INTEGRATED CONSTRUCTED WETLANDS (ICW):

THE CONCEPT AND ITS APPLICATION

Continuation of Landcare seminar

Wednesday, 17 February 2016

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THIS PRESENTATION

- LINKING - LAND AND WATER MANAGEMENT
- REANIMATING - FUNCTIONAL (AQUATIC) ECOSYSTEMS
- INTEGRATING - SOCIAL, ECONOMIC AND ENVIRONMENTAL NEEDS
- PROMOTING - CREATIVITY, INNOVATION AND ENTREPRENEURSHIP
- INTRODUCING - INTEGRATED CONSTRUCTED WETLAND (ICW): THEIR BASIC DESIGN, EXAMPLES AND PERFORMANCE

Towards sustainable water management:

- The challenge to think and act beyond just solving problems

- To develop sustainable capacities in managing water and water-borne contaminants

- Systemic, joined-up thinking and action

Objective:

Integrated and coherent social, economic and environmental action for the management of water and associated land interfaces – intercepting, retaining and treating

Some of the 'DRIVERS' demanding new paradigms:

- Loss of Natural Capital – ('NC – Ireland' conference)
- European Union (EU) FP7 meeting on animal health and welfare (*E. coli, Cryptosporidium etc.)*
- Findings and recommendations of the Intergovernmental Panel on Climate Change
- (Ireland's) struggle to meet its (EU) carbon emissions by 2020
- Sustainable intensification of pasture management under Food harvest (2020)
- Need to improve water quality (under the EU Water Framework Directive (WFD))
- Reducing flooding - increase attenuation (under the EU floods Directive.)
- Sustainable Use (of Pesticides Directive.)
- Other and Emerging Contaminants (EC) of water
- Urban Waste Water (EU Directive)

Etc.

In the wider context…….

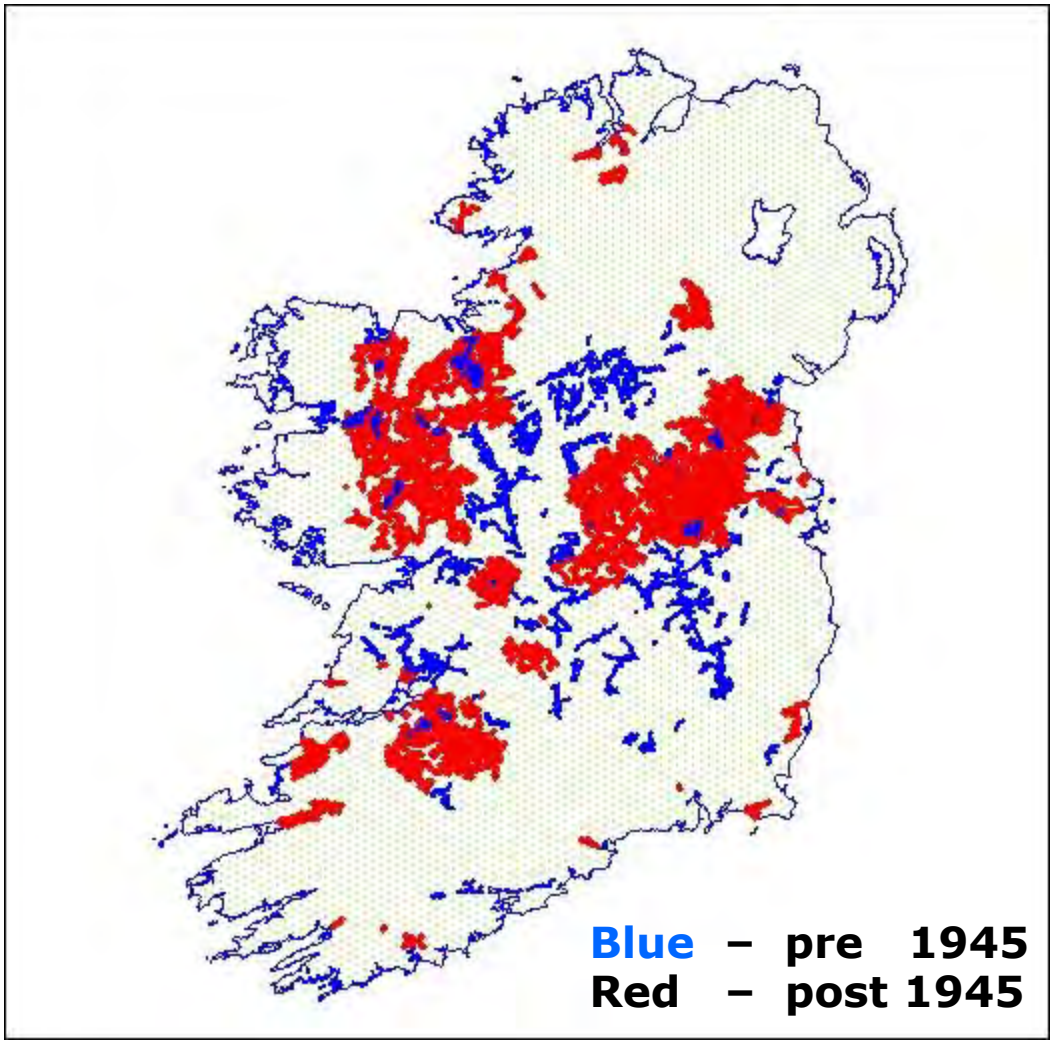
Human impact on Planet Earth has been accelerating for thousands of years; it's now ever more pervasive and its effects uncertain.

(9 Billion humans by 2050…….2 Billion more in 35 years?)

" Is another world Possible?"

Loss and recovery

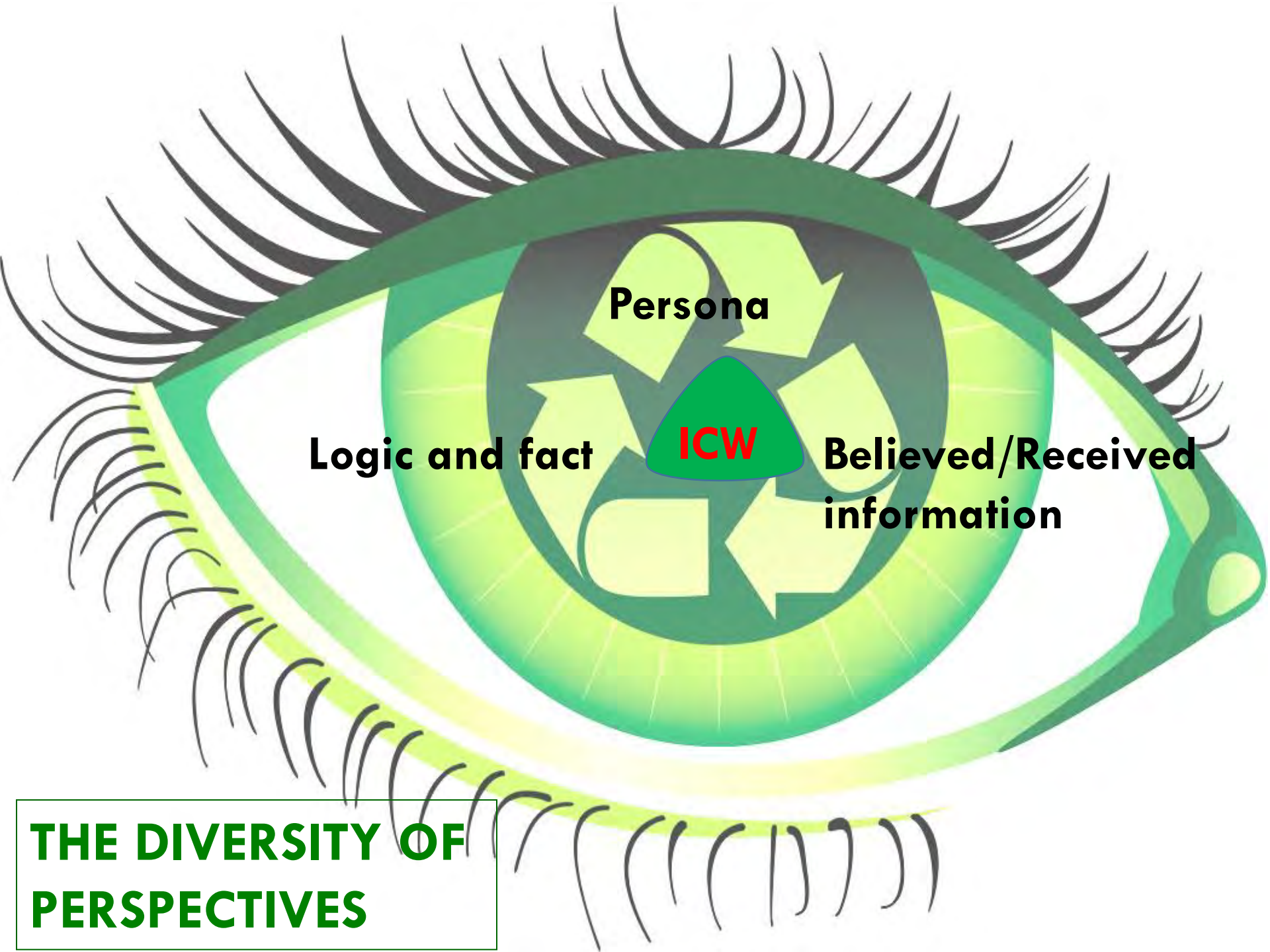
STATE ARTERIAL DRAINAGE IN IRELAND (RoI)



Restoring empathy and appreciation for wetlands requires understanding and……..

to understand how something works……
……the need to build or rebuild it and……

…….the need to remove the 'illusion of assumed understanding' !



THE DIVERSITY OF PERSPECTIVES

Forests have been ‘built’ and rebuilt……

……. so why not wetlands?

Ecological *reanimation* or *restoration*…….?

- ***Ecological reanimation*** focuses on facilitating **bio-geo-chemical processes** delivering self-managing (and self-facilitating) systems minimising 'leakiness' and entropy - sustainably

- ***Ecological restoration*** focuses on facilitating lost **biological assemblages** (within recent evolutionary time lines)

Understanding

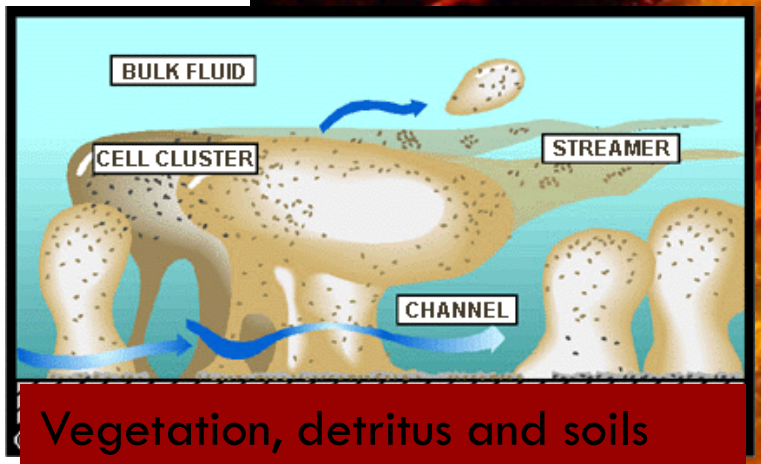
‘Tapping into’ 3.8 billion years of (microbial) evolution

Biofilms active on all support strata

On: solid substrates (soils and rock – and organic)

liquid – air (atmosphere) interfaces

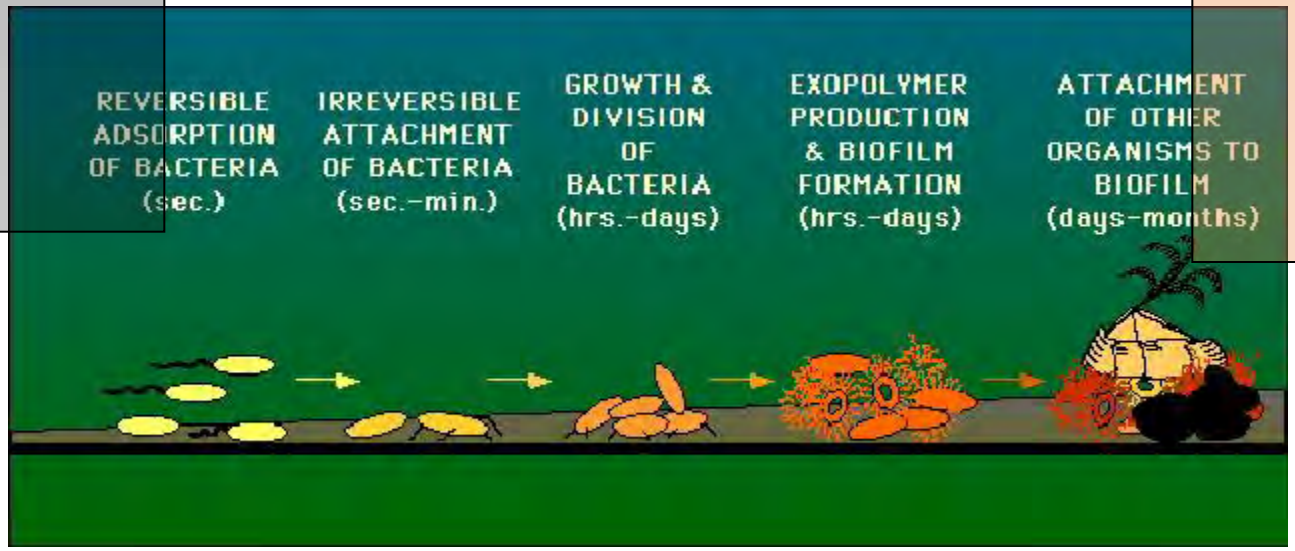
soft tissue of living organisms



Vegetation, detritus and soils

Commensal, symbiotic and parasitic

Biofilms: microcosms and ecosystems



ASKING

"Does the bowl in the garden mock nature, when night after night green frogs gather to prove it's a pool? Who says you can't make a pond out of a bowl?"

Han Yu, Tang dynasty

Who says we can't reanimate wetland ecosystems – providing functional ecosystems to serve society?

Society (land owners)

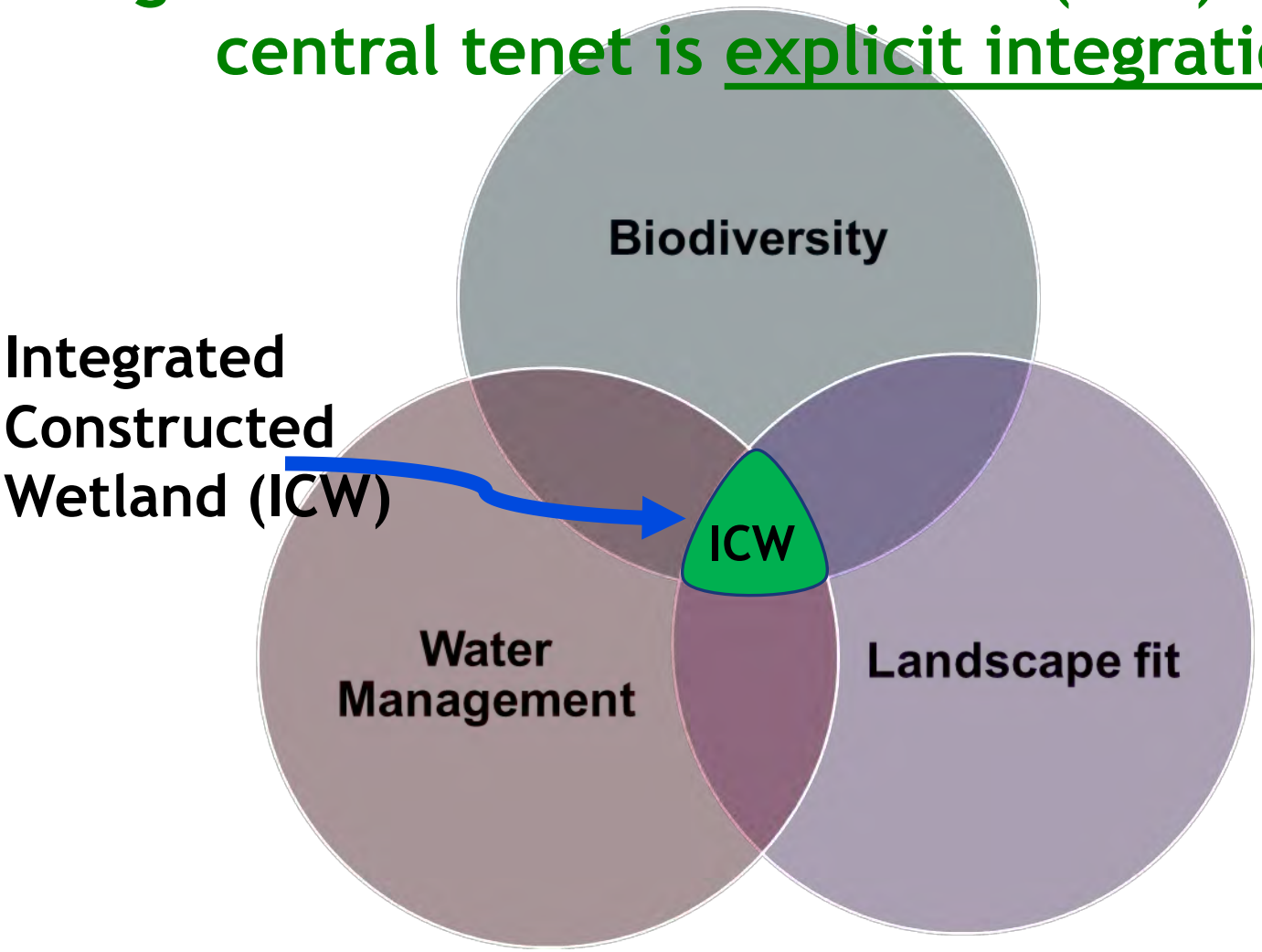
ASKING WHAT IF ……..?

- Land is used to make intercepting wetlands?
- Local soils are used?
- There is a serial cascade of inter-linked wetland cells?
- Tall emergent vegetation is used?
- Shallow depth is maintained?
- There is no pre-treatment?
- Drainage and sewage water are combined?

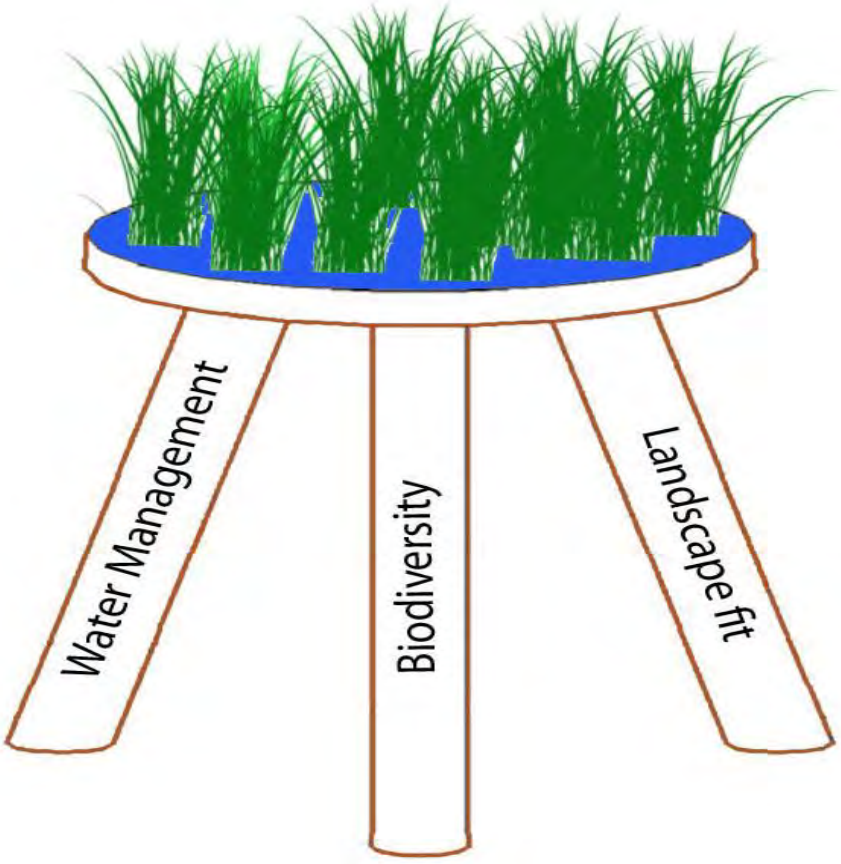
……and many more….?

Check out www.whatifwechange.org

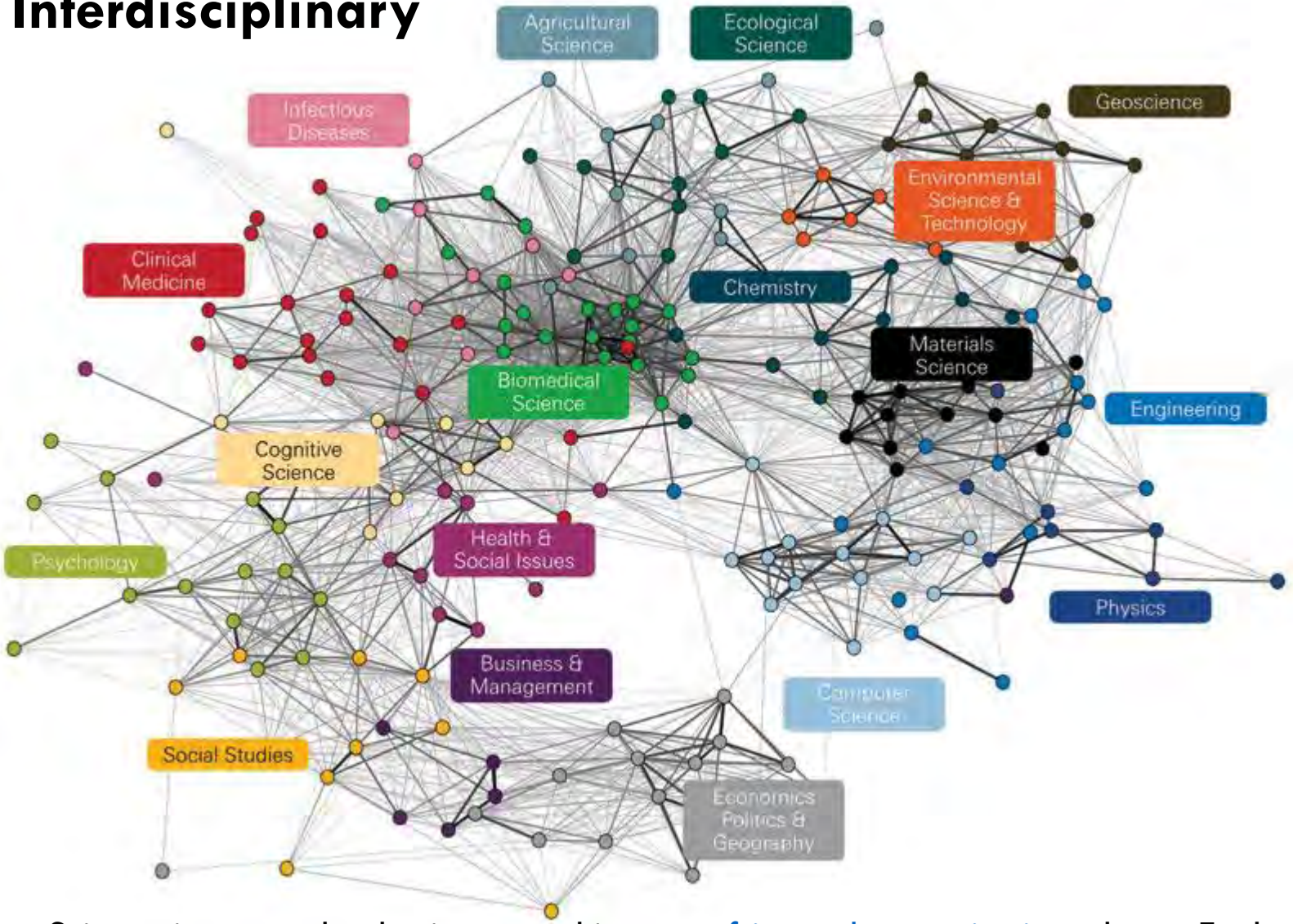
Integrated Constructed Wetland (ICW) concept's central tenet is explicit integration



Integration provides robustness:
Dependable stable function, with positive synergies



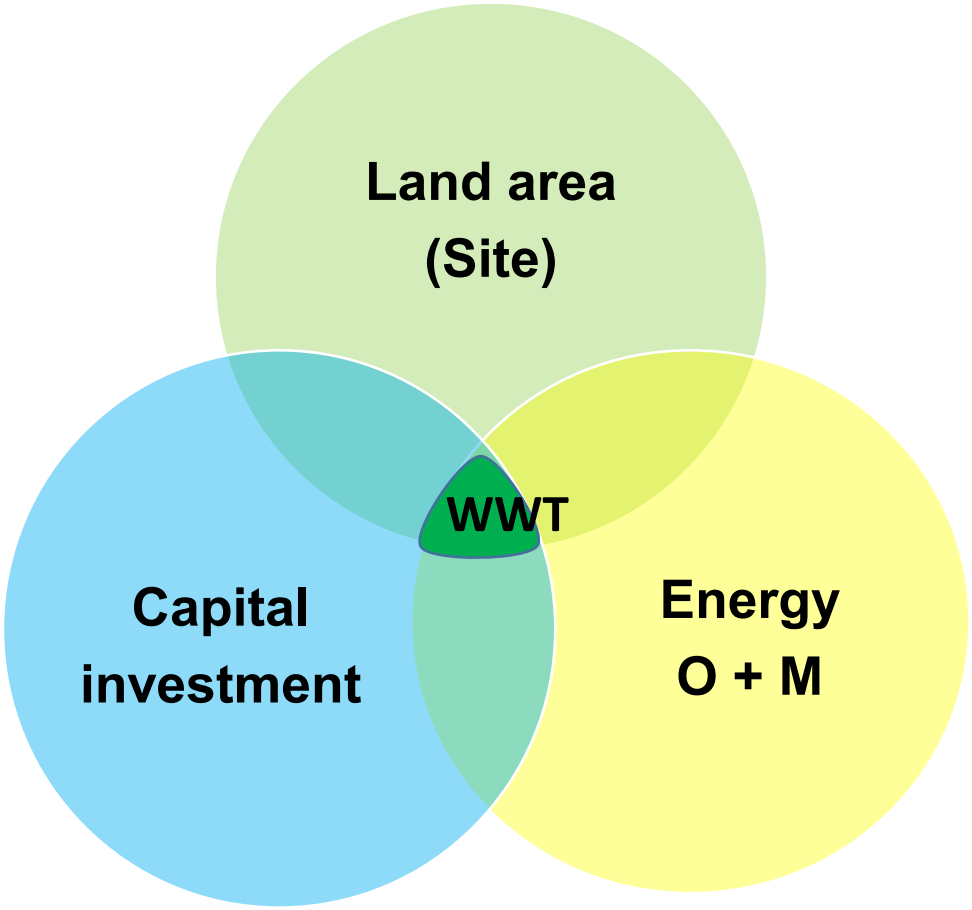
Interdisciplinary



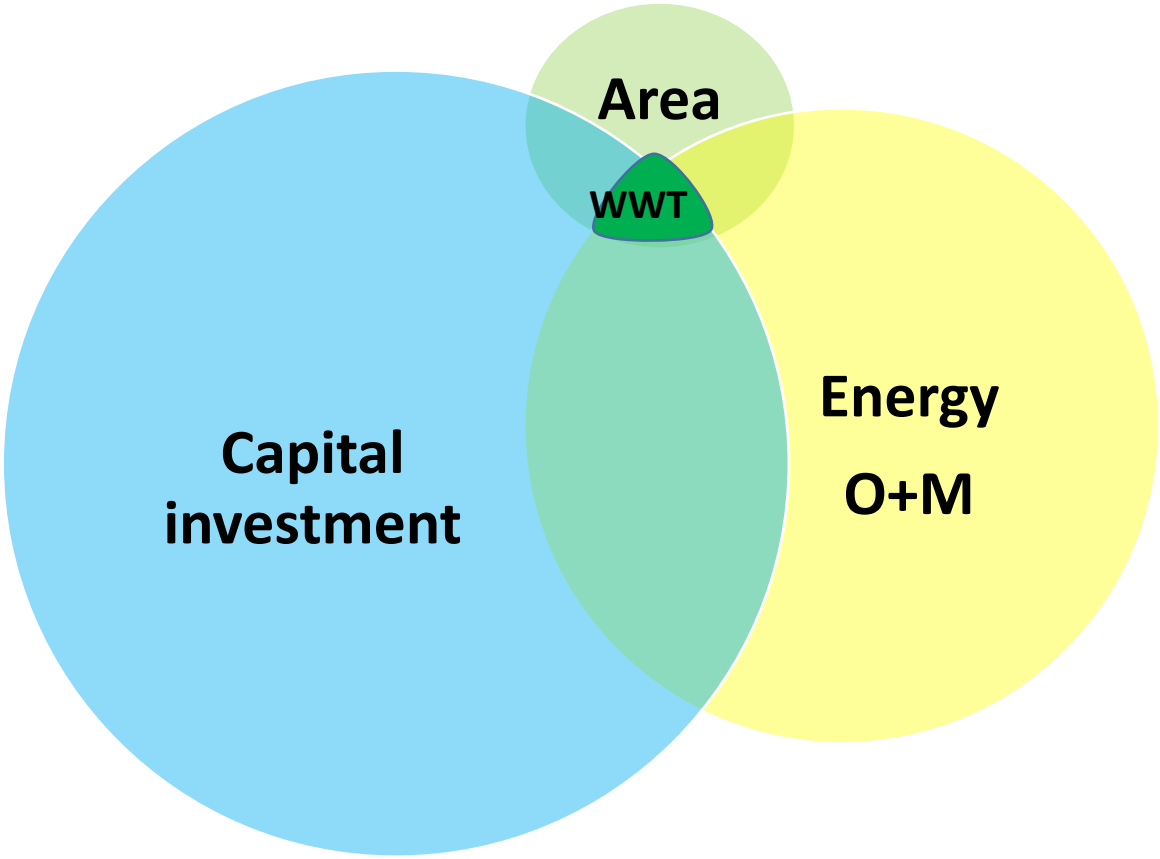
Science is a complex business, as this [map of journal cross-citations] shows. Each node represents a subdiscipline and the lines represent the strength of similarity between the nodes. Image: Rafols, I et al., Science overlay maps

Land use

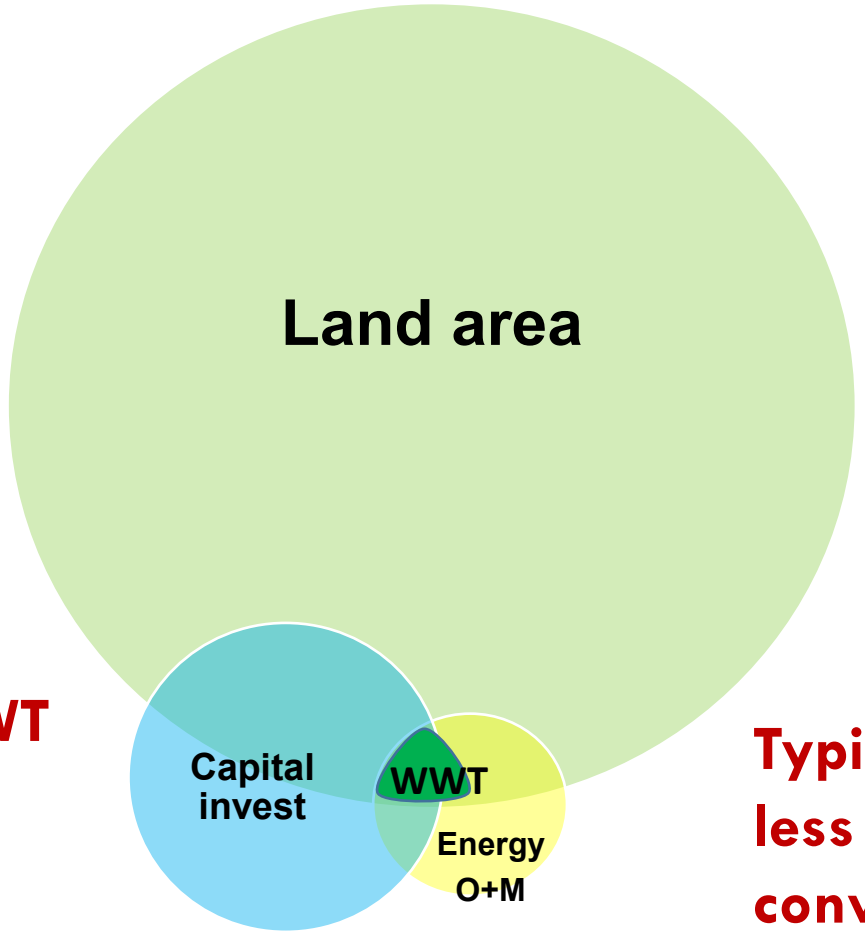
Primary cost factors for wastewater treatment systems



Cost of conventional electro-mechanical wastewater treatment (WWT) systems



Cost of Integrated Constructed Wetland (ICW) systems



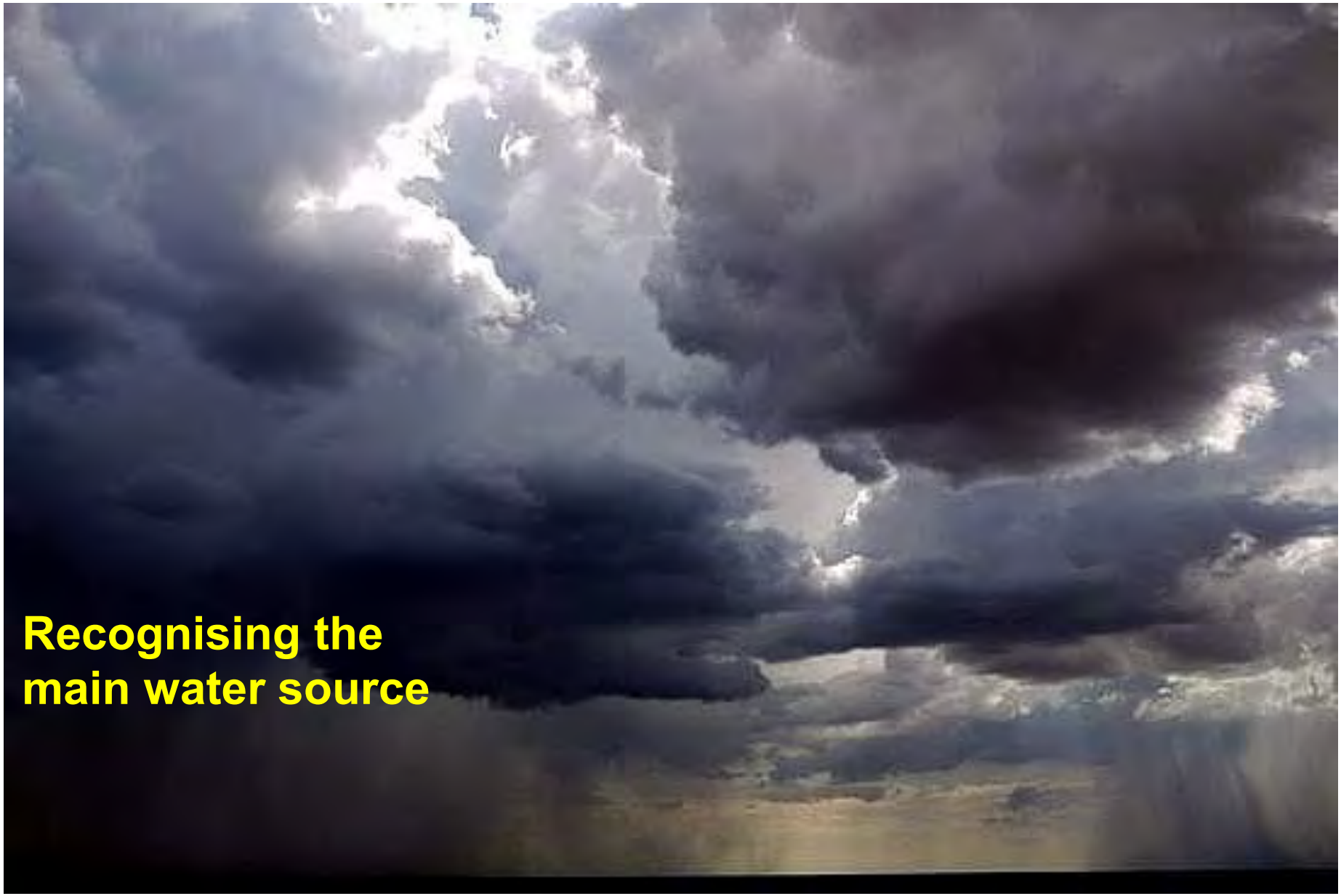
Typically 60 – 80% less than conventional WWT (including land cost)

Typically >90% less than conventional WWT

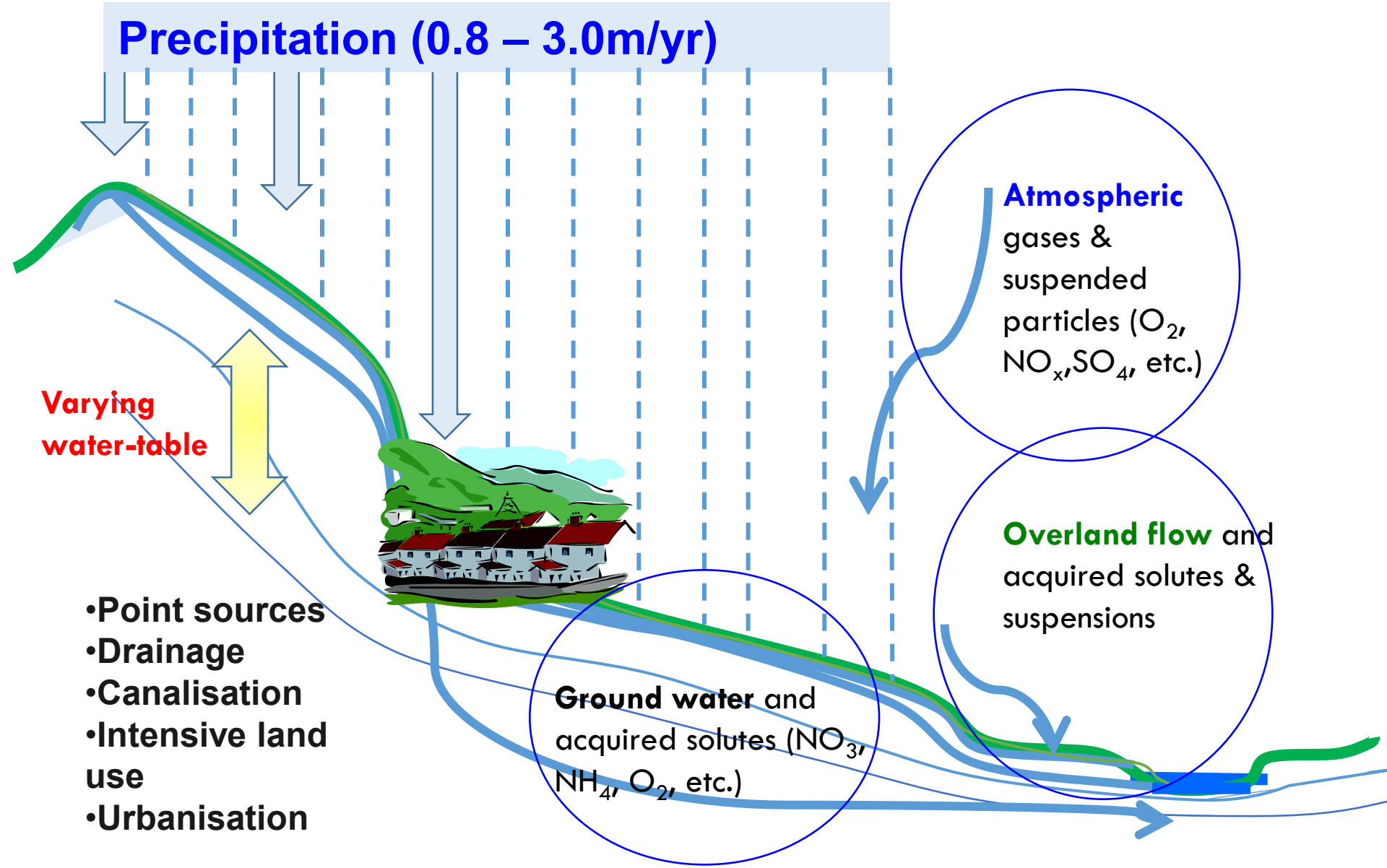
Water use

Annestown stream: from a canalised dirty weedy drain, to one that supports trout and salmon


25 years of reanimation

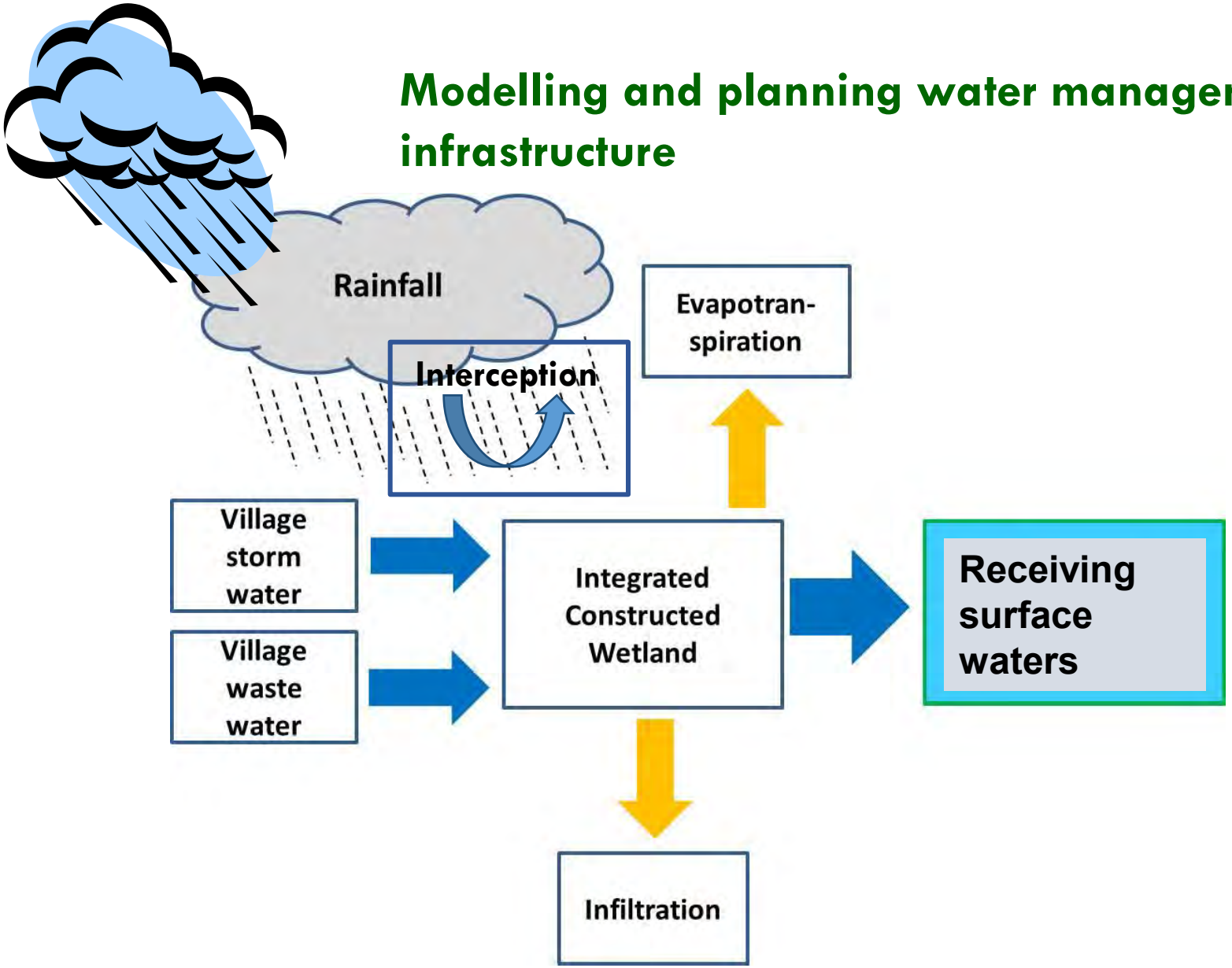

Recognising the
main water source


Flow (volume/time) - its
unpredictability/seasonality

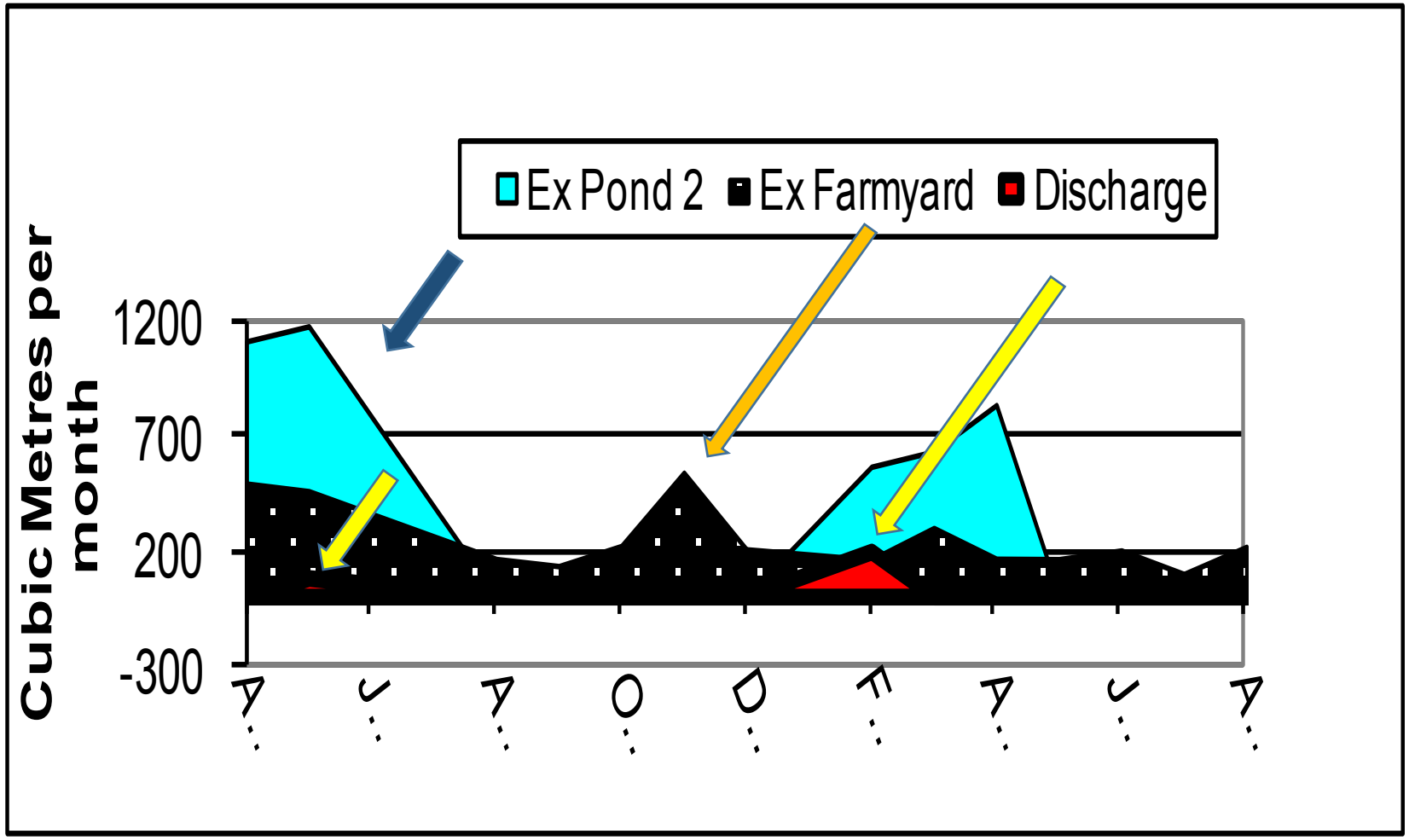


Water: a vector with 3 phases; gas, liquid and solid

Modelling and planning water management infrastructure



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



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

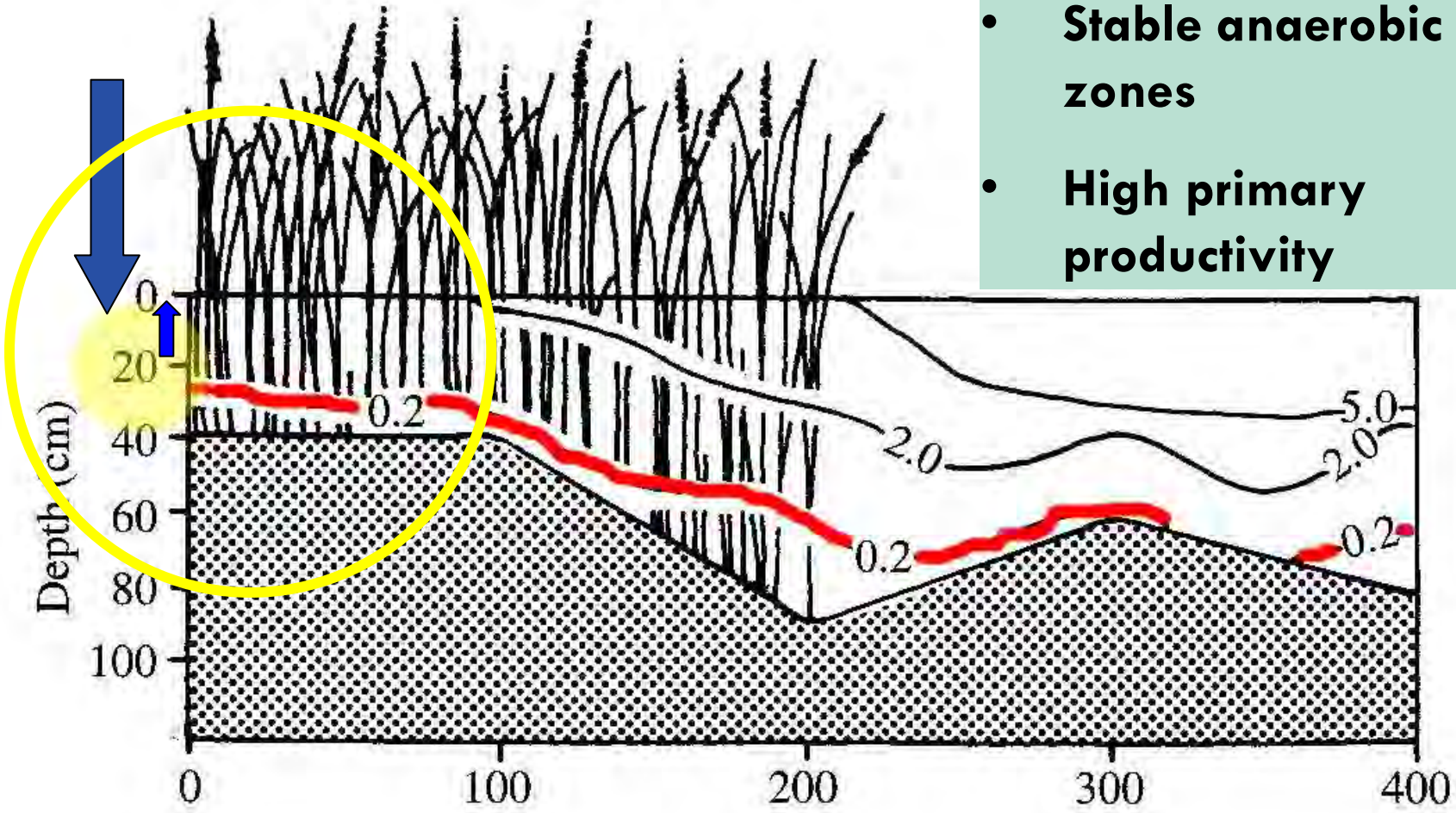
Water and its constituents can be recycled

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

Emergent vegetation & wetland design

Shallow water depth and emergent vegetation providing:

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

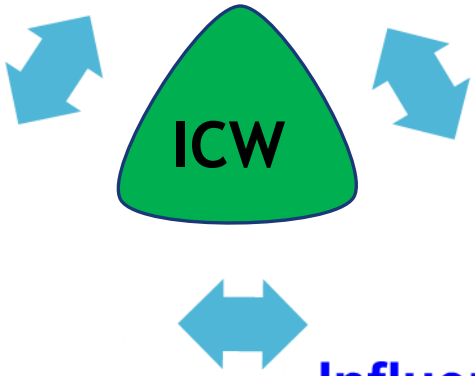


Dissolved O_2 isotherms / water depth

Specific requirements:

Hydraulic loading (Weather related flux flow)

Adequate area (Area:Flow)



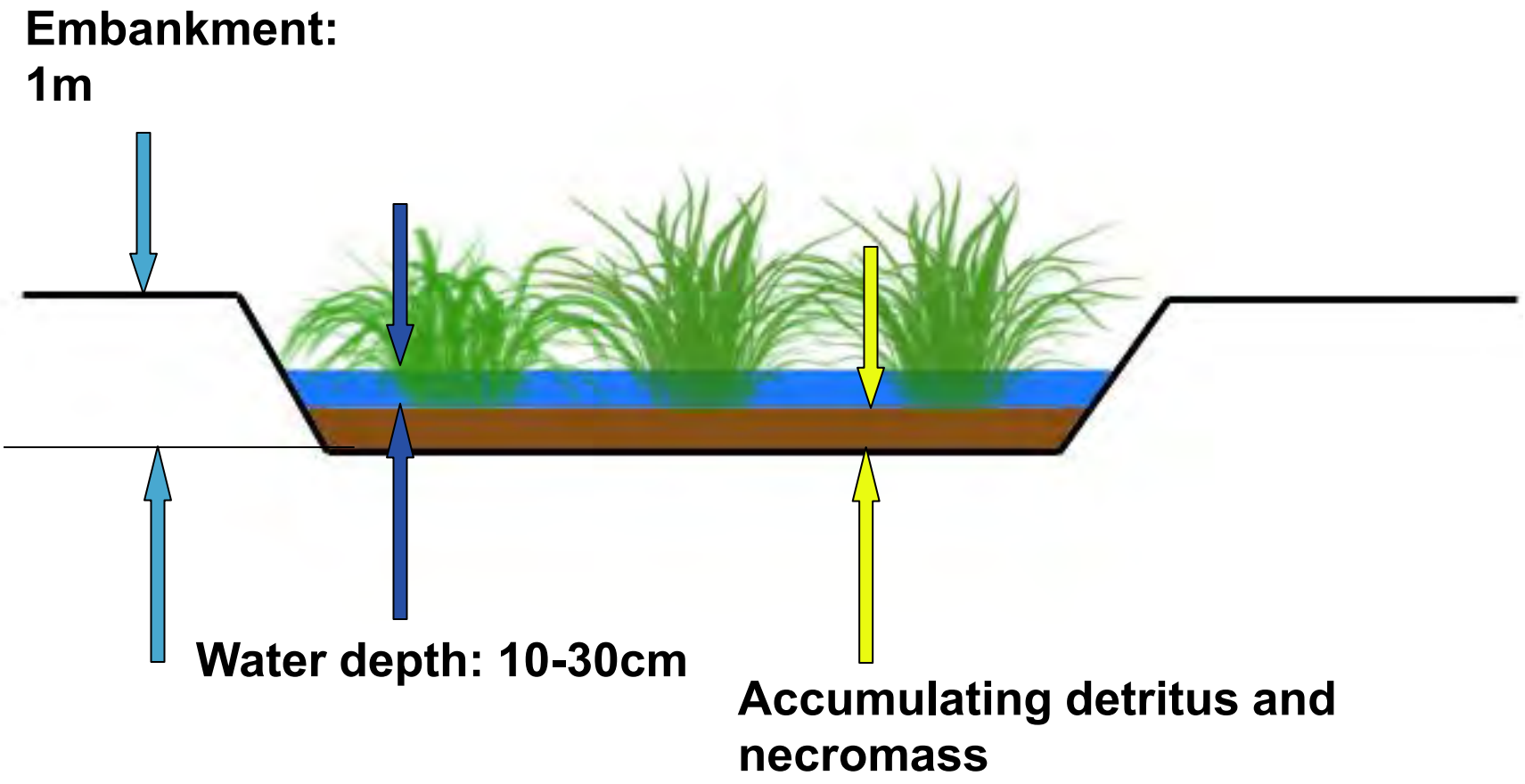
Soil characteristics and depth

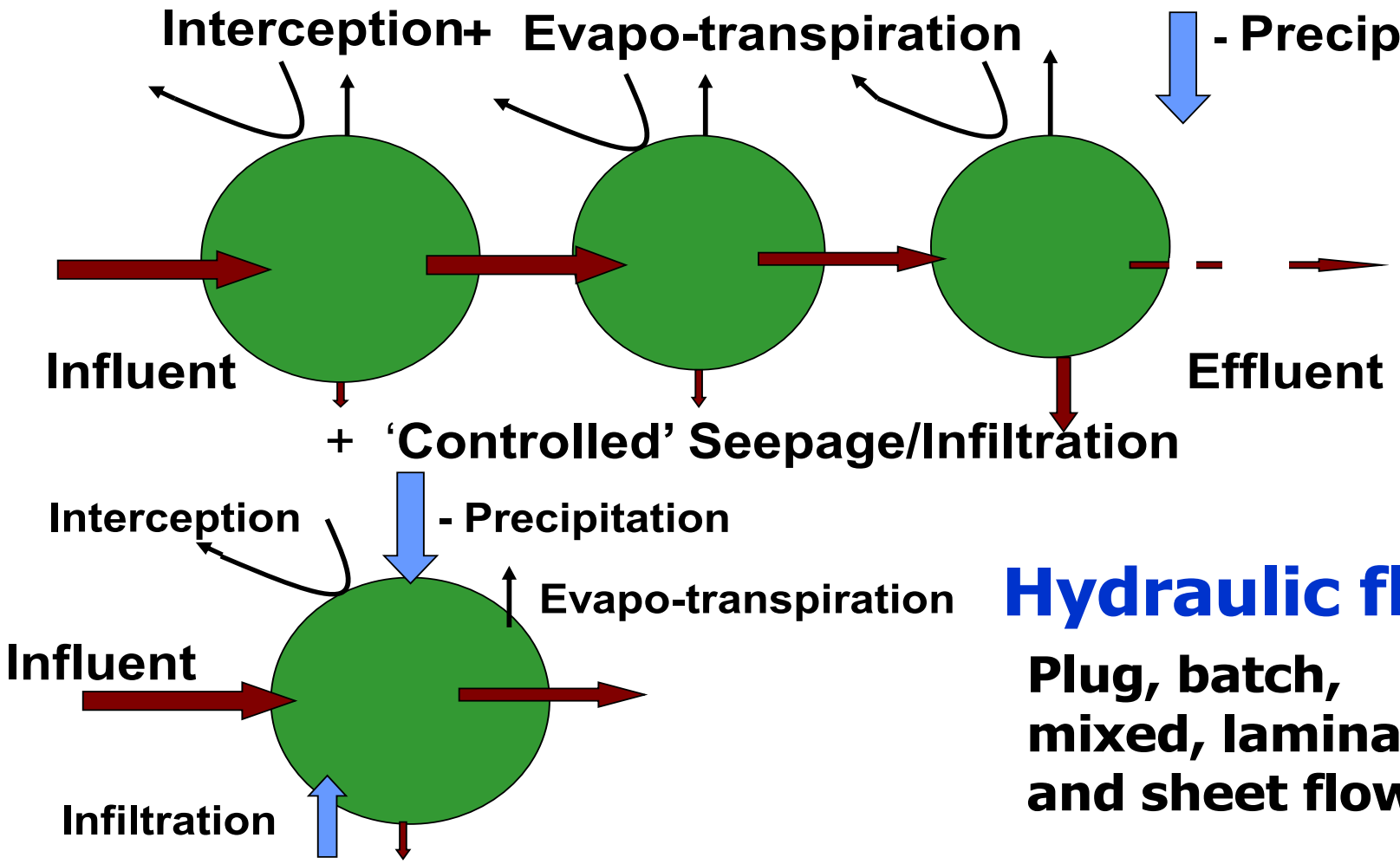
Influent characteristics (ionic strength, ammonium-N)

Use of local or on- site soils: Soil permeability

Toxicity to vegetation: need for recycling?

Cross sectional view of wetland cell showing embankment and water depth





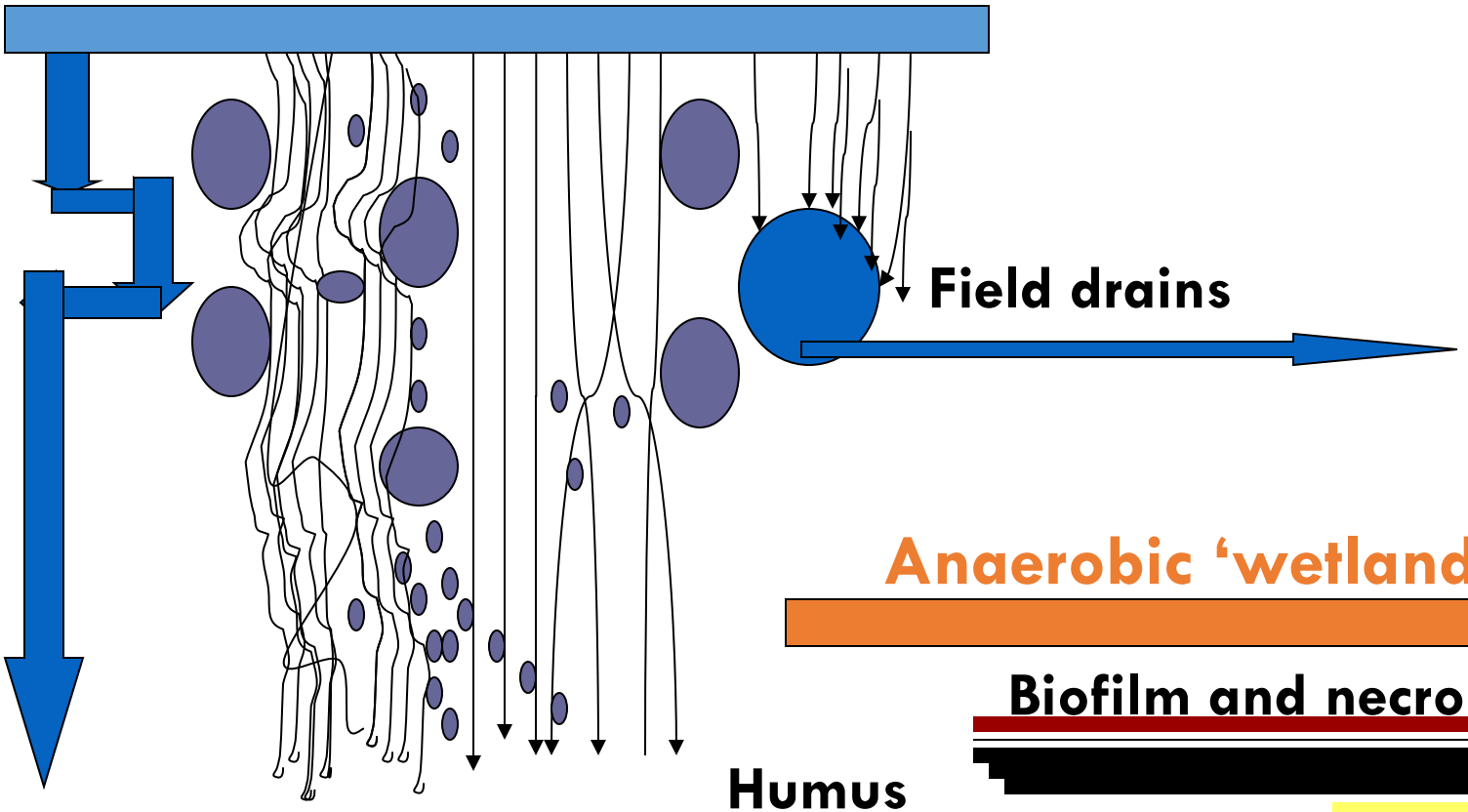
Hydraulic flows

Plug, batch, mixed, laminar and sheet flows

Soils

Using local and *in-situ* soils and location

Aerobic ‘terrestrial’ soil



Anaerobic ‘wetland’ soil

Biofilm and necromass

Humus

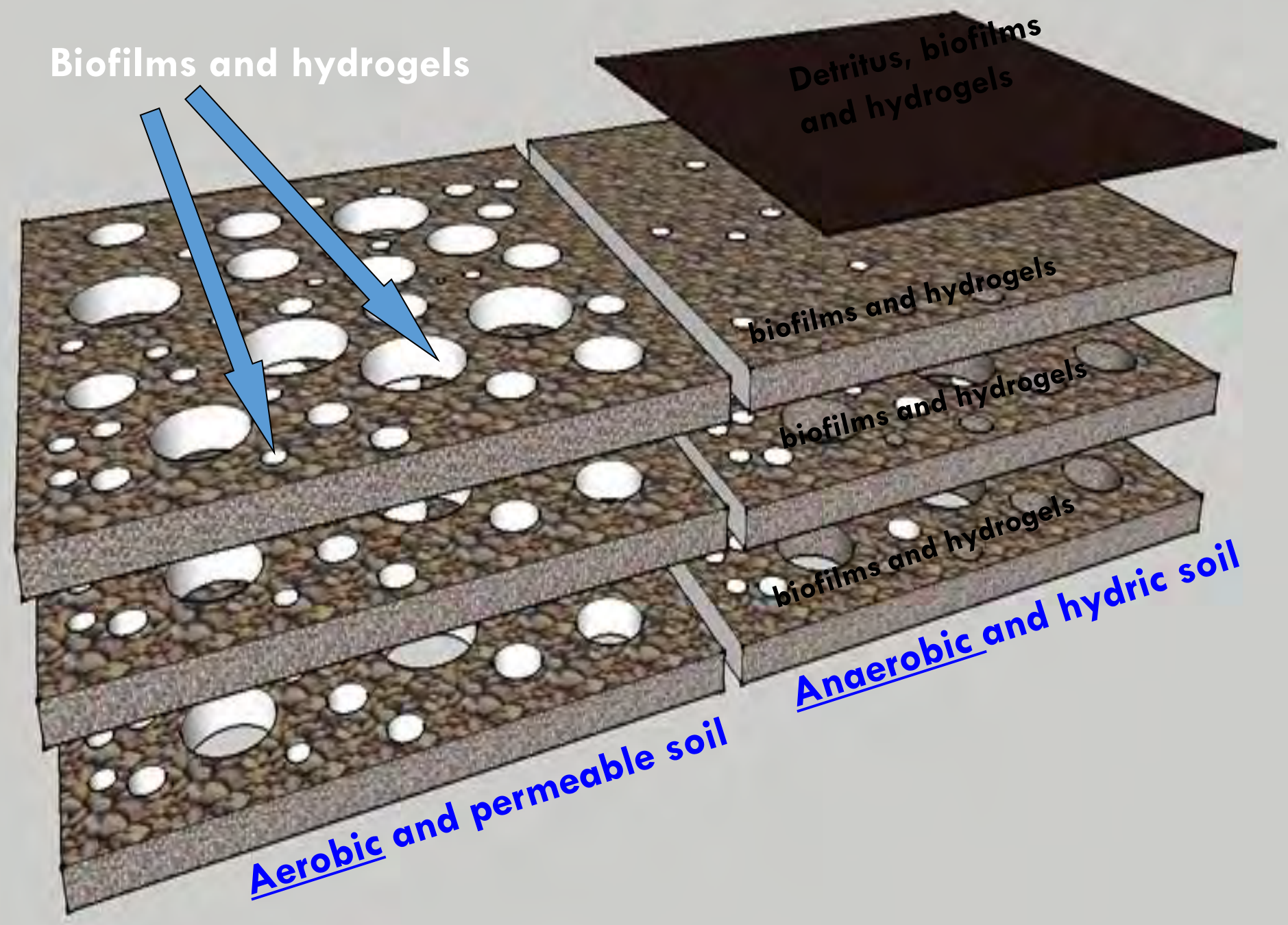
Humic/fumic acid (plasticers/surfactants)

Phenols

Methane bubbles

Fe^{2+} Mn^{2+} → Fe^{3+} Mn^{3+}

O_2 →


Biofilms and hydrogels
Detritus, biofilms and hydrogels
biofilms and hydrogels
biofilms and hydrogels
biofilms and hydrogels
Anaerobic and hydric soil
Aerobic and permeable soil

ICW systems have a soil-based infrastructure

Understanding the water table and infiltration to and from soil is essential

Wetland soils have an entirely different structure to aerobic/terrestrial soils;
they retain water!

1.) Level
2.) Establish base integrity:
- finish with re distributed topsoil
- remove drains/drainage
- flood and track (puddling)

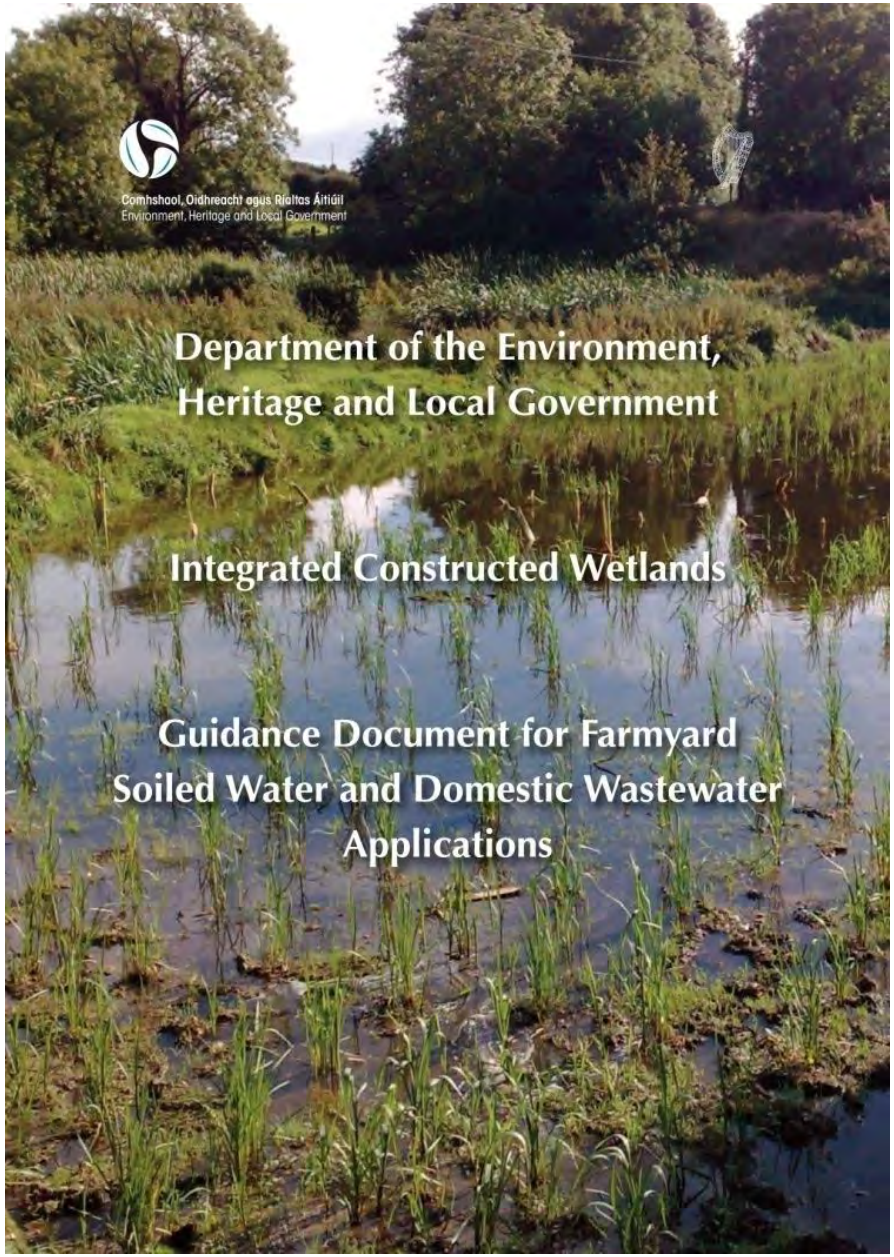

March 2012


March 2012


January 2013


August 2013

Guidance applied



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

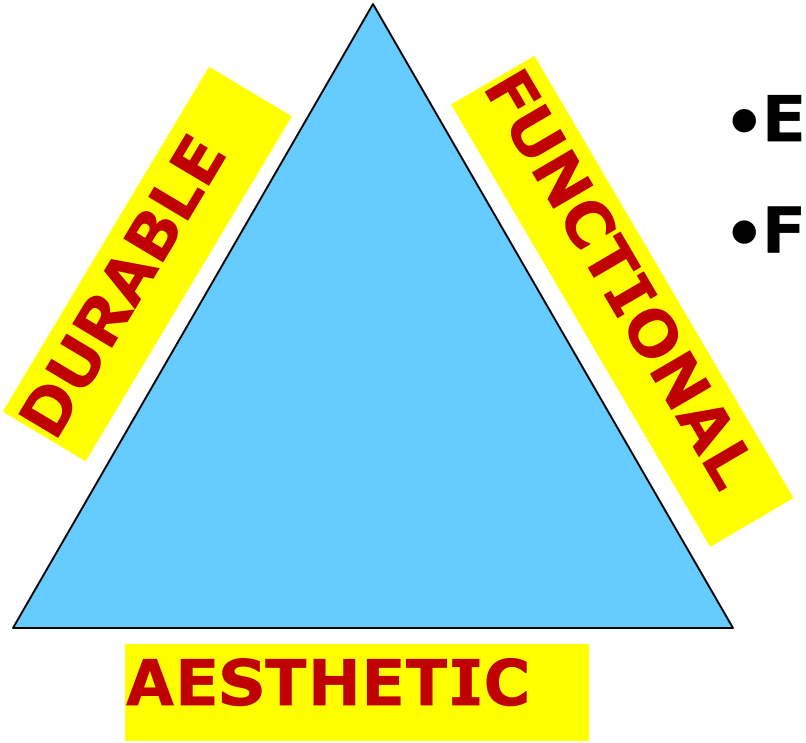
Department of Environment, Heritage & Local Government

National Parks & Wildlife Service

Éamon de Buitléar

Applies the 'universal design' model

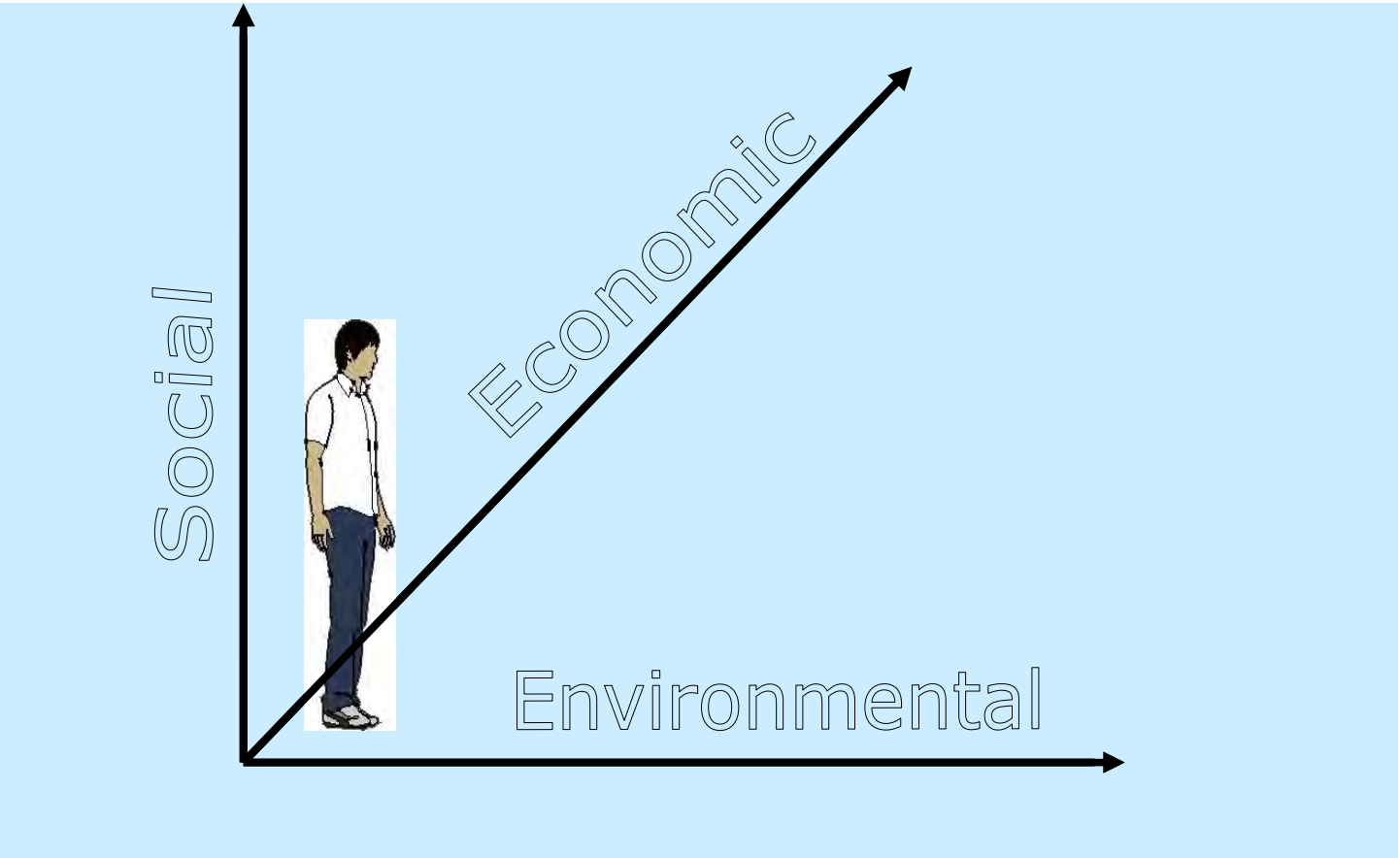
- Sustainable
- Robust
- Soc.Econ.Env. coherent

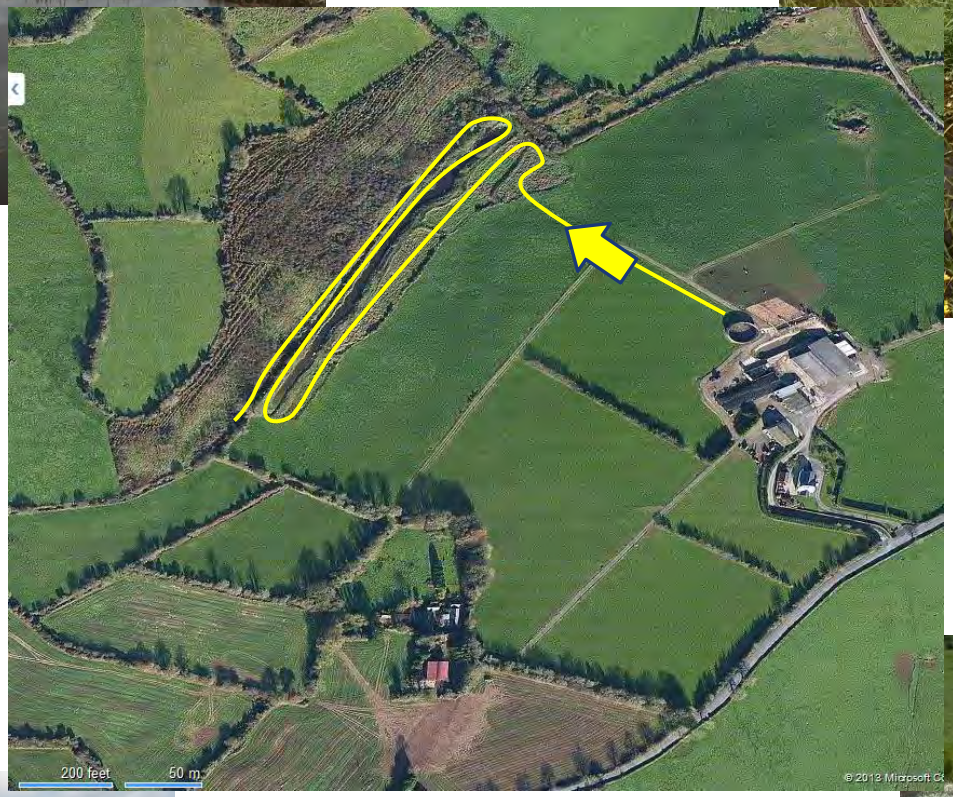


- Effective
- Fit for purpose

- Beautiful
- 'In context' - as if it had always been there

ICW concept considers the science of the 'total environment'

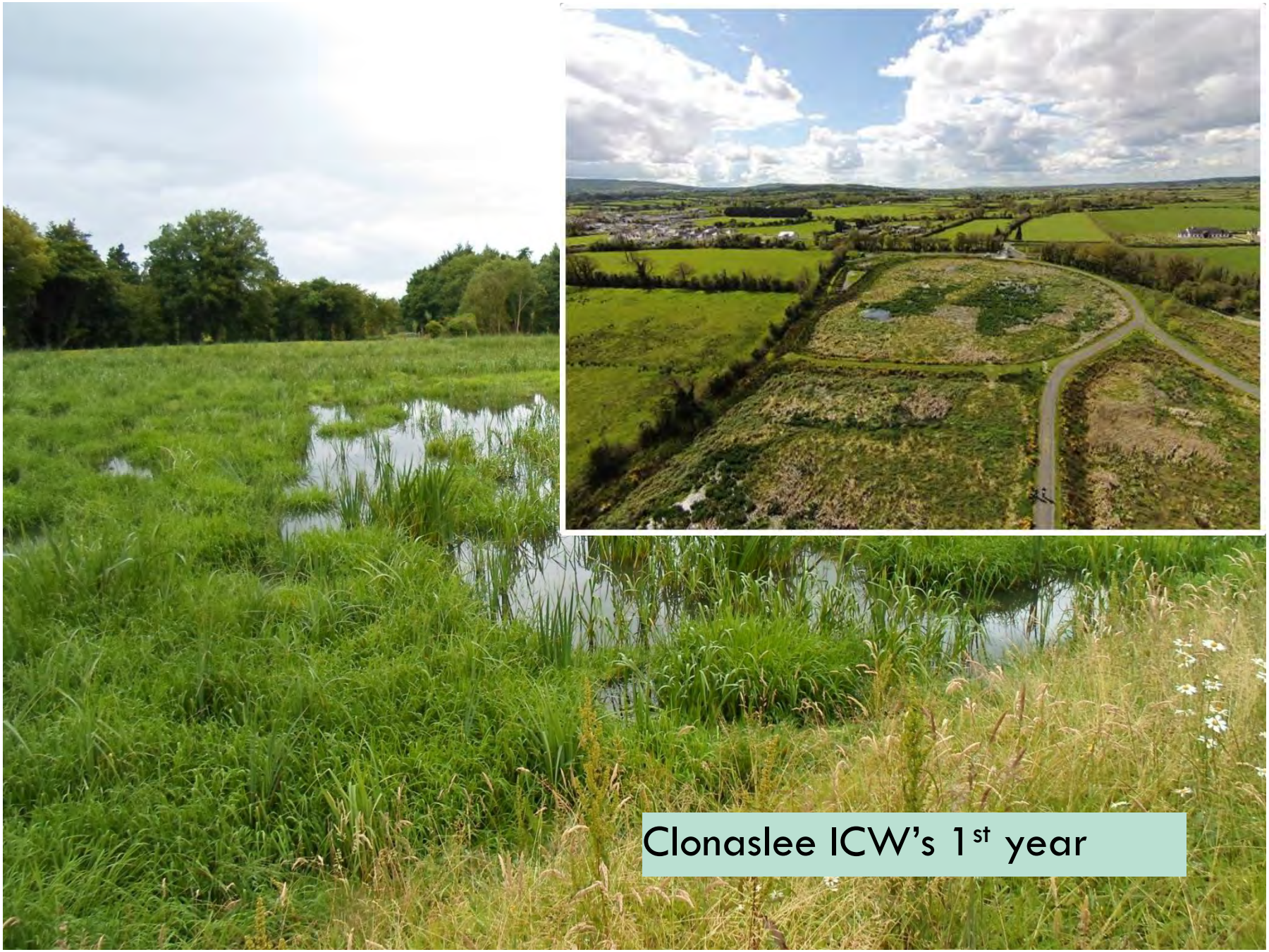



200 feet
50 m

Construction of ICW for the treatment of municipal wastewater; Clonaslee, C. Laois

Clonaslee Integrated Constructed Wetland

3 months after completion



Clonaslee ICW's 1st year

Clonaslee Integrated Constructed Wetland

Wastewater Treatment for Clonaslee, Co. Laois. 2013

The Clonaslee "Integrated Constructed Wetland" was officially opened by the Minister for the Environment, Community & Local Government , Phil Hogan on the 8th of February 2013.

Integrated Constructed Wetlands (ICWs) have been developed to treat a range of wastewaters including municipal sewage and have been in use in Ireland for the past 20 years.

The ICW at Clonaslee is comprised of a series of five ponds and two receiving settlement ponds covering approximately **5 Ha**.
This ICW has proved to be a **low cost, low energy & low maintenance alternative to traditional wastewater treatment systems** and are particularly suited to small rural villages and towns such as Clonaslee.

The ICW at Clonaslee has proven to remove over 90% of all pollutants from the received effluent and has improved to quality of the receiving River Clodiagh.

Site prior to construction

Primary settlement ponds

Entrance control buildings

Established planting July 2012

The Clonaslee ICW is designed to treat sewage and storm water flows from the town of Clonaslee. It has been designed to serve a population of 1200. Prior to the installation of the wetland system Clonaslee was served by a waste water treatment system, which had been in operation since its installation in the 1940's.

In 2009 Laois County Council set about upgrading the waste water treatment system to provide a system with increased capacity and to comply with Environmental Protection Agency (EPA) licensing requirements.

Pipe work installation

Newly planted pond

Soil Testing

Monitoring equipment

Final Pond during construction

The Clonaslee ICW provides a **low cost** solution to wastewater treatment, **enhances biodiversity** in the surrounding environment, provides a **recreational facility** for the local and regional population while also providing an **educational resource** for local and regional schools and colleges.

Clonaslee ICW was constructed in Winter/Spring 2011/2012 and has been in operation since May 2012. Since its commission, the ICW at Clonaslee has consistently **provided a high performance of effluent treatment** with all parameters discharging well below the Emission Limit Values as defined by the EPA discharge licence.

Other Integrated Constructed Wetlands around the country.....

Kilbogget Park, Dublin

Glaslough, Co. Monaghan

Tolka Valley Park, Dublin

Dungarvan Landfill

Dunhill, Co. Waterford

If you wish to view the site at Clonaslee or any other ICW site, please contact us to arrange an appointment.

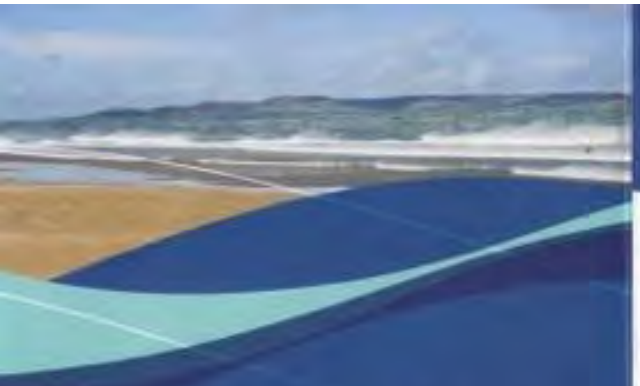
VESI Environmental Ltd.

3013 Euro Innovation Park, Euro Business Park, Little Island, Cork, Ireland.
Tel/Fax: +353 (0)21 4355912 Email: info@vesienviro.com Website: www.vesienviro.com

Glaslough Village sewage treatment, Co. Monaghan (Population equivalent = 1700)

A capital cost saving of c.70% and OM saving of 90%

Equestrians using riding trails along embankments of ICW systems---- babies taken for a stroll



Bag it and Bin it...
...don't flush it!

It is essential that you take care with what you flush down the toilet.

Blockages caused by objects that the sewerage system has not been designed for can create huge damage to your and possibly your neighbours' properties.

What can be flushed:

- Human waste (excrement)
- Toilet paper (not too much and not the most extra strong type)

Bag and bin all of the following:

- Sanitary items - towels, tampons, applicator, panty liners, backing strips, etc
- Disposable nappies, liners and baby wipes
- All wipes, including baby, bathroom and toilet
- Incontinence pads
- Condoms and femidoms
- Colostomy bags
- Bandages and plasters

Bin all of these:

- Cotton buds, cotton wool
- Contact lenses
- Toothbrushes

http://www.niwater.com/bag-it-and-bin-it/

...Play Safe Stay Safe...

NI Water has some simple steps on how to stay safe during construction work in your area:

1. Don't climb on barriers and fences - they are there to protect you from serious injury and accidents when NI Water construction work is going on.

2. Stay away from trenches and open manholes - they are dirty, deep and dangerous. They may also contain hazardous gases.

3. Be careful near roads - never run out from behind parked vans or lorries as you could be knocked down and injured.

4. Keep clear of equipment - you may see diggers, lorries, pipes and other equipment, but don't be tempted - steer clear and don't touch!

5. Obey 'Danger' signs - reservoirs and treatment works can be dangerous places, so stay well away and always obey the warning signs.

Northern Ireland Water
PO Box 1026
BELFAST
BT1 9DJ

Email: waterline@niwater.com
Waterline: 08457 440088
www.niwater.com

northern ireland water

northern ireland water

Stoneyford Integrated Constructed Wetland

Brief information on proposals


Tolka Valley Park ICW, Dublin City

Kilbogget Park, Cabineteely, Dublin

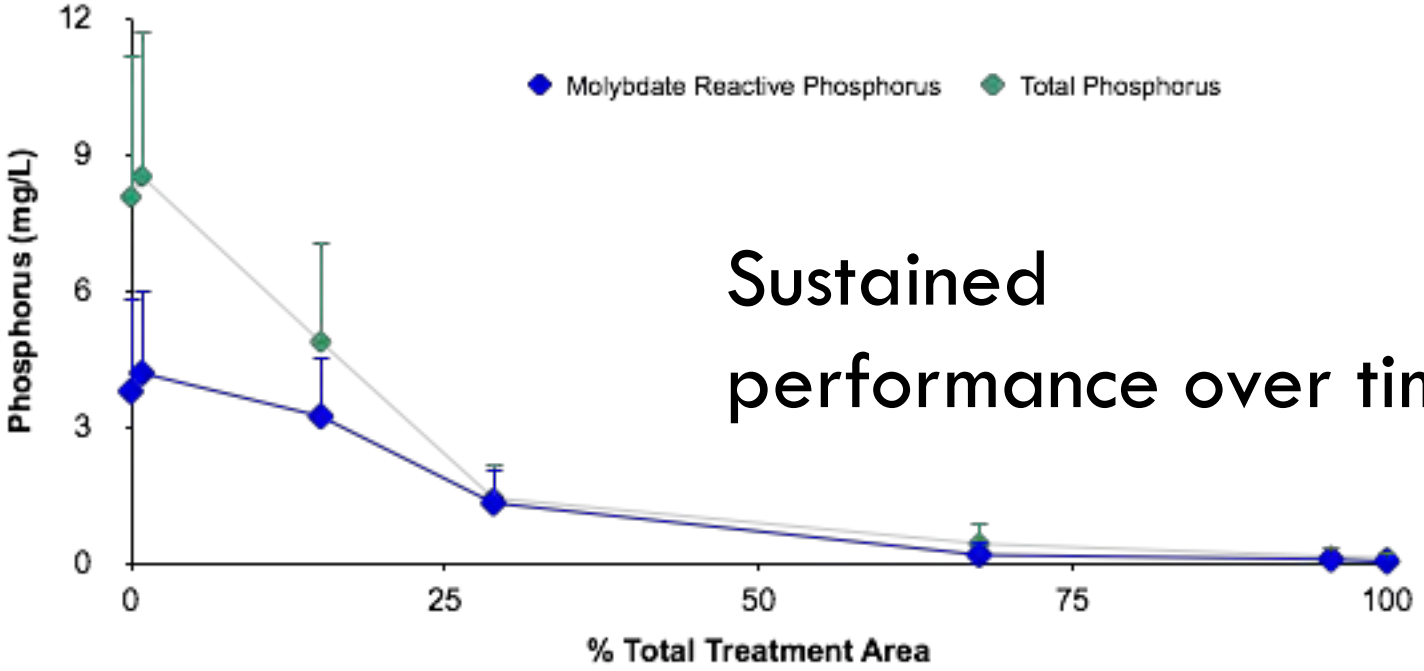
SINGLE HOUSE ICW

- ICW for single house
- No discharge to adjacent stream
- Integrated into garden

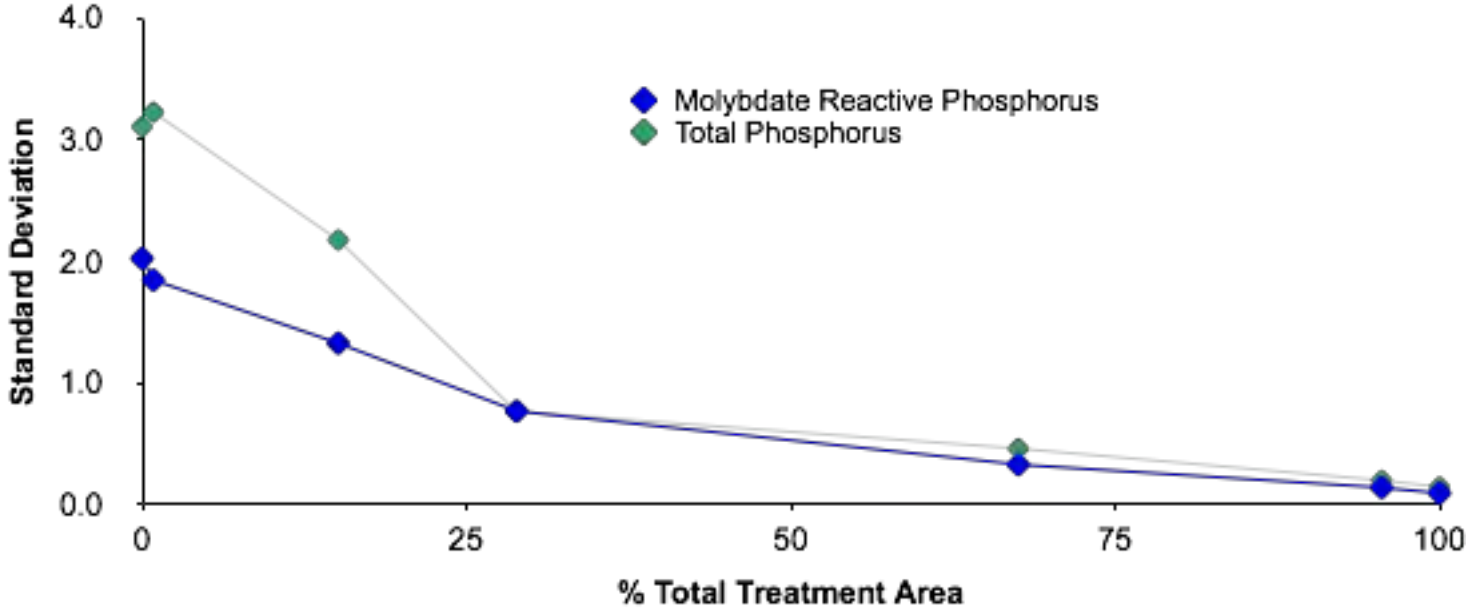
Building *empathy* with nature

Drainage increases flood risk: Wetlands attenuate

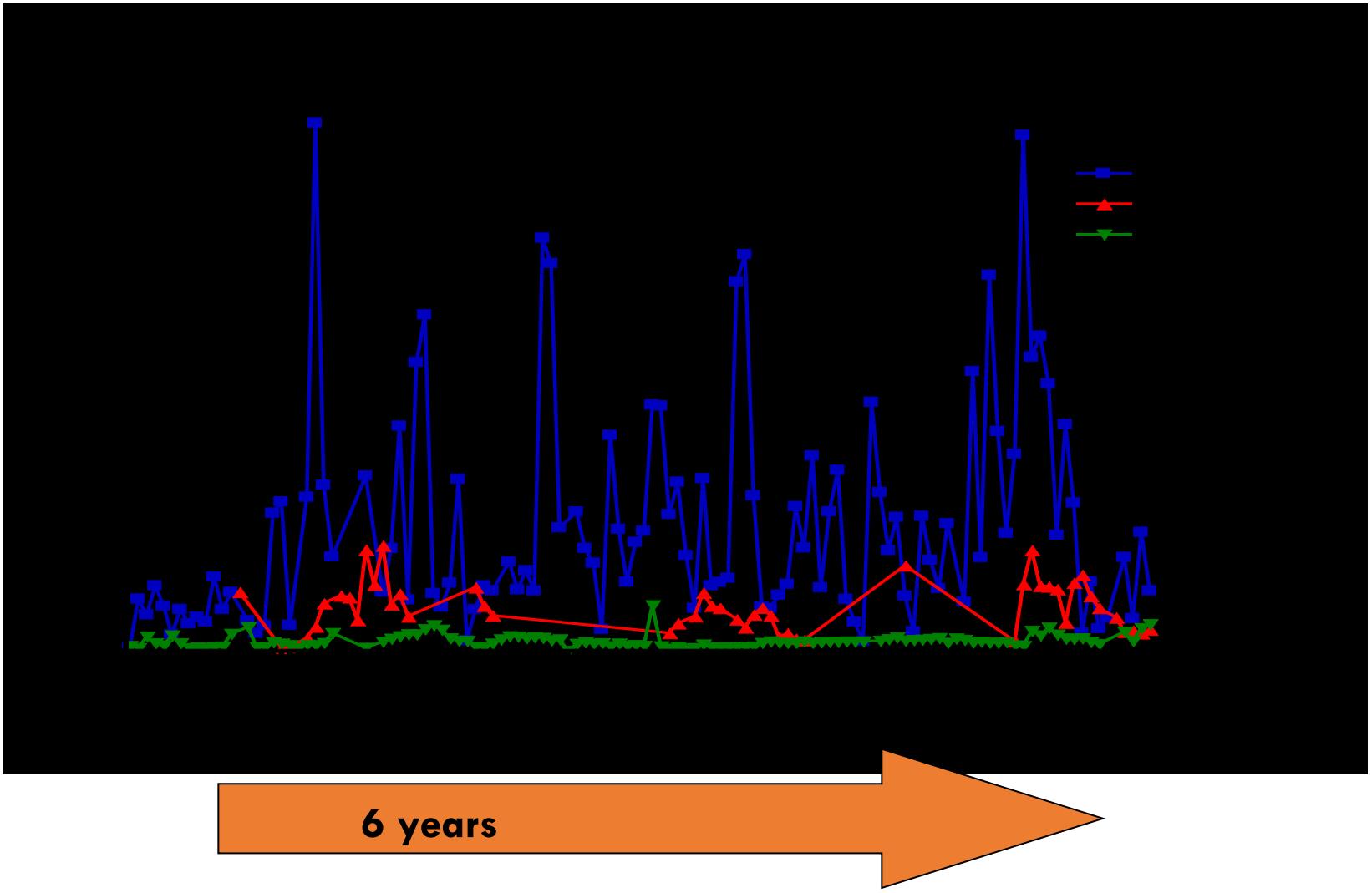
Performance



Sustained performance over time



Phosphorous reduction: the ‘least performing’ ICW of 12 farmyard ICW systems



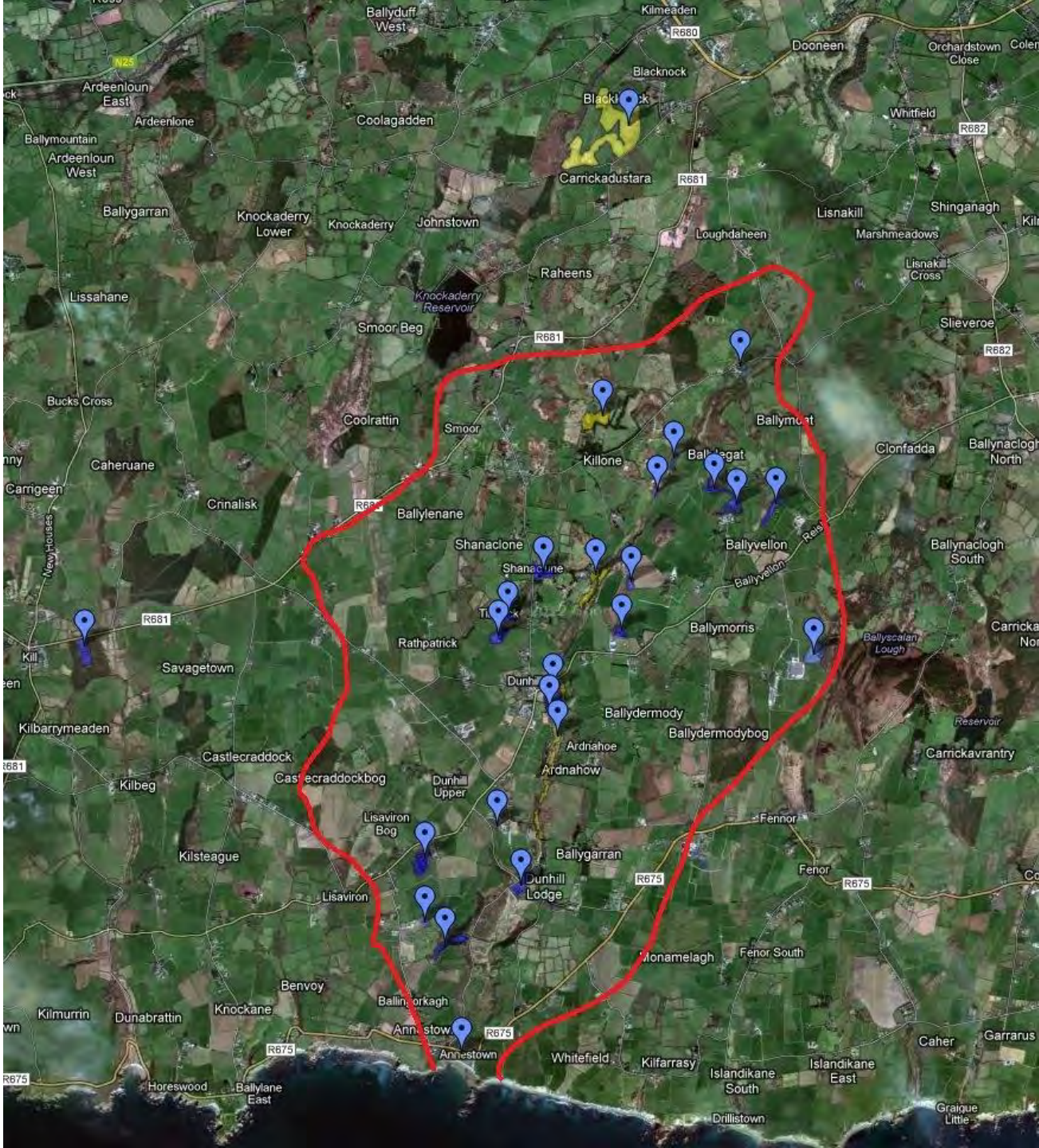
Bio-safety and ICW systems (coliform results (20/01/09)) - Glaslough ICW

CELL NUMBER	SAMPLING POINT	**ECOLI (Fecal Coliforms) per 100 mls**	TOTAL COLIFORMS per 100 mls	**ACCUMULATIVE PERCENTAGE OF ICW AREA**
Sludge pond	INLET	**559950**	>1209800	**1.2**
1	INLET	**86640**	>241960	**15**
2	INLET	**20924**	48392	**29**
3	INLET	**292**	1074	**67.5**
4	INLET	**<10**	63	**96**
5	OUTLET	**<5**	**49**	**100**
Mountain River Upstream	RIVER	**698**	2897	
Mountain River Downstream	RIVER	**429**	2737.5	

Anne Valley catchment : Map shows the most significant reanimated wetlands in the Anne Valley catchment, including ICW systems

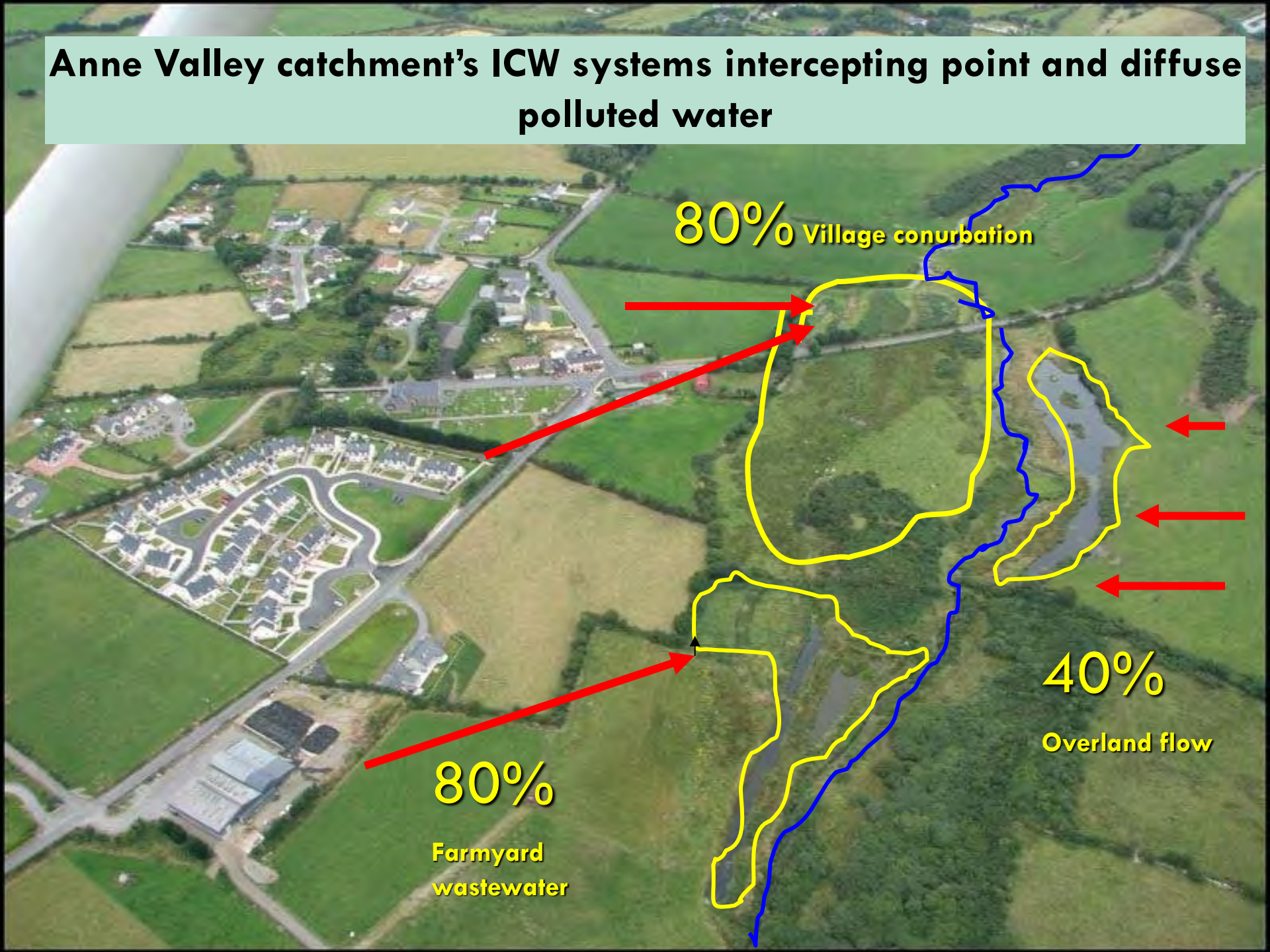
Catchment area = 2,500ha:

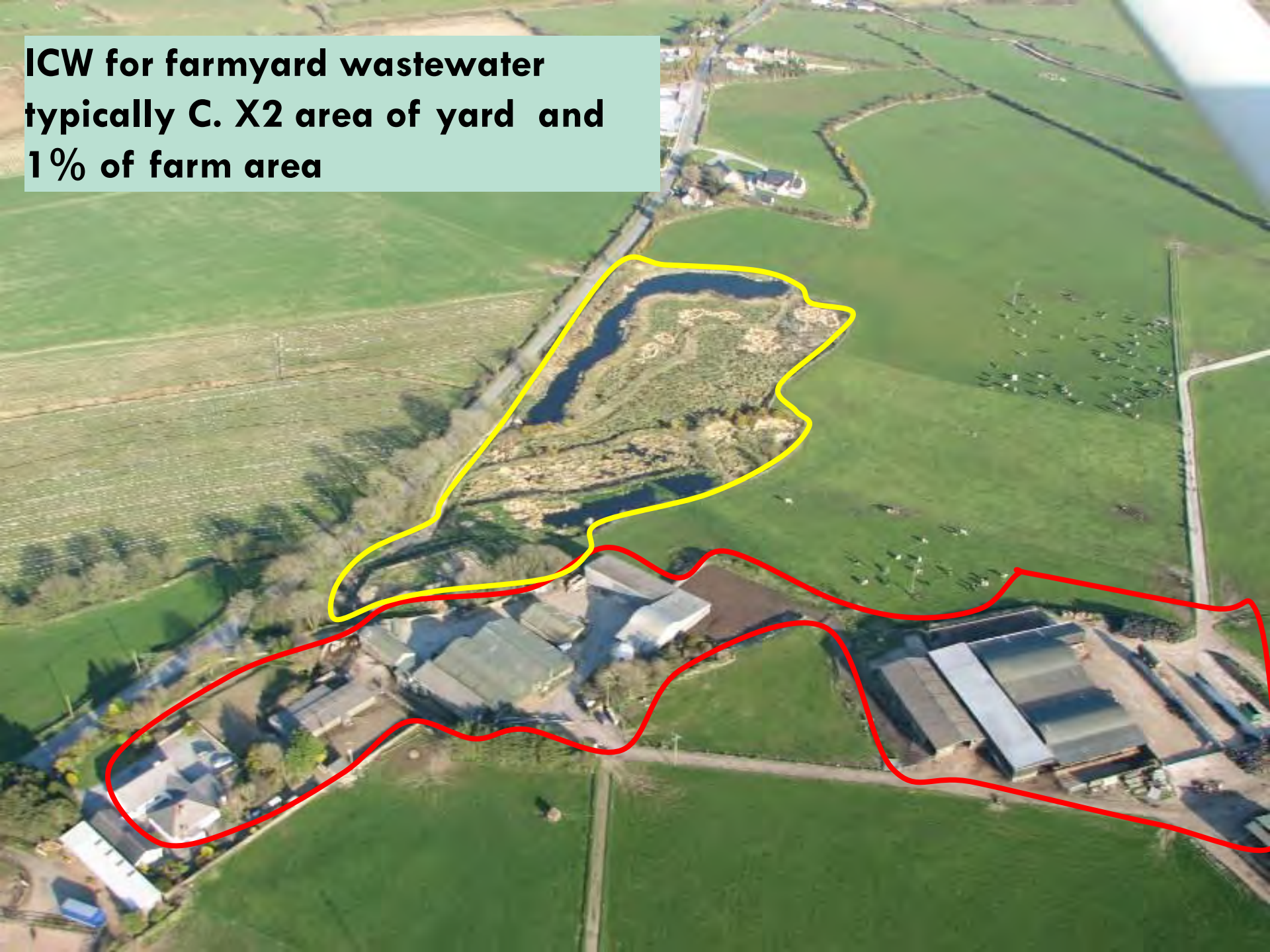
- **16 large (>1ha) integrated constructed wetland (ICW) systems**
- **C. 12.5 km re-profiled stream corridor**
- **C. 200ha forest plantation**
- **C. 20ha extant woodland**




Anne Valley: 2 Municipal waste water &
6 of14 Farmyard point sources
each with ICW treatment

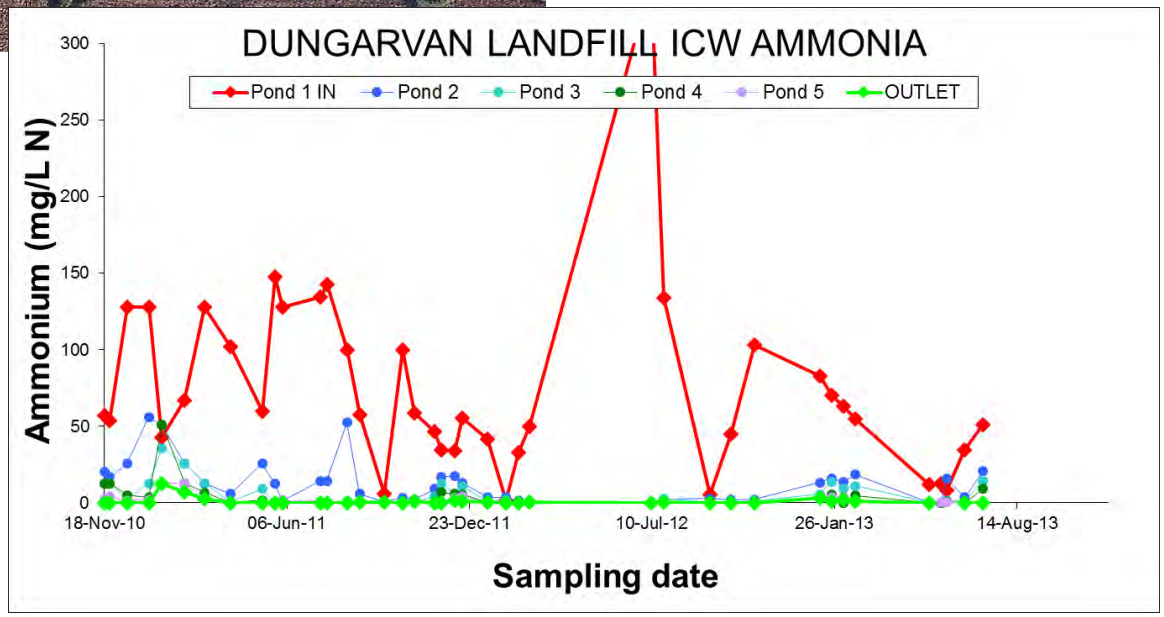
Anne Valley catchment's ICW systems intercepting point and diffuse polluted water

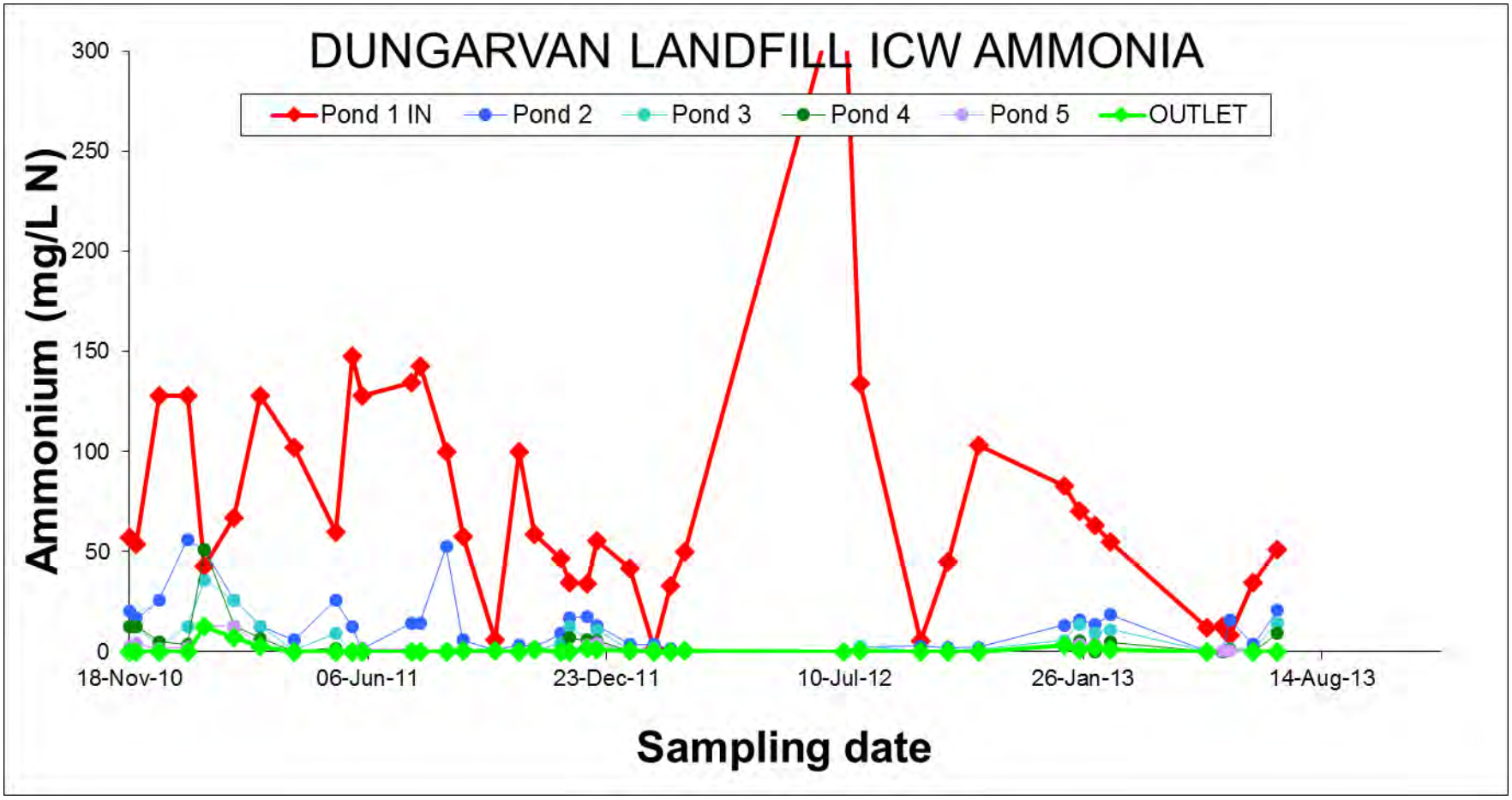



ICW for farmyard wastewater typically C. X2 area of yard and 1% of farm area

Little or no effluent flow during dry weather

Treating Landfill leachate




DUNGARVAN LANDFILL ICW AMMONIA
Pond 1 IN
Pond 2
Pond 3
Pond 4
Pond 5
OUTLET
Ammonium (mg/L N)
300
250
200
150
100
50
0
18-Nov-10
06-Jun-11
23-Dec-11
10-Jul-12
26-Jan-13
14-Aug-13
Sampling date

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

'Old' (1999) ICW

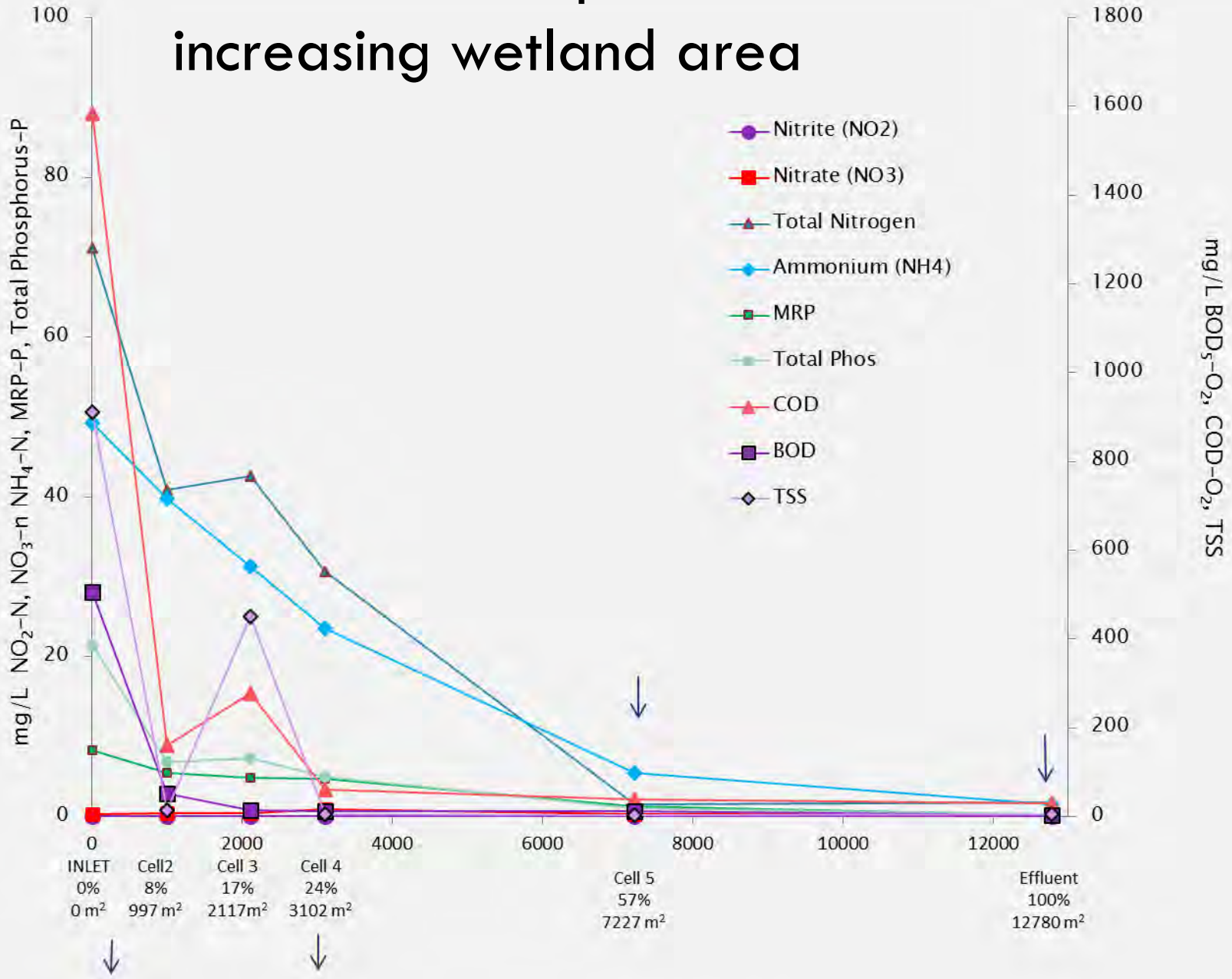
Functional treatment area = 2670m^2

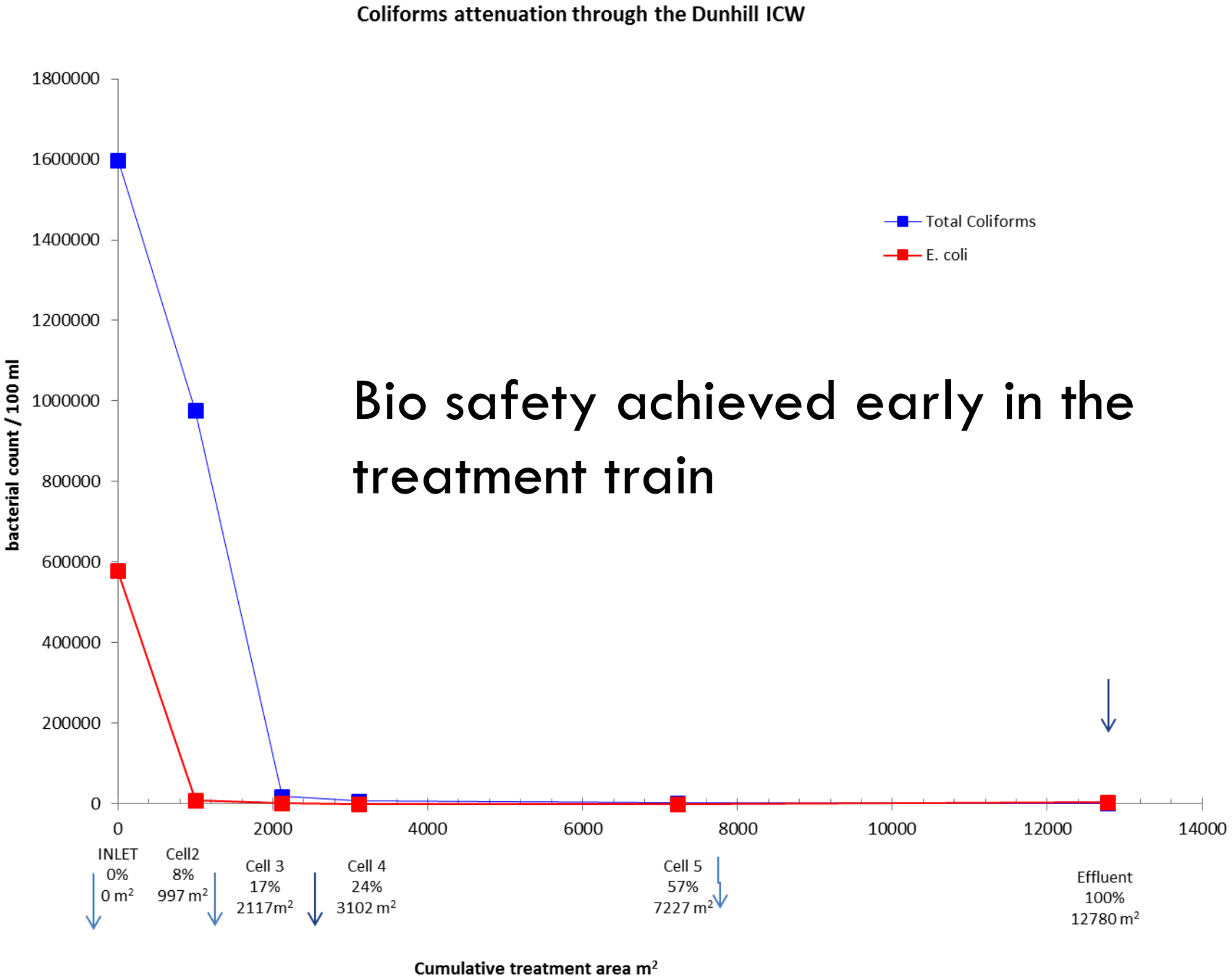
Newly extended (July 2012) ICW

Functional treatment area = 9678m^2

Total functional treatment area = 12348m^2 Flow/PE capacity = c.500)

Performance improves with increasing wetland area





Bio safety achieved early in the treatment train

Frequently asked questions

1. What is the Capital Cost for a 100PE to 1000PE wetland. 2,000 – 5,000m2/100PE & 35 - 70% for embankments & Design & Contractor costs c. €30,000/100PE
2. What is the annual operating cost for a 100PE and a 1000PE wetland. Depends on whether there is any pumping to first receiving cell, weekly inspection? Analyses & caretaker
3. Is there an optimum size of wetland. i.e. as a technology is it more suited to a particular size of town? Can be to a size where there is no surface discharge and there is no PE limit
4. What are the hydraulic limitations of wetlands, e.g. if a wetland is designed for a 1000 PE town can it cope with an associated full flow to treatment of 675m3/day. Can it cope with flows in excess of this? or are storm-water storage tanks necessary as at a conventional treatment facility. Flow rates are highly variable, generally driven by precipitation events - SD in the data shown in the accompanying presentation is close to zero
5. With a good maintenance regime what is the expected life span of a Constructed wetland? Is 50 years realistic, optimistic or pessimistic? Systems built in 1996 (18 yrs ago) have all cells working, 1st and 2nd cells may need detritus removed after 20 years, 1m high embankments good for 50 – 100yrs for the rest: Note the necro-mass is a valuable asset
6. What are the potential problems/drawbacks/limitations to the use of ICW. See presentation for benefits: Misuse is a possibility that can be catered for - essentially achieved in delivering design appropriate to location and management.
7. Are ICW systems capable of dealing with large load variations e.g. a small town with a 400PE load in the winter but a 1200 PE load in the summer. Yes!
8. Do you agree with a 50m2/per PE sizing(40m2 x 1.25) and do you think that this will allow for Storm water flows in excess of 3 times dry weather flow. ? For further discussion

Muff ICW - DETAILED COST ESTIMATES

CAPITAL COSTS

based on good site conditions / favourable ground conditions

Land		
Earthworks,		
Planting,		
Pipework,		
Access roads and landscaping		€275,000
Finishes (roads / paths around the ICW)		€25,000
Embankments (provisional item)		€100,000
monitoring equipment, incl ground water		€125,000
fencing, gates, etc.		€25,000
control building / cabin		€10,000
Site investigation		€5,000
Sewer infrastructure		€50,000
	SUB TOTAL	€615,000
Contingency (10%)		€30,750
Design / consultation		€15,000
	SUB TOTAL (Ex VAT)	€660,750
	VAT	€89,201
	CAPITAL TOTAL	€749,951

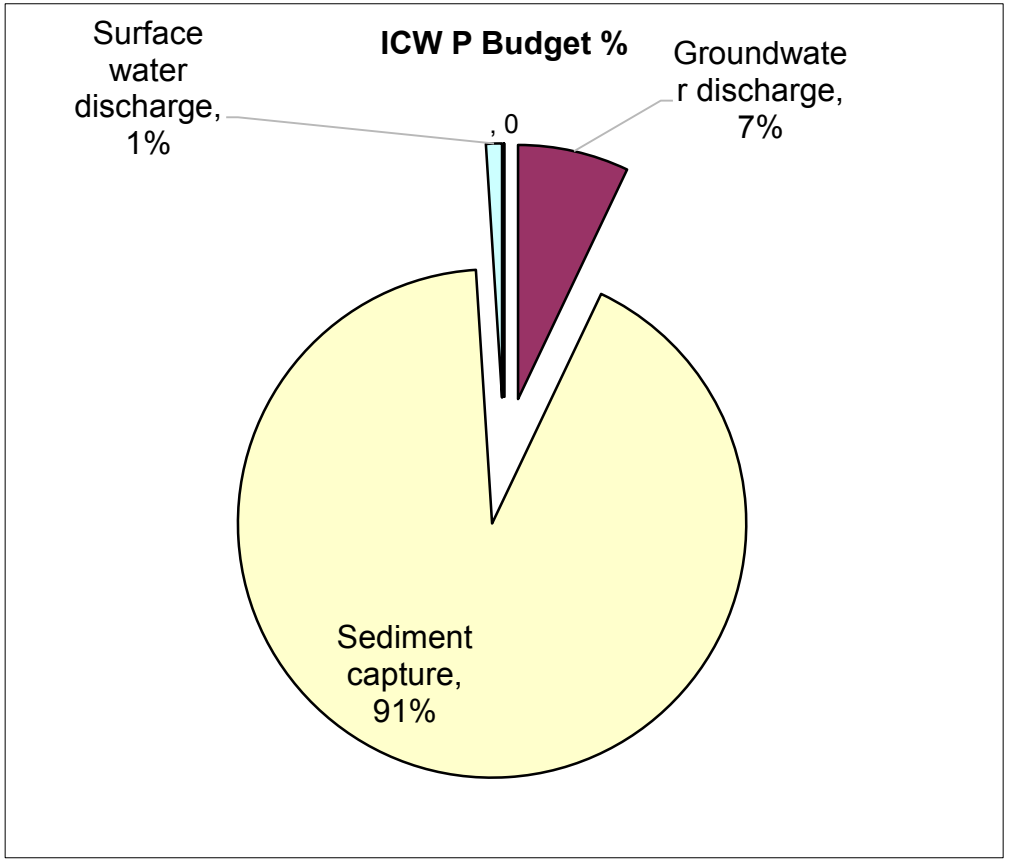
OPERATING COST	YEAR 1	YEAR 2	YEAR 3
ICW Phase 1 (approx 50%)			
Caretaker visit /monitoring / energy / Maintenance	€26,000		
NI Water (dual period / until ICW commissioned)	€172,656		
NI Water (reduced volume /after partial commissioning of ICW)	€28,776	€28,776	
ICW Phase 2		€25,000	€25,000
OPERATING TOTAL	€227,432	€53,776	€25,000

ICW sequester carbon, phosphorous and nitrogen

ICW Sediment phosphorus - P

ICW 11 Phosphorus-P sediment deposition per cell

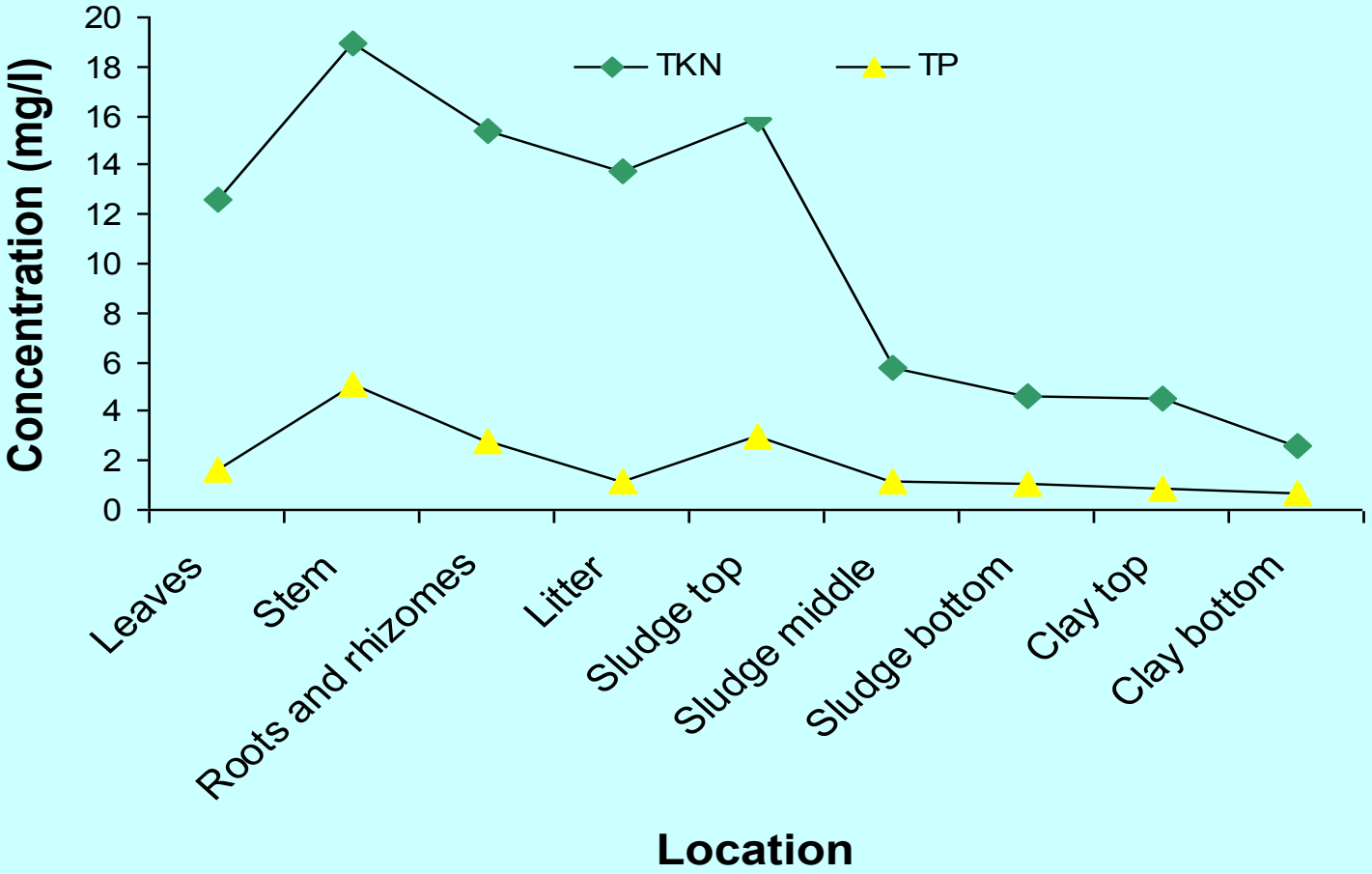
Cell	kg P per year	%
1	43	60
2	14	20
3	14	20



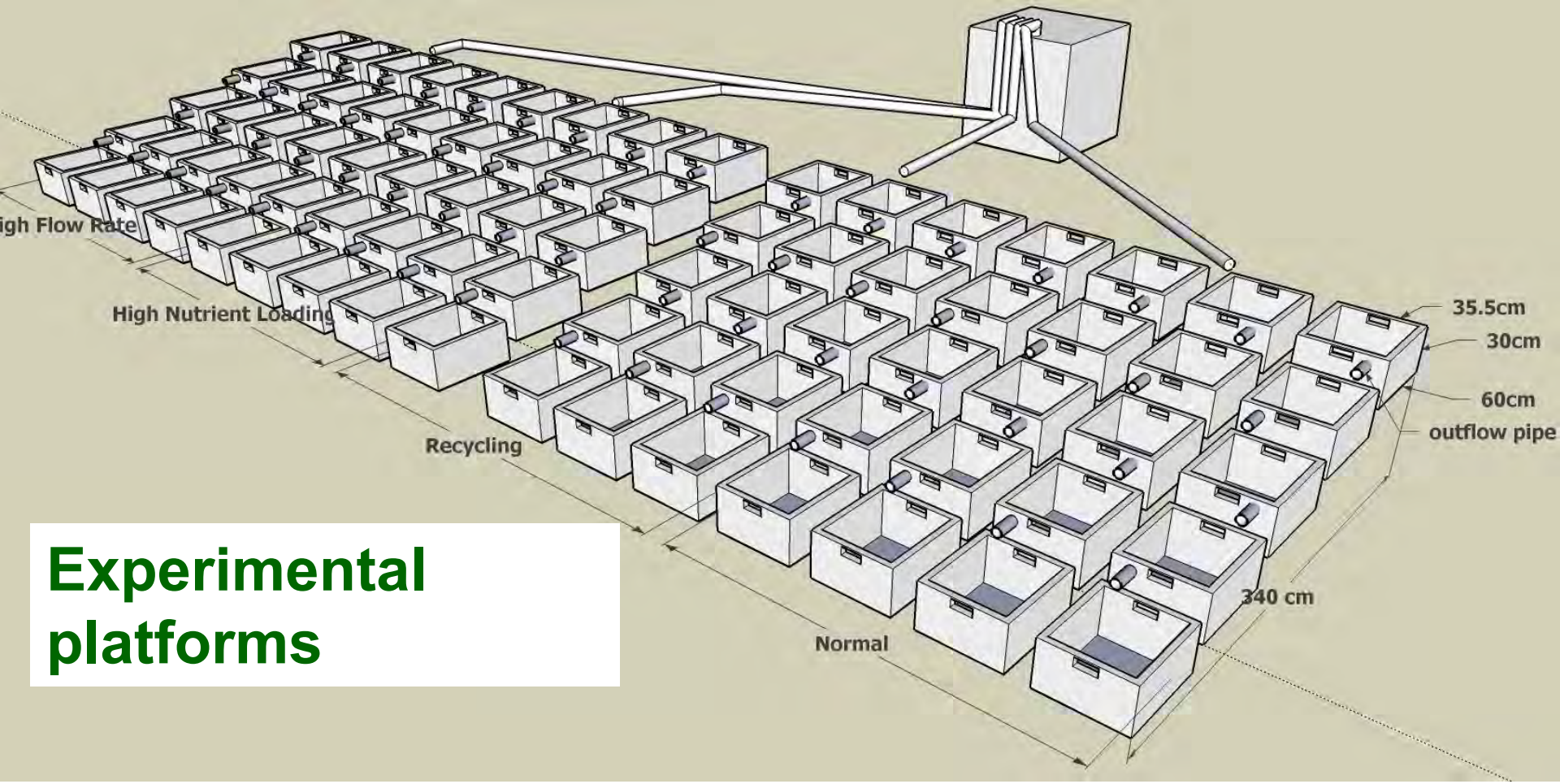
Phosphorus deposition in ICW

135 kg per ha per year

N and P storage in plants and sediments



De-watering wastewater sludges and slurries through ICW systems



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

Reconciling bridge between *needs* and *wants*

Societal needs

Clean Air, Water & Soil:

EU:WFD
- BWD
- UWWD
- SD
- Etc.

Ramsar (1971)

UN:EP
- CBD
- Climate change

Sectoral wants

Agriculture

Development:
- Urban
- Rural

Forestry:
- Timber
- Biomass

Fishing

Recreation

Nature conservation

- **Sustainable effective treatment of a wide range of polluted water sources with a very high level of contaminant chemical and pathogen removal.**

- **>99% of total phosphorus-P can be sustainably retained (and accessible for future re-use).**

- **>60% of inflowing nitrogen-N can be sustainably retained (also accessible for future re-use).**

- **>13t (dry) organic matter per ha (>4 t C/ha/yr) per year can sustainably accumulate within an ICW and be accessible for future re-use (e.g. land-spreading, fuel or pyrolysis).**

- **Water flow through an ICW can be greatly reduced or even eliminated (or re-used with a high level of bio-safety).**

- **ICW systems, incorporated in-stream or off-stream, improve surface water quality & attenuate flooding.**
-
- **ICW systems are highly cost effective to construct (typically 60% cheaper), and maintain and operate (typically 90% cheaper), compared with conventional treatments and practice methods.**

- **On-site or local soils are used - largely removing external environmental and capital costs.**
- **Their application increases biological diversity within and outside their immediate landscape setting.**
- **They have a high level of landscape compatibility.**
- **They are socially acceptable and provide educational, amenity and recreational facilities.**

Where to from here with the ICW concept?

- **National Wetland Steering Committee**
- **Guidance documents: adaptive-management**
- **Demonstrations: step-by-step**
- **Potential treatment streams: experimentation**
- **Research, development & training**
- **Community involvement: social inclusion**
- **International engagement: sharing expertise**

Conclusion

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

- They improve our surface-waters and landscapes.....and.....

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

ACKNOWLEDGEMENTS

- Paul Carroll and Sue Cook: Waterford County Council
- Dan Doody, Mark Johnstown: Monaghan County Council
- Community of Dunhill/Annestown, Co. Waterford
- Colleagues in Clare, Donegal, Down, Dublin, Galway, Kerry, Leitrim, Laois, Tyrone, Westmeath – EPA, Teagasc, Salford University, UCD
- Aila Carty and Dr. Caolan Harrington: VESI Environmental Ltd.

VESI Environmental Ltd.