WETLANDS AND AQUATIC SYSTEMS FOR WASTEWATER AND STORMWATER MANAGEMENT

Chairperson Dr Chris Tanner
National Institute of Water and Atmospheric Research Ltd
PO Box 11 115, Hamilton, New Zealand
Fax +64-7-856 0151
Email c.tanner@niwa.cri.nz

Facilitators Dr Clive Howard-Williams
Dr Chris Tanner

Rapporteurs Dr Brian Sorrell
Dr Otto Stein

INTRODUCTION

Constructed wetlands and a range of other aquatic-based "natural" systems are now widely accepted in many regions of the world as viable, cost-effective treatment technologies. Common first-generation treatment wetland concepts range from use of existing or restored natural wetlands, to simple constructed surface-flow marsh systems, and subsurface systems with horizontal or intermittent vertical-flow. Common aquatic systems include the use of microphytes and floating macrophytes, sometimes linked with aquaculture. Ancillary benefits of such systems, such as green-space and wildlife habitat creation, are often integrated with treatment objectives. Being relatively land-intensive, these systems tend to be most appropriate for dispersed and small to medium-scale applications, such as waste treatment for communities, towns, rural industries and farms, and filters for diffuse urban and agricultural runoff.

Basic treatment performance attributes have been defined over the last decade, initially extrapolating from knowledge of natural wetland processes and then gradually incorporating results from pilot trials and practical experience. Overly optimistic performance expectations have been dispelled and general principles of design, ecosystem establishment and operation have been drawn together into engineering guidelines. However, much of the accumulated knowledge of treatment efficiencies derives from simple "green box" input/output monitoring studies, where hydraulic flow data is absent or of poor quality. This limits our understanding of the relative importance of the constituent processes operating and thus the basis for future innovation.

It is now time in the evolution of wetland and aquatic-based treatment approaches to step back from the morass of information accumulated and look critically at our present state of knowledge. We need to clarify the key engineering, ecological, political and social factors influencing the utilisation of wetland and aquatic-based treatment systems and to identify where we should be heading in the future and what is holding progress back.

To help grapple with some of these issues the workshop utilized a local case study. The Christchurch City Council, as part of its Estuary Green Edge re-development plans, has proposed creation of a Wetland Ecotechnology Research Park. This would both contribute to the natural and aesthetic values of this ecological reserve, and provide information on treatment and beneficial re-use of secondary and tertiary sewage wastewaters and urban stormwaters. It is proposed to use this facility as a focus for community education, and to foster regional, national and international research collaboration on wetland treatment processes and related ecological issues such as wildlife habitat quality, weed and pest management and biodiversity.

WORKSHOP AIMS

The workshop was organized around a set of six points listed chronologically in order of discussion:

1 Describe optimal situations and designs for wetland treatment of wastewater and stormwater, and in contrast describe situations and designs where wetland treatment is inappropriate or where wetland treatment has not worked.

2 Based on these descriptions and discussions, and the Christchurch case study, define the minimum requirements for monitoring wetlands, and for reporting on wetland performance.

3 Describe the issues involved in assessing long-term sustainability of wetland treatment.

4 List the principal issues (advantages and disadvantages) associated with constructed or man-modified wetlands under the following headings:

4.1 Ecological issues
4.2 Engineering issues
4.3 Political issues
4.4 Social issues

5 What are the key research questions that need to be answered to improve wetland design and long term-sustainable performance.

6 What steps should be taken to facilitate the answering of the questions in Aim 5, and how can international collaboration for the global promotion of wetland treatment be advanced?

DISCUSSION OUTCOME OUTLINE

Optimal versus inappropriate situations

Optimal	Inappropriate
Steady flow	Overloading (chemical and hydrological) over long term
No channelisation	Wrong depth of substrate
Surface flow aspect ratio L/W <3	Wrong water depth
Subsurface flow aspect ratio L/W <1	Industrial use (unless treatability tests)
Mosaic of aerobic and anaerobic environments as needed	Bad hydraulics
BOD <2000-3000	No consultation of expertise
NH_4 <200 ppm	Re-suspension velocity
Sewage treatment	Retention time
Re-circulation	Short circuiting
pH >3	Too little water
pH <10	High internal concentrations of phytotoxins
Appropriate locally sourced plant species	Public health problems, e.g. mosquitoes
Multi-purpose, e.g. social and aesthetic habitat	No plans for future maintenance
Vegetation shading its gravel surface	Excessive solids
Pre-treatment for some removal processes	Wrong geomorphic location
Catchment geology considered	

Surface flow	Sub-surface	Pond
Treats first flush and low flow	Gravel <0.5 m	Temperature
	Gravel size	Algae blooms
	Fails if it becomes surface flow	

Minimum design and monitoring wetlands

- Line the system
- Minimum two trains of flow or incorporate a bypass swale
- Measure concentration through wetland, not just inflow and outflow
- Perform flow tracer studies
- Measure environmental and climatic variables
- Hydraulic checks within the wetland i.e. submerged gabions and separate cells
- Compare systems (A-B) Vs. (C-D)
- More replication needed
- Utilize side mesocosm cells
- Monoculture vs diverse plantings – necessary?
- Put some sub-surface cells
- Floating mats

Long-term sustainability

- Sedimentation and loss of volume thus retention time
- Algae growth and accumulation: percolate through gravel bar?
- P-retention: is liming required?
- What is the design life: 50 years?

Potential solutions

- o Increase height of berms to allow for long term accretion
- o Rotate cells
- o 20 year clean-out
- o Metals accumulation and toxic effects on wildlife
- o Eventual closure needs to considered
- o Link with stormwater to keep wet
- o Weed sedges invasion

Ecological issues

Negative	Positve
Pathogens	Wildlife habitat
Hormones	Carbon sink?
Weeds	
Mosquitoes and other vectors	
Effects on wildlife esp. in natural wetlands	
Greenhouse gas release	
Wildlife faecal inputs	`
Manipulate water level	
Edge design important	
Spreading of unwanted plants and propagales	
Wildlife effects on plant establishment	

Engineering issues

- Include multiple trains and cells
- Performance uncertainty and variability
- Pilot scale studies for “other” inputs
- Hydraulic controls
- Design with maintenance capabilities
- $ for maintenance
- Cost of land/other methods of land use

Political and social issues

- What goal: treatment on habitat?
- Health risk for visitors
- Liability – health, engineering
- Bird control if necessary
- Cost/benefit – habitat is a benefit
- Grow ornamental plants or plant for sale – benefit?
  - fodder
  - energy
  - building material
- Inherent variability or performance vs engineering risk
- Local, regional, vs national treatment criterion
- Need to meet cultural criteria
- Source reduction or end of pipe solution
- Public perception of green vs technology solution
- Wetlands look good to politicians
- Regulators need to accept them

Research questions/needs: Wastewater applications

- Pathogen removal efficacy
- N_2O and CH_4 greenhouse gases
- Loading and concentration levels
- Transferability of results
- ET/water balance species/size/age
- Conflicting results and opinions
- Does first order model open the green box?
- Quantify the performance variability between systems, seasonality
- Public awareness of pre-treatment need
- Design for worst case
- Different flow configurations: horizontal vs. vertical
- How to minimise short circuiting
- Role of invertebrates (worms)
- What do we measure? SS, BOD, pathogens
- Development of assessment tool – decision support system
- Need to link more with natural wetland knowledge
- Quantify the processes we know exist in wetlands
- Do different types of substrate make a difference in SSF
- Review information already available

Research questions/needs: Stormwater applications

- Type of sediment coming in urban or industrial

- Dealing with intermittent flow
- Retaining five sized particles
- Toxicity to plants/long term accumulation/bioaccumulation
- Design for the first flush vs low flow treatment
- How do you define first flush?
- How many cells?
- Re-release or pollutants due to wetting and drying
- Range of species for large hydraulic fluctuations
- A direct link to natural wetlands

How do we answer the questions?

- Wetlands conferences specific to New Zealand and Australia
- Journal editorial, call for collaboration
- Classroom/dissertation focus
- Curriculum development
- Use WWW for case study promotion
- Does IEES initiate a joint conference and promote collaboration?