential lots and formed a private utility to operate a simple community water supply and wastewater leaching field that was replaced in 1987 with a simple lagoon system. While the permit granted a maximum disposal of 230 m^3/day, discharge was intermittent, if at all.

In 1992, the property was purchased by Nippon Cable Company Limited and the resort's name was changed to Sun Peaks. Nippon's strategy for Tod Mountain was to upgrade the ski lift and trail system and transform the area into a major four-season, destination mountain resort with all the amenities.

In 1993, the resort operator, Sun Peaks Resort Corporation completed the Tod Mountain Master Plan and entered into an agreement with the Provincial Government to take the resort from a winter only ski hill to a year round community that will eventually support as many as 24,000 residences and visitors during any period.

Sun Peaks' base development has been rapidly expanding since 1993. As a consequence, wastewater flows at the Sun Peaks Utilities' treatment facility have been steadily increasing. Sun Peaks Utilities Co. Ltd., (known as SPUCL) has made a number of improvements to the lagoon system to keep pace with the increasing hydraulic and organic loading. These improvements ranged from surface aeration mixers to sub-surface fine bubble diffusion piping.

SIMPLE TO COMPLEX TREATMENT

After the 1998 Christmas period when the holding time in the 6,000 cubic meter lagoon dropped to under 6 days, Sun Peaks Utilities decided to replace the lagoon with a system that could deal with the growing flows. After evaluating a few alternatives, SPUCL decided to go with the Upflow Sludge Blanket Filtration (USBF) system supplied by Ecofluid Systems Inc. The Design/Build contract was awarded to Knappett Construction Ltd. in the latter part of July 1999, the construction began on August 24, 1999 and the plant started receiving wastewater on November 19, 1999. By December 15, the effluent was below 10 mg/l BOD_5 and 10 mg/l Total Suspended Solids.

PLANT DESIGN

The overall design of the system allowed for four bioreactors, each containing an anoxic zone, an aeration zone and a clarifier that contained a floating sludge blanket that acted as a filter media through which the final effluent was filtered. It is the floating sludge blanket in a "V" shape clarifier that makes handling of flows that can change 10 fold within a month and double from weekdays to weekend possible.

Year	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Highest Flow	930	997	1,244	1,206	1,303	1,362
Lowest Flow	35	42	127	157	186	198

The decision to go with the USBF system was based on a phased modular design of the plant allowing for incremental expansions that would match the growth of the resort. The first phase installed in 1999 included 2 bioreactors with 3 clarifiers and a waste sludge storage tank.

Depending on the flows, the sludge tank was pumped out from once a day to once a week. The sludge at about 0.5% solids was then trucked off site.

Plant Upgrades and Expansions

The resort's growth required a number of upgrades and expansions since its start up in 1999. In 2001, fourth clarifier was added to the initially installed three.

With the trucking costs to move the waste sludge off-site rising, the Utility went to community for approval in 2002 to increase usage rates in order to purchase a sludge dewatering centrifuge and to move towards composting on site.

In the summer of 2003, the plant biology was expanded by an addition of two biological compartments, anoxic and aeration.

Last year the plant airlift RAS pumps were exchanged for mechanical pumps to save air, and a new waste sludge pre-thickener was installed to improve sludge handling. Unfortunately only one third of the pre-thickener installation was completed in time for 2006/2007 winter operation.

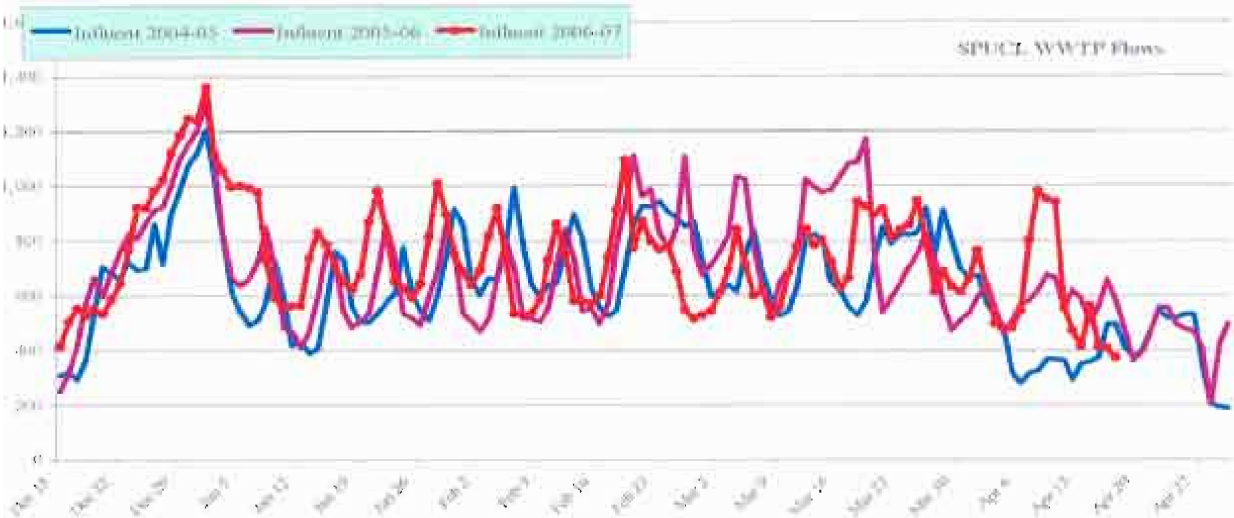
Unfortunately or fortunately, it never stops when you grow as rapidly as Sun Peaks, and so this year we will be upsizing the existing dewatering equipment, complete sludge pre-thickener installation, and add another air blower (bringing us to three).

At present the plant nominal average day capacity is 900 m^3/d, (300 kg BOD_5/d), with peak hourly flow of 120 m^3/h. With more air capacity and enhanced sludge management, we will be able to process increased flows expected this winter. As with any resort community, it is recognized that any additional plant expansion at the current site is limited by the available real estate.

Operating the plant for over seven years enabled us to gather the plant operating and costs data, and acquire experience, which may be of interest to you and which we will share with you in the following.

Operating Data

Each fall is like starting a new plant when we double the size from summer to winter mode. We take bets on what the new season's flows will be and whether we guess correctly on the number of homes built.



We have learned to track lift tickets sold and occupancy rates to help us get prepared for each week. We track when holiday fall and weather trends. You wouldn't believe how powder ski days and rain events can affect flows.

Influent Characteristics

Ski resorts (and this may apply to resorts in general) are not your 'typical influent' generators. Flows change dramatically from day to day and holiday period to holiday period. At Sun Peaks, we implemented the plumbing code similar to Australia for water conservation and thus the average daily flow per resident is currently 220 liters per day and dropping (the Canadian average is 375 liters per day). Then you add day visitors to the mix adding about 40 liters per person per day (very high ammonia content).

To get a better reading of the incoming influent, we analyzed hourly composite samples collected every hour throughout the day. The results illustrate a very uneven pattern of influent characteristics throughout the day as can be demonstrated by one such sample below.

2007	Low mg/L	Hour	High mg/L	Hour	Average mg/L
BOD_5	120	6:30 am	590	9:30 am	385
COD	310	5:30 am	1300	9:30 am	813
$N\text{-}NH_4$	30	1:30 pm	107	8:30 am	61

The variable biological loading throughout the day is a challenge on its own but it is not limited there. We also measured reduced alkalinity, and at times very high COD (possibly due to the type of cooking oils and cleaning detergents used in the resort's restaurants and hotels). Add to this, the fact that the influent temperature may change 5-7 deg C within a matter of days, and the highly fluctuating flow (as high as 110 m^3/h instantaneous hourly peak), and … well, you are getting the picture.

How do we cope?

To 'smooth-out' the variable biological loadings, our air blowers are controlled by a continuous DO monitor/VFD (variable frequency drive) system (this helps, except for being short of air at times, which will change with the installation of another blower this year).

Our well water has very little buffering capacity and with 3000 day skiers adding mostly ammonia to the wastewater stream, we have some issues with pH during the treatment process. To 'control' alkalinity we have been adding slaked lime ($Ca(OH)_2$) into the anoxic and aeration compartment – as much as 100 kg/day. This year, we have gone through almost 100 – 25 kg bags. The good news is that the slaked lime is available locally and is not expensive (about $11 per bag). It has proven very useful.

There is not much we can do about the rest of the challenges, except be more vigilant controlling FOG (fat, oil and grease) at source.

Effluent Parameters

Our MSR requires the effluent not to exceed 30 mg/l each for BOD_5 and TSS and as a rule we do much better. BOD_5 is typically less than 10 mg/l, TSS from 5 to 20 mg/l, ammonia less than 1 mg/l and Total Nitrogen in the 10 to 20 mg/l range. When we do not waste sludge and return the supernatant from the sludge dewatering process back into the influent flow, the Total Phosphorus is biologically reduced to 2 to 3 mg/l.

The following is an analysis of grab samples taken at about 11 am on March 7, 2007

		Bioreactor 1	Bioreactor 2	Bioreactor 3	Bioreactor 4
TSS	mg/l	5.7	9.7	3.7	3.7
Ammonia (as N)	mg/l	0.067	0.077	0.073	0.079
Nitrate (as N)	mg/l	6.75	4.17	7.42	6.58
Nitrite (as N)	mg/l	0.0504	0.0969	0.0545	0.0468
Total Nitrogen	mg/l	8.1	7.6	8.9	6.96
Total Phosphorus	mg/l	6.86	9.87	5.78	6.04
Chloride	mg/l	110	111	112	109
pH	mg/l	7.99	7.70	7.78	7.80
Conductivity		853	900	900	880

This sample was taken right after our highest day-flow period and after the US President's week (2nd highest annual occupancy period). Unfortunately BOD was not analyzed however, based on the other parameters it is safe to assume it was less than 10 mg/l. Together with averages of 5.7 mg/l for TSS, 0.074 mg/l for ammonia, and 7.9 mg/l for total nitrogen the results are well under the most stringent MSR requirements.

Total average phosphorus of 7.1 mg/l is much elevated from what we have experienced before the centrifuge installation. Almost all 'biologically uptaken' phosphorus returns to the system with the centrifuge supernatant recycle to the equalization tank.

Capital Costs

The total capital cost since 1999 to date, including the initial construction of the wastewater treatment plant, the upgrades and the sludge dewatering system, works out to a total of approximately $2,550 per m³/d, or $7,700 per kg BOD/d.

Looking back, SPRC and SPUCL have invested just over $2.5 million between the initial installation and subsequent upgrades to build a plant that can handle 1,000 cubic meters of peak sustainable flows (vs. peak day flows). If we were to build the same size plant today, (assuming no infrastructure other than the lagoon in place) the costs would be between $4 million and $5 million. This confirms that the decision in 1999 by the Board of Directors to proceed with wastewater treatment system that could grow in phases at the rate needed was the correct choice for a capital investment.

Operating Costs

Total operating cost includes many contributing costs of which the main 'direct costs' are the costs of electricity, wages and benefits, chemicals, repairs and maintenance, waste sludge disposal, and lab analysis.

Averaged over the respective years these direct operating costs shown in the following table:

Direct Costs	Fiscal 2001 2000-01	Fiscal 2002 2001-02	Fiscal 2003 2002-03	Fiscal 2004 2003-04	Fiscal 2005 2004-05	Fiscal 2006 2005-06
Wages & Benefits	65,577	81,071	89,100	103,332	98,870	134,161
Electricity	8,334	8,143	8,025	10,654	12,254	12,167
Chemicals	5,825	5,135	10,771	9,048	6,338	9,522
STP Disposal	23,309	41,660	15,256	23,020	7,300	2,835
Sewer analysis	11,976	13,106	10,140	9,666	10,174	9,091
Total	**115,021**	**149,115**	**133,292**	**155,720**	**134,936**	**167,776**
Total Flows (m³/year)		129,398	143,606	151,763	168,352	175,782
Total BOD (kg BOD_5/year)		42,701	47,390	50,082	55,556	55,366
Operating Costs						
$ per m³		$1.15	$0.93	$1.03	$0.80	$0.95
$ per kg BOD_5 *(Influent 330 mg/l BOD_5)*		$3.49	$2.81	$3.10	$2.43	$3.03

By tracking our costs on a biological loading basis, we know what expansion is going to cost from an operating point of view and can structure future rates that are in line with the costs. The operating costs are year round average costs and they are of course negatively affected by the high seasonality of our operation.

General Operating Experience

At Sun Peaks we developed 'per bed factors' to gauge both our water demand and the biological loading as opposed to the daily flows determination in a traditional municipal environment. The factors allow us to predict when each expansion will be needed rather than in the past where something had to break down before the system would be expanded.

After all, you have to get it right for the Christmas/New Years holiday period or you might as well go home. Nothing is more fun that going into the General Manager's office on New Year's Eve and saying that if the lagoon goes up 1 more inch, you are going to shut the town's water off. I had to do this December 31, 1998 and by November 1999, we had a new treatment plant.

Future Challenges & Considerations

With very little dilution and unhealthy eating habits, the upstream management of FOGs is becoming very important. We are currently working with the restaurants in the resort to become more proactive in dealing with their grease traps and oil trapping systems.

Sun Peaks is currently under a trial for biosolids management using composting. However there is a number of challenges that range from too cold in the winter, to too dry in the summer, to the price of land to perform composting. We are currently exploring options that may include gasification or gravel pit reclamation.

Our next challenge is the disposal of effluent. Our current use of rapid infiltration trenches only allows for a maximum daily discharge of 850 cubic meters. The resort is built on the side of a mountain and more land for RI trenches is limited. Options currently under study include stream augmentation, snow making and golf course irrigation. The challenge with the last two options is weather.

As you saw from the early flow graph, influent flows can change significantly from hour to hour and from day to day. Upstream flow balancing would allow more consistent flows into the plant and better treatment of the waste stream. From the first of November each year to the end of December, influent flows can increase five plus times.

The Operator's Experience

Our key challenge at Sun Peaks is that in addition to the wastewater treatment plant, we operate three water treatment plants and a gas distribution system. We have now reached a critical mass that allows us to have 5 operators on staff so that we can focus two of the operators on wastewater treatment to give us seven day week coverage.

Like many small utilities, getting, training and keeping operators is an increasing challenge, no matter what type of system you operate. The USBF system has been very tolerant to operator involvement and support on each expansion has been great.

The ownership of the resort is very happy with the modular expansion options of the USBF system and its ability to expand the system as needed when needed. After all, expansion costs are paid by new users being added to the system (via the developer) rather than the existing customers.

The community is very proud of the plant and that it uses a natural process to treat the wastewater. To confirm this, compare our wastewater rates of $2.17 per cubic meter with many other communities

Would we select the USBF system again – knowing what we know now? - YES!

Thank you for your attention and time permitting, we would be pleased to answer any questions you might have.

SNAW-NAW-AS FIRST NATION DECENTRALIZED WWTP
NANOOSE BAY, BC – THE SUCCESS STORY

INTRODUCTION

With the technological advances of small plant performance and reliability, decentralized wastewater treatment plants have now become eminently feasible. Smaller local treatment plants in place of a large central facility allow for considerable economical advantages including the reduction of costly collection infrastructure as well as providing the opportunity for smaller incremental-as-needed expansion phasing. Significant environmental and practical advantages also exist, including the possibility of reclaimed water re-use or disposal even in a very environmentally sensitive locality.

In early 2000's Indian & Northern Affairs Canada (INAC) was evaluating the construction of a wastewater treatment plant to serve the Snaw-naw-as First Nation village in Nanoose Bay in British Columbia. The plant was to initially serve the village itself but future expansions were anticipated including the village growth and the future commercial developments alongside the nearby highway. The treated effluent was to be discharged by an ocean outfall into the environmentally sensitive Nanoose Bay.

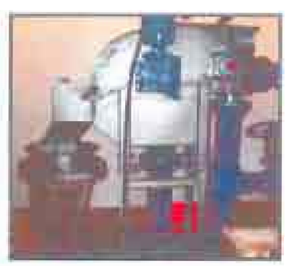
In 2002 INAC commissioned Chatwin Engineering and Novatec Consultants to prepare Expression of Interest (EOI) and later Request for Proposal (RFP) documents, and after the due evaluation process the project was in 2004 awarded to Knappett Construction Ltd of Victoria (General Contractor), and ECOfluid Systems Inc. (Treatment technology designer and provider), team, that had previously delivered a number of wastewater treatment projects in British Columbia. The project award, and the facility construction and operation included several innovative approaches, such as awarding the contract as a design/build/operate (DBO) contract, and a later inclusion of the development and implementation of the Band Members training to become Environmental Operators Certification Program (EOCP) certified operators in due time.

DESIGN CRITERIA

The design criteria for the new plant came directly from the decentralized facility order book:

- Produce high quality Class A effluent as stipulated by the Municipal Sewage Regulations (MSR), (BOD_5, TSS and Total Nitrogen of respectively less than 10, 10 and 20 mg/l, ammonia nitrogen of less than 1 mg/l and fecal coliform of less than 14/100 ml.)
- Discharge the treated effluent into the environmentally sensitive local recipient
- Allow for the future incremental plant expansion. The initial capacity of 119 m^3/d will be expanded in five future stages, each sized for an average day flow of approximately 132 m^3/d to an ultimate future average day capacity of 775 m^3/d. (In phases 4, 5 and 6, a mirror image plant is to be built).
- Build a decentralized treatment facility having a minimal visual, odor and noise impact on the neighbourhood
- Design an operator friendly plant keeping in mind that the plant will be for the most part operated by the Band member operator trainees
- Design a SCADA controlled plant that can be remotely monitored
- Develop and implement an operators' training program for the Snaw-naw-as Band members, with the ultimate aspiration to attain wastewater treatment plant operators' certificate as per the requirements of the EOCP

THE DESIGN



As mandated, the plant was designed to be simple and easy to operate. The influent is pumped into an IPEC drum screen with 6 mm openings and provided with a sealed, continuous bagging system. Screened influent drops into an equalization tank provided with a set of duplex equalization pumps which are controlled by float switches and timers.

The screened influent is then pumped through a flow splitter box into the anoxic compartments of two USBF bioreactors. Influent and recycled activated sludge mixed liquor flows to the aerobic compartment and the sludge and the treated water are eventually separated by the upflow sludge blanket filter (USBF).

From the sludge blanket filter the treated effluent flows to the filter feed tank, from which, controlled by flow switches, it is pumped through sand filters to the ultraviolet disinfection system overflow feed tank (which also serves as a reservoir for the sand filter backwash water). After flowing through the open channel Trojan UV disinfection unit, the effluent is discharged via ocean outfall into Nanoose Bay.

Waste sludge is thickened in the ECOfluid STP pre-thickeners to approximately 2% dry solids, and controlled by sludge pre-thickener pump timers, waste sludge is transferred to the sludge holding tank before being periodically hauled away for disposal.

The entire process is automatic and is SCADA monitored and controlled. Very little operator's direct input is required.

The design underwent extensive and drawn-out reviews by INAC and INAC appointed consultants, and the construction was finally given the go-ahead and commenced in April 2005.

THE PLANT

The first phase of the plant was built over the next six months. To keep with the design criteria, the entire plant was installed within a building esthetically blending with the surrounding environment.

The small bioreactors footprint allowed them to be installed belowground and within the building. Noise from the plant was reduced firstly by the fact that the USBF's self-regulating hydraulics result in minimal motorized noise-emanating equipment, and secondly by the blower enclosure noise abatement design. In fact, the noise from the nearby highway is often higher than that emanating from the plant.

USBF bioreactors operate odor free. The only other sources of odor, such as the screen room, and the equalization tank gas phase, are piped into the suction of an air fan which passes the collected gas through a biofilter bed. (The described odor abatement system was not ECOfluid's first and preferred choice. In most ECOfluid plants the above odorous gas would be piped to the suction of the air blowers and subsequently stripped during the mixed liquor aeration).

Phase I of this advanced plant was completed in October 2005, and the plant started to receive wastewater on October 20, 2005. The first sampling and analysis were performed within two weeks of the plant start-up and the data were well within the design parameters as evidenced by the following table.

Table 1 – First Samples and Analysis (Taken November 1, 2005)

BOD_5 [mg/l]	TSS [mg/l]	Nitrite Nitrate [mg/l]	Ammonia Nitrogen [mg/l]	TKN [mg/l]	Total Nitrogen [mg/l]	Fecal Coliform [CFU/100ml]
< 5	< 5	18.0	0.04	0.7	18.7	< 1

Plant Performance

In the last three years the plant performance has been consistently within the Class A design parameters. The following table summarizes annual averages of monthly sampling and analysis.

Table 2 – Annual average of plant samples and operating data

Year	Influent			Effluent								Power	WAS
	Flow	BOD Mg/l	TSS Mg/l	BOD Mg/l	TSS Mg/l	$N-NH_4$ Mg/l	N-NOx Mg/l	TKN Mg/l	TN Mg/l	Turb. NTU	Fecal Coliform Count/100 ml	Average kWh/d	Kg WAS / Kg BOD
2005	48	111	138	<5	<3	-	12.9	1.4	14.3	-	<10	-	-
2006	51	178	273	<10	<1	0.06	11.4	1.2	12.5	0.6	<1	-	-
2007	55	119	149	<10	<1	0.05	20.5	1.1	20.9	0.5	<1	248	-
2008	56	118	143	<10	<1	0.19	18.9	0.8	19.3	0.7	<1	255	0.54

Note: All data are annual averages of monthly sampling, testing and analysis which is performed by professional third party laboratory

Prior to sampling of the influent BOD, the operators and the designers were baffled by the elevated Total Nitrogen, which, while still within the design criteria, hovered higher than the 10 mg/l typically expected of the USBF plants. The subsequent analysis of the influent BOD confirmed the initial suspicion; the consistently low influent BOD did not provide sufficient donor carbon necessary for denitrification. It is interesting to observe that the one year the influent BOD was higher (2006), resulted in much better denitrification and TN was reduced to an average of 12.5 mg/l. Although the plant still performs within the design criteria, the addition of supplemental carbon on a trial basis will be implemented.

To compound the denitrification process challenge, it was recently discovered through the construction photos, that a fine air bubble diffuser was by error installed within the anoxic compartment instead of a coarse air bubbler intended for mixing. The situation will be corrected in early spring of 2009.

Addition of supplemental carbon, and replacement of the fine air diffuser in the anoxic compartment will no doubt bring the Total Nitrogen levels closer to, or below the USBF customary 10 mg/l.

The plant absolute power consumption is approximately 250 kWh/day. The specific power consumption (kWh/m³ or kWh/kg BOD) will reach its optimum when the plant capacity loading will increase.

Snaw-naw-as Band Members Operator Training

The development and the implementation of the Band Members operating training program were the first for INAC and ECOfluid. The program's goal was to have two band members to attain wastewater treatment plant operators' certificate as per the requirements of the EOCP. Two trainees were selected by the band and the training started even before the plant construction was completed.

List of Installations
Central and North America

ECOfluid Systems Inc. supplies custom design and package wastewater treatment plants. The following USBF plants were supplied and installed since 1998.

Plant Location	Capacity		Design Effluent Parameters					Application
	GPD	M^3/D	BOD	TSS	TN	TP	FC	
Mill Bay, BC (Phase 1)	21,500	80	10	10 (2 NTU)	10		2.2	Subdivision, school
Beecher Bay Indian Band, BC	10,500	40	10	15				Subdivision
Bowen Island, BC	42,000	160	10	15				Municipal
Coal Harbour, BC	60,000	230	10	15				Community
Duncan, BC	2,600	10	10	15				Residential cluster
Stillwood Camp, Chilliwack, BC (Phase 1)	13,000	50	10	15				Recreation camp
New Denver, BC	9,500	40	10	15				Hospital
Telegraph Cove 1, BC	4,500	20	10	15				Resort community
Telegraph Cove 2, BC	4,500	20	10	15				Resort community
Salmon Arm, BC	4,500	20	10	15				Municipal, School
Thetis Island, BC	4,500	20	10	15				Municipal
Kelowna, BC	4,500	20	10	15				School
Ainsworth, BC	30,000	120	10	10				Subdivision
Eagle Eye Golden, BC	5,000	20	20	20				Mountaintop restaurant
Sun Peaks Resort, Sun Peaks, BC (Phase 1)	80,000	300	10	15				Mountain, Ski resort
Holiday Park, Kelowna, BC	80,000	300	10	10				RBC replacement
Kicking Horse, Golden, BC (Phase 1)	80,000	300	10	10			200	Municipal, Ski resort
Strathmore, AB	1,000,000	4,000	15	15	(< 1 NH_3)		200	Municipal
Quinault Indian Auth., Moclips, WA	34,000	130	10	10			200	Subdivision
Bainbridge Island, WA	10,000	40	10	15				Hospital
Sun Peaks Resort, Sun Peaks, BC (Phase 2)	160,000	600	10	15				Mountain, Ski Resort
Penticton, BC	17,000	65	10	10				Subdivision
Nanoose First Nation, BC (Phase 1)	32,000	120	10	10	(< 1 NH_3)		100	Subdivision
Cowan Point, BC	40,000	150	10	10				Subdivision, golf course
Bay Point, FL	75,000	285	10	10	10	1	/	Municipal
Keremeos, BC	22,000	85	10	10				Mobile Home Park
Millsprings, BC (Phase 2)	16,000	60	10	10 (2 NTU)	10		2.2	Subdivision (Phase 2)

LIST OF INSTALLATIONS
CENTRAL AND NORTH AMERICA

Plant Location	Capacity		Design Effluent Parameters					Application
	GPD	M³/D	BOD	TSS	TN	TP	FC	
Merrit, BC	63,000	240	10	10 (2NTU)	10		2.2	Municipal subdivision
Rock Harbor, FL	7,500	28	10	10	10		10	Subdivision, school
Indigo Bay, FL	7,500	28	10	15	10		10	Subdivision
Nanny Cay, Tortola	50,000	190	10	10	10			Municipal
Angler's Reef, FL	20,000	75	10	10	10	1	10	Subdivision
Seaward, FL	14,000	50	10	10	10	1	10	Subdivision
Pahrump, NE	50,000	190	10	10	10		10	Municipal
Lake Alfred, FL	1,000,000	4,000	10	10	10		10	Municipal
Key's Fisheries, FL	45,000	170	10	10	10		10	Subdivision
Alder Bay, BC	20,000	75	10	15				Subdivision, RV Park
Saltsprings Island, BC	25,000	95	10	10	10		25	Subdivision (water reuse)
Key's Club, FL	10,000	40	10	10	10		10	Subdivision
Tonto Apache, Payson, AZ	85,000	320	10	10 (2 NTU)	10	1	1	Subd. & casino. (Water reuse)
Pemberton, BC	12,000	45	20	20				Camp
Stillwood Camp, Chilliwack, BC (Phase 2)	13,000	50	10	15				Recreation camp
District of Taylor, BC	80,000	300	10	10				Municipality
Gulf Corp., Freeport, TX	15,000	55	10	10				Sanitary wastewater
Millsprings, BC (Phase 3)	16,000	60	10	10 (2 NTU)	10		2.2	Subdivision (Phase 3)

*Includes plants under engineering and/or construction.

LIST OF INSTALLATIONS
CENTRAL AND NORTH AMERICA

The following USBF packaged plants were supplied and installed by a joint venture company between ECOfluid and a Kentucky company between 2000 and 2003. The partnership has been dissolved in 2003.

Plant Location	Capacity		Application
	GPD	M3/D	
Williamstown, KY	18,500	70	Demonstration
Chester County, PA	25,000	100	College
H.T.Hatley, GA	4,000	15	Warehouse
Riverview Foods, Warsaw, KY	10,000	40	Food processor
Attic Storage, Hiram, GA	4,000	15	Warehouse
Dole 1, La Cieba, Honduras	22,000	80	Food Processor
Dole 2, La Cieba, Honduras	22,000	80	Food Processor
Dole 3, Sonegera, Honduras	51,000	190	Food processor
Data Pro International, Belize	20,000	80	Industrial
Big Wheels, Huoma, LA	17,600	70	Truck Stop
Grande Harbor, Marathon, FL	8,000	30	Marina, Resort
Island Restaurant, Marathon FL	13,000	50	Restaurant,
Islander Resort, Florida Keys, FL	65,000	250	Restaurant, Resort
Palace Truck Stop, New Orleans, LA	22,700	90	Truck stop
Southdown Industries, Dayton, OH	5,000	20	Factory
TMB Partners, Lafayette, NJ	7,000	26	Municipal
Ziggies, Islamorada, FL	6,000	22	Restaurant
Alder Camp, Klamath, CA	17,000	70	Municipal Campground
Asbury Hills Camp, Cleveland, SC	15,000	60	Campground
Ben Lomond Camp, Santa Cruz, CA	15,000	60	Campground
Clinton St., Huoma, LA	120,000	480	Municipal
Demo Plant, Suffolk County, NY	8,500	35	Municipal
Eagle View MHP, Imperial, MO	25,000	100	Mobile Home Park
Everglades National Park #1, FL	2,000	8	Ranger Station
Everglades National Park #2, FL	4,000	16	Ranger Station
Florida Water, Marco Shores, FL	300,000	1,200	Municipal
French Creek School, Chester, PA	4,000	16	School
Golden Isle Marina, St. Simons, GA	31,000	180	Marina / Resort
Ingles Supermarket, Hull, GA	6,000	22	Food process
Marathon Marina, Marathon Key, FL	25,000	100	Municipal Marina
Mississippi Band of Choctaw Indians	100,000	400	Municipal Reservation
Oceanside Marina	20,000	80	Municipal Marina
Rivervista RV Park, Rabun, GA	12,600	45	RV park
Smoketree Lodge, Elk, NC	15,000	60	Municipal
Motel & Restaurant, Sparta KY	18,000	70	Sanitary
Sussex High School, Sussex VA	30,000	120	Sanitary
C. Velilla Project, Guadalajara, MX	100,000	400	Municipal Subdivision
Flextronics, Guadalajara, MX	120,000	480	Industrial
Processing Plant, Morelia, MX	66,000	245	Poultry Processing

LIST OF INSTALLATIONS
CENTRAL AND NORTH AMERICA

PLANTS OPERATED UNDER CONTRACT BY ECOFLUID

ECOfluid provides operations and maintenance services under contract with owners for the following plants in British Columbia:

Plant Location	Capacity		Design Effluent Parameters					Application
	GPD	M^3/D	BOD	TSS	TN	TP	FC	
Millsprings, Mill Bay, BC	21,500	80	10	10 (2 NTU)	10		2.2	Subdivision
Stillwood, Chilliwack, BC	26,000	100	10	15				Recreation camp
Bowen Island, BC	42,000	160	10	15				Municipality
Penticton, BC	17,000	65	10	10	(1 NH_3)			Subdivision
Nanoose First Nation, BC	32,000	120	10	10			100	Subdivision

USBF-SBR-MBR COMPARISON
THIRD PARTY EVALUATION

The following is an abbreviated version of the wastewater treatment processes evaluation by CPH Engineers Inc., Environmental Division, of Orlando, Florida.

USBF vs. SBR

- The Sequencing Batch Reactor (SBR) system has a larger aeration requirement than the Upflow Sludge Blanket Filtration (USBF) system. This is due to the fact that air is only supplied during a portion of the total SBR cycle time. The installed blower horsepower for the USBF process is therefore less than for the SBR process. (This can be as much as 50% less).

- The USBF process manages increased hydraulic loading better than the SBR process. This is due to a lower Sludge Volume Index (SVI) of the USBF, which results in a faster settling rate of the mixed liquor. Additionally, the USBF clarifier design has sloped sidewalls that automatically increase the surface settling area with the rising sludge blanket due to the flow increase. By comparison, in the SBR process the settling time cycle must be increased.

- The USBF process has an anoxic zone prior to the aeration zone. This serves two purposes. The first purpose is to "condition" the mixed liquor prior to the upflow solids contact flocculating clarifier, which helps to reduce or eliminate filamentous sludge and provide a low (80-120 ml/g) SVI. The second purpose is that it is used for biological reduction of nitrogen and phosphorous by respectively nitrification/denitrification and "luxury uptake" processes. This is accomplished by increasing the Hydraulic Residence Time (HRT) in the anoxic zone. By comparison, in the SBR process a separate carbon source is required for denitrification to reduce nitrogen and an anaerobic stir process is required to reduce phosphorous, which can be accomplished by an additional cycle or through the addition of another tank.

- The USBF design is a continuous flow system that incorporates the aeration zone, the clarifier and the anoxic zone in a single tank and the only mechanical equipment required is the blower, which is used for both aeration and air lifting the return activated sludge. The SBR process on the other hand, is normally a two-tank design and in addition to the aeration blowers, needs multiple pumps and motors to carry the different stages of the process to its completion.

- The USBF system has a smaller foot print and less overall height to the system. Typically, the USBF system can require up to 80% less land area compared to the SBR system.

- Overall, the USBF is a plug flow, self regulating process, easier to operate and maintain, due to the fact that there are no moving parts, other than the blowers, one on duty the other standby. Electrical consumption is about 60 % less than that of an SBR.

- The SBR must use chemicals and additional mechanical filtration in order to treat BOD, TSS, TN and P to the required effluent levels.

- The USBF process does not require the use of chemicals or for that matter any additional filtration. Filtration is accomplished by the "filtration blanket" within the clarifier.

USBF vs. MBR (Zenon)

- *The capital investment for the USBF is about 70% less than that for a Zenon MBR system.*

- The Zenon process requires a biological treatment system and chemicals in order to remove carbonaceous and nitrogenous oxygen demands in addition to the membranes used for TSS removal.

- MBR system requires a computerized control system that is essential for the operation of the system. Class "A" experienced operators must operate and "fine tune" the MBR system twenty four hours per day seven days per week.

- The USBF process is a self regulated system and very little, if any operator attention is required.
- The membranes in an MBR process must be cleaned on a daily basis by the use of "back-pulsing". This is done to reduce the possibility of fouling and debris collection on the membranes. The USBF process does not require the additional controls or daily cleaning of the internal components.
- MBR system has a potential for fouling of the membranes by biological, chemical (sulfates, carbonates, etc.) or physical contamination (hair, plastics, paper, etc.) associated with the waste stream.
- MBR system requires a fine mechanical bar screen (~1 mm) upstream of the unit to minimize the potential for physical fouling of the membranes. The USBF uses a standard mechanical bar screen.
- The membranes in the MBR must be cleaned by the use of a chemical cleaning process on a monthly or quarterly basis. The cleaning is done with NaOCl and acidic solutions, both of which must be handled and used properly to prevent injury to the operators.
- The USBF process is simpler and requires less equipment, and electricity to operate. The USBF flows via hydraulic gradeline (gravity) and the aeration is provided by fewer blowers. The MBR system on the other hand requires permeate suction pumps and internal recycle pumps in addition to the blower requirements in order to operate.
- MBR system typically requires the addition of chlorine in order to control filamentous growth within the system, as opposed to control of the filamentous sludge by the process itself as is with the USBF process.
- The USBF process has an extended sludge age of 25 to 30 days with low microbial loading which produces less excess, aerobically stabilized sludge and improves sludge structure and mechanical dewatering characteristics.

In summary, we believe that the USBF is a superior process for this application due to the following:

- Overall simpler process to operate
- Requires less electrical power
- Does note require computerized controls for operation
- No chemicals required for operation
- Less mechanical equipment to maintain
- Produces less sludge
- Requires less land area

The evaluation was prepared Mr. David E. Mahler, PE, VP., and Mr. Scott Breitenstein, P.E. of the CPH Engineers Inc. Orlando, Florida office. Tel: 407 425-0452

ECOfluid

UPFLOW SLUDGE BLANKET FILTRATION (USBF)

NUTRIENT REDUCTION

1 NITROGEN

Nitrogen is removed by nitrification and denitrification processes. Nitrification is autotrophic and all USBF integrated bioreactors are designed for complete nitrification of ammonia to NO_3. Denitrification however, is heterotrophic and requires carbon source. Conventional plants' "separate-sludge denitrification" requires that carbon is added, typically in the form of methanol. This adds to operating costs, and if used in excess, it increases effluent BOD_5 content.

USBF technology "single-sludge denitrification" approach uses an endogenous carbon source to maintain the denitrifiers. Influent is combined with nitrified mixed liquor in the anoxic compartment providing the carbon source needed for denitrification. Relatively high (2 to 4 times average daily flow) nitrified mixed liquor recycle rates are employed and sufficient denitrification retention times provided. Total nitrogen reduction to below 10 mg/l is readily achievable. [1]

2 PHOSPHORUS

USBF technology delivers not only high efficiency of organic matter reduction, but also increased efficiency of phosphorus removal. Two processes, biological phosphorus uptake and simultaneous chemical precipitation are employed with advantages.

The mechanics of biological phosphorus uptake, known as "luxury uptake", is due to exposure of activated sludge to alternating oxide and anoxic conditions. Under the conditions, the cells store more energy in the form of phosphorus than needed for their survival. If strictly oxide conditions are maintained during subsequent clarification, phosphorus will be retained by the cells and it will eventually be removed with excess sludge. Unlike most other methods of clarification, the upflow sludge blanket filter maintains oxide conditions in the filter and phosphorus reduction by biological uptake to about 2-2.5 mg/l is achievable.[2]

For further phosphorus reduction phosphorus precipitant chemicals such as aluminum sulfate, ferrous sulfate or other salts are used. In most domestic wastewater phosphorus is present in three forms, orthophosphate, polyphosphate and organic phosphorus. Polyphosphate and organic phosphorus cannot be readily precipitated but both are converted to orthophosphate during biological treatment, which can. Since the bulk of phosphorus reduction (up to 80%) is accomplished by biological uptake, the small polishing dosages of metal salt precipitant do not significantly increase sludge production.

In simultaneous chemical precipitation metal salts are advantageously dosed into an anoxic compartment of the USBF bioreactor. Continuous sludge internal circulation and mixing ensure efficient precipitation, coagulation and flocculation within the bioreactor with an added benefit of increased efficiency of the USBF clarifier. Reduction of total phosphorus to less than 0.5 mg/l is readily achievable. [2]

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[1] As demonstrated in a number of USBF plants. Please refer to Case Studies.

[2] Sludge decant return from storage or dewatering to bioreactors if such is the case must be chemically treated as anoxic conditions during quiescent periods will cause phosphorus release.

ECOfluid

Upflow Sludge Blanket Filtration (USBF)

Nitrogen Reduction Memorandum

Nitrogen is removed by nitrification and denitrification processes. Nitrification is autotrophic and all USBF integrated bioreactors deliver complete nitrification of ammonia to nitrate provided that certain minimum temperature is maintained [1] and alkalinity is available. [2] Denitrification is heterotrophic and requires carbon source. Processes using "separate-sludge denitrification" require that carbon is added. USBF technology "single-sludge denitrification" approach uses an endogenous carbon source to maintain the denitrifiers. Influent is combined with nitrified mixed liquor in the anoxic compartment providing the carbon source needed for denitrification.

The conditions that affect the process of denitrification are (not in the order of priority):

- Volumes or HRTs - The required 'biological' volume is divided into anoxic and oxide volumes. The ratio of the two varies depending on the degree of denitrification desired. The anoxic volume or HRT must allow for DO exertion and for the provision of anoxic conditions needed for fermentation.

- Mixing of the Anoxic Volume - Good mixing and roll of the anoxic compartment is important. Mixing should be 'gentle' so as not to break up the sludge flocs.

- DO Control - DO control throughout the bioreactor is the most important factor. The 'plug' flow of the mixed liquor in the oxide compartment allows for manual adjustment of individual aeration diffuser sections, and the overall air flow is typically controlled by a continuous DO monitor modulating the blower RPM via variable frequency drive (VFD). Anoxic compartment DO is 'controlled' only indirectly by the oxide compartment DO adjustment and control, and by providing sufficient compartment volume (see above).

- RAS Recycle - Mixed liquor containing nitrite/nitrates is recycled from the bottom of the clarifier to the anoxic compartment where the incoming BOD serves as the carbon source or electron donor for the reduction of nitrate to elemental nitrogen. The efficiency of the overall nitrogen reduction has been determined to be a function of the RAS flow multiple (the higher the multiple the higher efficiency). However, the recycle has to be balanced against other factors and based on experience a multiple of 2 to 4 provides a 'safety factor' for typical domestic wastewater while moderating the negative effects. RAS pumps are typically airlift pumps for smaller plants, and low head (low Hp), axial flow pumps provided with VFD drives for larger plants.

- Temperature – Low temperatures and dramatic changes in temperature inhibit or stop the process of denitrification.

- Carbon – Incoming wastewater is the source of carbon. [3] Carbon deficiency is typically not an issue with most municipal or domestic wastewater.

Case Studies

The following USBF plant operating data have been recorded:

Marco Shores, FLA

Effluent	Nitrate as N (mg/l)	Nitrite as N (mg/l)	Ammonia as N (mg/l)	TIN (mg/l)	TKN (mg/l)	TN (mg/l)
August 13, 2003	3.2	0.044U	0.05U	3.29	1.0	4.29
August 27, 2003	2.8	-	0.05U	2.8	0.74	3.54
September 10, 2003	3.1	-	0.05U	3.1	0.7	3.8
Design Parameters						**10**

Notes: 1. U denotes Under Detectable Limit

2. The plant is not equipped with SCADA, continuous DO monitor and VFD drives.

3. Official lab analysis available

[1] Nitrification was observed to function at temperatures as low as –3 deg C.

[2] Nitrification consumes 7.1 mg/l of alkalinity as $CaCO_3$ for each mg/l of ammonia oxidized.

[3] Reduction of 1 gram of nitrogen requires approximately 3 – 4 grams of BOD (or equivalent carbon)

KICKING HORSE SKI RESORT, BC

Effluent	Nitrate as N (mg/l)	Nitrite as N (mg/l)	Ammonia as N (mg/l)	TIN (mg/l)
March 15, 2007	4.8	1.9	0.778	7.5
March 22, 2007	3.0	0.07	0.149	3.22
March 29, 2007	3.4	0.0	0.142	3.54
April 2, 2007	5.8	0.67	0.097	6.57
April 9, 2007	3.0	0.2	0.035	3.24

Notes:
1. Nitrogen reduction was not the plant design objective (small anoxic compartment)
2. The plant serves a ski resort where flows, temperatures and biological loadings vary significantly from weekends to weekdays
3. Official lab analysis available

ISLAMORADA, FLA

2005						2006					
April	May	June	July	August	Sept	January	February	March	April	June	July
1.7	3.7	3.1	2.9	3.8	2.8	6.6	3.3	2.1	3.5	2.4	4.7

Notes:
1. The plant is a small plant without any automated controls
2. Due to wide influent flow fluctuations, small plant's denitrification is typically more difficult to manage than with larger plants.
3. Official lab analysis available

SNUG COVE, BC

	2005				2006		
	March	June	Sep	Dec	March	June	Sep
TN	7.83	4.44	6.54	8.27	2.78	4.41	6.2
TKN	2.2	1.9	5.2	4.7	2.3	3.8	4.3

Notes:
1. This plant is a very basic rendition of the USBF configuration. It was not designed for nitrogen reduction (small anoxic volume), and it is not equipped with continuous DO monitor and VFD drives.
2. Official lab analysis available

MILL BAY, BC

Mill Bay Effluent	Nitrate / Nitrite as N (mg/l)	TKN (mg/l)	TN (mg/l)
April 17, 2007	1.8	0.9	2.7
May 22, 2007	4.0	1.8	5.8
June 25, 2007	5.17	1.5	6.7
July 17, 2007	2.75	1.5	4.2
August 7, 2007	3.38	1.5	4.9
September 11, 2007	7.12	1.4	8.5
October 16, 2007	4.11	1.2	5.3
November 6, 2007	3.9	2.2	6.1
Design Parameters			**10**

Notes:
1. The plant is a water reclamation plant where the permitted effluent Total Nitrogen (TN) is <10 mg/l.
2. The plant is relatively small (150 m^3/d; 40,000 gpd) and experiences high infiltration.
3. Official lab analysis available

UPFLOW SLUDGE BLANKET FILTRATION (USBF)

PHOSPHORUS REDUCTION MEMORANDUM

One of the beneficial features of the USBF technology is increased efficiency of phosphorus removal. This is due to the fact that a significant amount of the influent phosphorus is reduced by biological phosphorus uptake.

The mechanics of biological phosphorus uptake, known as "luxury uptake", is due to exposure of activated sludge to alternating oxide and anoxic conditions. Under the conditions, the cells store more energy in the form of phosphorus than needed for their survival. If strictly oxide conditions are maintained during subsequent clarification, phosphorus will be retained by the cells and it will eventually be removed with excess sludge. Unlike most other methods of clarification, the upflow sludge blanket filtration process maintains oxide conditions in the filter, and phosphorus reduction by biological uptake to as low as 1 mg/l has been achieved as demonstrated in the table below.[1]

The following results were recorded during the 2007 Annual Report filing test period at Kicking Horse Ski Resort, Golden, BC:

	March 15	March 22	March 29	April 2	April 9	Average
Total Phosphorus [mg/l]	1.11	0.78	0.69	0.95	2.2	1.15

Notes:
1. Total Phosphorus reduction was entirely by the biological phosphorus uptake. NO CHEMICALS WERE USED.
2. 24 hour composite samples were analyzed.
3. Official lab analysis available

For further phosphorus reduction phosphorus precipitant chemicals such as aluminum sulfate, ferrous sulfate or other salts are used. In most domestic wastewater phosphorus is present in three forms, orthophosphate, polyphosphate and organic phosphorus. Polyphosphate and organic phosphorus cannot be readily precipitated but both are converted to orthophosphate during biological treatment, which can. Since the bulk of phosphorus reduction is accomplished by biological uptake, the small polish dosages of metal salt precipitant do not significantly increase sludge production.

In simultaneous chemical precipitation metal salts are dosed into the anoxic compartment of the USBF bioreactor. Continuous sludge internal circulation and mixing ensure efficient precipitation, coagulation and flocculation within the bioreactor with an added benefit of increased efficiency of the USBF clarifier.

The following effluent Total Phosphorus parameters were recorded at a 1 MGD (4,000 m^3/d) USBF facility during seven months period from June to December 2002. The facility was provided with aluminum sulfate (alum) dosing system. During the period dual 24-hour composite samples were taken and analyzed and only the higher results were recorded. The following are monthly averages of the daily composite sample analysis.

2002	June	July	August	Sept.	Oct.	Nov.	Dec.	Average
Total Phosphorus	0.4	0.5	0.2	0.3	0.4	0.5	0.3	0.4

Notes:
1. TP design parameter was 1.0 mg/l
2. The facility has not been provided with any post-biology (read post USBF) filtration
3. Since the bulk of the total phosphorus reduction was by biological uptake, the alum consumption and the ballast sludge production were light
4. Two 24-hour composite samples were analyzed. Only the higher results were recorded.
5. Official lab analysis available
6. With added post-biology (post USBF) microscreen filtration, reduction of Total Phosphorus to 0.1- 0.25 mg/l range is believed to be eminently possible

[1] Sludge decant return from storage or dewatering to bioreactors if such is the case must be chemically treated as anoxic conditions during quiescent periods will cause phosphorus release.

At another facility, Islander Resort in Florida, the following results were recorded in 2006:

2006	Jan	Feb	Mar	Apr	May	Jun	Jul	Average
Total Phosphorus	0.1	0.13	0.3	0.4	0.5	0.1	0.2	0.25

Notes:
1. TP design parameter was 1.0 mg/l
2. Islander Resort facility is at 12,000 GPD (45 m^3/d) a relatively small system with highly fluctuating flow and very rudimentary control system only
3. The facility is provided with post-biology (post USBF) microscreen filtration
4. In the original configuration ferric sulfate was used for chemical precipitation, but it was replaced with aluminum sulfate in the last few years
5. Grab samples as mandated by Florida Department of Environmental Protection were analyzed and recorded monthly
6. Official lab analysis available

1 MGD
Wastewater Treatment Plant

Upflow Sludge Blanket (USBF) Process

Prepared By:

ECOfluid Systems Inc

www.ecofluid.com

November 2008

Content

1 Introduction

This generic proposal has been prepared by ECOfluid Systems Inc. (ECOfluid). The proposal contains commercial and technical information that is proprietary and confidential. It is submitted on the understanding that it will not be disclosed in whole or in part to third parties not specifically authorized by, and without express written consent of ECOfluid.

The design utilizes award winning ECOfluid Upflow Sludge Blanket Filtration (USBF™) process technology. In awarding the process the 2006 Technology Leadership Award, Frost & Sullivan included the following in their press release:

"The company's advanced plants based on the USBF™ process, address the constant demand to produce high quality effluents. This single-sludge denitrification process incorporates all the processes required for biological treatment in a single reactor and circulation loop, using very little energy and no chemicals. While conventional processes such as SBR and extended aeration rely on the slow and inefficient sedimentation process, ECOfluid's USBF™ technology utilizes a fluidized bed or 'counter current' movement. This is a dynamic method that continually removes pollutants. In this process, the sewage that enters an anoxic compartment is drawn by gravity into an aeration compartment, and then to the bottom of the upflow sludge blanket filtration clarifier, from where it overflows. The remainder is then recycled from the bottom using airlift pumps, which require no power due to the internal loop configuration. This way, the mixture is exposed to anoxic aeration three or four times a day, resulting in superior biological nutrient removal, even without the use of added chemicals. Phosphorous removal, through a process known as "biological luxury uptake", is another cost-free benefit. "USBF™ does not require primary clarification prior to biological treatment and offers hydraulic flexibility because it easily accommodates high peak flows," says Frost & Sullivan Research Analyst Shilpa Tiku. "In fact, as the flow becomes greater, the sludge blanket rises higher and the filtration area expands simultaneously." ECOfluid's USBF™ technology is, therefore ideal for use in municipal and domestic wastewater treatment, water reclamation, industrial wastewater, and existing plant retrofits. Industrial wastewater is highly organic by nature, and biological packaged wastewater treatment offers an attractive option for treatment plants that are looking at viable and low-cost options. The USBF™ process is a self regulated system and very little, operator attention is required."

In 2002 the University of California, Davis rated the USBF™ technology as the highest ranked biological treatment system out of almost seventy technologies reviewed.

On December 5, 2007 ECOfluid has been selected by the Ottawa Centre for Research and Innovation (OCRI) as one of 2007 winners for Canada's Top Ten Cleantech Companies Competition.

ECOfluid has designed and built over a hundred plants incorporating the USBF technology in Canada and the United States and it currently has a number of long-term operations and maintenance contracts in British Columbia. ECOfluid's cross-reference of design, construction and operating experience provides clients with an enhanced level of comfort and minimizes their risk.

The following is a generic I MGD plant budget price proposal for the supply of a system utilizing the USBF technology complemented by pre- and post-treatment equipment and systems that have been packaged and successfully used with the USBF biological treatment in the past. The proposed configuration is one of many. Other, using alternate equipment and sub-systems, if so preferred by the client, can be incorporated and packaged with the USBF.

The proposal includes information based on incomplete data and design. ECOfluid reserves the right to modify the specifications upon completion of detailed design and engineering.

2 Design Criteria

2.1 Influent / Effluent Parameters:

For the purposes of this proposal, I MGD plant receiving medium strength (Metcalf & Eddy) concentration has been selected. The influent / effluent parameters are specified in the table below:

3 Process and Plant Description

3.1 Headworks

Raw sewage entering the plant is pumped into the headworks, which consist of integrated mechanical pre-treatment consisting of screening system, screenings wash, conveyance, and dewatering, and sand and grit removal. The systems are installed on an elevated structural steel support platform immediately ahead of the equalization tanks. Washed and dewatered reject materials discharge into a hopper located on the ground level and are hauled to a sanitary transfer station for disposal.

Integrated headworks

From the integrated pre-treatment system, the screened sewage discharges directly into the equalization tanks equipped with submerged mixers and coarse bubble air diffusers. Each equalization tank is provided with two sets of duplex submersible pumps. Controlled by level monitor, each set of pumps transfers screened influent into the common anoxic compartment of a 0.5 MGD bioreactor module.

3.2 Biological Treatment

Biological treatment takes place in a USBF process treatment facility. The facility consists of two 500,000 gpd bioreactors each containing two aerobic compartments, one anoxic compartment and four USBF sludge blanket filters, two each inserted within the aerobic compartments. The influent enters the anoxic compartment where it is mixed with sludge recycled from the bottom of the sludge blanket filters by means of submersible mixers. The sludge recycle is accomplished by RAS airlift pumps provided with the flow measuring boxes. The RAS airlift pumps are driven by independent RAS only dedicated air blowers. From the anoxic tanks the mixed liquor overflows to aerobic compartments equipped with high efficiency fine bubble aeration diffusers. (Both, sock type and disc diffusers have been used in the past).

Sock type fine bubble diffusers

Aerated and moved in a plug flow manner, mixed liquor eventually enters the bottom of the upflow sludge blanket filters.

The mixture of microbial cells and water enters the filter at the bottom and, as it rises, upward velocity decreases until the flocs of cells become stationary and thus form a filtering media. A high degree of filtration efficiency is achieved as colloid and very fine particles are filtered out. As the flocs become large and heavy, they descend to the bottom of the sludge blanket filter and subsequently are recycled back into the anoxic zone.

Upflow sludge blanket filtration eliminates the most commonly encountered problem of the conventional biological treatment plant – gravity separation. It has a substantially higher specific rate of separation than sedimentation, and in addition, it accommodates high peak flows and flow swings in a self-regulating manner. The higher the flow, the higher the sludge flocs rise and the larger the filtration area becomes.

Sludge blanket filter installation within aerobic compartment.

The sludge blanket filters are provided with a gravity surface skimmer system. Walls of the skimmer system are submerged just below the clarifier surface level. If and when required the surface is skimmed by opening the skimmer trough valve and the skimmings are transferred by gravity to the sludge transfer tank.

Clarified treated effluent is collected in a trough on top of the sludge blanket filters before flowing by gravity to post-treatment.

3.3 Nutrient Reduction

3.3.1 Nitrogen Reduction

Nitrogen is removed by nitrification and denitrification processes. Nitrification is autotrophic and all USBF integrated bioreactors deliver complete nitrification of ammonia to nitrate provided that certain minimum temperature is maintained and certain alkalinity is available. [1]

Denitrification is heterotrophic and requires carbon source. The USBF technology "single sludge denitrification" approach uses an endogenous carbon source to maintain the denitrifiers. Influent is combined with nitrified mixed liquor in the anoxic compartment providing the carbon source needed for denitrification. [2]

Increasingly stricter Total Nitrogen parameters are being specified. Where so, high degree of denitrification will be desired and the design will be "enhanced nitrogen reduction" optimized.

3.3.2 Phosphorus Reduction

One of the beneficial features of the USBF technology is increased efficiency of phosphorus removal. This is due to the fact that a significant amount of the influent phosphorus is reduced by biological phosphorus uptake.

The mechanics of biological phosphorus uptake, known as "luxury uptake", is due to exposure of activated sludge to alternating oxide and anoxic/anaerobic conditions. Under the conditions, the cells store more energy in the form of phosphorus than needed for their survival. If strictly oxide conditions are maintained during subsequent clarification, phosphorus is retained by the cells and is eventually removed with excess sludge. Upflow sludge blanket clarifiers maintain oxide conditions in the clarifiers and phosphorus reduction by biological uptake to as low as 1 mg/l has been accomplished.

For further phosphorus reduction phosphorus precipitant chemicals such as aluminum sulfate, ferrous sulfate or other salts are used. In most domestic wastewater phosphorus is present in three forms, orthophosphate, *polyphosphate and organic phosphorus. Polyphosphate* and organic phosphorus cannot be readily precipitated but both are converted to orthophosphate during biological

1 Nitrification consumes 7.1 mg/l of alkalinity as $CaCO_3$ for each mg/l of ammonia oxidized (Denitrification reactions produce 3.57 mg/l as $CaCO_3$)

2 Reduction of 1 gram of nitrogen requires approximately 3 – 6 grams of BOD (or equivalent carbon)

treatment, which can. Since the bulk of phosphorus reduction is accomplished by biological uptake, the small polishing dosages of metal salt precipitant do not significantly increase waste sludge production.

In simultaneous chemical precipitation metal salts are dosed into the anoxic compartment of the USBF bioreactor. Continuous sludge internal circulation and mixing ensure efficient precipitation, coagulation and flocculation within the bioreactor with an added benefit of increased efficiency of the sludge blanket filter.[3]

3.4 Filtration

Effluent filtration is typically achieved by either microfiltration or by membrane filtration.

3.4.1 Microfiltration

Microfiltration takes place in the gravity-flow-through drum microfilters. The filters are equipped with stainless steel filter media having 30-40 microns openings. Biologically treated effluent enters the inside of the microfilter drum and it is filtered as it passes through the filter media. The filters are constructed entirely from stainless steel and they are provided with automatic backwash using filtered effluent from behind the filters. Filtered out mud is collected in a container and periodically pumped to the sludge holding tank.

Channel installed microfilter

3.4.2 Membrane Filtration

Membrane filtration has been widely adopted by the wastewater treatment industry in recent years. To date, predominantly immersed membranes were used. These however, come with significant compromises involving costs, simplicity, flexibility, and other. Costly, 'special requirement influent fine screening' needs to be provided, and steps such as lifting and removing the membranes out of the bioreactor when required for maintenance are disruptive to routine plant operation. Additionally, membranes immersed in the bioreactor make optimization of the biological and the filtration processes difficult.

ECOfluid membrane system gets around the disadvantages of the immersed membranes by employing external membrane filtration (eMBR). The configuration reduces or eliminates many of the immersed membrane compromises. No special pre-treatment is required, the biological treatment can be optimized for biological nutrient removal (and include chemical precipitation if desired), and the membrane energy input is kept low by the membranes design and by the fact that the TSS of the effluent from the USBF™ sludge blanket filter is already less than 10 mg/l. The result is a membrane quality effluent, including giardia and cryptosporidium removal and turbidity reduction to 0.1 NTU, with significantly improved reliability, flexibility and simplicity of operation, and reduced capital and operating costs.[4]

External membrane filtration system (eMBR)

3.5 UV Disinfection

Gravity flow, open channel type system installed within concrete channels is provided. The system consists of two duty and two standby, UV lamp modules banks, installed within two concrete channels.

Concrete channel installed UV disinfection

3.6 Air Management

3 See attached Nitrogen and Phosphorus Reduction Memorandums

4 See attached USBF-eMBR description

Air is required for the biology in the fine bubble aeration diffusers, for RAS airlift pumps, in the equalization tank coarse bubble diffusers and in the sludge holding tanks for sludge post-stabilization.

Air to the biology is supplied by positive displacement blowers provided with variable frequency drives (VFD) and controlled by continuous dissolved oxygen monitors within the aeration tanks. Three air blowers are provided for the 1 MGD plant, two duty each serving 0.5 MGD module, and one common standby. Switching to standby blower requires operator's manual intervention.

Air for RAS airlift pumps and to the equalization and sludge holding tanks is provided by independent blowers.

3.7 Waste Sludge Management

Since the age of activated sludge in the bioreactors is in excess of 25 days, less excess sludge is generated, it is stabilized and its dewatering characteristics significantly improve. The bioreactors are provided with sludge pre-thickeners located in the aeration compartments, which pre-thicken the sludge to approx 1.5-2.5%. Controlled by timers the pre-thickened waste sludge (WAS) is periodically pumped into the sludge transfer tank.


Waste sludge pre-thickener

From the sludge transfer tank, sludge is transferred to sludge post-treatment which may consist of sludge processing to Class A biosolids, centrifuge dewatering, or other.

3.8 Electrical, Instrumentation and Controls

The plant is provided with SCADA systems, which monitor equipment running status and receive data from transmitting instruments. Typically, the entire process and operation control and alarm system consists of the following:

Integrated Headworks	Level switches Motor overload
Equalization Tank	Level monitor Level switch pH monitor Temperature monitor
EQ Tank Pumps	Motor overload Hour meter Leak detector Timer
EQ Tank Mixers	Motor overload Leak detector
Anoxic Mixers	Motor overload Leak detector
RAS Pumps c/w VFD	Motor overload Leak detector
Aeration Tank	DO monitor
Microfilters	Level switches
Mud Pump	Level switch
Membrane Filtration system	Auto-control and report
UV Disinfection	Intensity monitor Temperature monitor Elapsed time meter
Pre-thickener Pumps	Motor Overload 24 hour timer
Air Blowers c/w VFD	Pressure Indicator Pressure Relief Valve Pressure Switch Motor Overload Hour Meter
Sludge Transfer Pump	Motor Overload Hour Meter Moisture detector Leak detector
Emergency Power Genset	
Effluent Flowmeters	
MCC	

4. Plant O & M Considerations

4.1 Reduced Operating Requirements

The entire system is comprised of simple, well proven and tried equipment, systems and modules.

Unlike with immersed membranes, the USBF process does not require "special needs" ultra-fine screening. The proposed 'combi' style pretreatment is totally self-contained, fully enclosed headworks system with low maintenance, optimal throughput and simple, reliable operation.

Equalization tanks together with the USBF inherent hydraulic flexibility accommodate flow variations in a self-regulating manner.

The bioreactors including the sludge blanket filters contain very limited amount of rotating equipment, and that which they do are removable and serviceable 'on the go'.

The USBF sludge blanket filters on their own produce effluent having TSS of less than 10 mg/l.

Drum microscreen filters (if used for post-biology filtration) are fully automatic, simple, reliable and well proven devices requiring minimal operators' attention. The one factor that significantly contributes to operating simplicity and reduces operating and maintenance needs and costs, is the all gravity process flow. Pumped once from the equalization tank into the bioreactors, the entire flow through the process (biology, filtration and UV disinfection) is by gravity.

External membrane filtration (if used for post filtration) is safe, easy and dry. There is no exposure to chemicals and sludge, and no cranes are required. The compact design, minimal amount of moving parts, modularity of construction, high membrane flux rate, reduced power consumption, low fouling and ease of maintenance result in decreased operating and maintenance costs.

The efficiency of the channel type UV disinfection is aided by the reduced effluent suspended solids count, which also reduces the UV lamp cleaning requirements.

4.2 Reduced Power Consumption

Electric power consumption including operation of all equipment of the headworks, the biological treatment, filtration and UV disinfection is calculated to be approximately 2,600 kWh/day, or 850 kWh/foot-acre.

4.3 Pre-Thickened Waste Activated Sludge

At full design load (1 MGD, 220 mg/l BOD and TSS), the waste sludge generation is calculated to be approximately 1,000 lb/day. The sludge will be pre-thickened in the sludge pre-thickeners and in the sludge transfer tank to above 2% d.s. The generated sludge volume at full design loading and at 2% d.s. is estimated to be 800 cuft/day or 6,000 gpd.

4.4 Chemicals

Other than metal salts (aluminum sulfate for example) used for phosphorus precipitation, and cleaning chemicals for UV lamps and external membranes, no chemicals are used in the process.

4.5 SCADA Control

The plant is provided with a SCADA system which monitors and controls the plant operation, and transmits data and information to remote locations.

5. Budget and Costs Considerations

Based on experience and subject to qualifications below, the preliminary 'Order of Magnitude' cost estimate for a complete 1 MGD 'green field' plant installation is summarized in the table below.

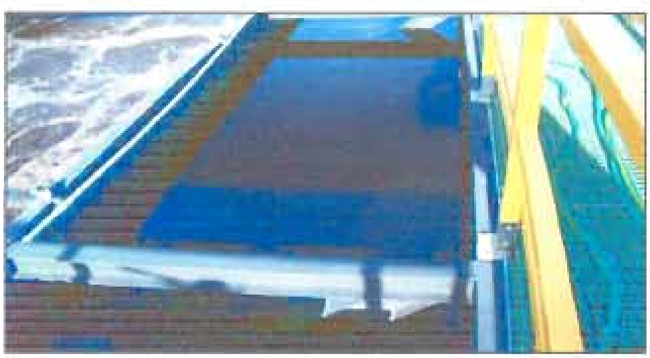
(1) Includes excavation, underground piping, drainage etc
(2) Includes MCC and control room, lab, process and air blower rooms
(3) All component cost estimates are 'supply and install' estimates
(4) Alternate equipment and component selection may affect prices and costs estimates
(5) Equivalent Dwelling Unit (EDU) is a unit measure where one unit is equivalent to wastewater effluent from one residence (1 EDU = 250 gallons per day).

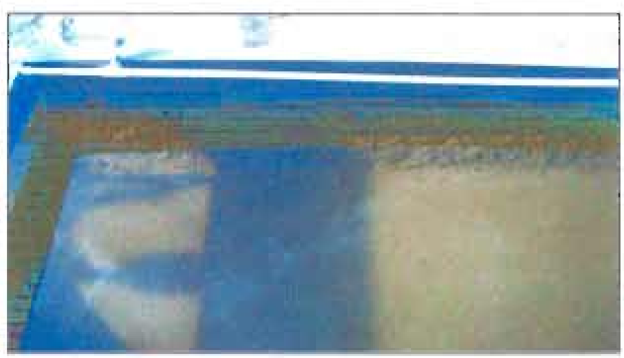
LAKE ALFRED WWTP, LAKE ALFRED, FL
CASE STUDY

When the City of Lake Alfred decided to upgrade their existing 1 MGD trickling filters wastewater treatment plant, they looked at a number of technologies and after an evaluation decided on the USBF process.

As part of the upgrade, the plant was provided with a new Fontana Integrated Headworks, which screens the influent, washes and dewaters the screenings, removes sand and grit, and deposits washed screenings and grit into separate bins. From the headworks, the screened influent flows to equalization tank (which is a reconditioned old trickling filters tank – trickling filters removed).

From the equalization tank, the influent is pumped into bioreactor modules. The influent first enters the anoxic tanks (above right in the forefront) and with the slide gate open, it passes into the aeration tanks. The still water in the pictures above and below is the treated effluent surface of the USBF sludge blanket filter, within which fluidized bed filtration (upflow sludge blanket filtration) takes place. The water is crystal clear as can be seen in the pictures below.





The above right picture shows raised sludge filter blanket approx 8-10 inches below clear water surface (the sludge blanket level was intentionally raised by prolonged influent pumping).

LAKE ALFRED WWTP, LAKE ALFRED, FL
CASE STUDY

Filtered clean effluent at the top of the sludge blanket filter overflows into a v-notch overflow trough located under the walkway. There are no moving mechanical parts within the sludge blanket filter/clarifier or the overflow troughs.

From the overflow trough the treated effluent flows by gravity into the Fontana drum microscreen filters. Picture on the right shows filtered effluent in the backwash well of the microfilter (the microfilter uses filtered effluent behind the filter for its automatic backwash).

From the effluent storage tank below the microfilters, the treated, filtered effluent is pumped to the existing chlorination.

	Influent		Effluent		
	BOD	TSS	BOD	TSS	NITRATE
Date	mg/L	mg/L	mg/L	mg/L	mg/L
4-Jun-08	181	192	5.03	3.6	3.60
11-Jun-08			4.76	2.5	3.73
18-Jun-08	219	366	5.09	2.0	3.75
25-Jun-08			5.45	5.0	3.79
Average	200	279	5.08	3.3	3.72

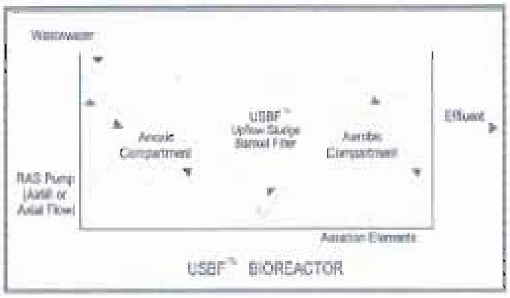
The plant retrofit and upgrade was completed and the plant started up in May 2007. As illustrated by the analysis of samples taken during the month of July 2008, the plant is exceeding its design parameters of <10 mg/l for BOD, TSS and Nitrate.

UPFLOW SLUDGE BLANKET FILTRATION (USBF™)

PROCESS SUMMARY

THE PROCESS

Operation of a USBF™ plant is simple and self-regulating. Wastewater enters the anoxic compartment of the bioreactor where it mixes with activated sludge recycled from the bottom of the sludge blanket filter. Agitated and moved in a plug flow manner, the mixed liquor flows into the bioreactor's aerobic compartment. After aeration, a stream of the mixed liquor enters the bottom of the sludge blanket filter where the sludge flocs and water are separated by upflow sludge blanket filtration. After separation, filtered effluent overflows into a collection trough and is discharged from the system. To complete the internal gravity circulation loop, activated sludge collecting at the bottom of the sludge blanket filter is recycled back into the bioreactor anoxic compartment.



THREE FEATURES THAT INCREASE EFFICIENCY AND REDUCE COSTS

Sludge Blanket Filter

The upflow sludge blanket filter introduces a substantially higher specific rate of separation than other commonly used separation techniques. Unlike conventional clarifiers, influent enters at the bottom and flows upwards. As the cross sectional area increases, the upflow velocity decreases until the activated sludge flocs become stationary and thus form a filtering media for activated sludge flowing through. High filtration efficiency is achieved and even particles with settling velocities too low to be removed by settling alone are filtered out.

High Sludge Concentration

Most traditional plants operate at low or medium sludge concentrations, typically 2,500 – 3,500 mg/l. USBF™ process by contrast operates at higher sludge concentrations, typically 4,000 – 6,000 mg/l resulting in longer sludge age and increased biological efficiency.

All Processes Integrated into One Bioreactor

Most conventional technologies carry out processes of nitrification, denitrification, clarification and sludge stabilization in a number of dedicated vessels. By contrast, USBF™ process incorporates these processes inside a compact bioreactor, reducing equipment size and liquid handling requirements.

Lake Alfred, FL 1 MGD (4,000 m³/d) WWTP (Four 0.25 MGD modules). Trickling filter plant retrofit.

BENEFITS

High Treatment Efficiency Including Biological Nutrient Removal (BNR)

The USBF™ process features an internal anoxic compartment for biological reduction of nitrogen and phosphorus by nitrification, denitrification and 'luxury uptake' processes respectively.

Alkalinity Recovery & Filamentous Bacteria Control

The integral denitrification process facilitates partial recovery of alkalinity during nitrification. As well, the anoxic selector is used to control filamentous bacteria growth within the system.

No Primary Clarification

USBF™ process does not require primary clarification prior to biological treatment. A proper screening facility and for larger plants, grit removal system is all that is required upstream of the bioreactors.

Hydraulic Flexibility

The sludge blanket filter prism or cone shape not only allows other treatment processes to take place around it, but it also facilitates superior hydraulic flexibility. The process easily accommodates high peak flows and flow swings in a self-regulating manner; the higher the flow, the higher the sludge blanket rises and the larger the filtration area becomes.

Modular expansion of the plant at Sun Peaks Ski Resort. Two original bioreactor modules (left) installed in 1999 supplemented by two additional modules in 2005

Modular and Flexible Design

Modularity of design allows owners to stage plant development and ensures that plants can be quickly expanded if and when growth demands.

Reduced Operating and Maintenance Requirements

The compact design, minimal amount of moving parts and self- regulating hydrau[...] contributing to lower
operating and maintenance costs.

Reduced Site Requirements

USBF™ process incorporates nitrification, denitrification, clarification and sludge stabilization into a compact bioreactor which reduces equipment size and liquid handling requirements and ultimately leads to a smaller plant footprint.

300 m³/d (80,000 GPD) USBF WWTP built in a residential subdivision between housing attesting to the non-odorous nature of the process

No Odor

Aerobic conditions throughout the bioreactor and extended sludge age eliminate or dramatically reduce odor. USBF™ plants can be located within populated areas without odor concerns.

Improved Sludge Characteristics

Low microbial loading (extended sludge age of 25-35 days) produces less excess sludge, which is aerobically stabilized, and which is characterized by improved structure and better dewatering capability.

APPLICATIONS

Municipal and Domestic Wastewater

Literally thousands of site constructed and packaged USBF™ treatment plants serving municipalities, communities, subdivisions, ski resorts, shopping centers, summer resorts, golf courses, hotels, restaurants etc. are in operation worldwide.

Water Reclamation

The USBF process alone is capable of removing BOD₅ and TSS to less than 10 mg/l without post-filtration, Total Nitrogen reduction to less than 10 mg/l and Total Phosphorus removal to about 2.5 mg/l. (The reduction of total phosphorus to less than 2.5 mg/l requires additional chemical precipitation). This high efficiency of the continuous flow USBF™ process paves the way to economical 'tertiary' post-treatment. Using the USBF™ process followed by membrane, sand or microscreen filtration, and UV disinfection, ECOfluid designs, builds and operates treatment plants producing Class A (or Title 22), or reclaimed water quality effluent at economical capital and operating costs.

Existing Plant Retrofits

The self-contained nature of the internal circulation loop and structural independence of the sludge blanket filter insert make it possible that virtually any tank can be converted to a wastewater treatment plant. Many existing RBC's, oxidation ditches and other plants have been retrofitted with USBF™ filters to increase treatment efficiency and/or plant capacity.

Industrial Wastewater

Many plants treating high strength industrial wastewater including food processing plants, slaughterhouses and rendering plants, dairy plants and pulp mills have been designed and are in successful operation worldwide.

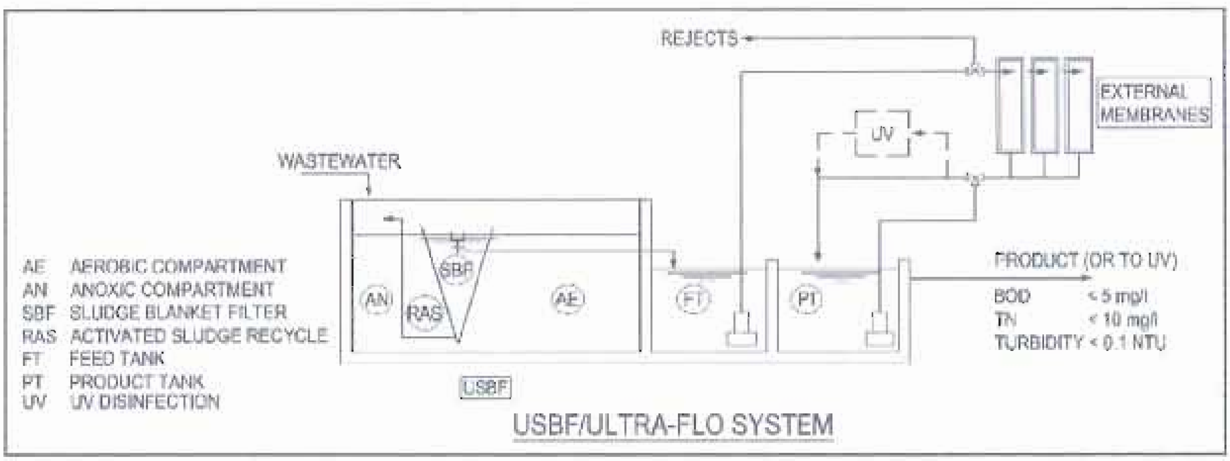
Upflow Sludge Blanket Filtration (USBF™)

AND

External Membrane System (eMBR)

In recent years, membrane filtration has been widely adopted by the wastewater treatment industry predominantly using immersed hollow fiber or panel membranes. The immersed membranes however, come with significant compromises involving costs, simplicity, flexibility, and more. Costly, 'special requirement influent fine screening' needs to be provided, and steps such as lifting and removing the membranes out of the bioreactor when required for maintenance are disruptive to routine plant operation. Additionally, membranes immersed in the bioreactor make optimization of the biological and the filtration processes difficult.

ECOfluid membrane system, which consists of an Upflow Sludge Blanket Filtration bioreactor followed by external membranes, builds on the treatment efficiency of the USBF™ process and utilizes external membranes for final polishing filtration. The configuration reduces or eliminates many of the immersed membrane compromises. No special pre-treatment is required, the biological treatment can be optimized for biological nutrient removal (and include chemical precipitation if desired), and the membrane energy input is kept low by the membranes design and by the fact that the TSS of effluent from the USBF™ sludge blanket filter is already less than 10 mg/l. The result is a membrane quality effluent, including giardia and cryptosporidium removal and turbidity reduction to 0.1 NTU, with significantly improved reliability, flexibility and simplicity of operation, and reduced capital and operating costs.



BRINGING IT TOGETHER:

The system brings together the best of the biological and the membrane processes. The advantages of the ECOfluid membrane system are:

No "Special Needs" Fine Screening

The external membranes do not require "special needs" ultra-fine screening typically required for immersed membranes.

No Primary Clarification

The USBF™ process does not require primary clarification.

Optimized Biological Processes Including Biological Nutrient Removal (BNR), Alkalinity Recovery & Filamentous Bacteria Control

The single sludge denitrification process facilitates total nitrogen reduction and partial recovery of alkalinity lost during nitrification. Total phosphorus is reduced by 'luxury uptake' process, and 'the anoxic selector' controls filamentous bacteria growth.

High Membrane Flux Rate and Reduced Fouling

The low membrane feed solids concentration (~10 mg/l) enables high flux rates and reduced membrane fouling.

Multi-Barrier Two Stage Filtration

Two step filtration - upflow sludge blanket fluidized bed filtration followed by membrane filtration for greater reliability

Easy and Economical Membrane Cleaning and Maintenance

The external membrane maintenance is safe, easy and dry. There is no exposure to chemicals and sludge and no cranes are required.

Modular and Flexible Design

The modular nature of the USBF™ process and the external membrane systems ensures that plants can be readily expanded in response to growth in demand.

Reduced Operating and Maintenance Requirements

The compact design, minimal amount of moving parts, modularity of construction, high membrane flux rate, significantly reduced power consumption, low fouling and ease of maintenance result in decreased operating and maintenance costs.

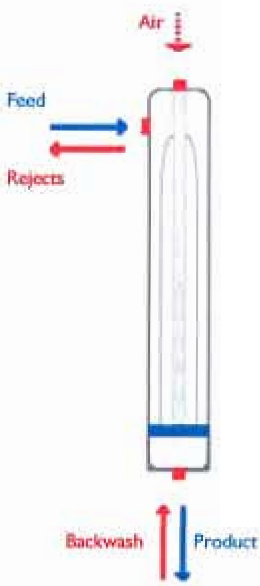
No Odor

Aerobic conditions throughout the process and extended sludge age eliminate or dramatically reduce odor. The plants can be located within populated areas without odor concerns.

Improved Sludge Characteristics

Low microbial loading (extended sludge age of 25-35 days) produces less waste sludge, which is aerobically stabilized, and which is characterized by improved structure and better dewatering capability.

About the Membranes



Ultra-Flo® membranes models MU 01 to MU 24 are designed for Cross-Flow and Dead-End (out-to-in) filtration. In dead-end filtration, one end of the hollow fiber is closed ensuring that the feed water permeates through the hollow fiber using less pressure.

The hollow fiber outside diameter is 2 mm and it is fabricated from hydrophilic modified PAN.

Each membrane cartridge is 8" dia x 60" long (200 mm dia x 1500 mm), its total surface area is 450 ft^2 (40 m^2), and the operating pressures are < 8 psig (55 kPa) and < 14 psig (97 kPa) for respectively feed and backwash.

MU 01-8 MU 04-8 MU 08-8 MU 20-8 MU 24-8

Plant Components and Equipment List

The plant is composed of pre-treatment headworks, two 0.5 MGD bioreactor modules, microfiltration or membrane filtration, and UV disinfection. Without limitation, the following equipment, components and parts is required:

Integrated Headworks IH (1)

Objective:	Screen out debris; remove sand and grit; convey, wash and press screenings.
Design Considerations:	The system is a compact integrated system provided with a coarse bar screen by-pass of the fine mechanical screen to equalization tank should it need to be taken out of service for maintenance.
Make:	TBA
Screen Openings:	3/16"
Capacity:	1,500 gpm peak flow
Material:	Stainless steel / plastic lamellas
Drives:	½ Hp, 115/1/60 screen motor ¼ Hp, 115/1/60 screen brushes motor 3 Hp, 460/3/60 screenings screw 3 Hp, 460/3/60 sand screws (2 of)
Alternative:	Number of other integrated systems are available and can be substituted

Equalization Tank EQT (1)

Objective:	Provide containment for screened influent before pumping to the biology
Capacity:	50,000 gallons
Material:	Concrete

Equalization Tank Pumps EQP (4) (2 for each 0.5 MGD module)

Objective:	Pump the contents of the equalization tank into the anoxic tanks of the bioreactors.
Type:	Submersible, non-clog
Make:	ABS, Meyers, Goulds, Flygt or equal
Capacity:	820 usgpm @ 25 ft TDH
Material:	Cast iron body and impeller
Drive:	10 Hp, 460/3/60
Accessories:	Base elbow c/w carrier and guide rails

Equalization Tank Mixer ETM (2)

Objective:	Mix incoming raw sewage
Design Considerations:	The mixers are provided with thermal and seal leak sensors.
Vendor/Make:	ABS, KSB, ITT Flygt or equal
Material:	Stainless steel propeller and shroud, cast iron body
Drive:	10 Hp, 460/3/60
Accessories:	Guide bars, lifting chain

Fine Bubble Diffusers (Lot)

Objective:	Provide for adequate mixing and oxygen transfer in the aeration compartments of the bioreactors.
Make:	High efficiency sock type or disc diffusers
Material:	EPDM flexible membrane, PVC headers and drops

Anoxic Mixer ANM (4)

Objective:	Mix incoming raw sewage and recycled mixed liquor.
Design Considerations:	The mixers are provided with thermal and seal leak sensors.
Vendor/Make:	ABS, KSB, ITT Flygt or equal
Material:	Stainless steel propeller and shroud, cast iron body
Drive:	10 Hp, 460/3/60
Accessories:	Guide bars, lifting chain

Sludge Blanket Filter SBF (8)

Objective:	Provide conditions for mixed liquor flocculated sludge and effluent separation.
Design Considerations:	The filters accommodate high peak flows and flow swings in a self-regulating manner - the higher the flow, the higher the sludge flocs rise and the larger the filtration area becomes. The filters are provided with adjustable effluent weir troughs and surface skimmer systems. Clarifier skimmings are transferred to sludge transfer tank.
Size:	13' wide x 12 high x 42' long
Material:	The sludge blanket filters are fabricated from steel with all steel surfaces factory sandblasted to SSPC 10 and painted with two coats of polyamide epoxy paint to 12 mils DFT.

Sludge Pre-Thickeners SPT and Pumps SPTP (8)

Objective:	Pre-thicken sludge to 1.5-2.5% d.s. content.
Design Consideration:	Pre-thickener is a large diameter pipe provided with sludge entry/exit openings. Sludge enters at the top and settles to the bottom from where it is periodically drawn out to the sludge transfer tank. The amount of excess sludge depends on the plant organic loading and the pump timer will have to be accordingly adjusted from time to time.
Type:	Submersible, non-clog
Material:	Cast iron body and impeller
Drive:	3 Hp, 460/3/60
Accessories:	Base elbow c/w carrier and guide rails

Microscreen Filters MFB (4) – MICROFILTRATION OPTION ONLY

Objective:	Provide means for residual suspended solids microfiltration.
Design Considerations:	Microfilter is a self-contained unit c/w mud and backwash pumps. Provided with dual air bubble level probes its operation is fully automatic.
Make:	Fontana or equal
Material:	Stainless steel body and filter media
Filter Media:	30 microns, stainless steel
Capacity:	2,200 gpm
Drive:	1 ½ hp, 460/3/60
Accessories:	Backwash pump – 1 ½ Hp, 460/3/60 Mud pump – 1 Hp, 460/3/60, c/w a float switch

External Membrane Filters (eMBR) (5) – MEMBRANE FILTRATION OPTION ONLY

Objective:	Provide means for residual suspended solids filtration.
Design Considerations:	External membrane filters are self-contained unit c/w backwash pumps and air blowers. Provided with dual air bubble level probes their operation is fully automatic.

Make:	TBA
Filter Media:	0.1 microns
Capacity:	1,300 gpm
Accessories:	Backwash pump – 3 Hp, 460/3/60 Air blower – 1 Hp, 460/3/60 Backwash tank Feed tank

UV Disinfection (2)

Objective:	Effluent disinfection to less than 2.2 MPN/100 ml (fecal coliform)
Design Considerations:	Open channel type system installed within concrete channels is provided. The system consists of two UV lamp module banks installed in series within each of the two concrete channels.
Capacity:	1,300 gpm
Fecal Coliform:	2.2 / 100 ml
Accessories:	UV intensity monitor, elapsed time meter, ground fault interrupter, cleaning rack

Air Blower AB 1 (3 – Two duty and one standby)

Objective:	Provide air for fine bubble aeration.
Design Consideration:	Three blowers are provided each capable of serving 0.5 MGD bioreactor. Two blowers are duty blowers the third is a common standby.
Make:	Dresser Roots, or equal
Capacity:	1,000 SCFM @ 7.5 psig
Material:	All iron
Drive:	50 Hp, 460/3/60
Accessories:	Filter/Silencer and Discharge Silencer, Pressure Relief Valve, Belt Drive and guard, Pressure and temperature gauges, VFD drive controlled by DO monitor

Air Blower AB 2 (3 – Two duty and one standby)

Objective:	Provide air for RAS airlift pumps, coarse bubble aeration in the equalization basin and sludge aerobic digesters.

Sludge Transfer Tank STPS (1)

Objective:	Provide containment for waste sludge and clarifier skimmings before transfer to sludge post treatment
Capacity:	50,000 gallons
Material:	Concrete

Sludge Transfer Pump STP (2)

Objective:	Pump the contents of the sludge transfer pump station to the sludge post treatment

Alum Storage and Dosing System ADS (1)

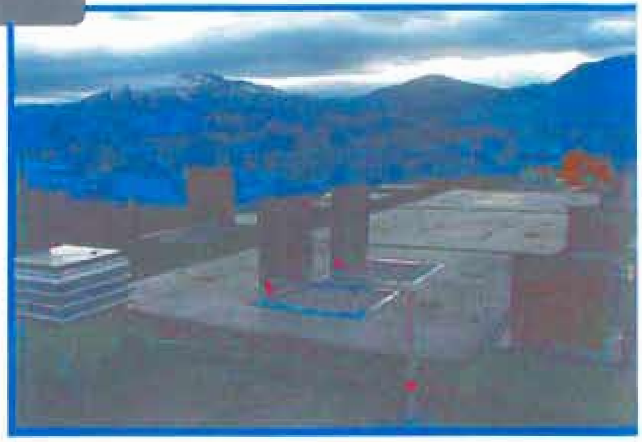
Objective:	Meter alum into the anoxic compartments of the bioreactors

Decentralized Wastewater Treatment

With the technological advances of small plant performance and reliability, decentralized plants and water re-use have now become eminently feasible and economically and environmentally advantageous. Smaller local treatment plants in place of a large central facility allow for a significant reduction of overall capital cost, phased construction and the possibility of local water re-use in dual plumbing or for irrigation and other non-potable uses.

Traditional centralized solutions require costly collection infrastructure which often represents a major portion of the total capital cost. Moreover, the centralized system does not readily accommodate the treated effluent reuse.

ECOfluid's Upflow Sludge Blanket Filtration (**USBF™**) process is an innovative technology that is highly suitable for decentralized treatment applications. Economical and easy to operate its features include high secondary treatment efficiency, biological nutrient removal (BNR), self-regulating hydraulics and very importantly NO ODOR. The **USBF™** process, followed by sand or membrane filtration and disinfection produces high quality re-usable water at economical capital and operating costs.



No Odor, No Noise, Out of Sight-
Two Decentralized Treatment Facilities

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Technology Leadership of the Year Award

Upflow Sludge Blanket Filtration (USBF)

Nitrogen Reduction Memorandum

Nitrogen is removed by nitrification and denitrification processes. Nitrification is autotrophic and all USBF integrated bioreactors deliver complete nitrification of ammonia to nitrate provided that certain minimum temperature is maintained [1] and alkalinity is available. [2] Denitrification is heterotrophic and requires carbon source. Processes using "separate-sludge denitrification" require that carbon is added. USBF technology "single-sludge denitrification" approach uses an endogenous carbon source to maintain the denitrifiers. Influent is combined with nitrified mixed liquor in the anoxic compartment providing the carbon source needed for denitrification.

The conditions that affect the process of denitrification are (not in the order of priority):

- Volumes or HRTs - The required 'biological' volume is divided into anoxic and oxide volumes. The ratio of the two varies depending on the degree of denitrification desired. The anoxic volume or HRT must allow for DO exertion and for the provision of anoxic conditions needed for fermentation.

- Mixing of the Anoxic Volume - Good mixing and roll of the anoxic compartment is important. Mixing should be 'gentle' so as not to break up the sludge flocs.

- DO Control - DO control throughout the bioreactor is the most important factor. The 'plug' flow of the mixed liquor in the oxide compartment allows for manual adjustment of individual aeration diffuser sections, and the overall air flow is typically controlled by a continuous DO monitor modulating the blower RPM via variable frequency drive (VFD). Anoxic compartment DO is 'controlled' only indirectly by the oxide compartment DO adjustment and control, and by providing sufficient compartment volume (see above).

- RAS Recycle - Mixed liquor containing nitrite/nitrates is recycled from the bottom of the clarifier to the anoxic compartment where the incoming BOD serves as the carbon source or electron donor for the reduction of nitrate to elemental nitrogen. The efficiency of the overall nitrogen reduction has been determined to be a function of the RAS flow multiple (the higher the multiple the higher efficiency). However, the recycle has to be balanced against other factors and based on experience a multiple of 2 to 4 provides a 'safety factor' for typical domestic wastewater while moderating the negative effects. RAS pumps are typically airlift pumps for smaller plants, and low head (low Hp), axial flow pumps provided with VFD drives for larger plants.

- Temperature – Low temperatures and dramatic changes in temperature inhibit or stop the process of denitrification.

- Carbon – Incoming wastewater is the source of carbon. [3] Carbon deficiency is typically not an issue with most municipal or domestic wastewater.

Case Studies

The following USBF plant operating data have been recorded:

Marco Shores, FLA

Effluent	Nitrate as N (mg/l)	Nitrite as N (mg/l)	Ammonia as N (mg/l)	TIN (mg/l)	TKN (mg/l)	TN (mg/l)
August 13, 2003	3.2	0.044U	0.05U	3.29	1.0	4.29
August 27, 2003	2.8	-	0.05U	2.8	0.74	3.54
September 10, 2003	3.1	-	0.05U	3.1	0.7	3.8
Design Parameters						10

Notes: 1. U denotes Under Detectable Limit
2. The plant is not equipped with SCADA, continuous DO monitor and VFD drives
3. Official lab analysis available

[1] Nitrification was observed to function at temperatures as low as ~3 deg C.
[2] Nitrification consumes 7.1 mg/l of alkalinity as $CaCO_3$ for each mg/l of ammonia oxidized.
[3] Reduction of 1 gram of nitrogen requires approximately 3 – 6 grams of BOD (or equivalent carbon)

KICKING HORSE SKI RESORT, BC

Effluent	Nitrate as N (mg/l)	Nitrite as N (mg/l)	Ammonia as N (mg/l)	TIN (mg/l)
March 15, 2007	4.8	1.9	0.778	7.5
March 22, 2007	3.0	0.07	0.149	3.22
March 29, 2007	3.4	0.0	0.142	3.54
April 2, 2007	5.8	0.67	0.097	6.57
April 9, 2007	3.0	0.2	0.035	3.24

Notes:
1. Nitrogen reduction was not the plant design objective (small anoxic compartment)
2. The plant serves a ski resort where flows, temperatures and biological loadings vary significantly from weekends to weekdays
3. Official lab analysis available

ISLAMORADA, FLA

2005						2006					
April	May	June	July	August	Sept	January	February	March	April	June	July
1.7	3.7	3.1	2.9	3.8	2.8	6.6	3.3	2.1	3.5	2.4	4.7

Notes:
1. The plant is a small plant without any automated controls
2. Due to wide influent flow fluctuations, small plant's denitrification is typically more difficult to manage than with larger plants
3. Official lab analysis available

SNUG COVE, BC

	2005				2006		
	March	June	Sep	Dec	March	June	Sep
TN	7.83	4.44	6.54	8.27	2.78	4.41	6.2
TKN	2.2	1.9	5.2	4.7	2.3	3.8	4.3

Notes:
1. This plant is a very basic rendition of the USBF configuration. It was not designed for nitrogen reduction (small anoxic volume), and it is not equipped with continuous DO monitor and VFD drives.
2. Official lab analysis available.

MILL BAY, BC

Mill Bay Effluent	Nitrate / Nitrite as N (mg/l)	TKN (mg/l)	TN (mg/l)
April 17, 2007	1.8	0.9	2.7
May 22, 2007	4.0	1.8	5.8
June 25, 2007	5.17	1.5	6.7
July 17, 2007	2.75	1.5	4.2
August 7, 2007	3.38	1.5	4.9
September 11, 2007	7.12	1.4	8.5
October 16, 2007	4.11	1.2	5.3
November 6, 2007	3.9	2.2	6.1
Design Parameters			**10**

Notes:
1. The plant is a water reclamation plant where the permitted effluent Total Nitrogen (TN) is <10 mg/l.
2. The plant is relatively small (150 m^3/d; 40,000 gpd) and experiences high infiltration.
3. Official lab analysis available

UPFLOW SLUDGE BLANKET FILTRATION (USBF)

PHOSPHORUS REDUCTION MEMORANDUM

One of the beneficial features of the USBF technology is increased efficiency of phosphorus removal. This is due to the fact that a significant amount of the influent phosphorus is reduced by biological phosphorus uptake.

The mechanics of biological phosphorus uptake, known as "luxury uptake", is due to exposure of activated sludge to alternating oxide and anoxic conditions. Under the conditions, the cells store more energy in the form of phosphorus than needed for their survival. If strictly oxide conditions are maintained during subsequent clarification, phosphorus will be retained by the cells and it will eventually be removed with excess sludge. Unlike most other methods of clarification, the upflow sludge blanket filtration process maintains oxide conditions in the filter, and phosphorus reduction by biological uptake to as low as 1 mg/l has been achieved as demonstrated in the table below.[1]

The following results were recorded during the 2007 Annual Report filing test period at Kicking Horse Ski Resort, Golden, BC:

	March 15	March 22	March 29	April 2	April 9	Average
Total Phosphorus [mg/l]	1.11	0.78	0.69	0.95	2.2	1.15

Notes: 1. Total Phosphorus reduction was entirely by the biological phosphorus uptake. NO CHEMICALS WERE USED.
2. 24 hour composite samples were analyzed.
3. Official lab analysis available

For further phosphorus reduction phosphorus precipitant chemicals such as aluminum sulfate, ferrous sulfate or other salts are used. In most domestic wastewater phosphorus is present in three forms, orthophosphate, polyphosphate and organic phosphorus. Polyphosphate and organic phosphorus cannot be readily precipitated but both are converted to orthophosphate during biological treatment, which can. Since the bulk of phosphorus reduction is accomplished by biological uptake, the small polish dosages of metal salt precipitant do not significantly increase sludge production.

In simultaneous chemical precipitation metal salts are dosed into the anoxic compartment of the USBF bioreactor. Continuous sludge internal circulation and mixing ensure efficient precipitation, coagulation and flocculation within the bioreactor with an added benefit of increased efficiency of the USBF clarifier.

The following effluent Total Phosphorus parameters were recorded at a 1 MGD (4,000 m^3/d) USBF facility during seven months period from June to December 2002. The facility was provided with aluminum sulfate (alum) dosing system. During the period dual 24-hour composite samples were taken and analyzed and only the higher results were recorded. The following are monthly averages of the daily composite sample analysis.

2002	June	July	August	Sept.	Oct.	Nov.	Dec.	Average
Total Phosphorus	0.4	0.5	0.2	0.3	0.4	0.5	0.3	0.4

Notes: 1. TP design parameter was 1.0 mg/l
2. The facility has not been provided with any post-biology (read post USBF) filtration
3. Since the bulk of the total phosphorus reduction was by biological uptake, the alum consumption and the ballast sludge production were light
4. Two 24-hour composite samples were analyzed. Only the higher results were recorded.
5. Official lab analysis available
6. With added post-biology (post USBF) microscreen filtration, reduction of Total Phosphorus to 0.1- 0.25 mg/l range is believed to be eminently possible

[1] Sludge decant return from storage or dewatering to bioreactors if such is the case must be chemically treated as anoxic conditions during quiescent periods will cause phosphorus release.

At another facility, Islander Resort in Florida, the following results were recorded in 2006:

2006	Jan	Feb	Mar	Apr	May	Jun	Jul	Average
Total Phosphorus	0.1	0.13	0.3	0.4	0.5	0.1	0.2	0.25

Notes:
1. TP design parameter was 1.0 mg/l
2. Islander Resort facility is at 12,000 GPD (45 m^3/d) a relatively small system with highly fluctuating flow and very rudimentary control system only
3. The facility is provided with post-biology (post USBF) microscreen filtration
4. In the original configuration ferric sulfate was used for chemical precipitation, but it was replaced with aluminum sulfate in the last few years
5. Grab samples as mandated by Florida Department of Environmental Protection were analyzed and recorded monthly
6. Official lab analysis available

USBF™ - Membrane Filtration (USBF™MF)

In recent years, membrane filtration has been widely adopted by the wastewater treatment industry predominantly using immersed hollow fiber or panel membranes. The immersed membranes however, come with significant compromises involving costs, simplicity, flexibility, and more. Costly, 'special requirement influent fine screening' needs to be provided, and steps such as lifting and removing the membranes out of the bioreactor when required for maintenance are disruptive to routine plant operation. Additionally, membranes immersed in the bioreactor make optimization of the biological and the filtration processes difficult.

The USBF™MF system, which consists of a USBF™ bioreactor followed by external membranes, builds on the treatment efficiency of the USBF™ process and utilizes external membranes for final polishing filtration. The configuration reduces or eliminates many of the immersed membrane compromises. No special pre-treatment is required, the biological treatment can be optimized for biological nutrient removal (and include chemical precipitation if desired), and the membrane energy input is kept low by the membranes design and by the fact that the TSS of effluent from the USBF™ is already less than 10 mg/l. The result is a membrane quality effluent with significantly improved reliability, flexibility and simplicity of operation, and reduced capital and operating costs.

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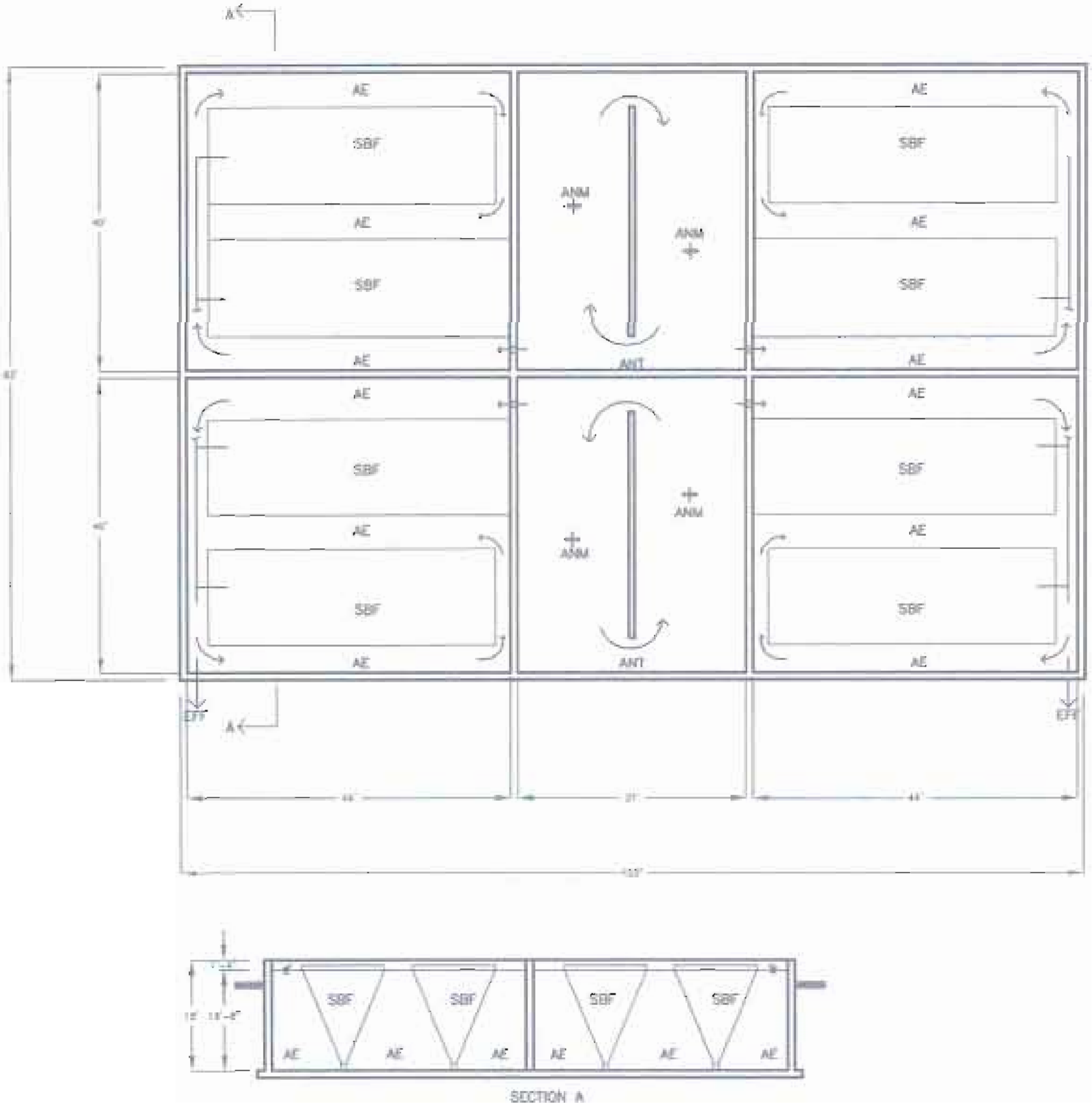
USBF™MF

merges efficient biological treatment system with compact external membranes

- No "Special Needs" Screening
- Optimized Biology (incl. BNR)
- Multi-barrier, two stage Filtration (USBF/MF)
- High Membrane Flux Rate & Reduced Fouling
- Clean-in-place (CIP)
- Modular & Flexible Design
- No Odor
- Significantly Reduced Power Cost



LEGEND

AE	AERATION COMPARTMENT
ANT	ANOXIC COMPARTMENT
ANM	ANOXIC MIXER
SBF	USBF™ SLUDGE BLANKET FILTER

DESIGN BASE

BOD:	220mg/l (METCALF & EDDY MEDIUM INFLUENT PARAMETER)
TSS:	220mg/l (METCALF & EDDY MEDIUM INFLUENT PARAMETER)
PEAKING FACTOR:	2.3

NOTES

1. PLANT CONFIGURATION CAN BE MODIFIED TO SUIT THE SITE REQUIREMENTS.
2. EQUALIZATION TANK, EFFLUENT PUMP TANK, SLUDGE HOLDING TANK, CHLORINE CONTACT TANK, HEADWORKS ROOM, POST TREATMENT PROCESS ROOM AND LAB AND CONTROL ROOM, WHICHEVER REQUIRED, ARE NOT SHOWN.

ECOfluid Systems Inc.

SITE CONSTRUCTED USBF WWTP
1 MGPD (~4,000m³/d)

TYPICAL ARRANGEMENT

ECOfluid Awards & Accolades

- 2007 – Awarded one of Canada's Top Ten Cleantech Companies

- 2006 – Received Frost & Sullivan Award for Technology Leadership

- 2006 – Received the Technology Merit Award from Environmental Business Journal

- 2002 – University of California, Davis – USBF™ technology was the highest ranked biological treatment system out of almost seventy technologies reviewed

"State of the art… an important environmental process revolution."

Lawrence K. Wang, PhD, PE, DEE, CO on the Upflow SludgeBlanket Filtration process

United Nations Industrial Development Organization (UNIDO)
Chief Editor, Humana Press, Albany, NJ
New York City Water Facilities Manager
City of Albany, NJ, Water Dept.

BENEFITS

High Treatment Efficiency Including Biological Nutrient Removal (BNR)

The USBF™ process features an internal anoxic compartment for biological reduction of nitrogen and phosphorus by nitrification, denitrification and 'luxury uptake' processes respectively.

Alkalinity Recovery & Filamentous Bacteria Control

The integral denitrification process facilitates partial recovery of alkalinity during nitrification. As well, the anoxic selector is used to control filamentous bacteria growth within the system.

No Primary Clarification

USBF™ process does not require primary clarification prior to biological treatment. A proper screening facility and for larger plants, grit removal system is all that is required upstream of the bioreactors.

Hydraulic Flexibility

The sludge blanket filter prism or cone shape not only allows other treatment processes to take place around it, but it also facilitates superior hydraulic flexibility. The process easily accommodates high peak flows and flow swings in a self-regulating manner; the higher the flow, the higher the sludge blanket rises and the larger the filtration area becomes.

Modular expansion of the plant at Sun Peaks Ski Resort. Two original bioreactor modules (left) installed in 1999 supplemented by two additional modules in 2005

Modular and Flexible Design

Modularity of design allows owners to stage plant development and ensures that plants can be quickly expanded if and when growth demands.

Reduced Operating and Maintenance Requirements

The compact design, minimal amount of moving parts and self- regulating hydrau , contributing to lower operating and maintenance costs.

Reduced Site Requirements

USBF™ process incorporates nitrification, denitrification, clarification and sludge stabilization into a compact bioreactor which reduces equipment size and liquid handling requirements and ultimately leads to a smaller plant footprint.

300 m³/d (80,000 GPD) USBF WWTP built in a residential subdivision between housing attesting to the non-odoros nature of the process

No Odor

Aerobic conditions throughout the bioreactor and extended sludge age eliminate or dramatically reduce odor. USBF™ plants can be located within populated areas without odor concerns.

Improved Sludge Characteristics

Low microbial loading (extended sludge age of 25-35 days) produces less excess sludge, which is aerobically stabilized, and which is characterized by improved structure and better dewatering capability.

APPLICATIONS

Municipal and Domestic Wastewater

Literally thousands of site constructed and packaged USBF™ treatment plants serving municipalities, communities, subdivisions, ski resorts, shopping centers, summer resorts, golf courses, hotels, restaurants etc. are in operation worldwide.

Water Reclamation

The USBF process alone is capable of removing BODs and TSS to less than 10 mg/l without post-filtration, Total Nitrogen reduction to less than 10 mg/l and Total Phosphorus removal to about 2.5 mg/l. (The reduction of total phosphorus to less than 2.5 mg/l requires additional chemical precipitation). This high efficiency of the continuous flow USBF™ process paves the way to economical 'tertiary' post-treatment. Using the USBF™ process followed by membrane, sand or microscreen filtration, and UV disinfection, ECOfluid designs, builds and operates treatment plants producing Class A (or Title 22), or reclaimed water quality effluent at economical capital and operating costs.

Existing Plant Retrofits

The self-contained nature of the internal circulation loop and structural independence of the sludge blanket filter insert make it possible that virtually any tank can be converted to a wastewater treatment plant. Many existing RBC's, oxidation ditches and other plants have been retrofitted with USBF™ filters to increase treatment efficiency and/or plant capacity.

Industrial Wastewater

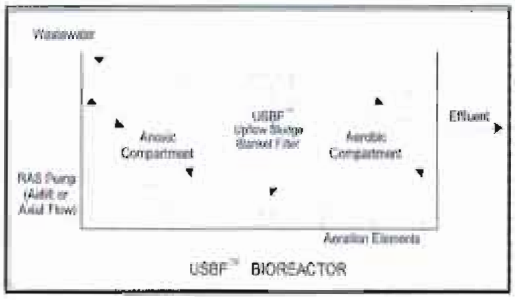
Many plants treating high strength industrial wastewater including food processing plants, slaughterhouses and rendering plants, dairy plants and pulp mills have been designed and are in successful operation worldwide.

UPFLOW SLUDGE BLANKET FILTRATION (USBF™)

PROCESS SUMMARY

THE PROCESS

Operation of a USBF™ plant is simple and self-regulating. Wastewater enters the anoxic compartment of the bioreactor where it mixes with activated sludge recycled from the bottom of the sludge blanket filter. Agitated and moved in a plug flow manner, the mixed liquor flows into the bioreactor's aerobic compartment. After aeration, a stream of the mixed liquor enters the bottom of the sludge blanket filter where the sludge flocs and water are separated by upflow sludge blanket filtration. After separation, filtered effluent overflows into a collection trough and is discharged from the system. To complete the internal gravity circulation loop, activated sludge collecting at the bottom of the sludge blanket filter is recycled back into the bioreactor anoxic compartment.



THREE FEATURES THAT INCREASE EFFICIENCY AND REDUCE COSTS

Sludge Blanket Filter

The upflow sludge blanket filter introduces a substantially higher specific rate of separation than other commonly used separation techniques. Unlike conventional clarifiers, influent enters at the bottom and flows upwards. As the cross sectional area increases, the upflow velocity decreases until the activated sludge flocs become stationary and thus form a filtering media for activated sludge flowing through. High filtration efficiency is achieved and even particles with settling velocities too low to be removed by settling alone are filtered out.

High Sludge Concentration

Most traditional plants operate at low or medium sludge concentrations, typically 2,500 – 3,500 mg/l. USBF™ process by contrast operates at higher sludge concentrations, typically 4,000 – 6,000 mg/l resulting in longer sludge age and increased biological efficiency.

All Processes Integrated into One Bioreactor

Most conventional technologies carry out processes of nitrification, denitrification, clarification and sludge stabilization in a number of dedicated vessels. By contrast, USBF™ process incorporates these processes inside a compact bioreactor, reducing equipment size and liquid handling requirements.

Lake Alfred, Fl, 1 MGD (4,000 m^3/d) WWTP (Four 0.25 MGD modules). Trickling filter plant retrofit.

USBF™ - Membrane Filtration (USBF™eMBR)

In recent years, membrane filtration has been widely adopted by the wastewater treatment industry predominantly using immersed hollow fiber or panel membranes. The immersed membranes however, come with significant compromises involving costs, simplicity, flexibility, and more. Costly, 'special requirement influent fine screening' needs to be provided, and steps such as lifting and removing the membranes out of the bioreactor when required for maintenance are disruptive to routine plant operation. Additionally, membranes immersed in the bioreactor make optimization of the biological and the filtration processes difficult.

The USBF™eMBR system, which consists of a USBF ™ bioreactor followed by external membranes, builds on the treatment efficiency of the USBF™ process and utilizes external membranes for final polishing filtration. The configuration reduces or eliminates many of the immersed membrane compromises. No special pre-treatment is required, the biological treatment can be optimized for biological nutrient removal (and include chemical precipitation if desired), and the membrane energy input is kept low by the membranes design and by the fact that the TSS of effluent from the USBF™ is already less than 10 mg/l. The result is a membrane quality effluent with significantly improved reliability, flexibility and simplicity of operation, and reduced capital and operating costs.

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Packaged Wastewater Treatment Technology Leadership of the Year Award

USBF™eMBR

merges efficient biological treatment system with compact external membranes

No "Special Needs" Screening

Optimized Biology (incl. BNR)

Multi-barrier, two stage Filtration (USBF/eMBR)

High Membrane Flux Rate & Reduced Fouling

Clean-in-place (CIP)

Modular & Flexible Design

No Odor

Significantly Reduced Power Cost

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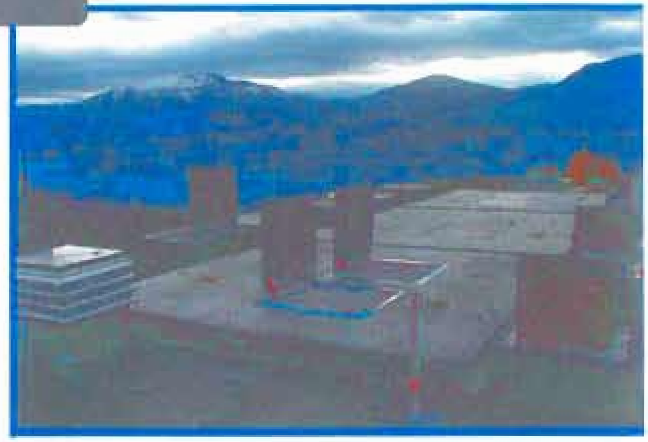

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ECOfluid SYSTEMS INC

Giving Water New Life

Residential | Industrial | Commercial
Municipal | Decentralized

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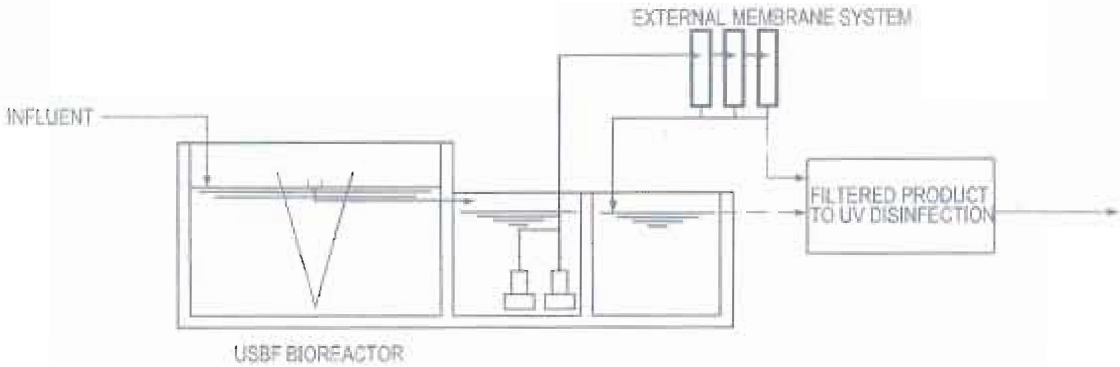
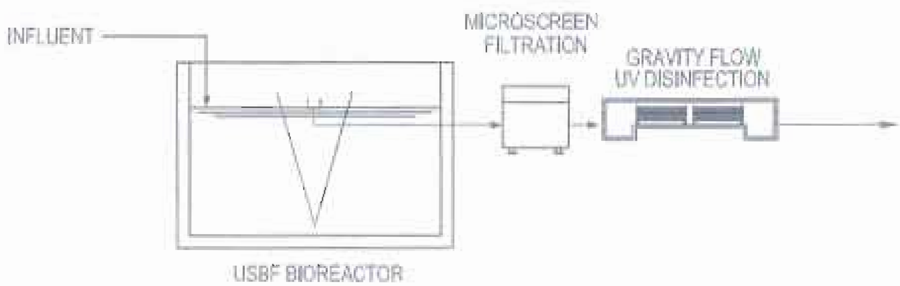
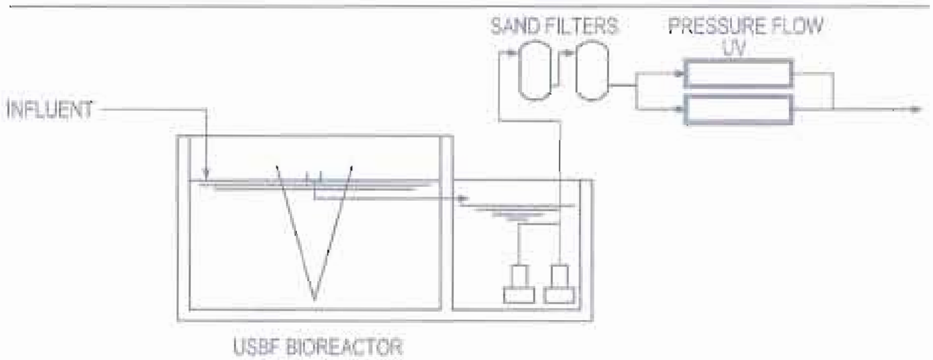


(A1) EXTERNAL MEMBRANE FILTRATION & DISINFECTION



(A2) GRAVITY FLOW FILTRATION & DISINFECTION



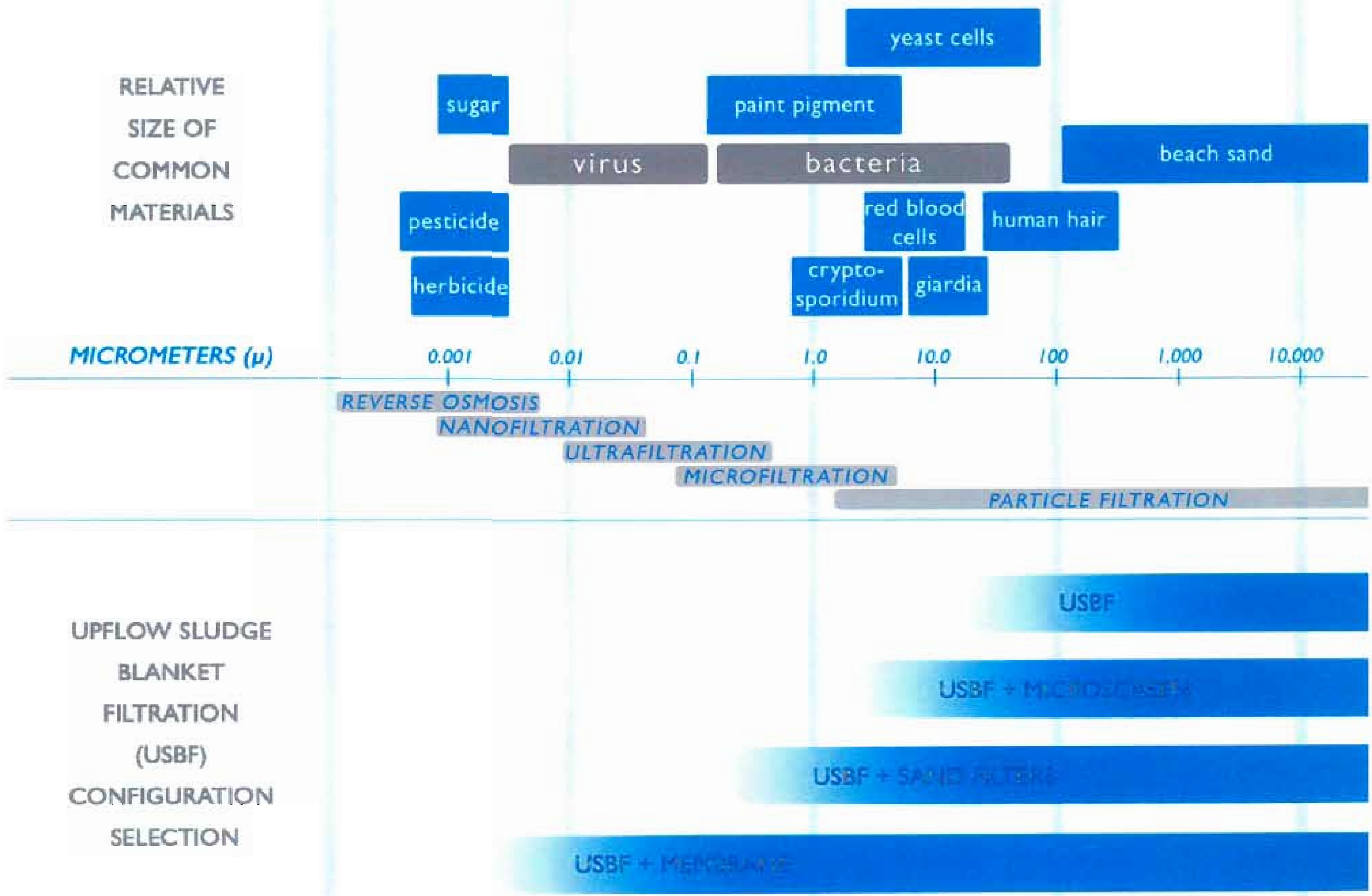
(A3) PRESSURE FLOW FILTRATION & DISINFECTION

USBF WWTP CLASS "A" & RECLAIMED WATER OPTIONS

CLASS "A" PARAMETERS	CLASS "A"	RECLAIMED WATER
BOD, max mg / L	10	10
TSS 10 mg / L	10	5
FC, median, fc / 100 ml	2.2	2.2
FC, any sample, fc / 100ml	14	14
TN, max, mg / L	20	NA
NITRATE - N, max, mg / L	10	NA
TURBIDITY, avg, NTU	2	2
TURBIDITY, any sample, NTU	5	5

ECOfluid

Filtration Selection Chart



ECOfluid

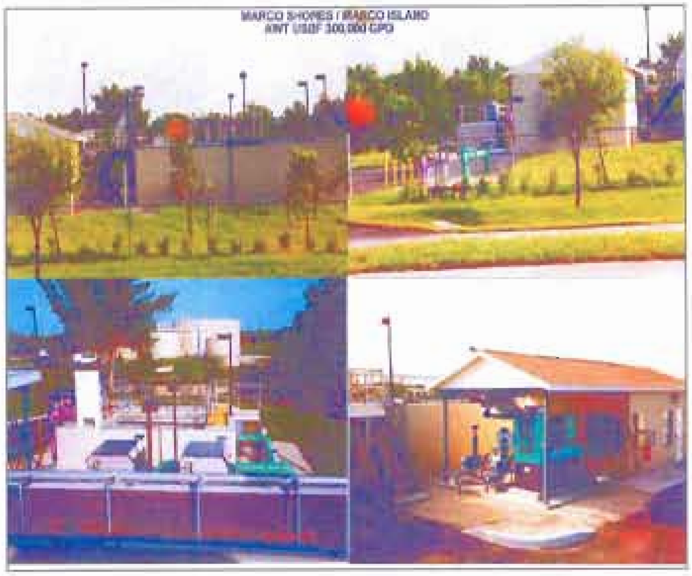
MARCO SHORES WWTP, MARCO SHORES, FL

CASE STUDY

This 300,000 GPD facility at Marco Shores, FLA employs USBF bioreactors immediately followed by microscreen filtration. No additional filtration is employed.

As illustrated by the operating data tabulated below, the plant designed for 10/10/10 mg/l BOD/ TSS /TN consistently delivers very low BOD, TSS and Total Nitrogen.

Disinfection in this plant is by chlorination.



OPERATING RESULTS

Date	TSS Pre-Filter [mg/l]	TSS Final Effluent [mg/l]	BOD Final Effluent [mg/l]	TN Final Effluent [mg/l]	TP Final Effluent [mg/l]	Fecal Coliform Final Effluent [CFU/100ml]
August 5, 2003	3	0.8				1
August 6, 2003	28	0.8				1
August 7, 2003		1.1				1
August 11, 2003	2.3	2.1				
August 12, 2003	4.0	3.3				1
August 13, 2003		0.6	2.5	4.2	3.1	1
August 14, 2003		0.7				1
August 18, 2003		6.3				1
August 19, 2003		6.9				1
August 20, 2003		0.6				1
August 21, 2003		1.1				1
August 26, 2003		2.2				1
August 27, 2003		1.4	3.6	6.3	2.8	1
August 28, 2003		0.8				1
August 29, 2003		1.6				1
September 8, 2003		2.6				1
September 9, 2003	5.0	0.8				1
September 10, 2003		1.0	2.2	6.8	3.5	
September 11, 2003		0.9				1
Design Parameters		**10**	**10**	**10**		**10**

Total Phosphorus was NOT the plant design parameter

STRATHMORE WWTP

CASE STUDY

OPERATING RESULTS

2002	Bioreactor 1			Bioreactor 2		
	SSV [ml/l]	MLSS [mg/l]	SVI [ml/g]	SSV [ml/l]	MLSS [mg/l]	SVI [ml/g]
June	474	5536	85	374	5236	71
July	820	5131	162	851	5419	159
August	732	4485	167	827	4572	182
September	806	4798	171	758	4620	165
October	780	3797	206	758	3766	201
November	914	5009	185	887	4749	188
December	914	4724	194	917	5065	182

After the plant turn-over to the plant operator in mid-June the operator "experimented" with operating parameters (lower DO, reduced MLSS…). The result was much higher than typical SSV and SVI in the following months.

WASTE ACTIVATED SLUDGE YIELD

2002	WAS [m³/m]	WAS [m³/d]	WAS [% ds]	WAS [kg/d]	WAS Yield [kg WAS / kg BOD and TSS]	WAS Yield [kg WAS / kg BOD]
June	1,684	56.1	0.54	303	0.19	0.37
July	2,954	95.3	0.53	505	0.37	0.75
August	2,978	96.1	0.45	432	0.28	0.56
September	3,347	111.6	0.47	524	0.35	0.69
October	3,908	126.1	0.38	479	0.29	0.58
November	1,969	65.6	0.47	308	0.18	0.38
December	2,465	79.5	0.49	390	0.25	0.49
Average	2,758	90.0	0.48	420	0.27	0.54

Averaged over seven months and including aluminum sulphate ballast sludge Waste Activated Sludge (WAS) yield was 0.27 kg/kg ((lb/lb) of combined BOD and TSS or 0.54 kg/kg (lb/lb) of BOD.

ALUM CONSUMPTION

2002	Alum [l/d]	Alum Consumption [l/kg TP]
June	161	11.4
July	145	10.7
August	322	20.8
September	261	16.7
October	230	14.8
November	87	5.6
December	205	13.0
Average	201	13.3

Alum solution consumption was 13.3 litres per kg (1.6 gal/lb) of Total Phosphorus removed. This would indicate that approximately 60% of the Total Phosphorus reduction was by biological "luxury" uptake.

STRATHMORE WWTP
CASE STUDY

The Strathmore WWTP was constructed to replace eight extended aeration lagoons. The plant was designed to process 4,000 m^3/day (1 MGPD) Average Day Flow, 10,000 m^3/day (2.6 MGPD) Peak Day Flow and the permit stipulated effluent of less than 20 mg/l BOD and TSS, less than 5/10 mg/l N-NH_3 in summer/winter respectively, less than 1 mg/l Total Phosphorus and less than 200 MPN/100 ml fecal coliform. The plant features included headworks, two USBF bioreactors, alum storage and dosing and a UV disinfection system. Alum solution (49%) was dosed into the anoxic compartment of the bioreactors. Phosphorus precipitation and coagulation took place within the bioreactor internal circulation. Filtration was solely by the USBF clarifiers - the process did not include effluent post-filtration.

The plant was operated in May 2002 by ECOfluid and turned over to the Owner's operator in mid June 2002. Seven months of the plant operation and performance in 2002 are summarized in the following summary tables. The results confirm that loaded very close to its design capacity the plant performed well within the design parameters and better.

All data are monthly averages of daily 24 hr composite samples. Daily duplicate 24 hour composite samples were sent to certified lab for analysis (Lab analysis available). Only the higher results were recorded.

INFLUENT DATA

2002	Flow [m^3/d]	BOD [mg/l]	BOD [kg/d]	TSS [mg/l]	TSS [kg/d]	TP [mg/l]	TP [kg/d]	NH_3 [mg/l]	NH_3 [kg/d]
June	3,818	213	813	208	794	4.1	15.7	14.4	55.0
July	3,739	179	669	189	707	4.1	15.3	14.5	54.2
August	3,431	226	775	218	748	4.7	16.1	16.0	54.9
September	3,335	229	764	221	737	5.0	16.7	19.8	66.0
October	3,237	255	825	252	816	5.2	16.8	19.9	64.4
November	3,091	266	822	304	940	5.5	17.0	20.3	62.7
December	2,969	269	799	251	745	5.6	16.6	24.5	72.7
Average	3,374	234	781	235	784	4.9	16.3	18	61
Design	**4,000**		**800**		**800**		**30**		**100**

In terms of BOD and TSS the plant seven months average loading was 98% of the design capacity.

EFFLUENT DATA

2002	CBOD [mg/l]	BOD [mg/l]	TSS [mg/l]	TP [mg/l]	NH_3 [mg/l]	Total Coli	Fecal Coli
June	7	12	16	0.4	0.1	14	10
July	5	7	8	0.5	0.1	27	14
August	4	5	7	0.2	0.2	26	14
September	4	6	8	0.3	0.4	117	24
October	4	7	14	0.4	0.1	112	23
November	4	6	9	0.5	0.1	23	13
December	4	6	9	0.3	0.4	19	13
Average	5	7	10	0.4	0.2	48	16
Design		**15**	**15**	**< 1**	**< 5/10**		**200**

- Although not recorded daily effluent Total Nitrogen when analyzed was < 10 mg/l
- Spikes of high pH (11) were experienced by the plant in October.

LAKE ALFRED WWTP, LAKE ALFRED, FL
CASE STUDY

Filtered clean effluent at the top of the sludge blanket filter overflows into a v-notch overflow trough located under the walkway. There are no moving mechanical parts within the sludge blanket filter/clarifier or the overflow troughs.

From the overflow trough the treated effluent flows by gravity into the Fontana drum microscreen filters. Picture on the right shows filtered effluent in the backwash well of the microfilter (the microfilter uses filtered effluent behind the filter for its automatic backwash).

From the effluent storage tank below the microfilters, the treated, filtered effluent is pumped to the existing chlorination.

	Influent		Effluent		
	BOD	TSS	BOD	TSS	NITRATE
Date	mg/L	mg/L	mg/L	mg/L	mg/L
4-Jun-08	181	192	5.03	3.6	3.60
11-Jun-08			4.76	2.5	3.73
18-Jun-08	219	366	5.09	2.0	3.75
25-Jun-08			5.45	5.0	3.79
Average	200	279	5.08	3.3	3.72

The plant retrofit and upgrade was completed and the plant started up in May 2007. As illustrated by the analysis of samples taken during the month of July 2008, the plant is exceeding its design parameters of <10 mg/l for BOD, TSS and Nitrate.

LAKE ALFRED WWTP, LAKE ALFRED, FL
CASE STUDY

When the City of Lake Alfred decided to upgrade their existing 1 MGD trickling filters wastewater treatment plant, they looked at a number of technologies and after an evaluation decided on the USBF process.

As part of the upgrade, the plant was provided with a new Fontana Integrated Headworks, which screens the influent, washes and dewaters the screenings, removes sand and grit, and deposits washed screenings and grit into separate bins. From the headworks, the screened influent flows to equalization tank (which is a reconditioned old trickling filters tank – trickling filters removed).

From the equalization tank, the influent is pumped into bioreactor modules. The influent first enters the anoxic tanks (above right in the forefront) and with the slide gate open, it passes into the aeration tanks. The still water in the pictures above and below is the treated effluent surface of the USBF sludge blanket filter, within which fluidized bed filtration (upflow sludge blanket filtration) takes place. The water is crystal clear as can be seen in the pictures below.

The above right picture shows raised sludge filter blanket approx 8-10 inches below clear water surface (the sludge blanket level was intentionally raised by prolonged influent pumping).

BCWWA 2007 AGM & CONFERENCE, PENTICTON, BC
SUN PEAKS UTILITIES WASTEWATER TREATMENT PLANT
7 YEARS OF OPERATIONS

PAPER PRESENTED BY PAT MILLER, MANAGER OF SUN PEAKS UTILITY CORPORATION

There are now over 12 USBF plants in operation in British Columbia. The facility at the Sun Peaks Resort is today the largest (in BC) and, installed in 1999, one of the earliest. This presentation will outline the plant's operating experiences and operating data, and touch on the resorts' future considerations towards environmental sustainability, including water reuse for golf course irrigation and snow making.

HISTORY

Sun Peaks Resort is situated at the base of Tod Mountain approximately 40 kilometers northeast of Kamloops, British Columbia. Tod Mountain, with a summit elevation of 2,152 meters was originally developed as a ski operation in the early 1960's. In 1972, the former operator decided to develop a few residential lots and formed a private utility to operate a simple community water supply and wastewater leaching field that was replaced in 1987 with a simple lagoon system. While the permit granted a maximum disposal of 230 m^3/day, discharge was intermittent, if at all.

In 1992, the property was purchased by Nippon Cable Company Limited and the resort's name was changed to Sun Peaks. Nippon's strategy for Tod Mountain was to upgrade the ski lift and trail system and transform the area into a major four-season, destination mountain resort with all the amenities.

In 1993, the resort operator, Sun Peaks Resort Corporation completed the Tod Mountain Master Plan and entered into an agreement with the Provincial Government to take the resort from a winter only ski hill to a year round community that will eventually support as many as 24,000 residences and visitors during any period.

Sun Peaks' base development has been rapidly expanding since 1993. As a consequence, wastewater flows at the Sun Peaks Utilities' treatment facility have been steadily increasing. Sun Peaks Utilities Co. Ltd., (known as SPUCL) has made a number of improvements to the lagoon system to keep pace with the increasing hydraulic and organic loading. These improvements ranged from surface aeration mixers to sub-surface fine bubble diffusion piping.

SIMPLE TO COMPLEX TREATMENT

After the 1998 Christmas period when the holding time in the 6,000 cubic meter lagoon dropped to under 6 days, Sun Peaks Utilities decided to replace the lagoon with a system that could deal with the growing flows. After evaluating a few alternatives, SPUCL decided to go with the Upflow Sludge Blanket Filtration (USBF) system supplied by Ecofluid Systems Inc. The Design/Build contract was awarded to Knappett Construction Ltd. in the latter part of July 1999, the construction began on August 24, 1999 and the plant started receiving wastewater on November 19, 1999. By December 15, the effluent was below 10 mg/l BOD_5 and 10 mg/l Total Suspended Solids.

PLANT DESIGN

The overall design of the system allowed for four bioreactors, each containing an anoxic zone, an aeration zone and a clarifier that contained a floating sludge blanket that acted as a filter media through which the final effluent was filtered. It is the floating sludge blanket in a "V" shape clarifier that makes handling of flows that can change 10 fold within a month and double from weekdays to weekend possible.

Year	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Highest Flow	930	997	1,244	1,206	1,303	1,362
Lowest Flow	35	42	127	157	186	198

The decision to go with the USBF system was based on a phased modular design of the plant allowing for incremental expansions that would match the growth of the resort. The first phase installed in 1999 included 2 bioreactors with 3 clarifiers and a waste sludge storage tank.

Depending on the flows, the sludge tank was pumped out from once a day to once a week. The sludge at about 0.5% solids was then trucked off site.

PLANT UPGRADES AND EXPANSIONS

The resort's growth required a number of upgrades and expansions since its start up in 1999. In 2001, fourth clarifier was added to the initially installed three.

With the trucking costs to move the waste sludge off-site rising, the Utility went to community for approval in 2002 to increase usage rates in order to purchase a sludge dewatering centrifuge and to move towards composting on site.

In the summer of 2003, the plant biology was expanded by an addition of two biological compartments, anoxic and aeration.

Last year the plant airlift RAS pumps were exchanged for mechanical pumps to save air, and a new waste sludge pre-thickener was installed to improve sludge handling. Unfortunately only one third of the pre-thickener installation was completed in time for 2006/2007 winter operation.

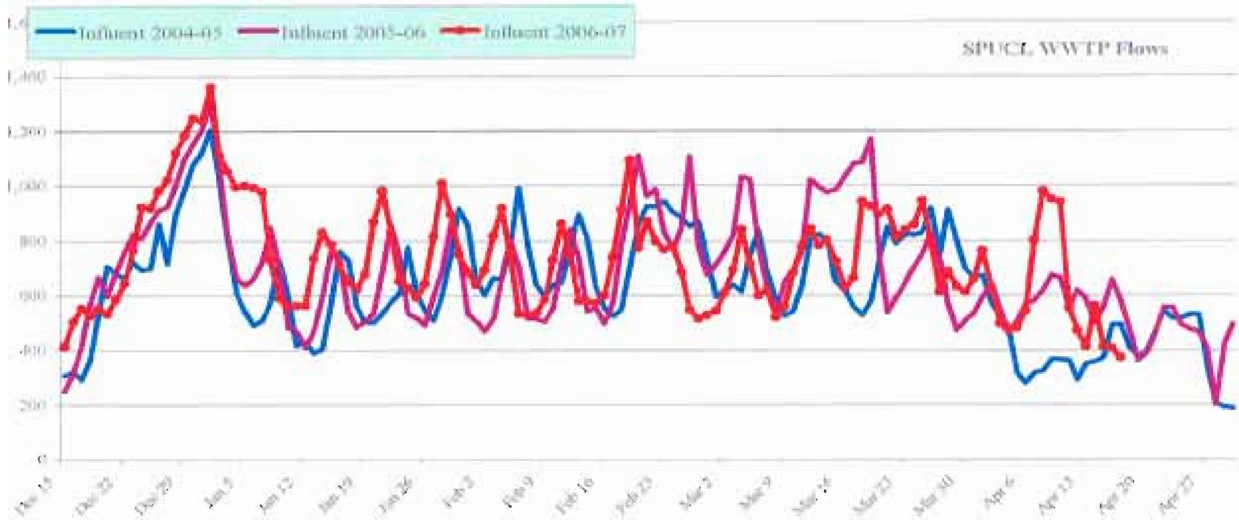
Unfortunately or fortunately, it never stops when you grow as rapidly as Sun Peaks, and so this year we will be upsizing the existing dewatering equipment, complete sludge pre-thickener installation, and add another air blower (bringing us to three).

At present the plant nominal average day capacity is 900 m^3/d, (300 kg BOD_5/d), with peak hourly flow of 120 m^3/h. With more air capacity and enhanced sludge management, we will be able to process increased flows expected this winter. As with any resort community, it is recognized that any additional plant expansion at the current site is limited by the available real estate.

Operating the plant for over seven years enabled us to gather the plant operating and costs data, and acquire experience, which may be of interest to you and which we will share with you in the following.

Operating Data

Each fall is like starting a new plant when we double the size from summer to winter mode. We take bets on what the new season's flows will be and whether we guess correctly on the number of homes built.



We have learned to track lift tickets sold and occupancy rates to help us get prepared for each week. We track when holiday fall and weather trends. You wouldn't believe how powder ski days and rain events can affect flows.

Influent Characteristics

Ski resorts (and this may apply to resorts in general) are not your 'typical influent' generators. Flows change dramatically from day to day and holiday period to holiday period. At Sun Peaks, we implemented the plumbing code similar to Australia for water conservation and thus the average daily flow per resident is currently 220 liters per day and dropping (the Canadian average is 375 liters per day). Then you add day visitors to the mix adding about 40 liters per person per day (very high ammonia content).

To get a better reading of the incoming influent, we analyzed hourly composite samples collected every hour throughout the day. The results illustrate a very uneven pattern of influent characteristics throughout the day as can be demonstrated by one such sample below.

2007	Low mg/L	Hour	High mg/L	Hour	Average mg/L
BOD_5	120	6:30 am	590	9:30 am	385
COD	310	5:30 am	1300	9:30 am	813
$N\text{-}NH_4$	30	1:30 pm	107	8:30 am	61

The variable biological loading throughout the day is a challenge on its own but it is not limited there. We also measured reduced alkalinity, and at times very high COD (possibly due to the type of cooking oils and cleaning detergents used in the resort's restaurants and hotels). Add to this, the fact that the influent temperature may change 5-7 deg C within a matter of days, and the highly fluctuating flow (as high as 110 m^3/h instantaneous hourly peak), and … well, you are getting the picture.

How do we cope?

To 'smooth-out' the variable biological loadings, our air blowers are controlled by a continuous DO monitor/VFD (variable frequency drive) system (this helps, except for being short of air at times, which will change with the installation of another blower this year).

Our well water has very little buffering capacity and with 3000 day skiers adding mostly ammonia to the wastewater stream, we have some issues with pH during the treatment process. To 'control' alkalinity we have been adding slaked lime ($Ca(OH)_2$) into the anoxic and aeration compartment – as much as 100 kg/day. This year, we have gone through almost 100 – 25 kg bags. The good news is that the slaked lime is available locally and is not expensive (about $11 per bag). It has proven very useful.

There is not much we can do about the rest of the challenges, except be more vigilant controlling FOG (fat, oil and grease) at source.

Effluent Parameters

Our MSR requires the effluent not to exceed 30 mg/l each for BOD_5 and TSS and as a rule we do much better. BOD_5 is typically less than 10 mg/l, TSS from 5 to 20 mg/l, ammonia less than 1 mg/l and Total Nitrogen in the 10 to 20 mg/l range. When we do not waste sludge and return the supernatant from the sludge dewatering process back into the influent flow, the Total Phosphorus is biologically reduced to 2 to 3 mg/l.

The following is an analysis of grab samples taken at about 11 am on March 7, 2007

		Bioreactor 1	Bioreactor 2	Bioreactor 3	Bioreactor 4
TSS	mg/l	5.7	9.7	3.7	3.7
Ammonia (as N)	mg/l	0.067	0.077	0.073	0.079
Nitrate (as N)	mg/l	6.75	4.17	7.42	6.58
Nitrite (as N)	mg/l	0.0504	0.0969	0.0545	0.0468
Total Nitrogen	mg/l	8.1	7.6	8.9	6.96
Total Phosphorus	mg/l	6.86	9.87	5.78	6.04
Chloride	mg/l	110	111	112	109
pH	mg/l	7.99	7.70	7.78	7.80
Conductivity		853	900	900	880

This sample was taken right after our highest day-flow period and after the US President's week (2nd highest annual occupancy period). Unfortunately BOD was not analyzed however, based on the other parameters it is safe to assume it was less than 10 mg/l. Together with averages of 5.7 mg/l for TSS, 0.074 mg/l for ammonia, and 7.9 mg/l for total nitrogen the results are well under the most stringent MSR requirements.

Total average phosphorus of 7.1 mg/l is much elevated from what we have experienced before the centrifuge installation. Almost all 'biologically uptaken' phosphorus returns to the system with the centrifuge supernatant recycle to the equalization tank.

Capital Costs

The total capital cost since 1999 to date, including the initial construction of the wastewater treatment plant, the upgrades and the sludge dewatering system, works out to a total of approximately $2,550 per m^3/d, or $7,700 per kg BOD/d.

Looking back, SPRC and SPUCL have invested just over $2.5 million between the initial installation and subsequent upgrades to build a plant that can handle 1,000 cubic meters of peak sustainable flows (vs. peak day flows). If we were to build the same size plant today, (assuming no infrastructure other than the lagoon in place) the costs would be between $4 million and $5 million. This confirms that the decision in 1999 by the Board of Directors to proceed with wastewater treatment system that could grow in phases at the rate needed was the correct choice for a capital investment.

Operating Costs

Total operating cost includes many contributing costs of which the main 'direct costs' are the costs of electricity, wages and benefits, chemicals, repairs and maintenance, waste sludge disposal, and lab analysis.

Averaged over the respective years these direct operating costs shown in the following table:

Direct Costs	Fiscal 2001 2000-01	Fiscal 2002 2001-02	Fiscal 2003 2002-03	Fiscal 2004 2003-04	Fiscal 2005 2004-05	Fiscal 2006 2005-06
Wages & Benefits	65,577	81,071	89,100	103,332	98,870	134,161
Electricity	8,334	8,143	8,025	10,654	12,254	12,167
Chemicals	5,825	5,135	10,771	9,048	6,338	9,522
STP Disposal	23,309	41,660	15,256	23,020	7,300	2,835
Sewer analysis	11,976	13,106	10,140	9,666	10,174	9,091
Total	**115,021**	**149,115**	**133,292**	**155,720**	**134,936**	**167,776**
Total Flows (m^3/year)		129,398	143,606	151,763	168,352	175,782
Total BOD (kg BOD_5/year)		42,701	47,390	50,082	55,556	55,366
Operating Costs						
$ per m^3		$1.15	$0.93	$1.03	$0.80	$0.95
$ per kg BOD_5 *(Influent 330 mg/lBOD_5)*		$3.49	$2.81	$3.10	$2.43	$3.03

By tracking our costs on a biological loading basis, we know what expansion is going to cost from an operating point of view and can structure future rates that are in line with the costs. The operating costs are year round average costs and they are of course negatively affected by the high seasonality of our operation.

General Operating Experience

At Sun Peaks we developed 'per bed factors' to gauge both our water demand and the biological loading as opposed to the daily flows determination in a traditional municipal environment. The factors allow us to predict when each expansion will be needed rather than in the past where something had to break down before the system would be expanded.

After all, you have to get it right for the Christmas/New Years holiday period or you might as well go home. Nothing is more fun that going into the General Manager's office on New Year's Eve and saying that if the lagoon goes up 1 more inch, you are going to shut the town's water off. I had to do this December 31, 1998 and by November 1999, we had a new treatment plant.

Future Challenges & Considerations

With very little dilution and unhealthy eating habits, the upstream management of FOGs is becoming very important. We are currently working with the restaurants in the resort to become more proactive in dealing with their grease traps and oil trapping systems.

Sun Peaks is currently under a trial for biosolids management using composting. However there is a number of challenges that range from too cold in the winter, to too dry in the summer, to the price of land to perform composting. We are currently exploring options that may include gasification or gravel pit reclamation.

Our next challenge is the disposal of effluent. Our current use of rapid infiltration trenches only allows for a maximum daily discharge of 850 cubic meters. The resort is built on the side of a mountain and more land for RI trenches is limited. Options currently under study include stream augmentation, snow making and golf course irrigation. The challenge with the last two options is weather.

As you saw from the early flow graph, influent flows can change significantly from hour to hour and from day to day. Upstream flow balancing would allow more consistent flows into the plant and better treatment of the waste stream. From the first of November each year to the end of December, influent flows can increase five plus times.

The Operator's Experience

Our key challenge at Sun Peaks is that in addition to the wastewater treatment plant, we operate three water treatment plants and a gas distribution system. We have now reached a critical mass that allows us to have 5 operators on staff so that we can focus two of the operators on wastewater treatment to give us seven day week coverage.

Like many small utilities, getting, training and keeping operators is an increasing challenge, no matter what type of system you operate. The USBF system has been very tolerant to operator involvement and support on each expansion has been great.

The ownership of the resort is very happy with the modular expansion options of the USBF system and its ability to expand the system as needed when needed. After all, expansion costs are paid by new users being added to the system (via the developer) rather than the existing customers.

The community is very proud of the plant and that it uses a natural process to treat the wastewater. To confirm this, compare our wastewater rates of $2.17 per cubic meter with many other communities

Would we select the USBF system again – knowing what we know now? - YES!

Thank you for your attention and time permitting, we would be pleased to answer any questions you might have.

Snaw-naw-as First Nation Decentralized WWTP
Nanoose Bay, BC – The Success Story

Introduction

With the technological advances of small plant performance and reliability, decentralized wastewater treatment plants have now become eminently feasible. Smaller local treatment plants in place of a large central facility allow for considerable economical advantages including the reduction of costly collection infrastructure as well as providing the opportunity for smaller incremental-as-needed expansion phasing. Significant environmental and practical advantages also exist, including the possibility of reclaimed water re-use or disposal even in a very environmentally sensitive locality.

In early 2000's Indian & Northern Affairs Canada (INAC) was evaluating the construction of a wastewater treatment plant to serve the Snaw-naw-as First Nation village in Nanoose Bay in British Columbia. The plant was to initially serve the village itself but future expansions were anticipated including the village growth and the future commercial developments alongside the nearby highway. The treated effluent was to be discharged by an ocean outfall into the environmentally sensitive Nanoose Bay.

In 2002 INAC commissioned Chatwin Engineering and Novatec Consultants to prepare Expression of Interest (EOI) and later Request for Proposal (RFP) documents, and after the due evaluation process the project was in 2004 awarded to Knappett Construction Ltd of Victoria (General Contractor), and ECOfluid Systems Inc. (Treatment technology designer and provider), team, that had previously delivered a number of wastewater treatment projects in British Columbia. The project award, and the facility construction and operation included several innovative approaches, such as awarding the contract as a design/build/operate (DBO) contract, and a later inclusion of the development and implementation of the Band Members training to become Environmental Operators Certification Program (EOCP) certified operators in due time.

Design Criteria

The design criteria for the new plant came directly from the decentralized facility order book:

- Produce high quality Class A effluent as stipulated by the Municipal Sewage Regulations (MSR), (BOD_5, TSS and Total Nitrogen of respectively less than 10, 10 and 20 mg/l, ammonia nitrogen of less than 1 mg/l and fecal coliform of less than 14/100 ml.)
- Discharge the treated effluent into the environmentally sensitive local recipient
- Allow for the future incremental plant expansion. The initial capacity of 119 m^3/d will be expanded in five future stages, each sized for an average day flow of approximately 132 m^3/d to an ultimate future average day capacity of 775 m^3/d. (In phases 4, 5 and 6, a mirror image plant is to be built).
- Build a decentralized treatment facility having a minimal visual, odor and noise impact on the neighbourhood
- Design an operator friendly plant keeping in mind that the plant will be for the most part operated by the Band member operator trainees
- Design a SCADA controlled plant that can be remotely monitored
- Develop and implement an operators' training program for the Snaw-naw-as Band members, with the ultimate aspiration to attain wastewater treatment plant operators' certificate as per the requirements of the EOCP

The Design

As mandated, the plant was designed to be simple and easy to operate. The influent is pumped into an IPEC drum screen with 6 mm openings and provided with a sealed, continuous bagging system. Screened influent drops into an equalization tank provided with a set of duplex equalization pumps which are controlled by float switches and timers.

The screened influent is then pumped through a flow splitter box into the anoxic compartments of two USBF bioreactors. Influent and recycled activated sludge mixed liquor flows to the aerobic compartment and the sludge and the treated water are eventually separated by the upflow sludge blanket filter (USBF).

From the sludge blanket filter the treated effluent flows to the filter feed tank, from which, controlled by flow switches, it is pumped through sand filters to the ultraviolet disinfection system overflow feed tank (which also serves as a reservoir for the sand filter backwash water). After flowing through the open channel Trojan UV disinfection unit, the effluent is discharged via ocean outfall into Nanoose Bay.

Waste sludge is thickened in the ECOfluid STP pre-thickeners to approximately 2% dry solids, and controlled by sludge pre-thickener pump timers, waste sludge is transferred to the sludge holding tank before being periodically hauled away for disposal.

The entire process is automatic and is SCADA monitored and controlled. Very little operator's direct input is required.

The design underwent extensive and drawn-out reviews by INAC and INAC appointed consultants, and the construction was finally given the go-ahead and commenced in April 2005.

THE PLANT

The first phase of the plant was built over the next six months. To keep with the design criteria, the entire plant was installed within a building esthetically blending with the surrounding environment.

The small bioreactors footprint allowed them to be installed belowground and within the building. Noise from the plant was reduced firstly by the fact that the USBF's self-regulating hydraulics result in minimal motorized noise-emanating equipment, and secondly by the blower enclosure noise abatement design. In fact, the noise from the nearby highway is often higher than that emanating from the plant.

USBF bioreactors operate odor free. The only other sources of odor, such as the screen room, and the equalization tank gas phase, are piped into the suction of an air fan which passes the collected gas through a biofilter bed. (The described odor abatement system was not ECOfluid's first and preferred choice. In most ECOfluid plants the above odorous gas would be piped to the suction of the air blowers and subsequently stripped during the mixed liquor aeration).

Phase I of this advanced plant was completed in October 2005, and the plant started to receive wastewater on October 20, 2005. The first sampling and analysis were performed within two weeks of the plant start-up and the data were well within the design parameters as evidenced by the following table.

Table 1 – First Samples and Analysis (Taken November 1, 2005)

BOD_5 [mg/l]	TSS [mg/l]	Nitrite Nitrate [mg/l]	Ammonia Nitrogen [mg/l]	TKN [mg/l]	Total Nitrogen [mg/l]	Fecal Coliform [CFU/100ml]
< 5	< 5	18.0	0.04	0.7	18.7	< 1

Plant Performance

In the last three years the plant performance has been consistently within the Class A design parameters. The following table summarizes annual averages of monthly sampling and analysis.

Table 2 – Annual average of plant samples and operating data

Year	Influent			Effluent								Power	WAS
	Flow	BOD Mg/l	TSS Mg/l	BOD Mg/l	TSS Mg/l	$N\text{-}NH_4$ Mg/l	N-NOx Mg/l	TKN Mg/l	TN Mg/l	Turb. NTU	Fecal Coliform Count/100 ml	Average kWh/d	Kg WAS / Kg BOD
2005	48	111	138	<5	<3	-	12.9	1.4	14.3	-	<10	-	-
2006	51	178	273	<10	<1	0.06	11.4	1.2	12.5	0.6	<1	-	-
2007	55	119	149	<10	<1	0.05	20.5	1.1	20.9	0.5	<1	248	-
2008	56	118	143	<10	<1	0.19	18.9	0.8	19.3	0.7	<1	255	0.54

Note: All data are annual averages of monthly sampling, testing and analysis which is performed by professional third party laboratory

Prior to sampling of the influent BOD, the operators and the designers were baffled by the elevated Total Nitrogen, which, while still within the design criteria, hovered higher than the 10 mg/l typically expected of the USBF plants. The subsequent analysis of the influent BOD confirmed the initial suspicion; the consistently low influent BOD did not provide sufficient donor carbon necessary for denitrification. It is interesting to observe that the one year the influent BOD was higher (2006), resulted in much better denitrification and TN was reduced to an average of 12.5 mg/l. Although the plant still performs within the design criteria, the addition of supplemental carbon on a trial basis will be implemented.

To compound the denitrification process challenge, it was recently discovered through the construction photos, that a fine air bubble diffuser was by error installed within the anoxic compartment instead of a coarse air bubbler intended for mixing. The situation will be corrected in early spring of 2009.

Addition of supplemental carbon, and replacement of the fine air diffuser in the anoxic compartment will no doubt bring the Total Nitrogen levels closer to, or below the USBF customary 10 mg/l.

The plant absolute power consumption is approximately 250 kWh/day. The specific power consumption (kWh/m³ or kWh/kg BOD) will reach its optimum when the plant capacity loading will increase.

Snaw-naw-as Band Members Operator Training

The development and the implementation of the Band Members operating training program were the first for INAC and ECOfluid. The program's goal was to have two band members to attain wastewater treatment plant operators' certificate as per the requirements of the EOCP. Two trainees were selected by the band and the training started even before the plant construction was completed.

List of Installations
Central and North America

ECOfluid Systems Inc. supplies custom design and package wastewater treatment plants. The following USBF plants were supplied and installed since 1998.

Plant Location	Capacity		Design Effluent Parameters					Application
	GPD	M^3/D	BOD	TSS	TN	TP	FC	
Mill Bay, BC (Phase 1)	21,500	80	10	10 (2 NTU)	10		2.2	Subdivision, school
Beecher Bay Indian Band, BC	10,500	40	10	15				Subdivision
Bowen Island, BC	42,000	160	10	15				Municipal
Coal Harbour, BC	60,000	230	10	15				Community
Duncan, BC	2,600	10	10	15				Residential cluster
Stillwood Camp, Chilliwack, BC (Phase 1)	13,000	50	10	15				Recreation camp
New Denver, BC	9,500	40	10	15				Hospital
Telegraph Cove 1, BC	4,500	20	10	15				Resort community
Telegraph Cove 2, BC	4,500	20	10	15				Resort community
Salmon Arm, BC	4,500	20	10	15				Municipal, School
Thetis Island, BC	4,500	20	10	15				Municipal
Kelowna, BC	4,500	20	10	15				School
Ainsworth, BC	30,000	120	10	10				Subdivision
Eagle Eye Golden, BC	5,000	20	20	20				Mountaintop restaurant
Sun Peaks Resort, Sun Peaks, BC (Phase 1)	80,000	300	10	15				Mountain, Ski resort
Holiday Park, Kelowna, BC	80,000	300	10	10				RBC replacement
Kicking Horse, Golden, BC (Phase 1)	80,000	300	10	10			200	Municipal, Ski resort
Strathmore, AB	1,000,000	4,000	15	15	(< 1 NH_3)		200	Municipal
Quinault Indian Auth., Moclips, WA	34,000	130	10	10			200	Subdivision
Bainbridge Island, WA	10,000	40	10	15				Hospital
Sun Peaks Resort, Sun Peaks, BC (Phase 2)	160,000	600	10	15				Mountain, Ski Resort
Penticton, BC	17,000	65	10	10				Subdivision
Nanoose First Nation, BC (Phase 1)	32,000	120	10	10	(< 1 NH_3)		100	Subdivision
Cowan Point, BC	40,000	150	10	10				Subdivision, golf course
Bay Point, FL	75,000	285	10	10	10	1	/	Municipal
Keremeos, BC	22,000	85	10	10				Mobile Home Park
Millsprings, BC (Phase 2)	16,000	60	10	10 (2 NTU)	10		2.2	Subdivision (Phase 2)

LIST OF INSTALLATIONS
CENTRAL AND NORTH AMERICA

Plant Location	Capacity		Design Effluent Parameters					Application
	GPD	M³/D	BOD	TSS	TN	TP	FC	
Merrit, BC	63,000	240	10	10 (2NTU)	10		2.2	Municipal subdivision
Rock Harbor, FL	7,500	28	10	10	10		10	Subdivision, school
Indigo Bay, FL	7,500	28	10	15	10		10	Subdivision
Nanny Cay, Tortola	50,000	190	10	10	10			Municipal
Angler's Reef, FL	20,000	75	10	10	10	1	10	Subdivision
Seaward, FL	14,000	50	10	10	10	1	10	Subdivision
Pahrump, NE	50,000	190	10	10	10		10	Municipal
Lake Alfred, FL	1,000,000	4,000	10	10	10		10	Municipal
Key's Fisheries, FL	45,000	170	10	10	10		10	Subdivision
Alder Bay, BC	20,000	75	10	15				Subdivision, RV Park
Saltsprings Island, BC	25,000	95	10	10	10		25	Subdivision (water reuse)
Key's Club, FL	10,000	40	10	10	10		10	Subdivision
Tonto Apache, Payson, AZ	85,000	320	10	10 (2 NTU)	10	1	1	Subd. & casino. (Water reuse)
Pemberton, BC	12,000	45	20	20				Camp
Stillwood Camp, Chilliwack, BC (Phase 2)	13,000	50	10	15				Recreation camp
District of Taylor, BC	80,000	300	10	10				Municipality
Gulf Corp., Freeport, TX	15,000	55	10	10				Sanitary wastewater
Millsprings, BC (Phase 3)	16,000	60	10	10 (2 NTU)	10		2.2	Subdivision (Phase 3)

*Includes plants under engineering and/or construction.

LIST OF INSTALLATIONS
CENTRAL AND NORTH AMERICA

The following USBF packaged plants were supplied and installed by a joint venture company between ECOfluid and a Kentucky company between 2000 and 2003. The partnership has been dissolved in 2003.

Plant Location	Capacity		Application
	GPD	M³/D	
Williamstown, KY	18,500	70	Demonstration
Chester County, PA	25,000	100	College
H.T.Hatley, GA	4,000	15	Warehouse
Riverview Foods, Warsaw, KY	10,000	40	Food processor
Attic Storage, Hiram, GA	4,000	15	Warehouse
Dole 1, La Cieba, Honduras	22,000	80	Food Processor
Dole 2, La Cieba, Honduras	22,000	80	Food Processor
Dole 3, Sonegera, Honduras	51,000	190	Food processor
Data Pro International, Belize	20,000	80	Industrial
Big Wheels, Huoma, LA	17,600	70	Truck Stop
Grande Harbor, Marathon, FL	8,000	30	Marina, Resort
Island Restaurant, Marathon FL	13,000	50	Restaurant,
Islander Resort, Florida Keys, FL	65,000	250	Restaurant, Resort
Palace Truck Stop, New Orleans, LA	22,700	90	Truck stop
Southdown Industries, Dayton, OH	5,000	20	Factory
TMB Partners, Lafayette, NJ	7,000	26	Municipal
Ziggies, Islamorada, FL	6,000	22	Restaurant
Alder Camp, Klamath, CA	17,000	70	Municipal Campground
Asbury Hills Camp, Cleveland, SC	15,000	60	Campground
Ben Lomond Camp, Santa Cruz, CA	15,000	60	Campground
Clinton St., Huoma, LA	120,000	480	Municipal
Demo Plant, Suffolk County, NY	8,500	35	Municipal
Eagle View MHP, Imperial, MO	25,000	100	Mobile Home Park
Everglades National Park #1, FL	2,000	8	Ranger Station
Everglades National Park #2, FL	4,000	16	Ranger Station
Florida Water, Marco Shores, FL	300,000	1,200	Municipal
French Creek School, Chester, PA	4,000	16	School
Golden Isle Marina, St. Simons, GA	31,000	180	Marina / Resort
Ingles Supermarket, Hull, GA	6,000	22	Food process
Marathon Marina, Marathon Key, FL	25,000	100	Municipal Marina
Mississippi Band of Choctaw Indians	100,000	400	Municipal Reservation
Oceanside Marina	20,000	80	Municipal Marina
Rivervista RV Park, Rabun, GA	12,600	45	RV park
Smoketree Lodge, Elk, NC	15,000	60	Municipal
Motel & Restaurant, Sparta KY	18,000	70	Sanitary
Sussex High School, Sussex VA	30,000	120	Sanitary
C. Velilla Project, Guadalajara, MX	100,000	400	Municipal Subdivision
Flextronics, Guadalajara, MX	120,000	480	Industrial
Processing Plant, Morelia, MX	66,000	245	Poultry Processing

List of Installations
Central and North America

Plants Operated under Contract by Ecofluid

ECOfluid provides operations and maintenance services under contract with owners for the following plants in British Columbia:

Plant Location	Capacity		Design Effluent Parameters					Application
	GPD	M^3/D	BOD	TSS	TN	TP	FC	
Millsprings, Mill Bay, BC	21,500	80	10	10 (2 NTU)	10		2.2	Subdivision
Stillwood, Chilliwack, BC	26,000	100	10	15				Recreation camp
Bowen Island, BC	42,000	160	10	15				Municipality
Penticton, BC	17,000	65	10	10	(1 NH_3)			Subdivision
Nanoose First Nation, BC	32,000	120	10	10			100	Subdivision

USBF-SBR-MBR COMPARISON
THIRD PARTY EVALUATION

The following is an abbreviated version of the wastewater treatment processes evaluation by CPH Engineers Inc., Environmental Division, of Orlando, Florida.

USBF vs. SBR

- The Sequencing Batch Reactor (SBR) system has a larger aeration requirement than the Upflow Sludge Blanket Filtration (USBF) system. This is due to the fact that air is only supplied during a portion of the total SBR cycle time. The installed blower horsepower for the USBF process is therefore less than for the SBR process. (This can be as much as 50% less).

- The USBF process manages increased hydraulic loading better than the SBR process. This is due to a lower Sludge Volume Index (SVI) of the USBF, which results in a faster settling rate of the mixed liquor. Additionally, the USBF clarifier design has sloped sidewalls that automatically increase the surface settling area with the rising sludge blanket due to the flow increase. By comparison, in the SBR process the settling time cycle must be increased.

- The USBF process has an anoxic zone prior to the aeration zone. This serves two purposes. The first purpose is to "condition" the mixed liquor prior to the upflow solids contact flocculating clarifier, which helps to reduce or eliminate filamentous sludge and provide a low (80-120 ml/g) SVI. The second purpose is that it is used for biological reduction of nitrogen and phosphorous by respectively nitrification/denitrification and "luxury uptake" processes. This is accomplished by increasing the Hydraulic Residence Time (HRT) in the anoxic zone. By comparison, in the SBR process a separate carbon source is required for denitrification to reduce nitrogen and an anaerobic stir process is required to reduce phosphorous, which can be accomplished by an additional cycle or through the addition of another tank.

- The USBF design is a continuous flow system that incorporates the aeration zone, the clarifier and the anoxic zone in a single tank and the only mechanical equipment required is the blower, which is used for both aeration and air lifting the return activated sludge. The SBR process on the other hand, is normally a two-tank design and in addition to the aeration blowers, needs multiple pumps and motors to carry the different stages of the process to its completion.

- The USBF system has a smaller foot print and less overall height to the system. Typically, the USBF system can require up to 80% less land area compared to the SBR system.

- Overall, the USBF is a plug flow, self regulating process, easier to operate and maintain, due to the fact that there are no moving parts, other than the blowers, one on duty the other standby. Electrical consumption is about 60 % less than that of an SBR.

- The SBR must use chemicals and additional mechanical filtration in order to treat BOD, TSS, TN and P to the required effluent levels.

- The USBF process does not require the use of chemicals or for that matter any additional filtration. Filtration is accomplished by the "filtration blanket" within the clarifier.

USBF vs. MBR (Zenon)

- *The capital investment for the USBF is about 70% less than that for a Zenon MBR system.*

- The Zenon process requires a biological treatment system and chemicals in order to remove carbonaceous and nitrogenous oxygen demands in addition to the membranes used for TSS removal.

- MBR system requires a computerized control system that is essential for the operation of the system. Class "A" experienced operators must operate and "fine tune" the MBR system twenty four hours per day seven days per week.

- The USBF process is a self regulated system and very little, if any operator attention is required.
- The membranes in an MBR process must be cleaned on a daily basis by the use of "back-pulsing". This is done to reduce the possibility of fouling and debris collection on the membranes. The USBF process does not require the additional controls or daily cleaning of the internal components.
- MBR system has a potential for fouling of the membranes by biological, chemical (sulfates, carbonates, etc.) or physical contamination (hair, plastics, paper, etc.) associated with the waste stream.
- MBR system requires a fine mechanical bar screen (~1 mm) upstream of the unit to minimize the potential for physical fouling of the membranes. The USBF uses a standard mechanical bar screen.
- The membranes in the MBR must be cleaned by the use of a chemical cleaning process on a monthly or quarterly basis. The cleaning is done with NaOCl and acidic solutions, both of which must be handled and used properly to prevent injury to the operators.
- The USBF process is simpler and requires less equipment, and electricity to operate. The USBF flows via hydraulic gradeline (gravity) and the aeration is provided by fewer blowers. The MBR system on the other hand requires permeate suction pumps and internal recycle pumps in addition to the blower requirements in order to operate.
- MBR system typically requires the addition of chlorine in order to control filamentous growth within the system, as opposed to control of the filamentous sludge by the process itself as is with the USBF process.
- The USBF process has an extended sludge age of 25 to 30 days with low microbial loading which produces less excess, aerobically stabilized sludge and improves sludge structure and mechanical dewatering characteristics.

In summary, we believe that the USBF is a superior process for this application due to the following:

- Overall simpler process to operate
- Requires less electrical power
- Does note require computerized controls for operation
- No chemicals required for operation
- Less mechanical equipment to maintain
- Produces less sludge
- Requires less land area

The evaluation was prepared Mr. David E. Mahler., PE. VP., and Mr. Scott Breitenstein., P.E. of the CPH Engineers Inc., Orlando., Florida office. Tel: 407 425-0452

UPFLOW SLUDGE BLANKET FILTRATION (USBF)
NUTRIENT REDUCTION

1 NITROGEN

Nitrogen is removed by nitrification and denitrification processes. Nitrification is autotrophic and all USBF integrated bioreactors are designed for complete nitrification of ammonia to NO_3. Denitrification however, is heterotrophic and requires carbon source. Conventional plants' "separate-sludge denitrification" requires that carbon is added, typically in the form of methanol. This adds to operating costs, and if used in excess, it increases effluent BOD_5 content.

USBF technology "single-sludge denitrification" approach uses an endogenous carbon source to maintain the denitrifiers. Influent is combined with nitrified mixed liquor in the anoxic compartment providing the carbon source needed for denitrification. Relatively high (2 to 4 times average daily flow) nitrified mixed liquor recycle rates are employed and sufficient denitrification retention times provided. Total nitrogen reduction to below 10 mg/l is readily achievable. [1]

2 PHOSPHORUS

USBF technology delivers not only high efficiency of organic matter reduction, but also increased efficiency of phosphorus removal. Two processes, biological phosphorus uptake and simultaneous chemical precipitation are employed with advantages.

The mechanics of biological phosphorus uptake, known as "luxury uptake", is due to exposure of activated sludge to alternating oxide and anoxic conditions. Under the conditions, the cells store more energy in the form of phosphorus than needed for their survival. If strictly oxide conditions are maintained during subsequent clarification, phosphorus will be retained by the cells and it will eventually be removed with excess sludge. Unlike most other methods of clarification, the upflow sludge blanket filter maintains oxide conditions in the filter and phosphorus reduction by biological uptake to about 2-2.5 mg/l is achievable.[2]

For further phosphorus reduction phosphorus precipitant chemicals such as aluminum sulfate, ferrous sulfate or other salts are used. In most domestic wastewater phosphorus is present in three forms, orthophosphate, polyphosphate and organic phosphorus. Polyphosphate and organic phosphorus cannot be readily precipitated but both are converted to orthophosphate during biological treatment, which can. Since the bulk of phosphorus reduction (up to 80%) is accomplished by biological uptake, the small polishing dosages of metal salt precipitant do not significantly increase sludge production.

In simultaneous chemical precipitation metal salts are advantageously dosed into an anoxic compartment of the USBF bioreactor. Continuous sludge internal circulation and mixing ensure efficient precipitation, coagulation and flocculation within the bioreactor with an added benefit of increased efficiency of the USBF clarifier. Reduction of total phosphorus to less than 0.5 mg/l is readily achievable. [2]

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[1] As demonstrated in a number of USBF plants. Please refer to Case Studies.

[2] Sludge decant return from storage or dewatering to bioreactors if such is the case must be chemically treated as anoxic conditions during quiescent periods will cause phosphorus release.

ECOfluid

UPFLOW SLUDGE BLANKET FILTRATION (USBF)
NITROGEN REDUCTION MEMORANDUM

Nitrogen is removed by nitrification and denitrification processes. Nitrification is autotrophic and all USBF integrated bioreactors deliver complete nitrification of ammonia to nitrate provided that certain minimum temperature is maintained [1] and alkalinity is available. [2] Denitrification is heterotrophic and requires carbon source. Processes using "separate-sludge denitrification" require that carbon is added. USBF technology "single-sludge denitrification" approach uses an endogenous carbon source to maintain the denitrifiers. Influent is combined with nitrified mixed liquor in the anoxic compartment providing the carbon source needed for denitrification.

The conditions that affect the process of denitrification are (not in the order of priority):

- Volumes or HRTs - The required 'biological' volume is divided into anoxic and oxide volumes. The ratio of the two varies depending on the degree of denitrification desired. The anoxic volume or HRT must allow for DO exertion and for the provision of anoxic conditions needed for fermentation.
- Mixing of the Anoxic Volume - Good mixing and roll of the anoxic compartment is important. Mixing should be 'gentle' so as not to break up the sludge flocs.
- DO Control - DO control throughout the bioreactor is the most important factor. The 'plug' flow of the mixed liquor in the oxide compartment allows for manual adjustment of individual aeration diffuser sections, and the overall air flow is typically controlled by a continuous DO monitor modulating the blower RPM via variable frequency drive (VFD). Anoxic compartment DO is 'controlled' only indirectly by the oxide compartment DO adjustment and control, and by providing sufficient compartment volume (see above).
- RAS Recycle - Mixed liquor containing nitrite/nitrates is recycled from the bottom of the clarifier to the anoxic compartment where the incoming BOD serves as the carbon source or electron donor for the reduction of nitrate to elemental nitrogen. The efficiency of the overall nitrogen reduction has been determined to be a function of the RAS flow multiple (the higher the multiple the higher efficiency). However, the recycle has to be balanced against other factors and based on experience a multiple of 2 to 4 provides a 'safety factor' for typical domestic wastewater while moderating the negative effects. RAS pumps are typically airlift pumps for smaller plants, and low head (low Hp), axial flow pumps provided with VFD drives for larger plants.
- Temperature – Low temperatures and dramatic changes in temperature inhibit or stop the process of denitrification.
- Carbon – Incoming wastewater is the source of carbon. [3] Carbon deficiency is typically not an issue with most municipal or domestic wastewater.

CASE STUDIES

The following USBF plant operating data have been recorded:

MARCO SHORES, FLA

Effluent	Nitrate as N (mg/l)	Nitrite as N (mg/l)	Ammonia as N (mg/l)	TIN (mg/l)	TKN (mg/l)	TN (mg/l)
August 13, 2003	3.2	0.044U	0.05U	3.29	1.0	4.29
August 27, 2003	2.8	-	0.05U	2.8	0.74	3.54
September 10, 2003	3.1	-	0.05U	3.1	0.7	3.8
Design Parameters						**10**

Notes: 1. U denotes Under Detectable Limit
2. The plant is not equipped with SCADA, continuous DO monitor and VFD drives.
3. Official lab analysis available

[1] Nitrification was observed to function at temperatures as low as ~3 deg C
[2] Nitrification consumes 7.1 mg/l of alkalinity as $CaCO_3$ for each mg/l of ammonia oxidized
[3] Reduction of 1 gram of nitrogen requires approximately 3 – 6 grams of BOD (or equivalent carbon)

KICKING HORSE SKI RESORT, BC

Effluent	Nitrate as N (mg/l)	Nitrite as N (mg/l)	Ammonia as N (mg/l)	TIN (mg/l)
March 15, 2007	4.8	1.9	0.778	7.5
March 22, 2007	3.0	0.07	0.149	3.22
March 29, 2007	3.4	0.0	0.142	3.54
April 2, 2007	5.8	0.67	0.097	6.57
April 9, 2007	3.0	0.2	0.035	3.24

Notes:
1. Nitrogen reduction was not the plant design objective (small anoxic compartment)
2. The plant serves a ski resort where flows, temperatures and biological loadings vary significantly from weekends to weekdays
3. Official lab analysis available

ISLAMORADA, FLA

2005						2006					
April	May	June	July	August	Sept	January	February	March	April	June	July
1.7	3.7	3.1	2.9	3.8	2.8	6.6	3.3	2.1	3.5	2.4	4.7

Notes:
1. The plant is a small plant without any automated controls
2. Due to wide influent flow fluctuations, small plant's denitrification is typically more difficult to manage than with larger plants
3. Official lab analysis available

SNUG COVE, BC

	2005				2006		
	March	June	Sep	Dec	March	June	Sep
TN	7.83	4.44	6.54	8.27	2.78	4.41	6.2
TKN	2.2	1.9	5.2	4.7	2.3	3.8	4.3

Notes:
1. This plant is a very basic rendition of the USBF configuration. It was not designed for nitrogen reduction (small anoxic volume), and it is not equipped with continuous DO monitor and VFD drives.
2. Official lab analysis available

MILL BAY, BC

Mill Bay Effluent	Nitrate / Nitrite as N (mg/l)	TKN (mg/l)	TN (mg/l)
April 17, 2007	1.8	0.9	2.7
May 22, 2007	4.0	1.8	5.8
June 25, 2007	5.17	1.5	6.7
July 17, 2007	2.75	1.5	4.2
August 7, 2007	3.38	1.5	4.9
September 11, 2007	7.12	1.4	8.5
October 16, 2007	4.11	1.2	5.3
November 6, 2007	3.9	2.2	6.1
Design Parameters			**10**

Notes:
1. The plant is a water reclamation plant where the permitted effluent Total Nitrogen (TN) is <10 mg/l.
2. The plant is relatively small (150 m^3/d; 40,000 gpd) and experiences high infiltration.
3. Official lab analysis available

Upflow Sludge Blanket Filtration (USBF)

Phosphorus Reduction Memorandum

One of the beneficial features of the USBF technology is increased efficiency of phosphorus removal. This is due to the fact that a significant amount of the influent phosphorus is reduced by biological phosphorus uptake.

The mechanics of biological phosphorus uptake, known as "luxury uptake", is due to exposure of activated sludge to alternating oxide and anoxic conditions. Under the conditions, the cells store more energy in the form of phosphorus than needed for their survival. If strictly oxide conditions are maintained during subsequent clarification, phosphorus will be retained by the cells and it will eventually be removed with excess sludge. Unlike most other methods of clarification, the upflow sludge blanket filtration process maintains oxide conditions in the filter, and phosphorus reduction by biological uptake to as low as 1 mg/l has been achieved as demonstrated in the table below.[1]

The following results were recorded during the 2007 Annual Report filing test period at Kicking Horse Ski Resort, Golden, BC:

	March 15	March 22	March 29	April 2	April 9	Average
Total Phosphorus [mg/l]	1.11	0.78	0.69	0.95	2.2	1.15

Notes:
1. Total Phosphorus reduction was entirely by the biological phosphorus uptake. NO CHEMICALS WERE USED.
2. 24 hour composite samples were analyzed.
3. Official lab analysis available

For further phosphorus reduction phosphorus precipitant chemicals such as aluminum sulfate, ferrous sulfate or other salts are used. In most domestic wastewater phosphorus is present in three forms, orthophosphate, polyphosphate and organic phosphorus. Polyphosphate and organic phosphorus cannot be readily precipitated but both are converted to orthophosphate during biological treatment, which can. Since the bulk of phosphorus reduction is accomplished by biological uptake, the small polish dosages of metal salt precipitant do not significantly increase sludge production.

In simultaneous chemical precipitation metal salts are dosed into the anoxic compartment of the USBF bioreactor. Continuous sludge internal circulation and mixing ensure efficient precipitation, coagulation and flocculation within the bioreactor with an added benefit of increased efficiency of the USBF clarifier.

The following effluent Total Phosphorus parameters were recorded at a 1 MGD (4,000 m^3/d) USBF facility during seven months period from June to December 2002. The facility was provided with aluminum sulfate (alum) dosing system. During the period dual 24-hour composite samples were taken and analyzed and only the higher results were recorded. The following are monthly averages of the daily composite sample analysis.

2002	June	July	August	Sept.	Oct.	Nov.	Dec.	Average
Total Phosphorus	0.4	0.5	0.2	0.3	0.4	0.5	0.3	0.4

Notes:
1. TP design parameter was 1.0 mg/l
2. The facility has not been provided with any post-biology (read post USBF) filtration
3. Since the bulk of the total phosphorus reduction was by biological uptake, the alum consumption and the ballast sludge production were light
4. Two 24-hour composite samples were analyzed. Only the higher results were recorded.
5. Official lab analysis available
6. With added post-biology (post USBF) microscreen filtration, reduction of Total Phosphorus to 0.1- 0.25 mg/l range is believed to be eminently possible

[1] Sludge decant return from storage or dewatering to bioreactors if such is the case must be chemically treated as anoxic conditions during quiescent periods will cause phosphorus release.

At another facility, Islander Resort in Florida, the following results were recorded in 2006:

2006	Jan	Feb	Mar	Apr	May	Jun	Jul	Average
Total Phosphorus	0.1	0.13	0.3	0.4	0.5	0.1	0.2	0.25

Notes:
1. TP design parameter was 1.0 mg/l
2. Islander Resort facility is at 12,000 GPD (45 m^3/d) a relatively small system with highly fluctuating flow and very rudimentary control system only
3. The facility is provided with post-biology (post USBF) microscreen filtration
4. In the original configuration ferric sulfate was used for chemical precipitation, but it was replaced with aluminum sulfate in the last few years
5. Grab samples as mandated by Florida Department of Environmental Protection were analyzed and recorded monthly
6. Official lab analysis available