Waste Stabilisation Pond Workshops

- Nick Walmsley
- May 2018

water NEW ZEALAND

The New Zealand Water & Wastes Association Waiora Aotearoa

A consistent approach across the 3 waters sector

Workshop Program

- Pond Classifications and typical performance
- What to size for
- Upgrade Options; by performance and process
- O & M requirements
- Monitoring & Sampling
- Troubleshooting
- Colour Observations
- Maintenance requirements
- Observations on “Where to from here?”

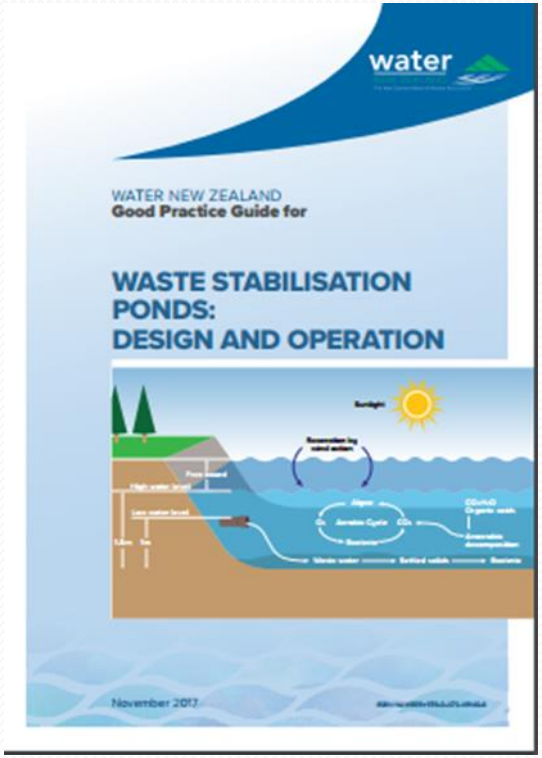
water NEW ZEALAND

The WSP Guide

Contents:

1. General
2. Design and Construction
3. Pond Modifications and Upgrades
4. Operation and Maintenance
5. Resource Consent and Pond Monitoring
6. Frequently Asked Questions

What is the Guide?
Why do we need it?
What does it cover?



water NEW ZEALAND

Authors and Reviewers

NZWWA 2007 draft Guide:
Steve Cameron, NZET Ltd
Stu Clark, NZET Ltd

Authors:

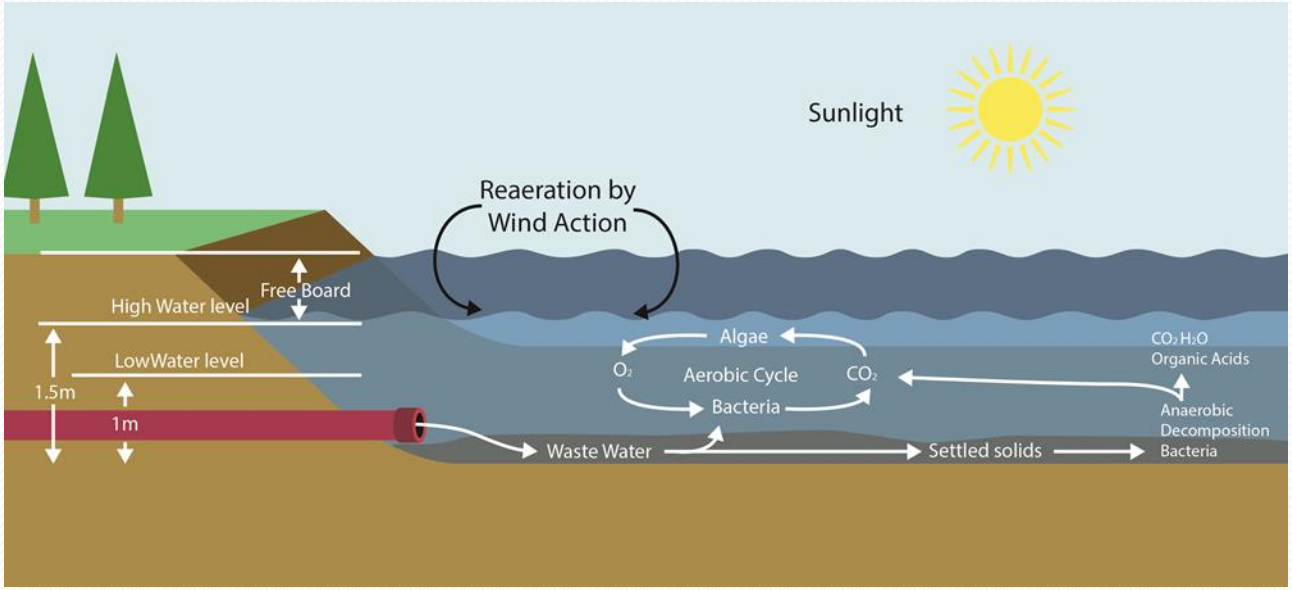
- Humphrey Archer, *CH2M Beca Ltd*
- Gilles Altner, *Global Environmental Engineering Ltd*
- Rupert Craggs, *NIWA*
- John Wong, *Parklink*
- Regan Senior, *Parklink*
- Hugh Ratsey, *The Wastewater Specialists*
- Nick Walmsley, *Water New Zealand*

WSMG Reviewers:

- Paul Gaydon, Horowhenua D.C.
- Terry Dodd, Dunedin C.C.
- Peter Cowdell, Water Northland
- Mike Bourke, Christchurch C.C.
- Barry Somers, Northland D.C.

water NEW ZEALAND

Pond Classifications



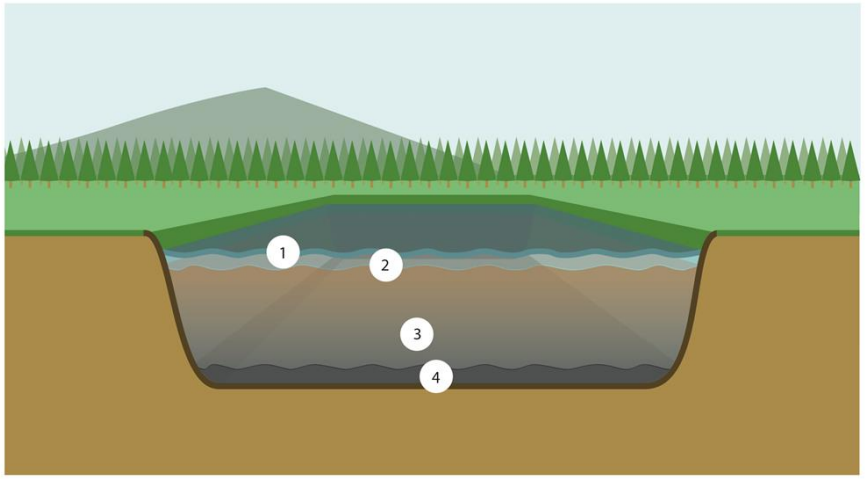
- Classifications based on organic loading
- Waste Stabilisation Ponds not Oxidation Ponds
- Anaerobic, Facultative, Maturation not primary, secondary, tertiary
- Partially/Fully Mixed Aerated Lagoons are different
- Nearly 200 community WSPs in NZ; appear simple but need skilled operation and regular attention!

water NEW ZEALAND

Anaerobic Ponds

Layers:

① is aerobic liquid
② is anoxic liquid
③ is anaerobic liquid
④ is anaerobic sludge

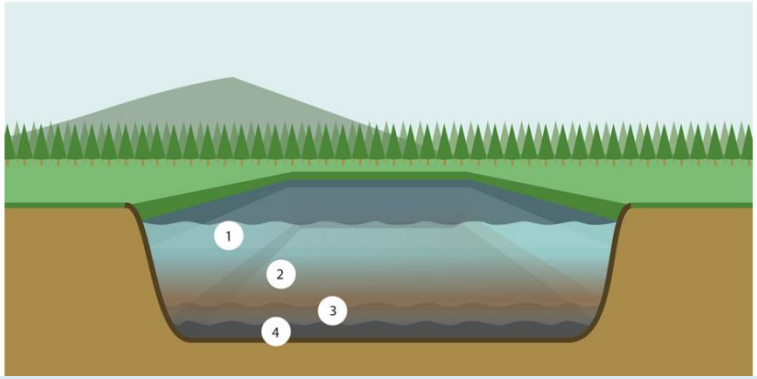


- High organic load; all oxygen used by bacteria
- Usually deep; ≥ 3m
- Often used to treat high strength wastewaters
- Can but need not smell if loaded and operated properly

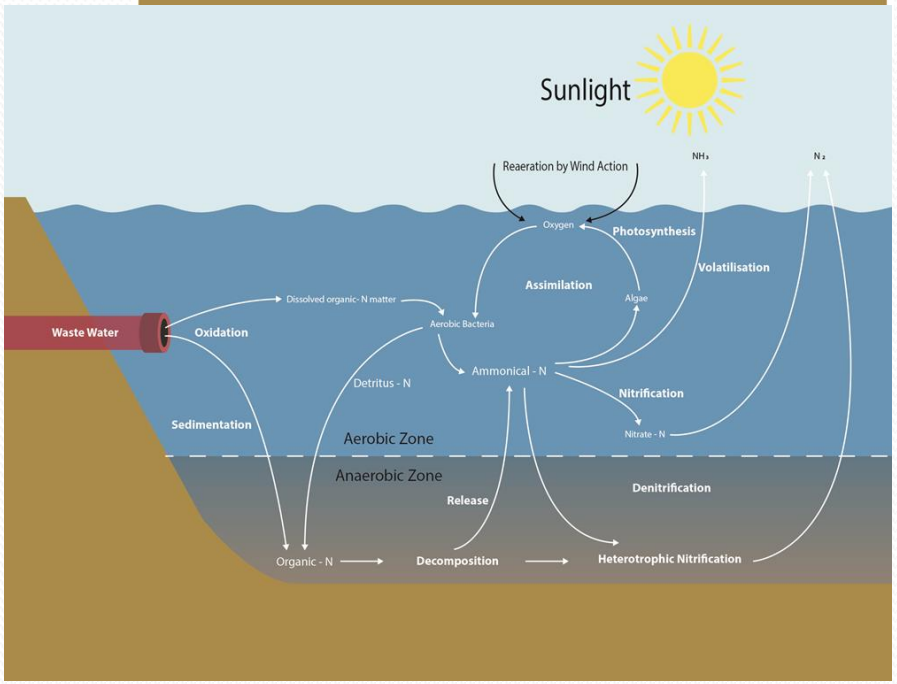
Facultative Ponds

Layers:

① is aerobic liquid
② is anoxic liquid
③ is anaerobic liquid
④ is anaerobic sludge



- Aerobic surface with algae & aerobic bacteria
- 1.3-1.5m depth
- < 1W/m³ aeration/mixing



water NEW ZEALAND

Maturation Ponds

- Predominantly aerobic depth 0.8 - 1.5m
- Traditional design based on temperature decay rate
- Designs now include:
  - Minimising algal growth
  - Exposure to sunlight radiation
  - Multiple ponds in series
  - Perimeter planting (wetland ponds) to increase habitat value

Typical WSP Effluent Quality

One and Two cell Facultative WSP Systems
(Hickey et al 1989)

Contaminant	Minimum	Median	95%ile
BOD_5 (mg/l)	7	27	70
Suspended solids (mg/l)	10	56	150
Faecal coliform bacteria (#/100 ml)	9×10^1	4.3×10^3	2.3×10^5
Total Phosphorus (mg/l)	1.3	8.2	11.3
Dissolved Reactive Phosphorus (mg/l)	0.8	5	9.5
Ammoniacal Nitrogen (mg/l–N)	0.001	7	29

Can get better quality than this with modern upgrades.

Historical Vs Current Sizing Criteria

	Historical	Current
Anaerobic Ponds	<0.2 Kg BOD/m^3.d + natural cover	≤ 0.3 Kg BOD/m^3.d & specific designs e.g. CAP, HRAL
Facultative Ponds	Pop^n Equiv @ 70g BOD_5 e.g. 84 KgBOD/ha/d	Specific loadings Up to 250KgBOD/ha/d
Maturation Ponds	20d retention	Smaller multiple ponds in series

water NEW ZEALAND

Algal Ponds (HRAPs & AHPs)

HRAPs:

- Promote aerobic process
- Don't treat raw wastewater but follow primary processes
- Shallow (300-600mm), Short HRTs (4-8d)
- Paddlewheel mixing (≈0.5 kW/ha, 0.15-0.2 m/s)
- High rate algal production & treatment
- Can add CO_2 to enhance N removal
- Ave annual effluent <15 BOD_5; <15 TSS; <10 TN; <5 NH_4-N; <6 TP; <4 DRP <100 E.coli) but highly temperature dependent

AHPs:

- Gravity settlers & algal thickeners
- 6-8hrs retention
- 70-90% TSS removal at 1-3%DS

Partially & Fully Mixed Aerated Lagoons

- Not WSPs but separate treatment processes
- 2-6 d HRT
- High TSS due to BOD conversion
- ≥ 4 W/m^3 aeration
- Can be operated by timer and/or DO meter
- Low aeration efficiency at less than 2m depth
- Following processes should allow for TSS capture

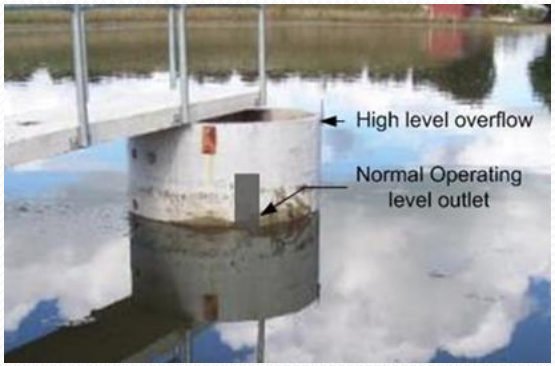
What to size for

- Seasonal peaks:
  - ≤ 25% population growth
  - Tourists – summer or winter?
  - Industry – export market or local produce growth?
  - Commerce – may align with tourists
  - Climate – coldest month & warmest month
  - Rainfall, seepage and evaporation

Consider all the above for both flows and loads

Facultative Ponds

- Mixing:
  - Wind plus max 1 W/m³ surface mixing
- Hydraulics:
  - No short circuiting
  - Inlet flow control e.g.
  - cf Guidelines for the hydraulic control of WSP



Pond Modifications and Upgrades

Drivers:

- Significant operational problems e.g. odour, non-compliance with consents, complaints, equipment failures
- An increase in loading or changes in consent conditions
- Political reasons

Experience shows that generally all reasons have an O&M root cause. Therefore **examine O&M practices and requirements first!**

What Can You Upgrade To Improve?

Algal Solids

Biomass Solids

Inert Solids

Surface Sludge

BOD

Ammoniacal-N

Total N

Total P

Faecal Bacteria and Viruses

Odour

pH & Alkalinity

Temperature stratification

Low DO

Wave height

water NEW ZEALAND

Upgrade Options for Algal Solids

Mechanism	Upgrade Options	Use		Refer Sections
		Pond	Term	
Prevention	Artificial pond cover	F/M	L	3.4.10
	Aeration & mixing	F/M	S/L	3.4.4, 3.4.5
Retention	Improved outlet structure	F/M	S/L	3.4.2
	Pond subdividing	F/M	L	3.4.6
	Wetlands / Floating wetlands	F/M	L	3.4.8, 3.5.8
Electrical inhibition	Ultrasound	(F)/M	S/(L)	3.4.11
Filtration	Pond internal biological filter	F/M	L	3.4.8, 3.4.9
	Pond external micro screening	F/M	L	3.5.1
	Pond external membrane treatment	F/M	L	3.5.2
	Pond external biological filter (trickling filter)	F/M	L	3.5.6
	Slow sand filtration	(F)/M	L	3.5.1
	Rapid sand filtration	F/(M)	L	3.5.1
Chemical dosing	Pond internal	F/M	S	3.4.10
Flotation	DAF / IAF	F/M	L	3.5.3
Code: A/F/M: Anaerobic, Facultative, Maturation pond; S/L: short, long-term; (…): limited application				

water NEW ZEALAND

Upgrade Options for Dissolved BOD

Mechanism	Upgrade Options	Use		Refer Sections
		Pond	Term	
Prevention	Desludging	A/F	L	3.4.12, 4.4.7
Treatment	Aeration & mixing	F/(M)	S/L	3.4.4, 3.4.5
	Improve pond hydraulics	A/F/(M)	L	3.4.3
	Subdivide	F/(M)	L	3.4.6
	Pond internal biological filter	F/(M)	L	3.4.8, 3.4.9
	Pond external biological filter	F/(M)	L	3.5.6
	Chemical aeration	F	S	3.4.10
	Other (aeration & mixing)	F/(M)	S	3.4.14
Code: A/F/M: Anaerobic, Facultative, Maturation pond; S/L: short, long-term; (…): limited application				

water NEW ZEALAND

Upgrade Options for Ammoniacal-N within Pond/at Outlet

Mechanism	Upgrade Options	Use		Refer Sections
		Pond	Term	
Prevention	Desludging	F/(M)	S/L	3.4.12, 4.4.7
Treatment	Aeration & mixing	F/(M)	S/L	3.4.4, 3.4.5
	Improve pond hydraulics	F/(M)	L	3.4.3
	Subdivide	F/(M)	L	3.4.6
	Pond internal biological filter	F/(M)	L	3.4.8, 3.4.9
	Pond external biological filter	F/(M)	L	3.5.6
	Other (aeration & mixing)	F/(M)	S	3.4.14
Code: A/F/M: Anaerobic, Facultative, Maturation pond; S/L: short, long-term; (…): limited application				

water NEW ZEALAND

Pre-Pond	In-Pond	Post-Pond
Screening	Inlet modifications	Post filtration
Septage reception	Outlet modifications	Membrane Filtration
Grit removal	Flow Direction Devices	DAF or IAF
Septage Ponds, Imhoff Tanks, Geobags	Aeration and/or Mixing	Lamella Clarifiers
Anaerobic Ponds	Subdividing ponds	Micro-sand injected Rapid Gravity Settlers
Pre-aeration	Attached Growth Media	UV disinfection
DAF or IAF	Floating Wetlands	External Rock Filters
Physical or Chemical Precipitation	Pond Covers and In-Pond Rock Filters, Bio-domes	Other external filters e.g. Bark, Biofiltro
pH adjustment	Chemical Dosing; for alkalinity or TP change	Wetlands
Heavy metals and/or chemicals Adsorption	Ultrasonic Algae Control	Electrocoagulation
Hydrocarbon pre-treatment	Enhanced Microbial Digestion	
Other Industrial specific pre-treatment	Pond Conversions	

Pre-Pond Upgrades

- Screening
- Septage Receiving Stations
- Grit removal
- Septage ponds, Imhoff Tanks, Geobags
- Anaerobic Ponds
- Pre-aeration
- DAF or IAF
- Physical or Chemical Precipitation
- pH adjustment
- Alkalinity adjustment
- Heavy metals and/or chemicals Adsorption
- Hydrocarbon pre-treatment
- Other Industrial specific pre-treatment

water NEW ZEALAND

In-Pond Upgrades

- Inlet Modifications e.g. jetting or distribution – *often 1st priority*
- Outlet Modifications – *often 2nd priority*
- Flow Direction Devices; active or passive
- Aeration and/or Mixing
- Subdividing ponds
- Attached Growth Media
- Floating Wetlands
- Pond Covers and In-Pond Rock Filters, Bio-domes, Bio-shells
- Chemical Dosing; for alkalinity or TP change
- Ultrasonic Algae Control
- Enhanced Microbial Digestion
- Pond Conversions

Post-Pond Upgrades

- Post Filtration
- Membrane Filtration
- DAF or IAF
- Lamella Clarifiers
- Micro-Sand Injected Rapid Gravity Settlers
- UV Disinfection
- External Rock Filters
- Other External Filters e.g. Bark, Biofiltro
- Wetlands
- Electrocoagulation

Indicative Effluent Quality From Improved Pond Systems

Contaminant	BOD_5 g/m³	SS g/m³	TN g/m³	NH_4-N g/m³	TP g/m³	DRP g/m³	FC cfu/100 ml	*E. coli* cfu/100 ml
Facultative (Primary) Pond	40	50	40	15	8	6	20×10^3	10×10^3
Maturation (Tertiary), Pond	30	40	35	13	8	6	10×10^3	5×10^3
Multiple Maturation (Tertiary), Ponds in Series	30	40	25	10	8	6	2×10^3	1×10^3
Membrane-Filtration	5	1	5	10	4	4	Detection limit	Detection limit
Rock Groynes	30	35	30	10	8	6	5×10^3	2×10^3
Growth Media Ponds	20	30	12	4	6	4	5×10^3	2×10^3
Coagulation and Sand Filtration	5	5	20	10	5	3	50	10
Wetlands	15	15	25	5	6	4	5×10^3	2×10^3
Wetlands and UV Light	15	15	25	5	6	4	200	100
High Rate Algae Pond Systems	15	15	10	5	6	4	200	100

water NEW ZEALAND

Operations & Maintenance (O&M)

WSP require less O&M than mechanical systems…

BUT THEY DO REQUIRE REGULAR O&M!

- Monitor the health of the WSP process.
- Undertake general housekeeping around the site.
- Maintain the structural integrity of the WSP.
- Collect samples for resource consent compliance.

water NEW ZEALAND

Monitoring & Sampling

- Resource Consent Monitoring – minimal requirement
- Influent Monitoring:
  - Community
  - Septage and Industrial Discharges
- Process:
  - pH, DO, EC, Temperature, Algae, sludge level, solids concentration and contaminant levels
- Between Ponds
- External Parameters:
  - Air Temperature, Wind Speed, Solar Radiation, Catchment and Pond rainfall and evaporation

Recommended Monitoring Schedule

Parameter	Method	Frequency	Comments
DO	In-situ or on-line	Daily or continuously	Remote sites may be visited once or twice per week
pH	In-situ or on-line	Daily or continuously	Remote sites may be visited once or twice per week
Conductivity	In-situ or on-line	Daily or continuously	Remote sites may be visited once or twice per week
Temperature	In-situ or on-line	Daily or continuously	Remote sites may be visited once or twice per week
Algal TSS	Laboratory		Depending on WSP complexity
Algal Species	Laboratory		Depending on WSP complexity
Chlorophyll *a*	Laboratory or on-line	Weekly or continuously	Depending on WSP complexity
Sludge level	In-situ	1 – 5 yearly	Depending on rate of accumulation
Sludge characteristics	Laboratory	1 – 5 yearly	For desludging purposes

water NEW ZEALAND

Recommended Sampling Schedule

Parameter	Method	Frequency	Comments
DO	In-situ or on-line	Daily or continuously	Remote sites may be visited once or twice per week
pH	In-situ or on-line	Daily or continuously	Remote sites may be visited once or twice per week
Conductivity	In-situ or on-line	Daily or continuously	Remote sites may be visited once or twice per week
Temperature	In-situ or on-line	Daily or continuously	Remote sites may be visited once or twice per week
Algal TSS	Laboratory		Depending on WSP complexity
Algal Species	Laboratory		Depending on WSP complexity
Chlorophyll *a*	Laboratory or on-line	Weekly or continuously	Depending on WSP complexity
Sludge level	In-situ	1 – 5 yearly	Depending on rate of accumulation
Sludge characteristics	Laboratory	1 – 5 yearly	For desludging purposes

water NEW ZEALAND

Troubleshooting

Smells & Odours
Low DO
Stratification and Pond Turn-over
Unexpected Pond Crashes
Insufficient Algal Growth
Excessive Algal Growth
Blue-Green Algae (Cyanobacteria) Blooms
Colour Observations
Invasive Plant Growth
Flies, Mosquitos, Midges
Fish
Birds
Effluent Deterioration
Overloading
Sludge Accumulation
Excessive Floating Matter

Maintenance

General Housekeeping:

- Keep clean and tidy
- Check data collection, transmission, recording

Equipment maintenance
Instrument Maintenance
Inlet & Outlet Structures
Waveband Maintenance & Repair
Pond Liner Maintenance & Repair
Desludging Methods
Other e.g. rodent or bird issues
Review Resource Consent Conditions
Prepare in advance for Resource Consent Applications

Colour Observations

Principal causes of Effluent Quality Loss

water NEW ZEALAND

Troubleshooting

Smells & Odours
Low DO
Stratification and Pond Turn-over
Unexpected Pond Crashes
Insufficient Algal Growth
Excessive Algal Growth
Blue-Green Algae (Cyanobacteria) Blooms
Colour Observations
Invasive Plant Growth
Flies, Mosquitos, Midges
Fish
Birds
Effluent Deterioration
Overloading
Sludge Accumulation
Excessive Floating Matter

water NEW ZEALAND

Colour Observations

Pond Colour	Interpretation
Dark green and partially transparent	Unimportant presence of other microorganisms in the effluent High pH and DO values Pond in good condition
Orange red	Bloom of *Daphnia* or *Moina* which will reduce pond algae and DO concentrations
Yellow green or excessively clear	The result of a rotifers, protozoa or cladoceran bloom which graze on the algae and can decimate their population in days If the conditions persist, there will be a decrease in DO and the potential for odour nuisance.
Greyish	Overload of organic matter and/or short detention time Incomplete anaerobic digestion in the sludge layer The pond should be put out of operation
Milky green	The pond is in a self-flocculation process as a result of high pH and temperature causing flocculation of algae with magnesium and calcium hydroxides.
Blue greenish	Excessive proliferation of cyanobacteria The bloom of a certain species forms a scum that decomposes easily, leading to bad smells, reduction of light penetration and green algae, as a consequence, reduction in oxygen production
Brownish red	Overload of organic matter Presence of photosynthetic sulphide-oxidising bacteria (they require light and sulphides, use CO_2 as an electron acceptor, do not produce oxygen and do not help in BOD removal).

Source: Arceivala (1981) and CETESB (1989)

Principal Causes of Effluent Quality Loss

Contaminant	Typical Effluent Concentration	Deviation	Potential Causes	Potential Solutions
TSS	10 – 150 mg/L	> 50 mg/L	Algal growth Sludge build-up	Outlet shading Desludge
BOD	15 – 110 mg/L	> 40 mg/L	Algal growth Sludge build-up	Outlet shading Desludge
NH_4-N (winter)	0.5 – 30 mg/L	> 15 mg/L	Cold temperatures Sludge build-up Low DO Overloading	- Desludge Add aeration Reduce load
NH_4-N (Summer)	0.1 – 10 mg/L	> 5 mg/L	Sludge build-up Low DO Overloading	Desludge Add aeration Reduce load
DRP	2 – 12 mg/L	> 6 mg/L	High influent concentrations Sludge build-up	- Desludge
TP	4 – 16 mg/L	> 8 mg/L	High influent concentrations Sludge build-up	- Desludge
E. coli	2,000 – 50,000 cfu/100mL	> 10,000 cfu/100mL	Short-circuiting	Improve hydraulics
Faecal coliforms	5,000 – 100,000 cfu/100mL	> 20,000 cfu/100mL	Short-circuiting	Improve hydraulics

water NEW ZEALAND

Maintenance

- General Housekeeping:
  - Keep clean and tidy
  - Check data collection, transmission, recodring
- Equipment maintenance
- Instrument Maintenance
- Inlet & Outlet Structures
- Waveband Maintenance & Repair
- Pond Liner Maintenance & Repair
- Desludging Methods
- Other e.g. rodent or bird issues
- Review Resource Consent Conditions
- Prepare in advance for Resource Consent Applications

Where to from here?

Putting it into practice:

- Training - at all levels plus refreshers
- Budgeting for correct O&M e.g.
  - enough/correct staff
  - Enough/correct monitoring; influents and effluents
  - Regular desludging to long term use/disposal
- Updating SOPs
- Reviewing Resource Consent details
- Making sure it happens all the time!

water NEW ZEALAND

WSP Guide Workshops

Location	Date
Balclutha	Tuesday 1 May
Christchurch	Wednesday 2 May
Nelson	Thursday 3 May
Ngaruawahia	Wednesday 9 May
Kerikeri	Thursday 10 May
WIOG Conference, Palmerston North	Friday 11 May

water NEW ZEALAND