"LANDSCAPE-SCALE WATER MANAGEMENT IN IRELAND: THE INTEGRATED CONSTRUCTED WETLAND (ICW) CONCEPT"

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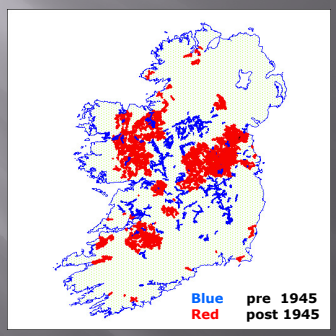
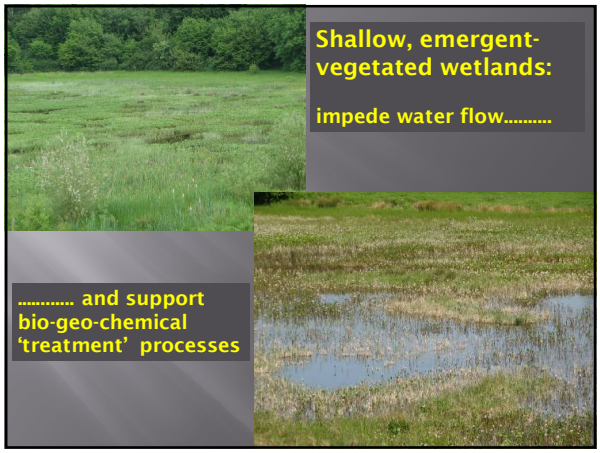
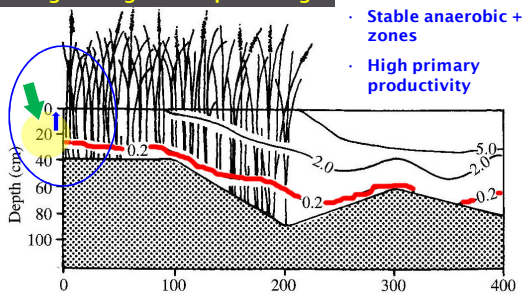
State arterial drainage in Ireland



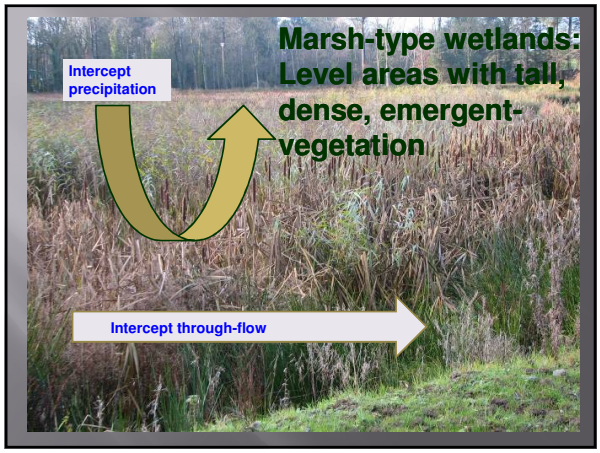


Shallow water depth and emergent vegetation providing:

- High hydraulic impedance
- Stable anaerobic + O_2 zones
- High primary productivity



Dissolved O_2 isotherms / water depth

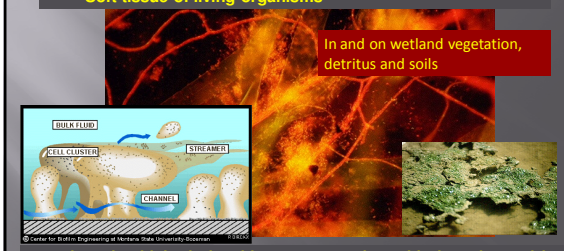


Facilitating biofilms, active on all supporting strata

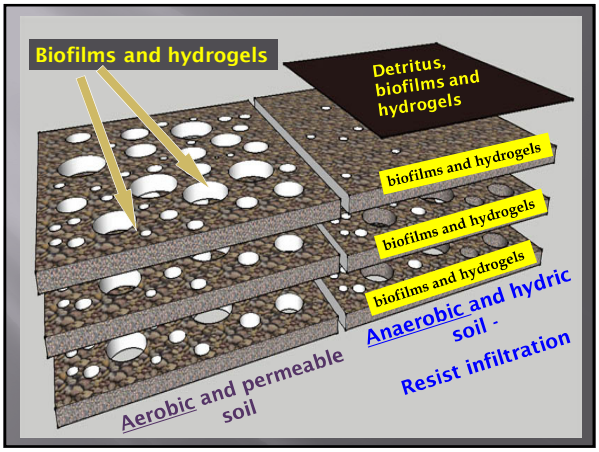
On: Solid substrates (rock, soils, plants and detritus)

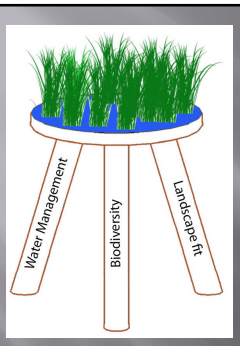
Liquid – air (gaseous) interfaces

Soft tissue of living organisms



Complex microbial relationships: commensal, symbiotic and parasitic





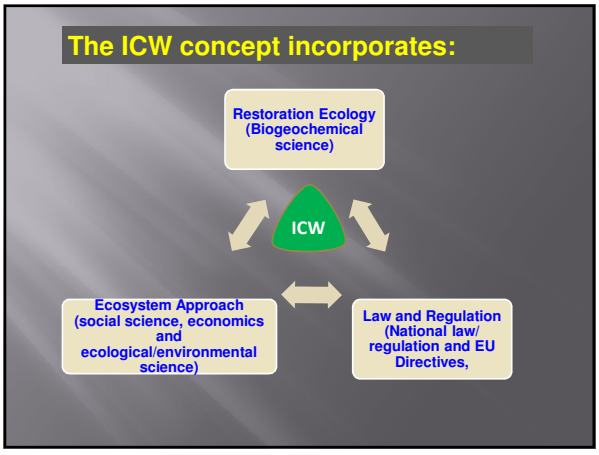
The ICW concept is based upon - *integration* and *joined-up thinking*

Explicitly integrating
3 objectives:
- ✓Total water management
- ✓Landscape-fit
- ✓Biodiversity

Explicit integration **provides:**

synergies, robustness and acceptability

The ICW concept incorporates:



Key ICW requirements

Hydraulic loading (Weather related flux flow)

Adequate area (area:flow)

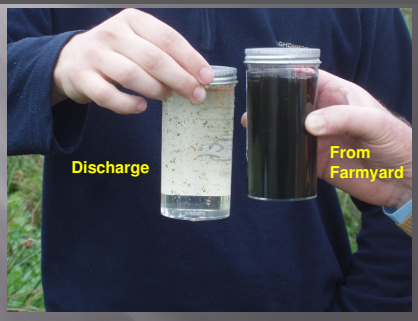
Soil characteristics and depth

Influent characteristics (ionic strength, ammonium-N)

Use of local or on- site soils (Permeability)

Recycling from within ICW (Conc.)

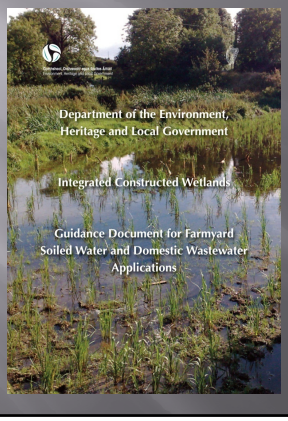
ICW systems have a proven record of delivering sustained water quality since 1996



Animal slurry, waste and polluted water are both a danger and opportunity!

ICW systems produce clean water ---and many additional values & other benefits

Water and its constituents can be recycled

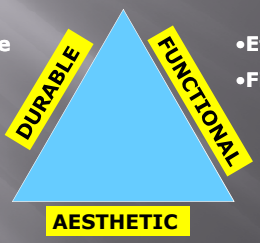


Published December 2010 with contributions from:

- Department of Agriculture, Fisheries & Food
- Forest Service
- Environmental Protection Agency
- Central Fisheries Board
- Eastern Regional Fisheries Board
- Office of Public Works
- County and City Managers' Association
- Department of Environment, Heritage & Local Government
- National Parks & Wildlife Service
- Éamon de Buitléar

Applies the 'universal design' model

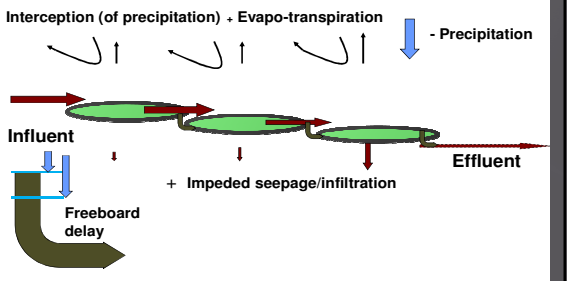
- Sustainable
- Robust
- S.E.E. coherent



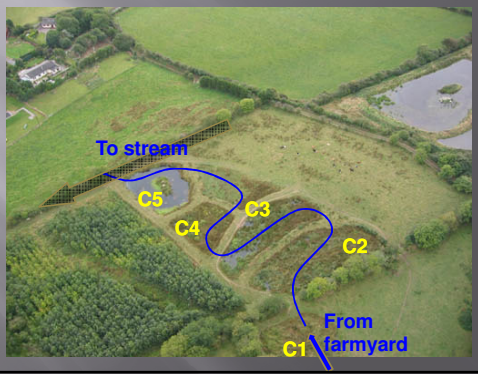
- Effective
- Fit for purpose

- Beautiful
- 'In context' (as if had always been there)

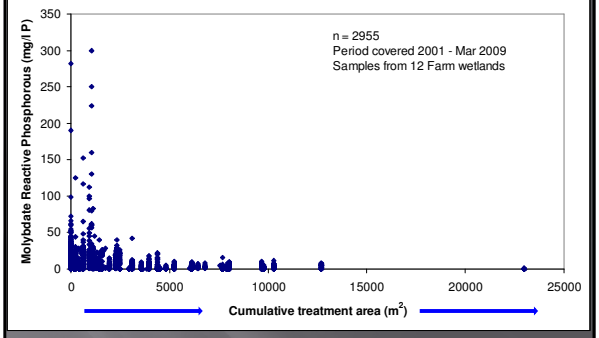
Basic ICW hydraulic model



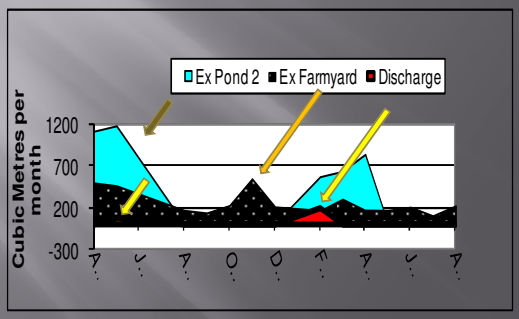
ICW systems' multiple cells



ICWs in Anne valley catchment, Co. Waterford: The importance of functional area

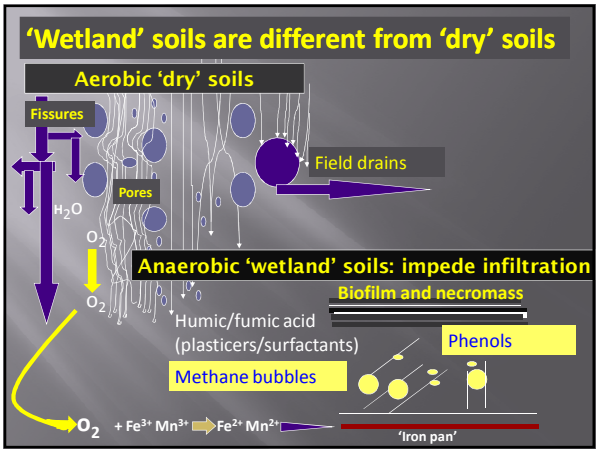


Monthly water-flow over 1 year for Farm ICW '11' with 4 cells

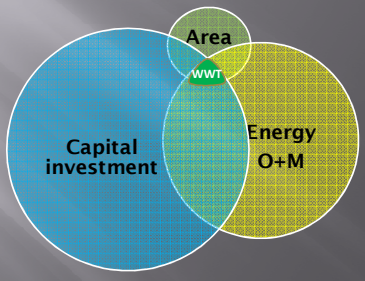


Using local and *in-situ* soils

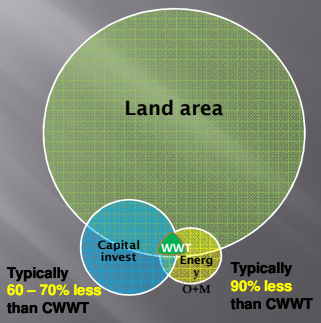
'Wetland' soils are different from 'dry' soils



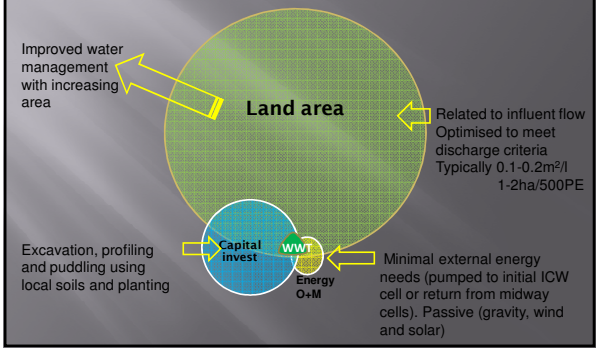
Requirements of conventional electro-mechanical wastewater treatment systems



Requirements of Integrated Constructed Wetland (ICW) systems

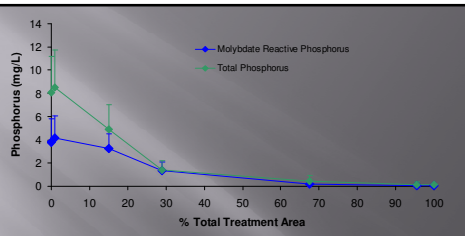


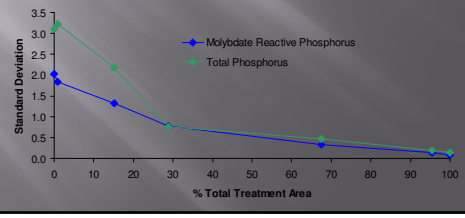
Integrated Constructed Wetland (ICW) systems



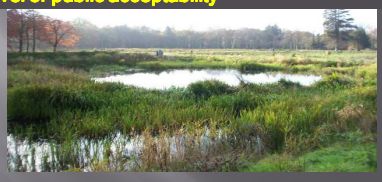
Sewage treatment (Population equivalent = 1700)

With a capital cost saving of **c.70% per PE**



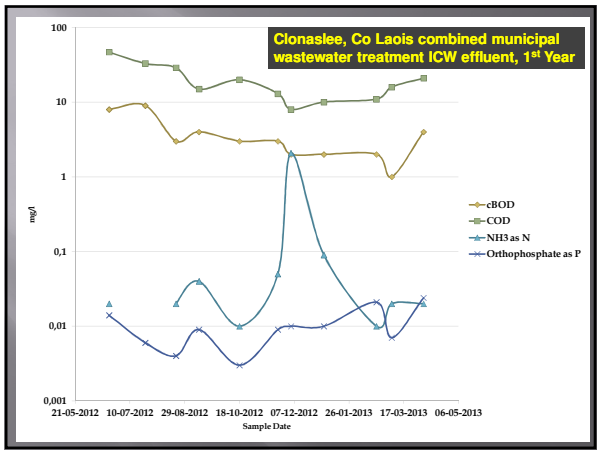


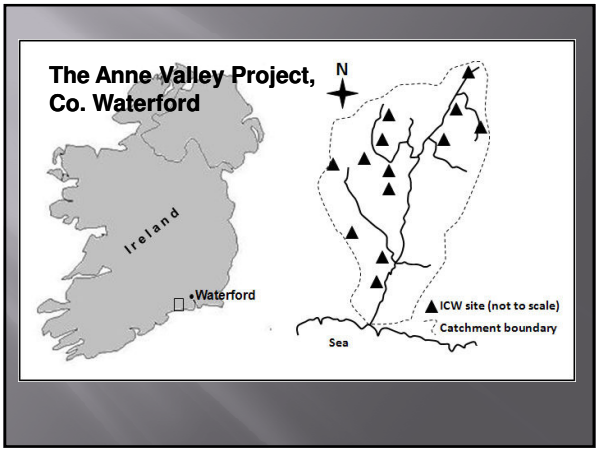
Landscape-fit: Generates empathy - amenity and biodiversity ---- ICW systems have a high level of public acceptability

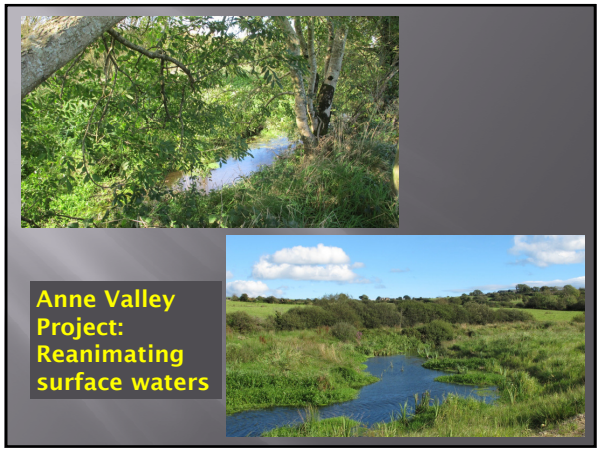


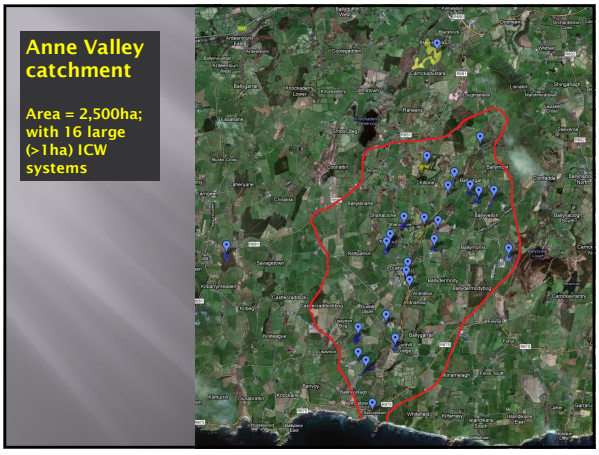
Clonaslee: Combined storm and municipal wastewater ICW

Under construction, 2011



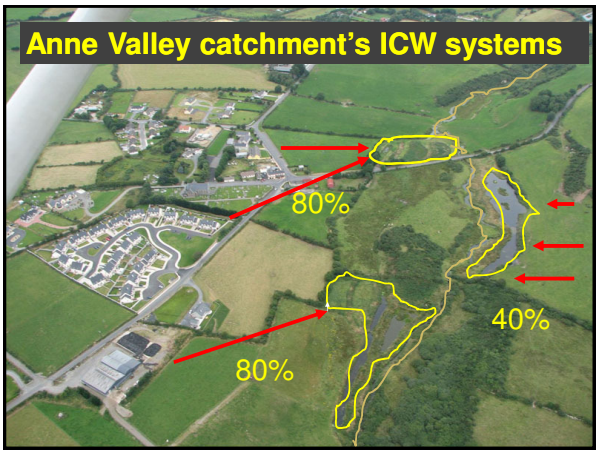


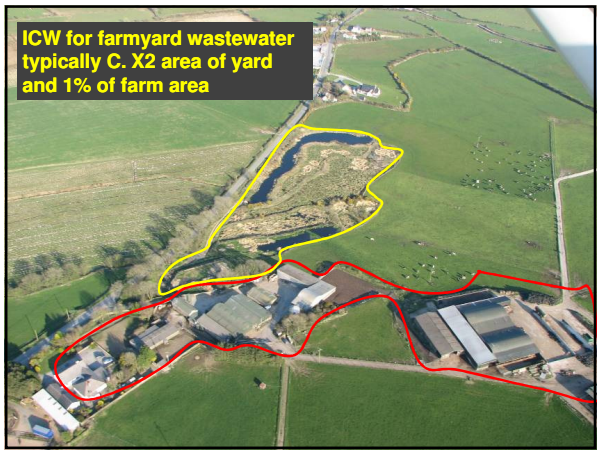


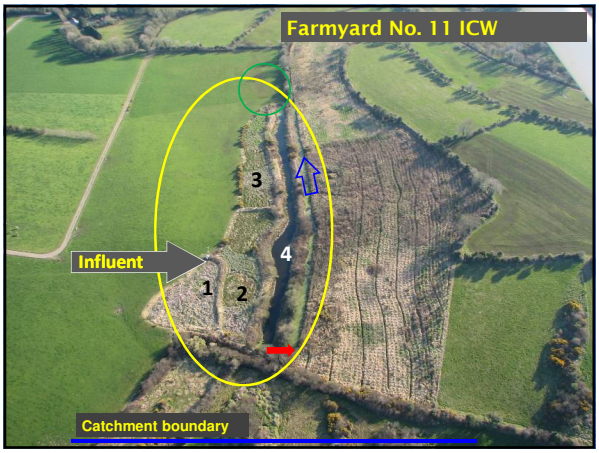


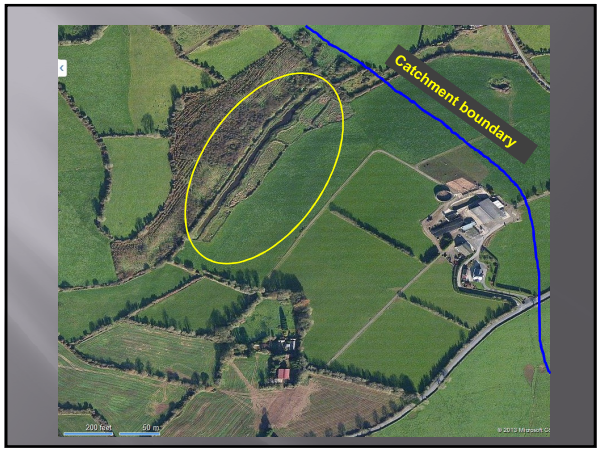
ICW INFLUENT COMPOSITION (from 12 farmyards)

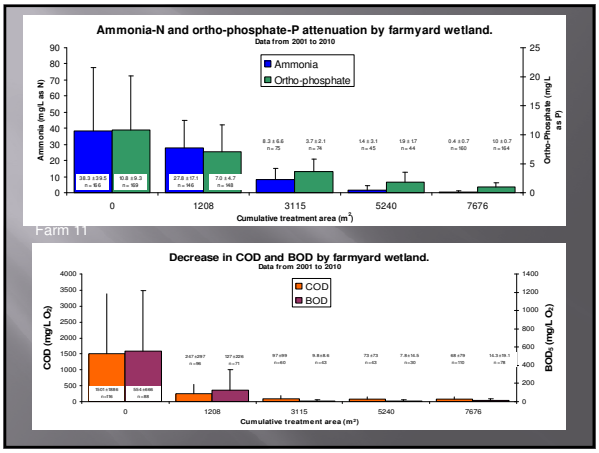
Constituents	Farmyard Dirty Water	Range of Values	Std. Dev.
COD (mg/L)	2200	20 - 90,000	8000
BOD (mg/L)	1200	2 - 60,000	5000
Ammonia-N (mg/L)	80	0.1 - 1900	170
Nitrate-N (mg/L)	<1	<1 - 10	25
MRP (mg/L)	25	0.01 - 900	70









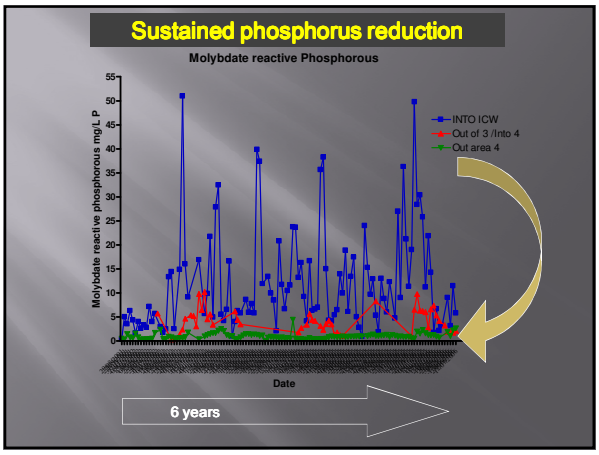


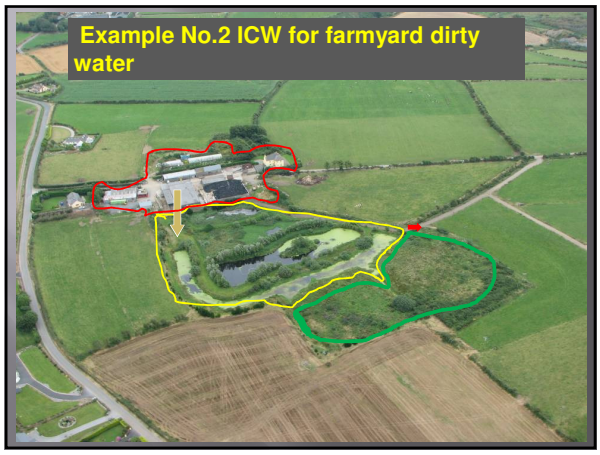
MRP (mg/L) mass-reduction (%) for 13 ICW systems

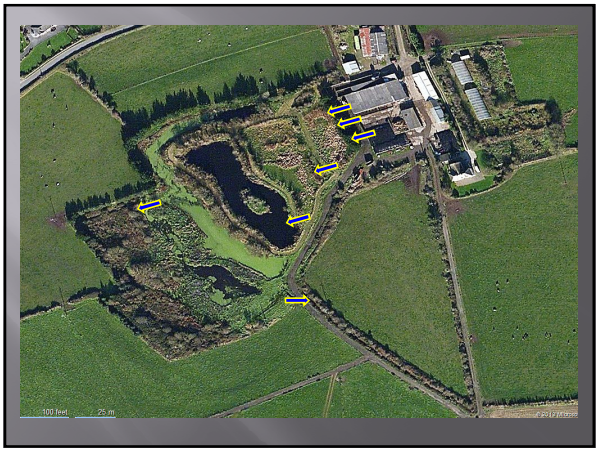
ICW number	1	2	3	4	5	6	*7
MRP reduction	99.7	98.2	81.4	92.9	98.3	98.8	30.1

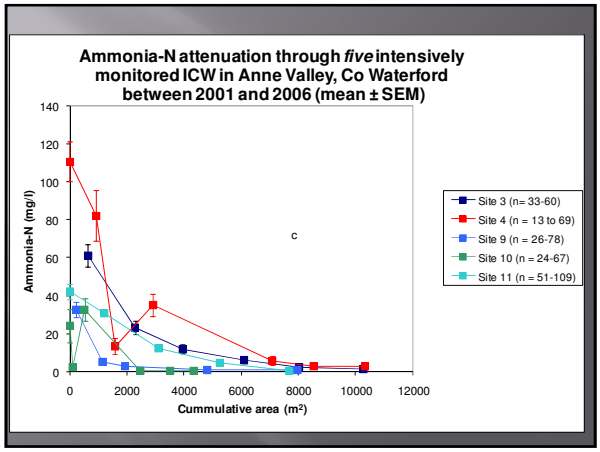
ICW number	8	9	10	11	12	13
MRP reduction	97.2	96.2	99.6	92.0	99.0	93.3

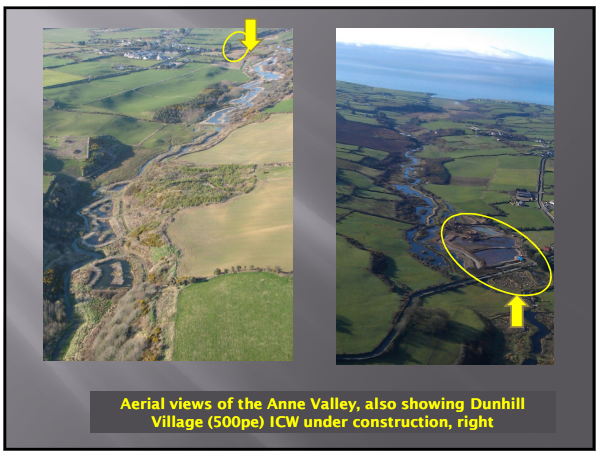
*Note: No. 7 became undersized when an additional 40 houses were added to the sewage system.


Sustained phosphorus reduction
Molybdate reactive Phosphorous
Molybdate reactive phosphorous mg/L P
INTO ICW
Out of 3 /Into 4
Out area 4
Date
6 years


Example No.2 ICW for farmyard dirty water




Ammonia-N attenuation through five intensively monitored ICW in Anne Valley, Co Waterford between 2001 and 2006 (mean ± SEM)
Ammonia-N (mg/l)
Cummulative area (m²)
Site 3 (n= 33-60)
Site 4 (n = 13 to 69)
Site 9 (n = 26-78)
Site 10 (n = 24-67)
Site 11 (n = 51-109)


Aerial views of the Anne Valley, also showing Dunhill Village (500pe) ICW under construction, right


March 2012
March 2013

Recently enlarged Dunhill village ICW (operational - 12 July 2012)

'Old' (1999) ICW

Functional treatment area = 2670m²

Newly extended (July 2012) ICW

Functional treatment area = 9678m²

Total functional treatment area = 12348m² (a combined flow PE capacity = c.500)

Starting construction on enlarged Dunhill village ICW : November 2011

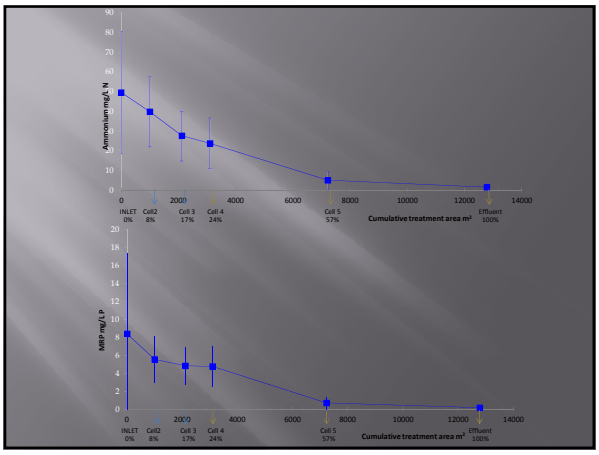
March 2012

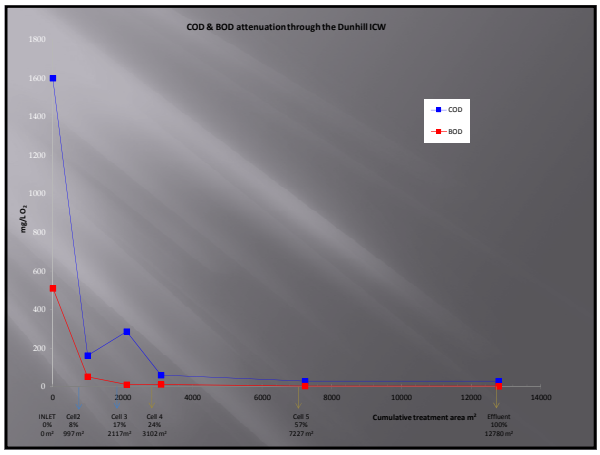
August 2012

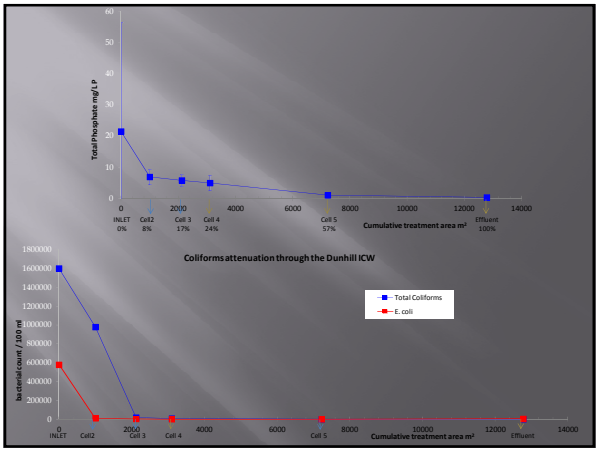
January 2013

Dunhill ICW samples taken 5/9/12

Station ID	Lab number	Location	E coli per 100 mls	Ammonium mg/l N	MRP mg/l P
7100	833	Pond 1 inlet	1,200,000	49	5.8
7300	834	pond 2 inlet	>1,200,000	33	4.1
7400	835	pond 3 inlet	<200	12.9	2.1
7480	836	pond 4 inlet (new side of ICW)	<200	8.4	1.2
7600	837	pond 5 inlet	<50	0.04	0.33
7650	838	Out of ICW pond 5	<20	0.01	0.02
7780	839	outfall from ICW (combined WW and stormwater)	24	0.07	0.006
US7	840	River u/s of ICW	48	0.02	0.04
DS7	841	River d/s of ICW	52	0.02	0.04
Ref. pond	842	Groundwater reference pond	6	0.03	0.006

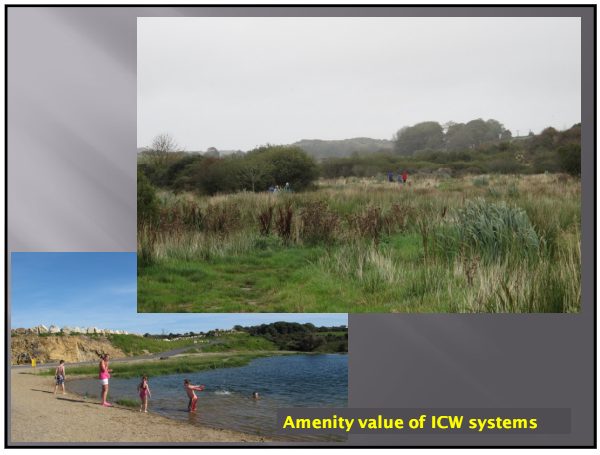


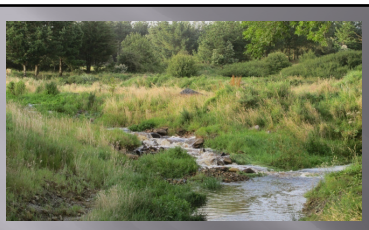




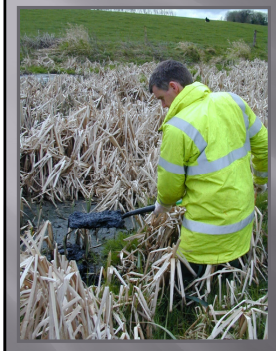
Summary performance of Dunhill ICW: July 2012 to May 2013

	Ammonium mg/L N			MRP mg/L P			Total P (mg/L P)		
Location	Mean	SD	n	Mean	SD	n	Mean	SD	n
Cell 1 Inlet	49.582	30.925	94	8.382	9.009	93	21.44	34.91	48
Effluent from cell 5 and ICW	1.554	2.533	13	0.171	0.221	13	0.36	0.18	6
% reduction between Cell 1 and final outflow	99.3			99.7			99.3		

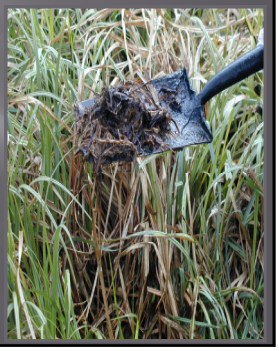




Flood attenuation



A valuable resource;
Secure retention of phosphorus P and nitrogen N



Also: Long-term carbon sequestration (>13t/ha/yr)

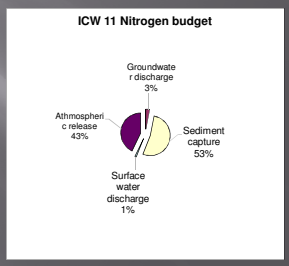
ICW Sediment nitrogen - N

ICW 11 Nitrogen deposition per cell

Cell	kg N per year	%
1	145	62
2	35	26
3	29	11

Nitrogen deposition in ICW

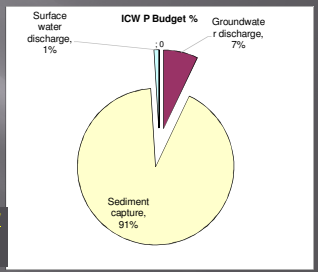
400 kg per ha per year



ICW Sediment phosphorus - P

ICW 11 Phosphorus-P sediment deposition per cell

Cell	kg P per year	%
1	43	60
2	14	20
3	14	20



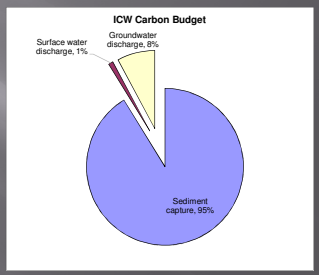
Phosphorus deposition in ICW

135 kg per ha per year

ICW Sediment carbon - C

ICW 11 Carbon sediment deposition per cell

Cell	kg C per year	%
1	960	43
2	730	32
3	558	24

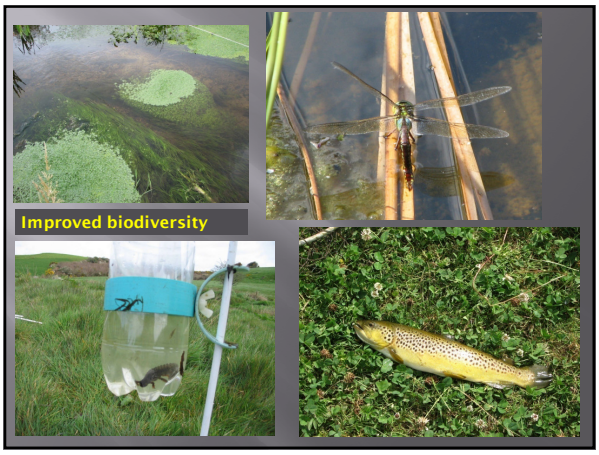


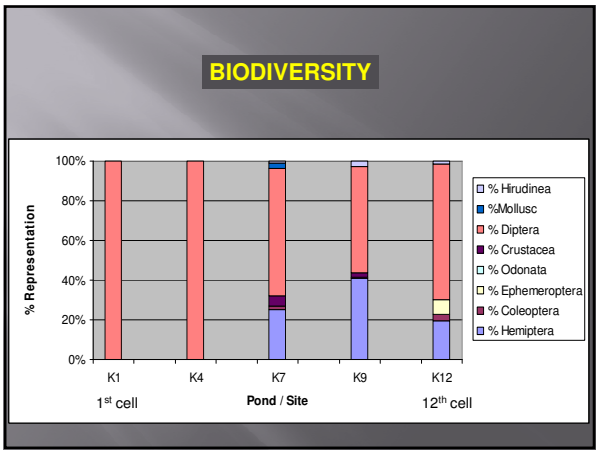
Carbon deposition in ICW

3700 kg per ha per year

13.56t CO^2 per ha per year

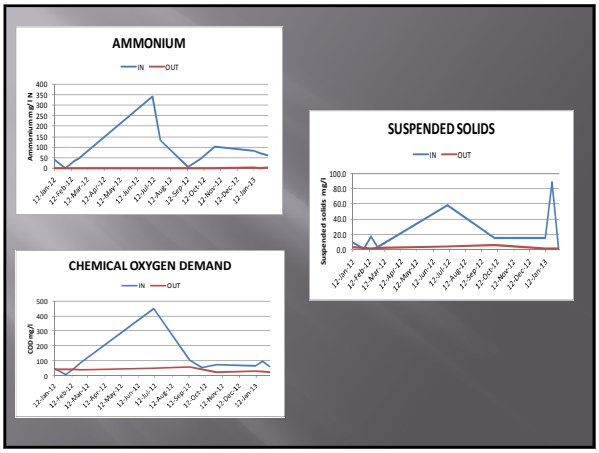
(likely to be an under estimate)

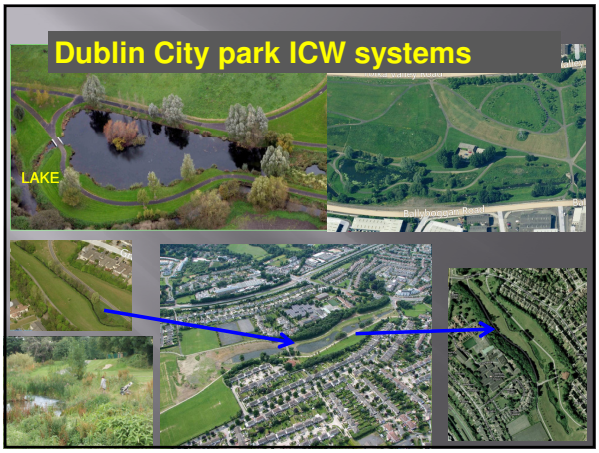

Improved biodiversity


BIODIVERSITY
100%
80%
60%
40%
20%
0%
% Representation
K1
K4
K7
K9
K12
1st cell
Pond / Site
12th cell
% Hirudinea
%Mollusc
% Diptera
% Crustacea
% Odonata
% Ephemeroptera
% Coleoptera
% Hemiptera

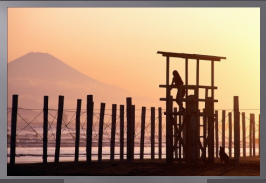

ICW treating Leachate from
at closed landfill: Dungarvan, Co. Waterford


Dungarvan, ICW treating landfill leachate


AMMONIUM
IN
OUT
CHEMICAL OXYGEN DEMAND
SUSPENDED SOLIDS


Dublin City park ICW systems
LAKE

ICW Concept provides a *platform* for innovation in natural resource management



Resources:
Biomass
Bio-char
Nutrient store
Hydrocarbon-replacement
New food crops
Materials

and more.....

Services:
Water supply
Nutrient capture
Carbon sequestration
Flood attenuation
Recreation and amenity
Biodiversity

Conclusion

Integrated Constructed Wetlands (ICW) really work,.....

they improve surface-waters and landscapes and.....

deliver diverse benefits to many people in ***an inherently sustainable, consistent, low cost-effective way***

The Dunhill Primary School students and future generations might say:
"Thank you for your attention ------for taking Nature's way "

Relative magnitude (per unit area) of ecosystem services derived from sixteen ICW systems in the Annestown Stream catchment (based on the methodology used in Millennium Ecosystem Assessment, 2005). (Scale • low: ● medium; ● high.)

Provision	Comments and examples	ICW
Food	Production of fish, wild game, fruits, grains and rhizomes	●
Freshwater	Storage and retention of water for domestic, industrial and agricultural use	●
Fibre and fuel	Production of fuel wood, peat and fodder	●
Biochemical	Extraction of medicines and other materials from biota	•
Genetic material	Genes for resistance to plant pathogens, ornamental species, etc.	●
Regulating		
Climate regulation	Source of and sink for greenhouse gases; influence temperature, precipitation and other climatic processes	●
Water regulation	Impeding/regulating hydrological flows to surface water; groundwater recharge/discharge	●
Water purification and waste treatment regulation	Retention, recovery and removal of excess nutrients and other pollutants	●
Erosion regulation	Retention of soils and sediments	●
Natural hazard regulation	Flood control and storm protection	●
Pollination	Habitat for pollinators	●
Cultural		
Spiritual and inspirational	Source of inspiration; many religions attach spiritual and religious values to aspects of wetland ecosystems	●
Recreational	Opportunities for recreational activities	●
Aesthetic	Many people find beauty or aesthetic value in aspects of wetland ecosystems	●
Educational	Opportunities for formal and informal education and training, helping to promote awareness of water and aquatic dependent life	●
Supporting		
Soil formation	Sediment retention and accumulation of organic matter	●
Nutrient cycling	Storage, recycling, processing and acquisition of nutrients	●

Key ICW requirements

Hydraulic loading (Weather related flux flow)

Adequate area (area:flow)

ICW

Soil characteristics and depth

Influent characteristics (ionic strength, ammonium-N)

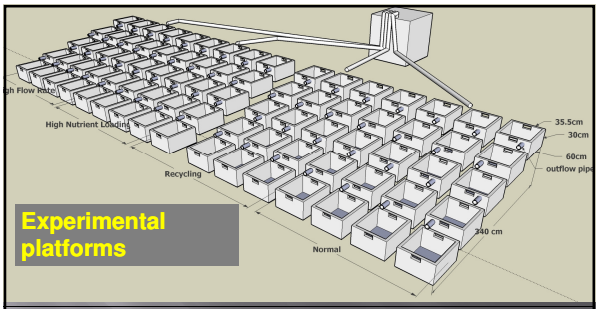
Use of local or on- site soils (Permeability)

Recycling from within ICW (Conc.)

Water management

Requires Time and Space:

- Time to allow processes
- Space (LxBxD) to allow residence time for processes: Physical, Chemical and Biological
- Acknowledging fluxes in volume and flow (all 'open-systems' are vulnerable to rainfall events, *i.e.* stormwater)
- Efficacy indicators as determined by biological/ecological status and water chemistry



Experimental platforms

	Normal In	Normal Out	% reduction	Recycle In	Recycle Out	% reduction	HNL[a] In	HNL[a] Out	% reduction	HFR[b] In	HFR[b] Out	% reduction
Ammonia	99.46	0.53	99.5	99.46	0.18	99.9	185.72	0.69	99.7	99.46	1.94	98.1
MRP	1.62	0.03	98.1	1.62	0.04	97.5	3.2	0.05	98.5	1.62	0.05	96.9
Nitrite	1.85	0.08	95.7	1.85	0.06	96.8	8.58	0.16	98.2	1.85	0.45	76.7
Nitrate	6.96	2.33	66.6	6.96	1.44	79.1	2.95	4.78	0	6.96	8.42	0
TON	9.45	2.41	74.5	9.45	1.51	84.1	12.19	4.94	60	9.45	8.87	0

For consideration:

- Alliances and co operation: a need for within and between interested and effected parties
- Awareness and understanding: through demonstration and doing , supported by research
- Many areas needing ICW application: agriculture, mining, landfills
- Funding and revenue generation: EU and 'Others' providing funds for innovation through exploring new areas (energy, amenity, nutrient recovery, crops)