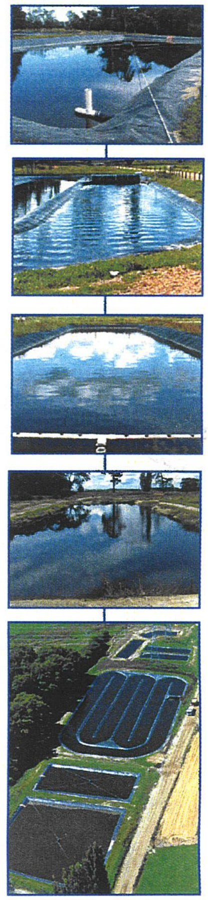
NIWA Advanced Pond Systems:
Concepts, performance, and features



INTRODUCTION

Wastewater oxidation ponds have been traditionally used for domestic sewage treatment in small and medium sized communities in New Zealand and are often used to treat dairy farm and other agricultural wastewaters. They are cost-effective, require little maintenance, and have generally performed well in terms of BOD_5 and solids removal. However, nutrient removal, algae removal, and disinfection are highly inconsistent, and the effluent discharged into receiving waters is usually of poor quality.

New Zealand communities and farmers face a considerable financial burden if they replace or upgrade existing pond systems using "mechanical" treatment systems such as packaged activated sludge plants. Thus there is a critical need for a cost-effective alternative upgrade option for pond systems. Since New Zealand already has considerable investment in pond technology, it makes good economic sense to upgrade treatment, while making use of existing pond infrastructure. Advanced Pond Systems provide a particularly cost-effective approach as a pond-based retrofit, while also being very competitive for new waste treatment facilities.

ADVANCED POND SYSTEMS

Advanced Pond Systems (APS) incorporate many improvements on conventional pond design. They require similar land area to conventional ponds, virtually eliminate sludge disposal, produce less odour, and are capable of ***consistently*** providing a higher degree of nutrient removal and disinfection than conventional systems. Moreover, APS are much easier to operate, and are more energy efficient and economical.

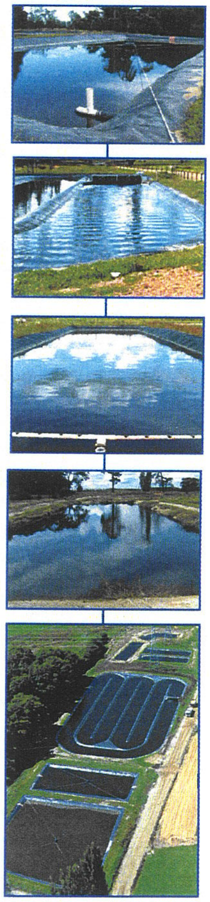
AIWPS in St Helena, California

APS systems are based on Advanced Integrated Wastewater Pond Systems (AIWPS) that were developed by Oswald and co-workers at the University of California at Berkeley. Several systems that were designed during this development have been operating in California for 30 years.

APS systems are a "quantum leap" over conventional oxidation ponds because they integrate ecological engineering principles and incorporate many different (physical, chemical, and microbiological) natural treatment

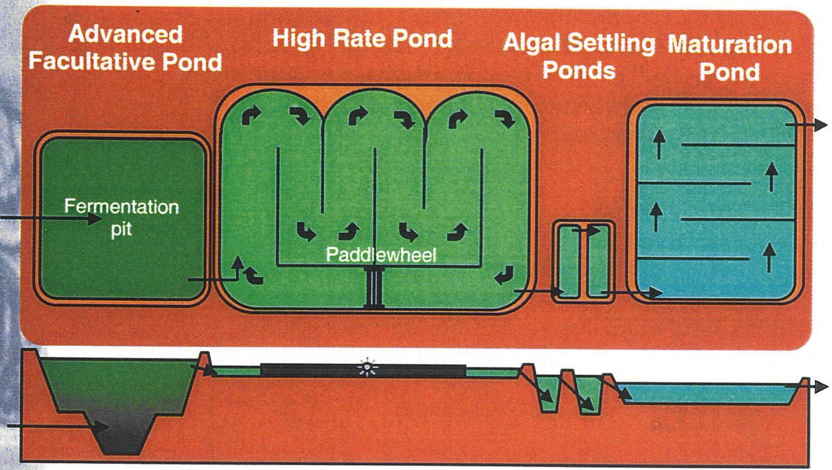
APS Technical Series 1

processes. The diversity of natural treatment processes that occur in the different ponds of the system makes APS much more resilient and robust than mechanical treatment plants.



Our knowledge and experience of how these treatment processes are influenced by environmental conditions is used to promote particular processes and arrange them in the most favourable sequence for wastewater treatment. Typically, APS consist of four types of ponds arranged in series (an Advanced Facultative Pond, a High Rate Pond, Algal Settling Ponds, and a Maturation Pond).

The Advanced Facultative Pond (AFP) is **deep** to promote sedimentation of wastewater solids and anaerobic decomposition to methane. However, the pond is designed so that its surface remains aerobic, thus reducing potential odour problems. Biogas can be collected by a submerged gas canopy and potentially used for energy production. Effluent from the AFP flows by gravity to the High Rate Pond and the subsequent ponds.

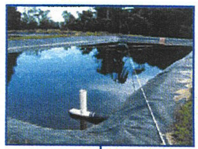


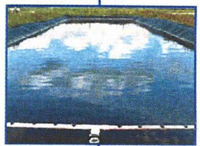
A typical Advanced Pond System.

The High Rate Pond (HRP) is a **shallow**, continuous raceway around which the wastewater is circulated by a **paddlewheel**. HRPs promote aerobic decomposition of remaining dissolved organic matter from the wastewater. In contrast to mechanical aeration, which is very energy intensive, HRP paddlewheels typically use only one tenth of the energy required for a pond aerator. Daytime algal photosynthesis in the HRP can cause **supersaturation** of oxygen (typically 20 g m^{-3}), whereas mechanical aeration typically results in dissolved oxygen concentrations of about 2 g m^{-3}. HRPs have the additional advantage of removing nutrients (ammoniacal-N and phosphate) that might otherwise cause eutrophication of receiving waters.

Algal photosynthesis also raises the pH of the HRP. This, in combination with the shallow depth enhances the rate of sunlight inactivation of faecal microbes, and promotes photo-oxidation of organic contaminants. The high pH further contributes to nutrient removal through promoting volatilisation of ammonia and precipitation of phosphates. Algal-rich HRP water is recirculated to the surface of the AFP to provide an oxygen-rich layer that eliminates any major odour problems.

A dairy farm APS in the Waikato designed for Dexcel.





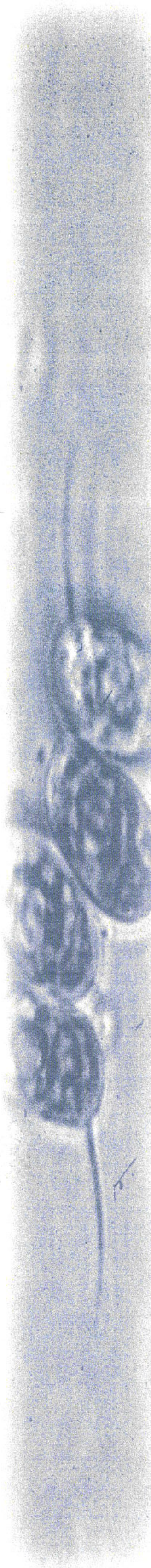
The Algal Settling Ponds (ASPs) promote natural settling of the algae biomass and provide storage for the periodic recovery of the settled algae. Gentle mixing in the HRP promotes the growth of large colonial microalgal species, which tend to flocculate and can be **easily settled** in the ASPs. This differs substantially from conventional pond systems, which tend to be dominated by motile algal species that are difficult to settle out. Settled algal biomass does not readily decompose and is a non-noxious material unlike (malodorous) sewage sludge. Algal Drying Beds can be included in the design for on-site processing of the algal solids and use in landscaping. The algal biomass can be recovered for fertiliser because it is rich in nitrogen, phosphorus, and potassium. NIWA is currently conducting research to ensure the use of algal biomass in this manner is acceptable from a public health viewpoint.

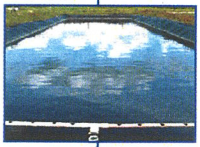
The Maturation Pond (MP) promotes further **solar-UV disinfection** and polishing of the wastewater, and enables effluent storage before discharge or subsequent reuse. Algal growth in the MP is minimised by zooplankton grazing and dividing the pond into short residence time "cells".

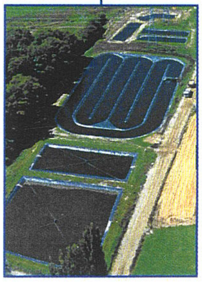
APS PERFORMANCE

Over the last 5 years NIWA has developed and evaluated APS under New Zealand conditions and has calibrated the design and operation of the system. APS consistently provide higher effluent quality than conventional pond systems:

- Removal of wastewater solids measured as total suspended solids, (TSS), and particulate Biochemical Oxygen Demand (BOD) through settling and anaerobic digestion in Advanced Facultative Ponds;
- Complete anaerobic digestion of wastewater sludge negates removal for at least 20 years;
- Excellent disinfection without the use of artificial UV treatment;
- Consistently good nutrient removal (particularly of potentially toxic ammonia).







The typical median effluent quality of APS compared with conventional oxidation ponds treating domestic sewage is given below.

Water quality variable	APS	Conventional Ponds
BOD_5 (g m^{-3})	< 20	< 40
TSS (g m^{-3})	< 40	< 90
NH_4-N (g m^{-3})	< 5	< 20
TKN (g m^{-3})	< 10	< 40
DRP (g m^{-3})	< 5	< 10
TP (g m^{-3})	< 7	< 15
E. coli (MPN / 100 ml)	< 100	<40,000

APS systems can be designed to provide a high quality effluent that may be discharged to all but the most sensitive receiving waters or can be used for irrigation. If necessary, further effluent polishing can be provided by, for example, a constructed wetland.

ADDITIONAL FEATURES

Other key features of APS are:

- Minimal odour compared with conventional methods of treatment;
- Simple operation and maintenance;
- Construction and operation costs are typically less than half those of mechanical treatment plants (e.g., activated sludge, sequencing batch reactors);
- Sustainable treatment solution with significant potential for energy and nutrient recovery.

APS is an extremely cost-effective technology, eminently suitable for small to medium sized communities, dairy farms, and other intensive animal production enterprises needing to minimise nutrient and faecal microbe contamination of waterways.

CONTACT INFORMATION

Business Opportunities
Dr Jim Cooke
Phone: +64-7-856 1744
Cellular: +64-21-738587
Email: j.cooke@niwa.co.nz

Engineering & Project Management
Dr Fouad Al Momen
MIPENZ, MNZWWA, Reg. Engineer
Phone: +64-7-859 1887
Cellular: +64-21-0342143
Email: f.almomen@niwa.co.nz

Technical Enquiries
Dr Rupert Craggs
Phone: +64-7-859 1807
Email:
r.craggs@niwa.co.nz

NIWA Information Series No. 32 2003

ISSN 1174-264X