Seminar/Workshop:
Wednesday, 17 February 2016, 9:00am–4:00pm
University of Waikato, Hamilton

LANDCARE RESEARCH
MANAAKI WHENUA

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Reanimating land-water interfaces and associated habitats using 'Integrated Constructed Wetlands'

RORY HARRINGTON

VESI Environmental Ltd.

THIS PRESENTATION

- **TOWARDS COHERENT LAND, WATER (and air) MANAGEMENT**
- **ECOLOGICAL REANIMATION AND RESTORATION**
- **INTEGRATING SOCIAL, ECONOMIC AND ENVIRONMENTAL NEEDS**
- **CREATIVITY, INNOVATION AND ENTREPRENEURSHIP….What if?**
- **SOME EXAMPLES AND PERFORMANCE**

Leonardo Da Vinci

"Take thought, when you are speaking of water, that you first recount your experiences and only afterwards your reflections"

Inspired by *'lost'* biotypes (habitat types) and ecosystem functional analyses

- **Marshes, fens and bogs**
- **Forest/woodland**

- **Reanimation (restoration)**
- **Ecosystem dynamics**
- **Evolutionary biology**

- **Understanding human-generated impacts through an 'ecosystem approach'**

Earliest human Arctic occupation

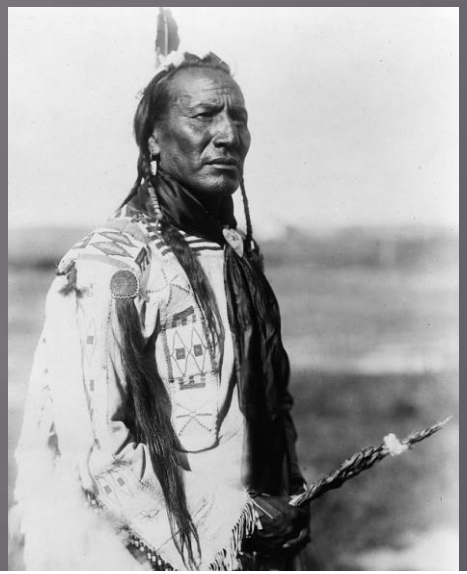
Paleolithic records of humans in the Eurasian Arctic (above 66°N) are scarce, stretching back to 30,000 to 35,000 years ago at most. Pitulko et al. have found evidence of human occupation **45,000 years ago at 72°N**, well within the Siberian Arctic. The evidence is in the form of a frozen mammoth carcass bearing many signs of weapon-inflicted injuries, both pre- and postmortem. The remains of a hunted wolf from a widely separate location of similar age indicate that humans may have spread widely across northern Siberia at least 10 millennia earlier than previously thought.

Science 15 Jan 2016:
Vol. 351, Issue 6270, pp. 260-263. DOI: 10.1126/science.aad0554

Shallow, emergent-vegetated wetlands:

impede water flow.....

..... and support bio-geo-chemical processes



Uses for wetland vegetation

Contains phytol and coumarin: repels mosquitoes

Known in Ireland as ‘holy’ grass (*Hierocloe odorata*), in Poland it is known as ‘bison grass’, used in herbal medicine and in the production of distilled beverages (e.g., Żubrówka, Wisent)

St. BRIGID’S CROSS

Sources of food e.g. *Typha* pollen and rhizome starch

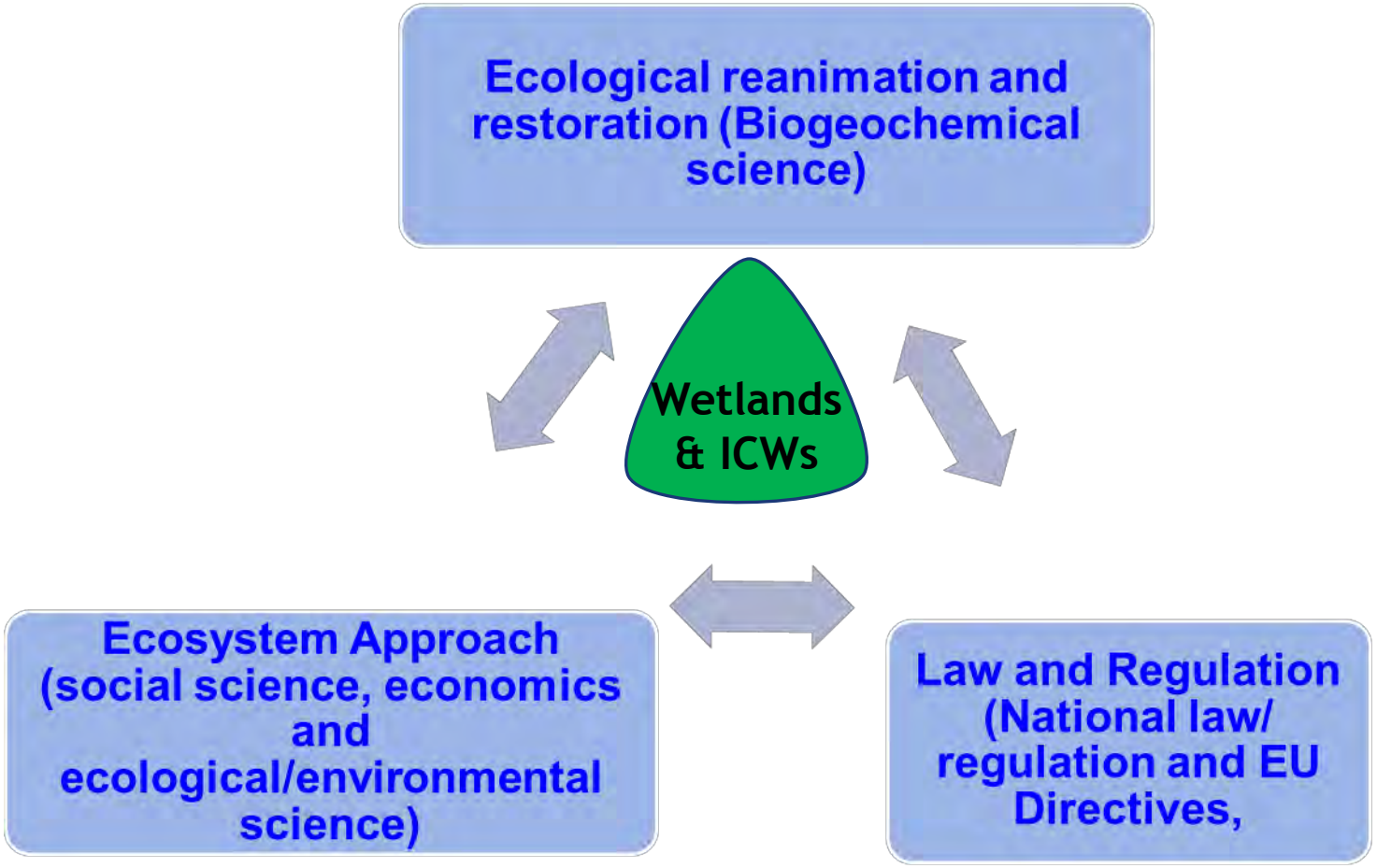
Wetland (and woodland) reanimation recognises that:

Water management is fundamentally a land use issue! (*e.g.* pollution, aquatic habitats)……

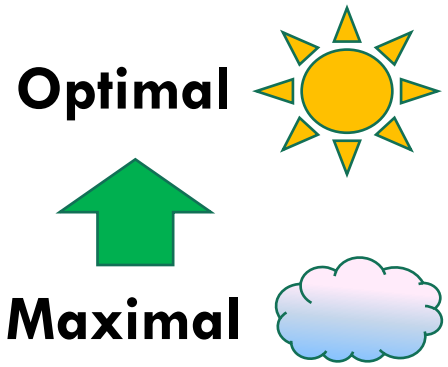
Land management is also a water use issue! (*e.g*. drainage, flooding)

<u>Wetlands (and woodland) combine the two:</u>
facilitating each…. and air quality

REANIMATING WETLAND INFRASTRUCTURES ACKNOWLEDGES THE ROLES OF :



The need for ‘new’ economies



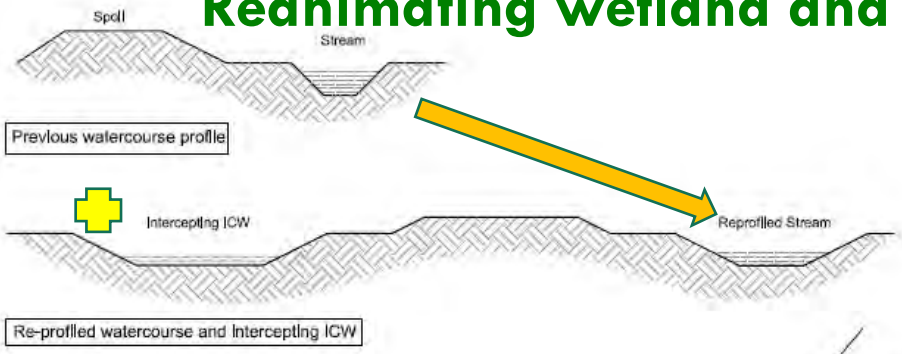
Multiple purpose/benefits

Single purpose/limited use

Starting in 1987/8, Annestown stream:

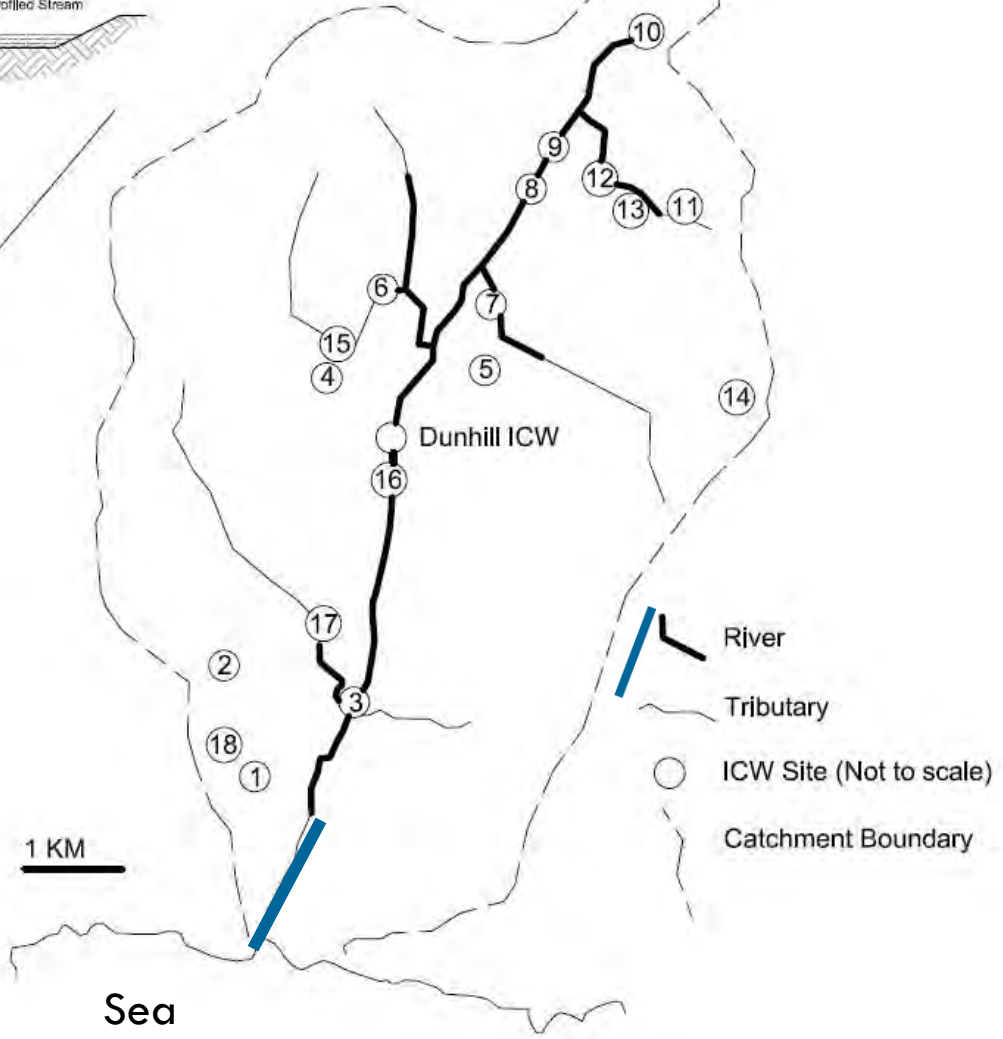
From a canalised dirty, weedy agricultural drain to one that now supports trout and salmon

Reanimating wetland and riparian infrastructures



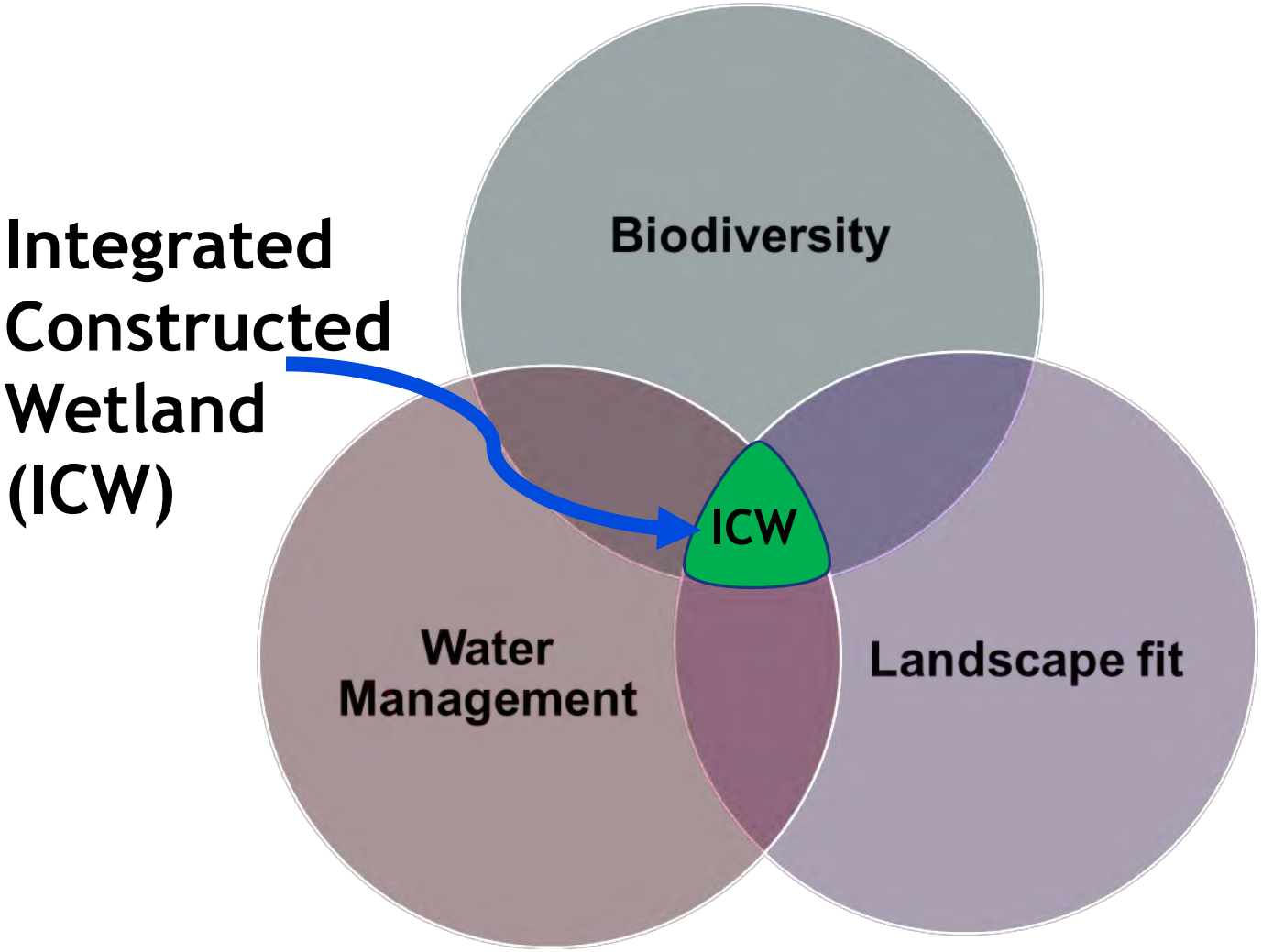
Cut & fill approach – using site characteristics and soils

Approx. 12.5 km of stream and tributaries re-profiled with in-stream & parallel interception- channels, and 22 ICWs treating point sources of pollution

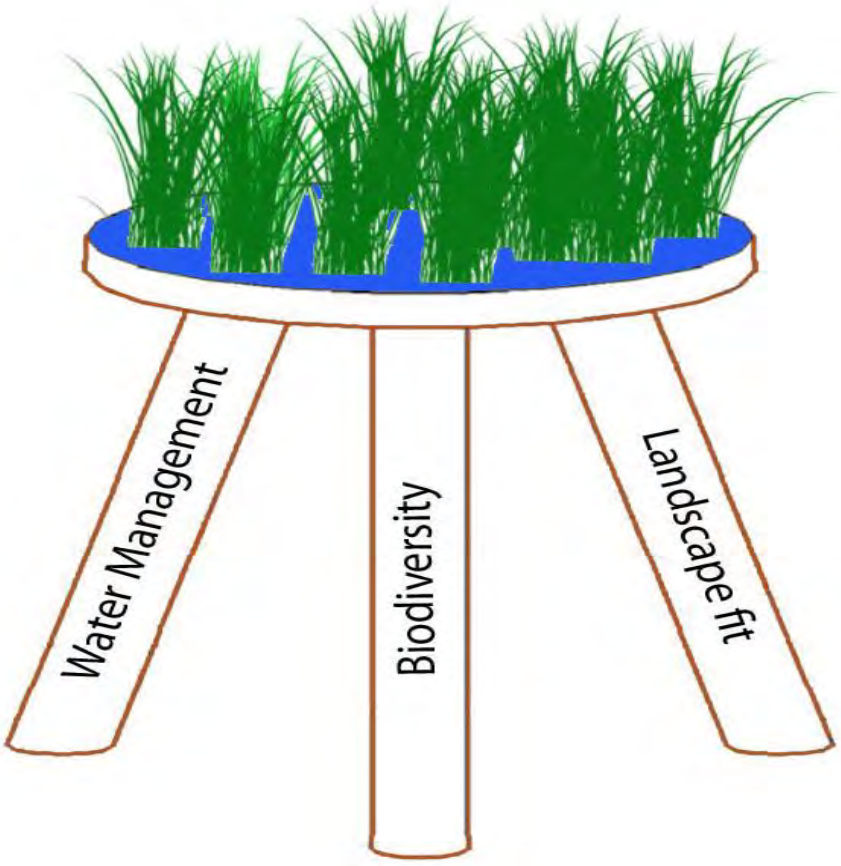



WATER MANAGEMENT:ENGAGEMENT WITH LANDSCAPE: ITS SOILS & VEGETATION TO INTERCEPT, RETAIN, & TREAT
water
water
Forest establishment close to flood-line with internal drainage
ICW Embankments above flood-line
Lower Annevalley, Co. Waterford

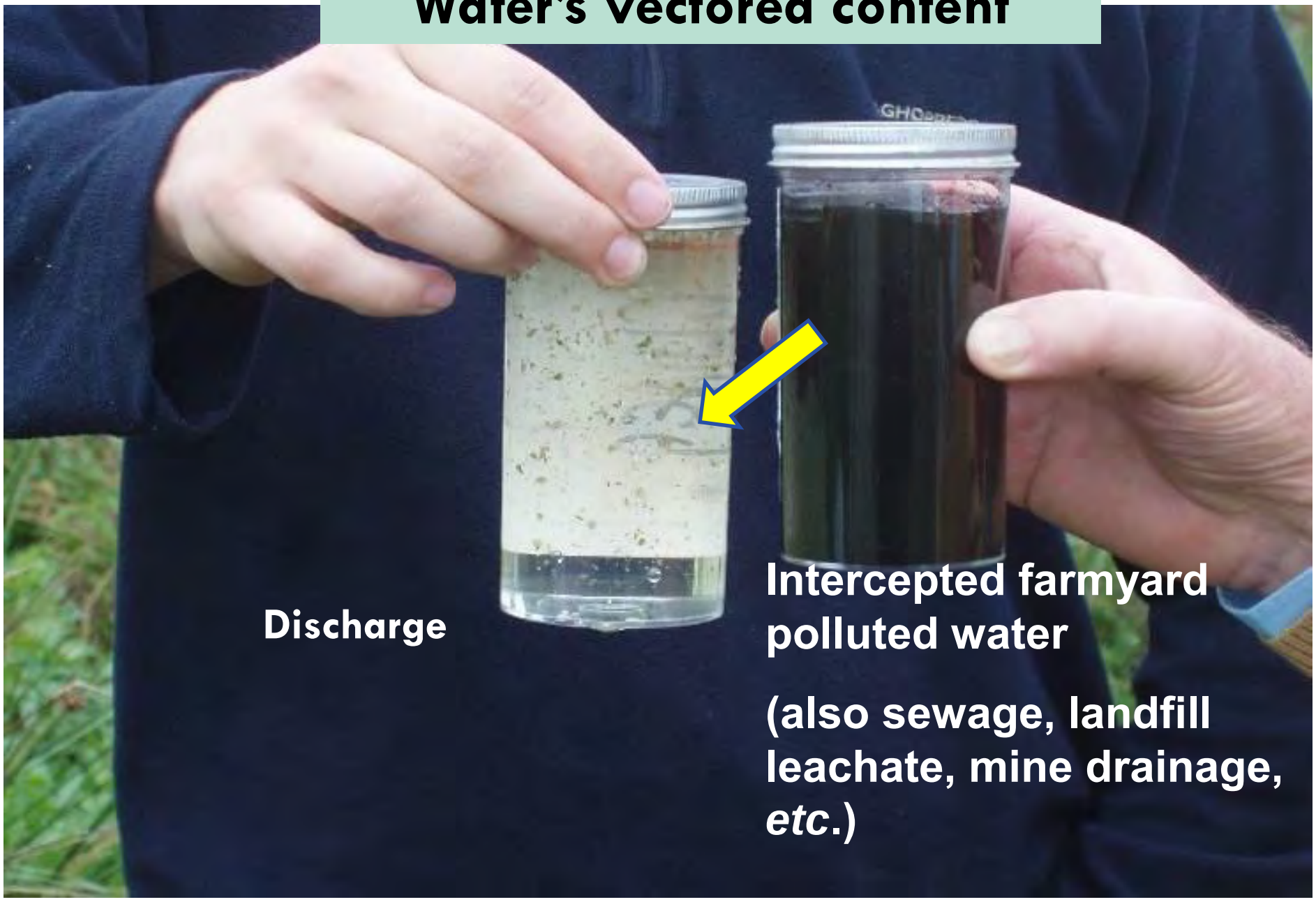
Integrated Constructed Wetland (ICW) concept explicitly integrates



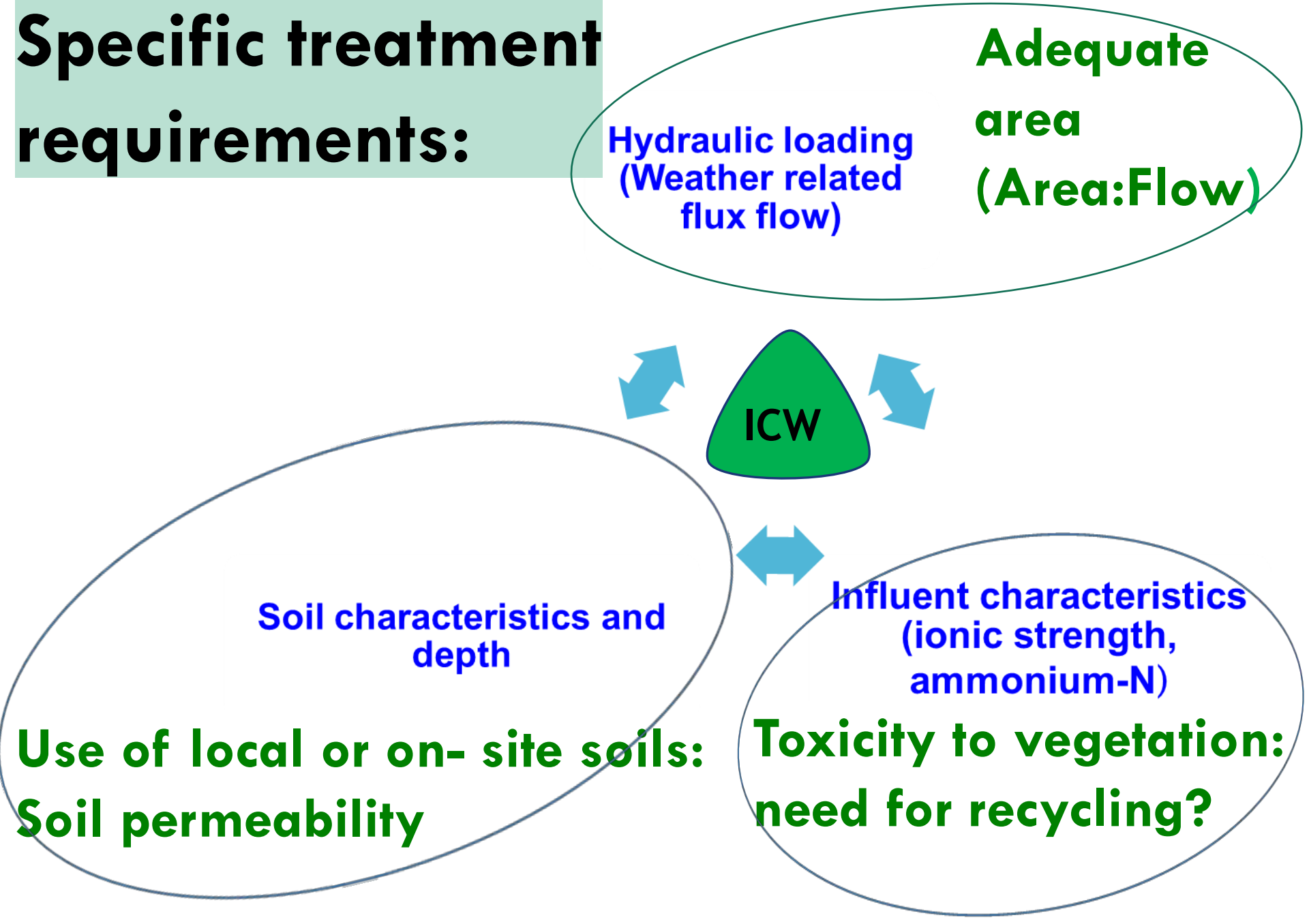
Integration provides robustness:
Dependable stable function, with positive synergies



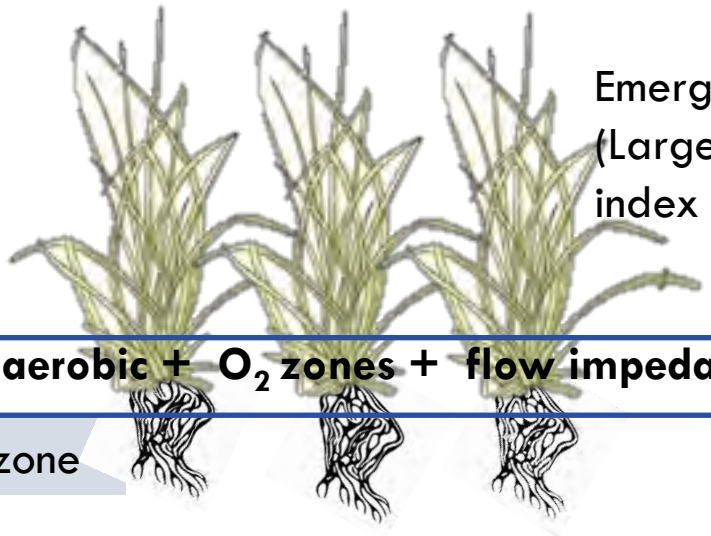
Water's vectored content



Specific treatment requirements:



Cross section of wetland showing key functional zones



Emergent vegetation
(Large leaf area
index (LAI)) **High primary productivity**

Water surface with preferential flow

Stable anaerobic + O_2 zones + flow impedance

Aquatic zone

Detritus zone

Root zone
(Rhizosphere)

Level areas with tall, dense emergent vegetation <u>intercepting</u> water flow ensures good hydraulic impedance

Little or no effluent flow during dry weather

BASIC ICW HYDRAULIC MODEL

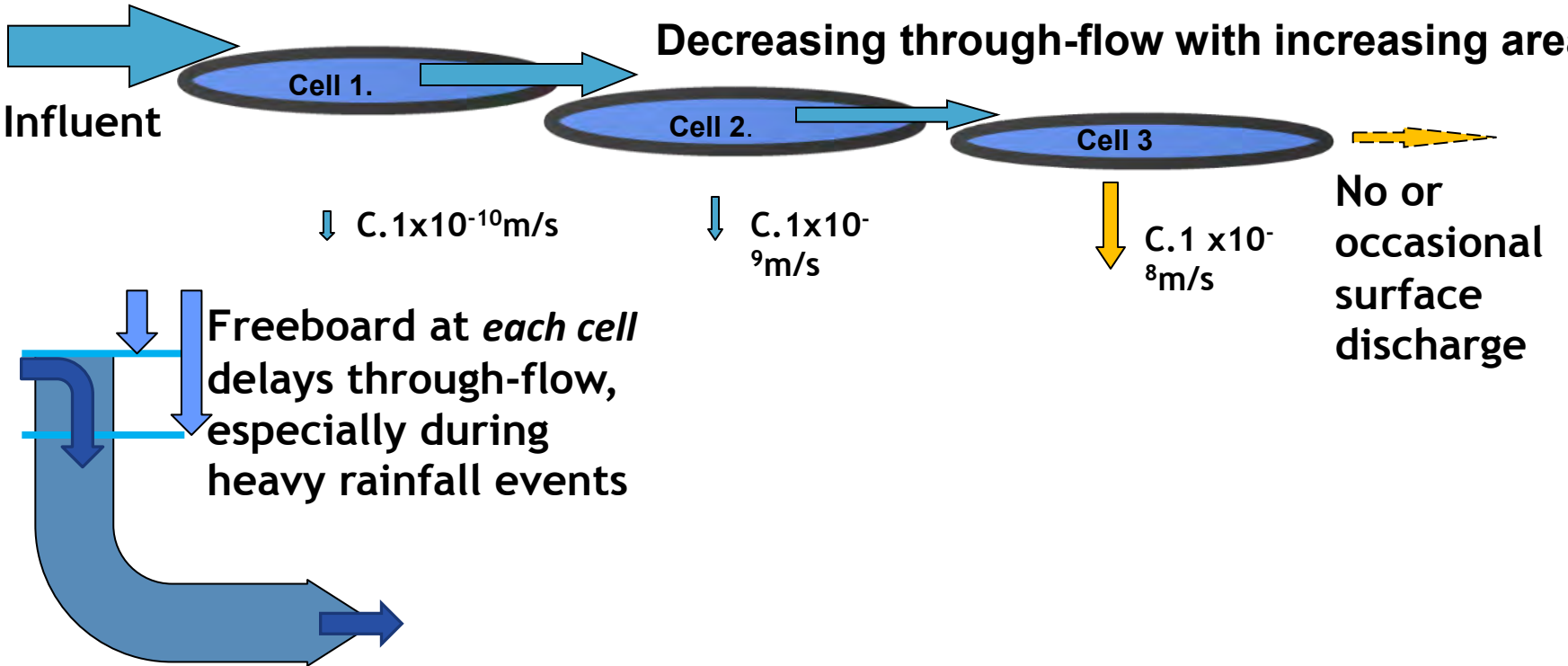
Wetland emergent vegetation intercepting precipitation

(Typically 20-40%)

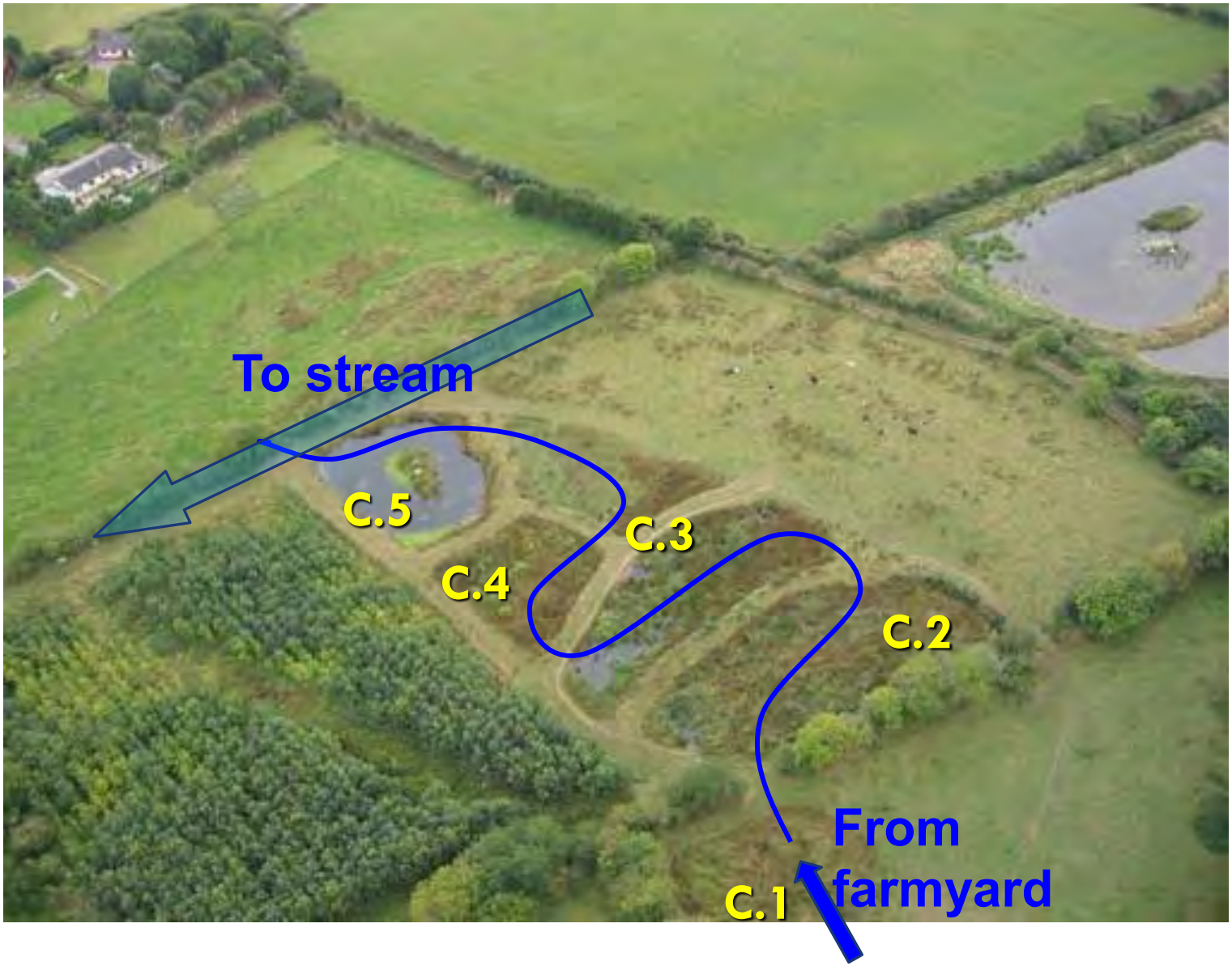
Precipitation

Wind speed, light & temperature influencing evapo-tanspiration

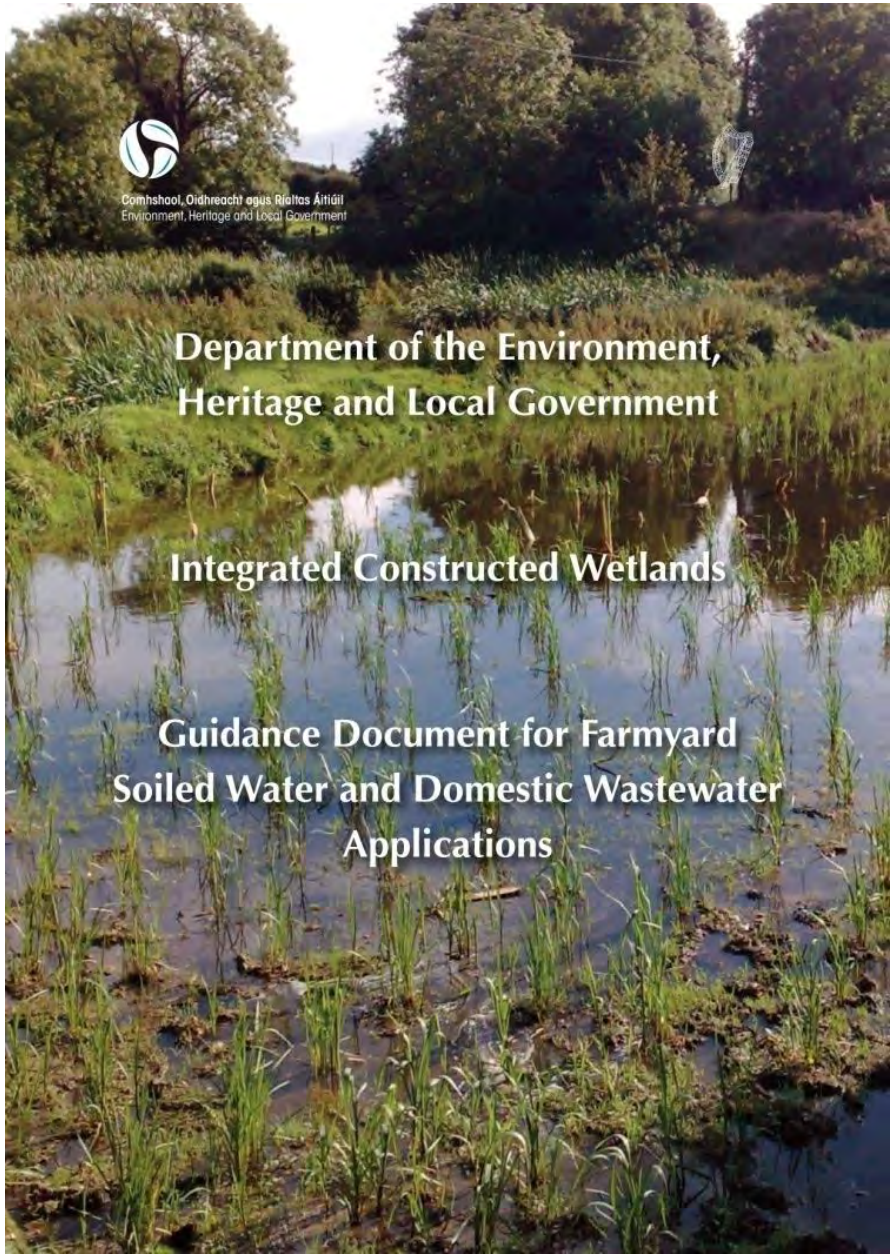
(Typically 120-200% of open pan transpiration)



Wetlands with multiple cells (ICW)



A BESPOKE, SITE-SPECIFIC APPROACH REQUIRING UNDERSTANDING AND GUIDANCE



Guidelines published December 2010 with contributions from:

Department of Agriculture, Fisheries & Food

Forest Service

Environmental Protection Agency

Central Fisheries Board

Eastern Regional Fisheries Board

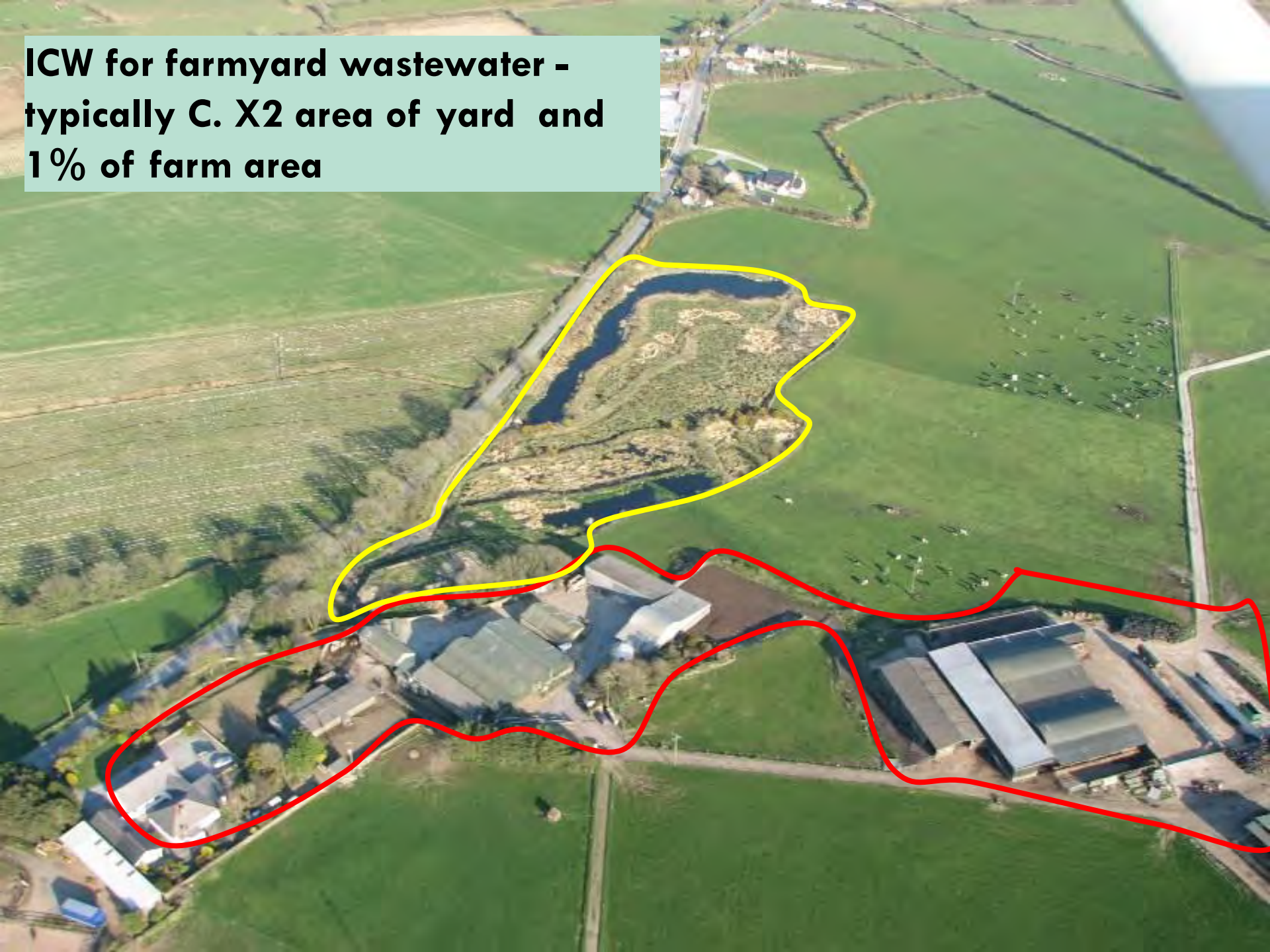
Office of Public Works

County and City Managers' Association

Department of Environment, Heritage & Local Government

National Parks & Wildlife Service

Éamon de Buitléar


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

DUNHILL ICW TREATING VILLAGE SEWAGE AND STORMWATER

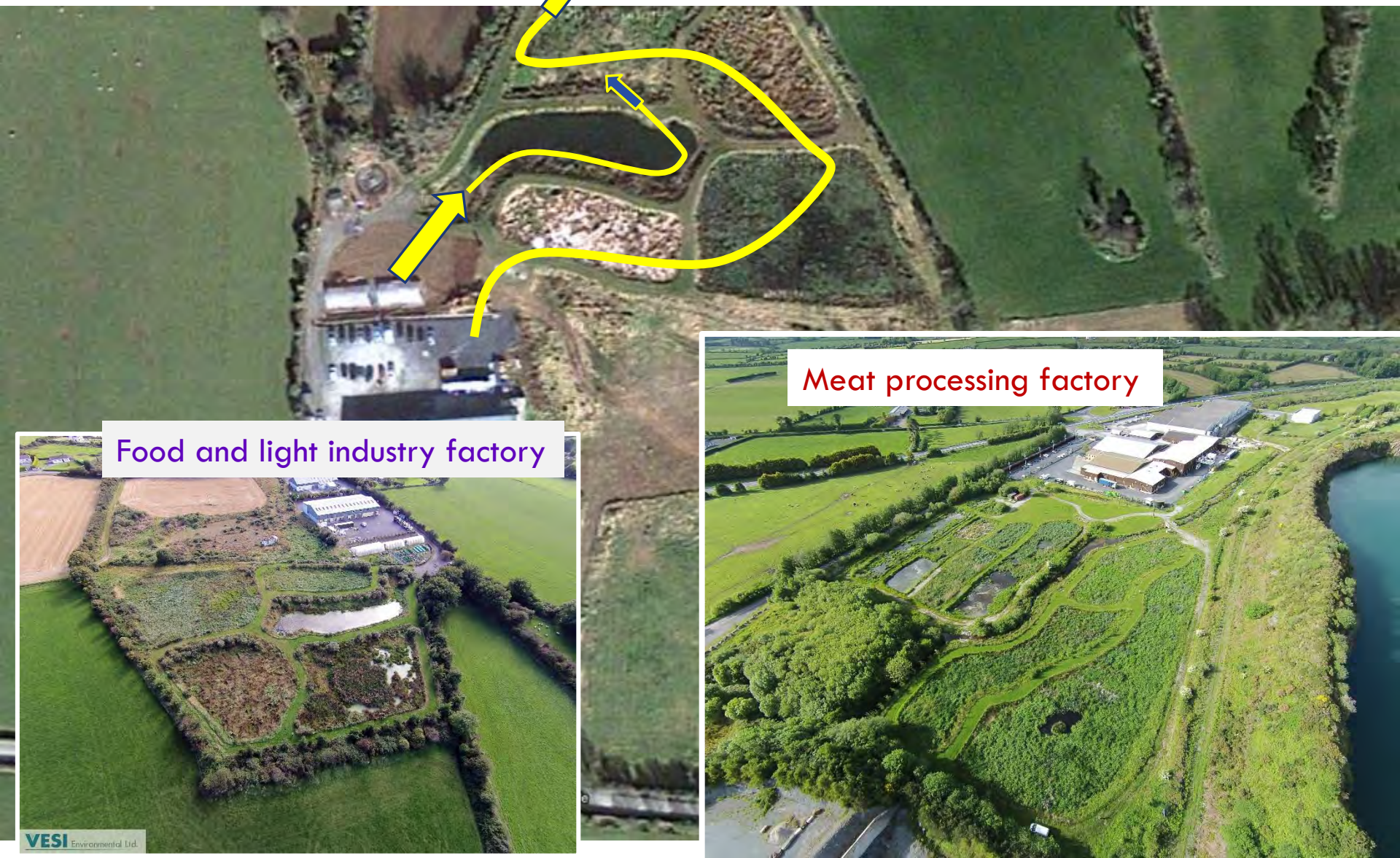
Construction of ICW for the treatment of municipal wastewater; Clonaslee, C. Laois

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

A capital cost saving of c.70% and O&M saving of c.90%

Industrial use of ICW systems: Dunhill Enterprise Park

Storm-water & wastewater with separate pathways



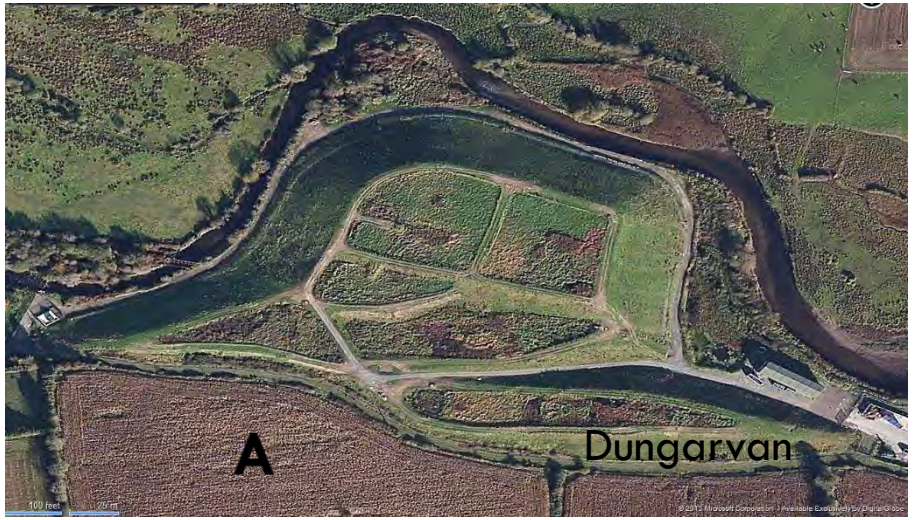
Food and light industry factory

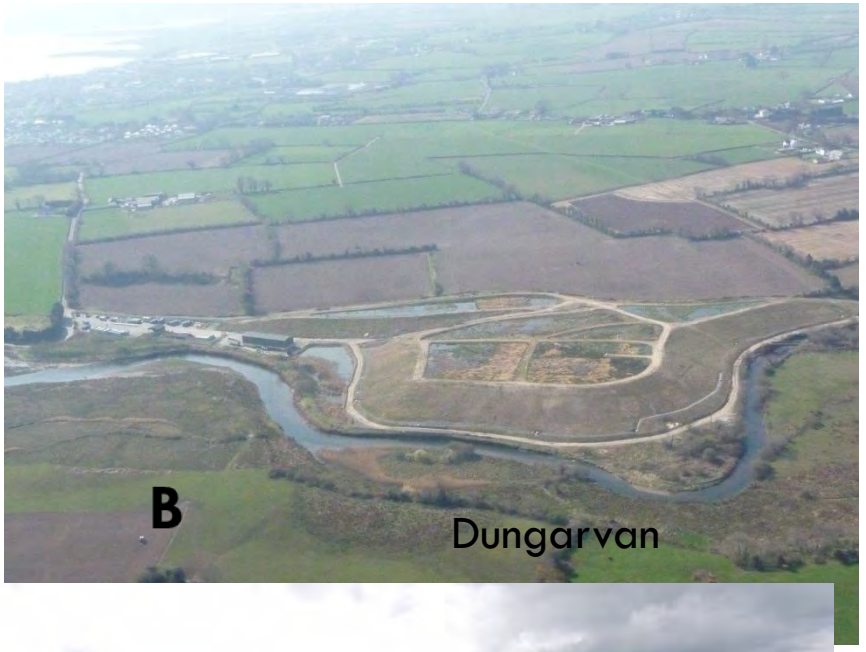
Meat processing factory


Tolka Valley Park ICW, Dublin City

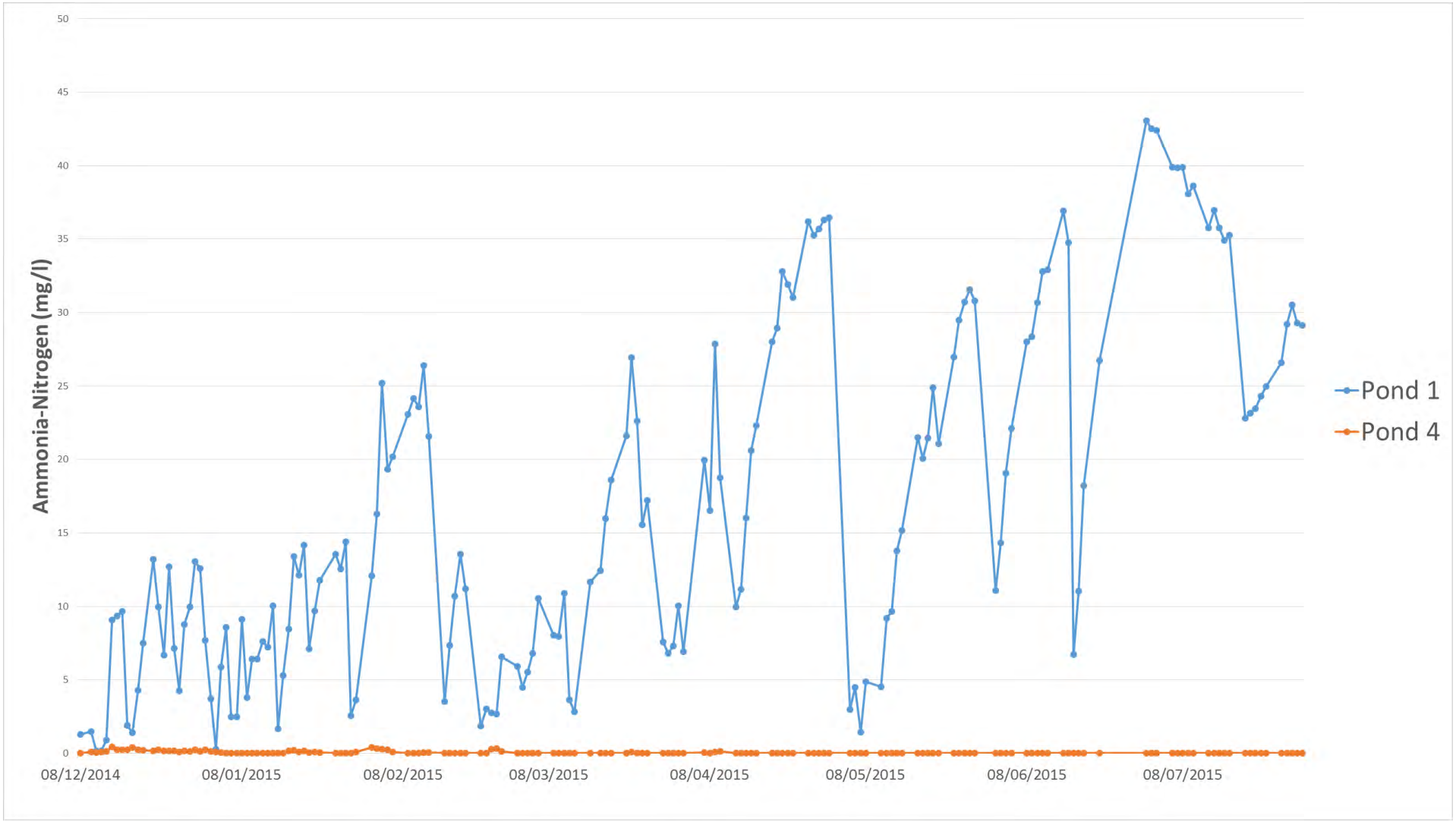
Tolka Valley Park ICW, Dublin City

Treating Landfill Leachate (A/B) & Mine Drainage (C/D)

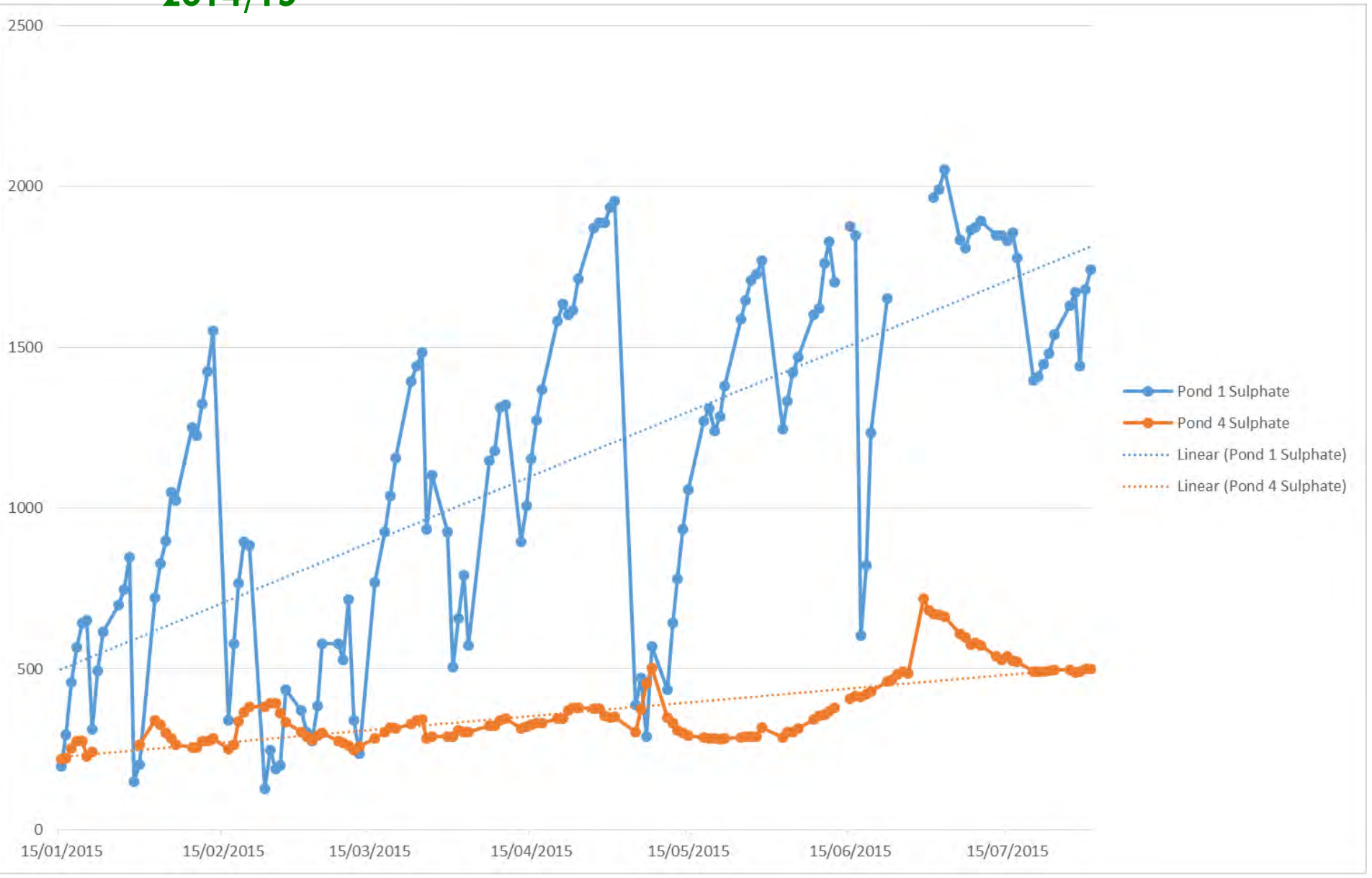




Ammonia-N reduction from Galmoy Zn/Pb mine cap-drainage 2014/15



Sulphate reduction from Galmoy Zn/Pb mine cap-drainage 2014/15



New Challenges – AMD at Cu/Zn Somincor-Lundin mine, Portugal

SINGLE HOUSE POST-SEPTIC TANK ICW

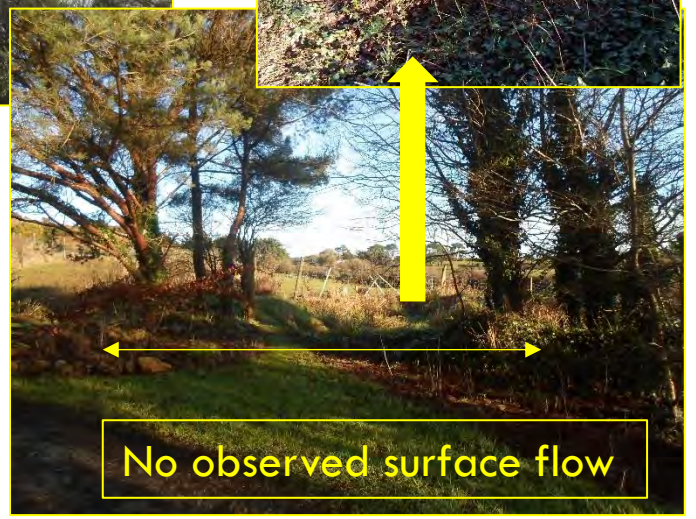
Self- evident performance

Bio/chemo-monitoring

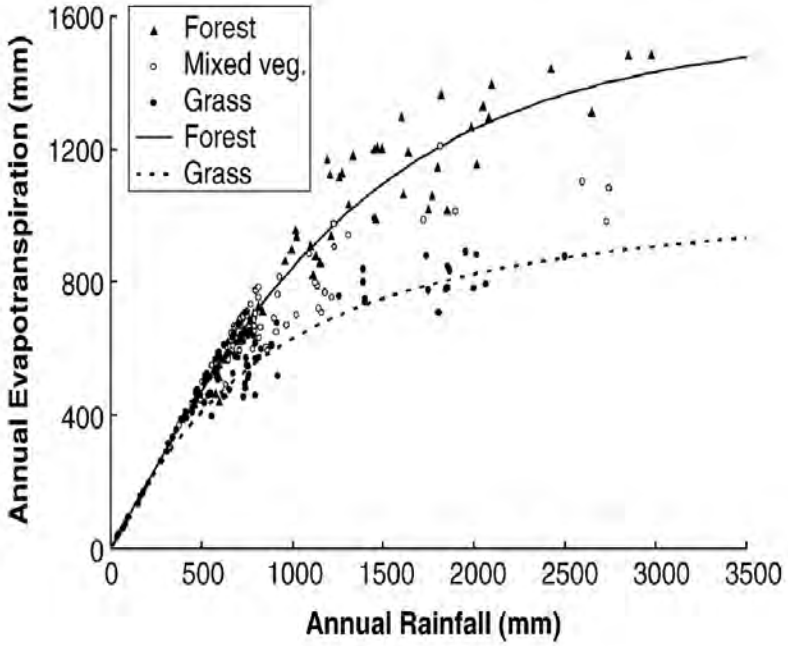
- ICWs for single/multiple house septic tank
- No ‘discharge’ to adjacent stream
- Integrated into garden/surrounds (e.g. ‘parks’)

A role for trees and woodland to deplete surface water

15 year old Cushenstown wood Co. Wexford showing broadleaf forest establishment on internally (limited) drained ground

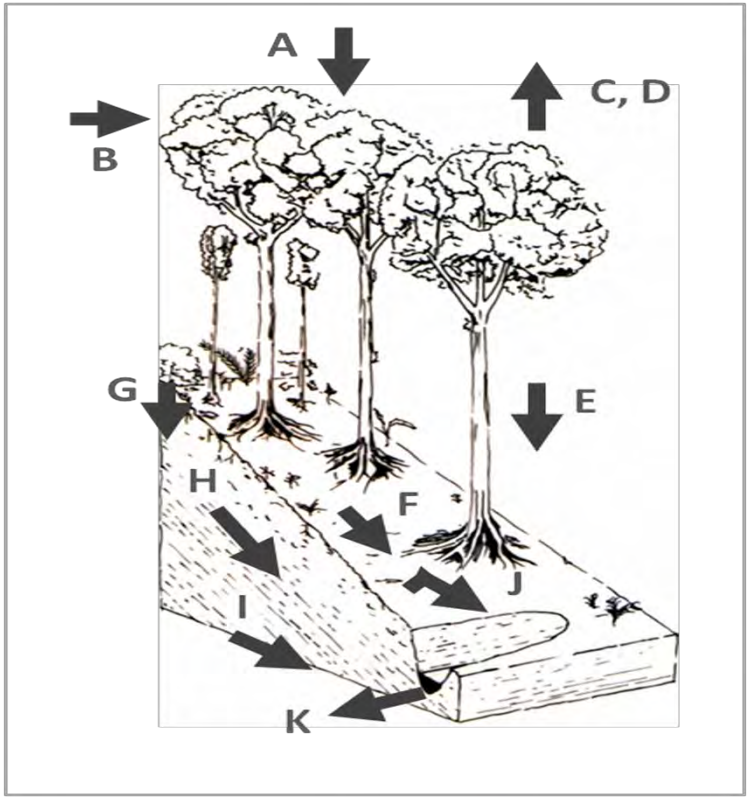


5 and 4 year old mixed forest/woodland in the Dunnhill/Annestown stream catchment showing integrated tree establishment on internally (limited) drained ground



Evaporation by forest and grassland basins (mm/yr) against annual rainfall

Zhang et al (2001 Water Resources Res 37: 701-708)

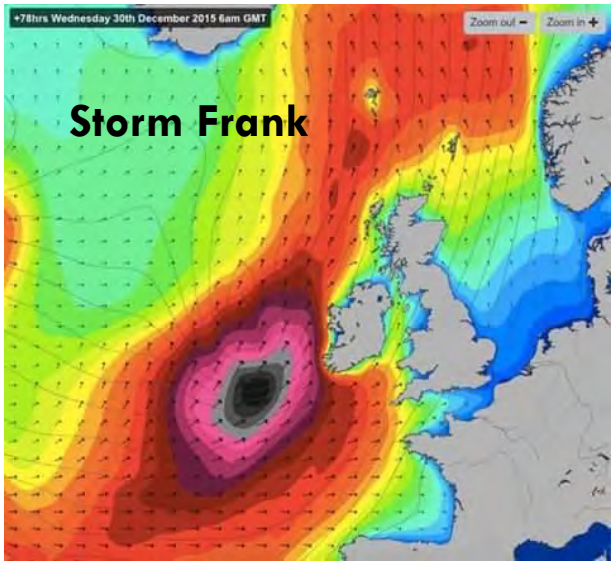


Hydrological pathways are shown on a forested hill-slope:

Adapted by NA Chappell from the original diagram by Nick Scarle published in Douglas (1977) Humid Landforms. MIT Press

Tree canopy evapo-transpiration and their roots, increase (precipitation-) interception and soil-infiltration: delivering enhanced water balance and much reduced runoff

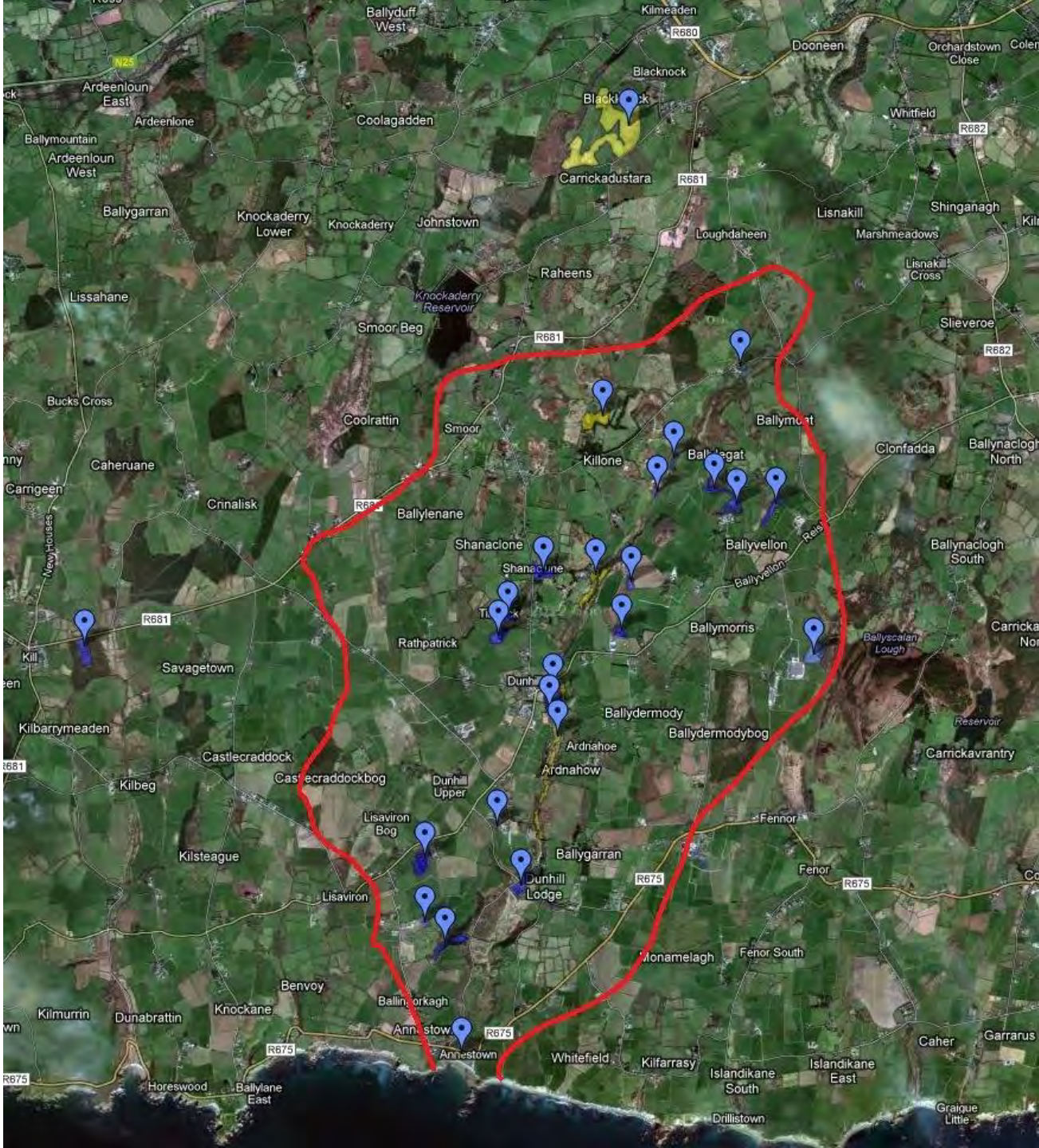
Drainage increases flood risk: Wetlands attenuate



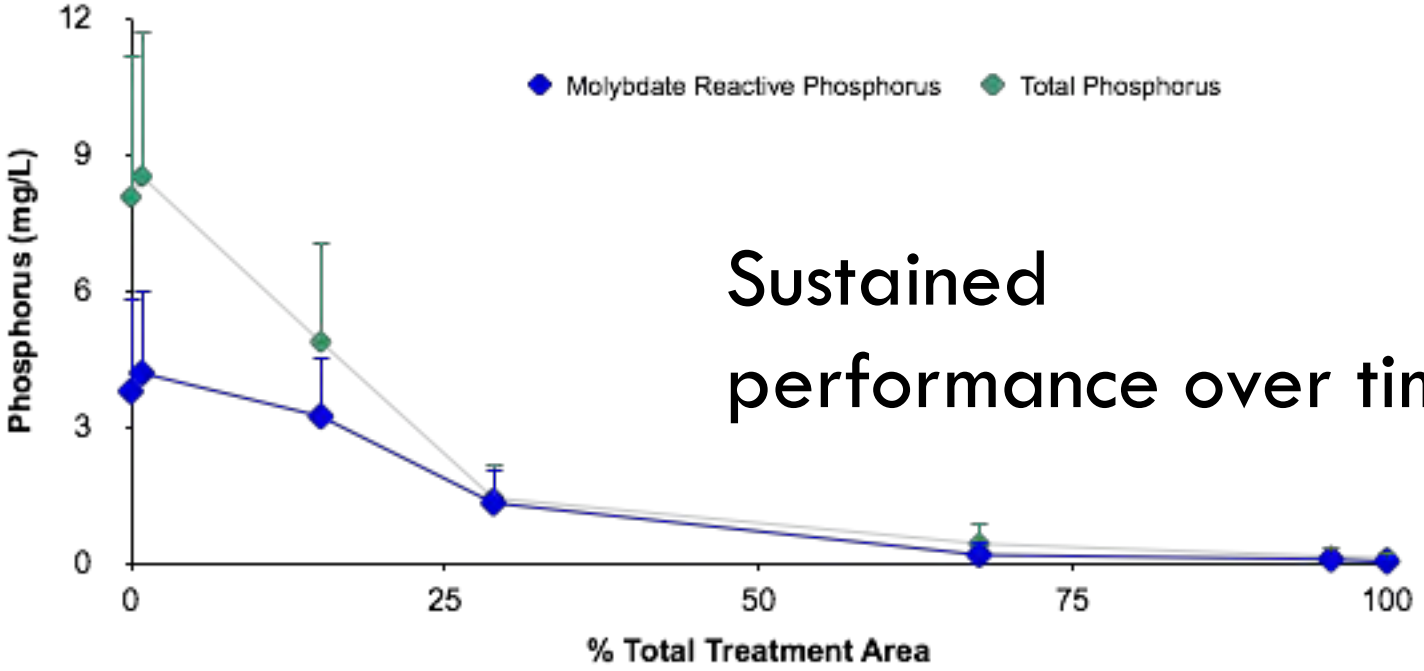
Anne Valley catchment : Map shows the most significant reanimated wetlands in the Anne Valley catchment, including ICW systems

Catchment area = 2,500ha:

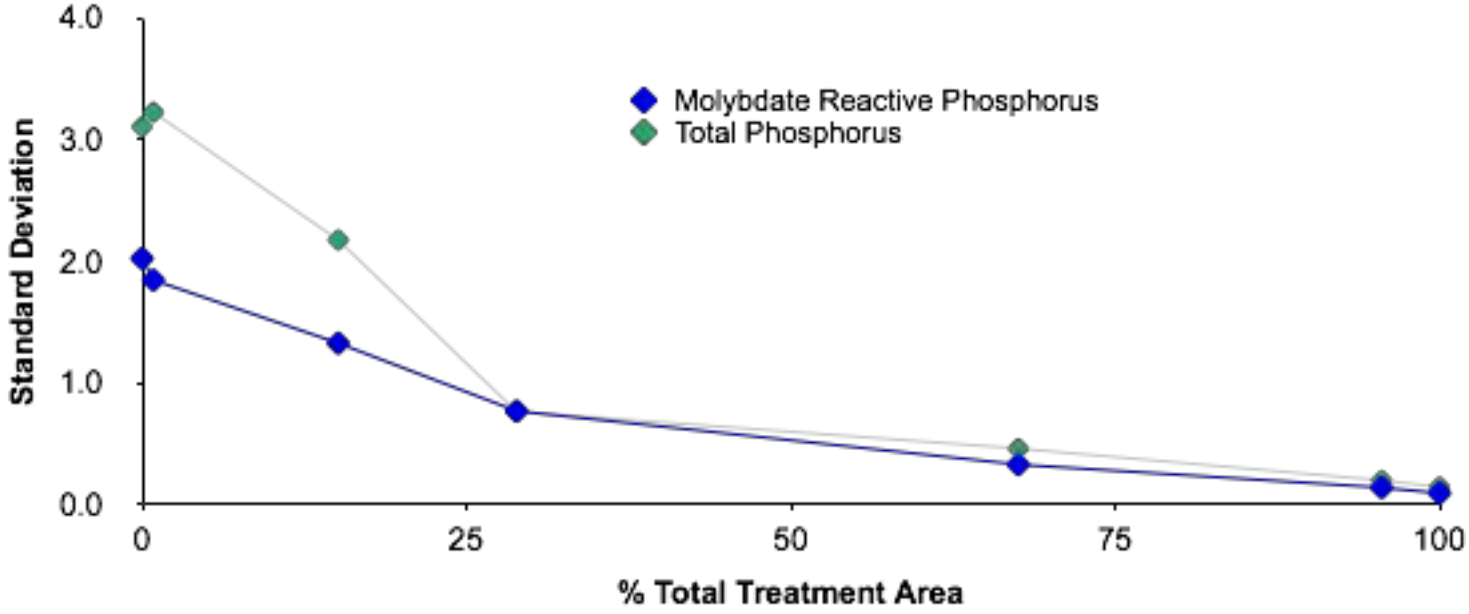
- **16 large (>1ha) integrated constructed wetland (ICW) systems**
- **C. 12.5 km re-profiled stream corridor**
- **C. 200ha forest plantation**
- **C. 20ha extant woodland**




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



Sustained performance over time



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

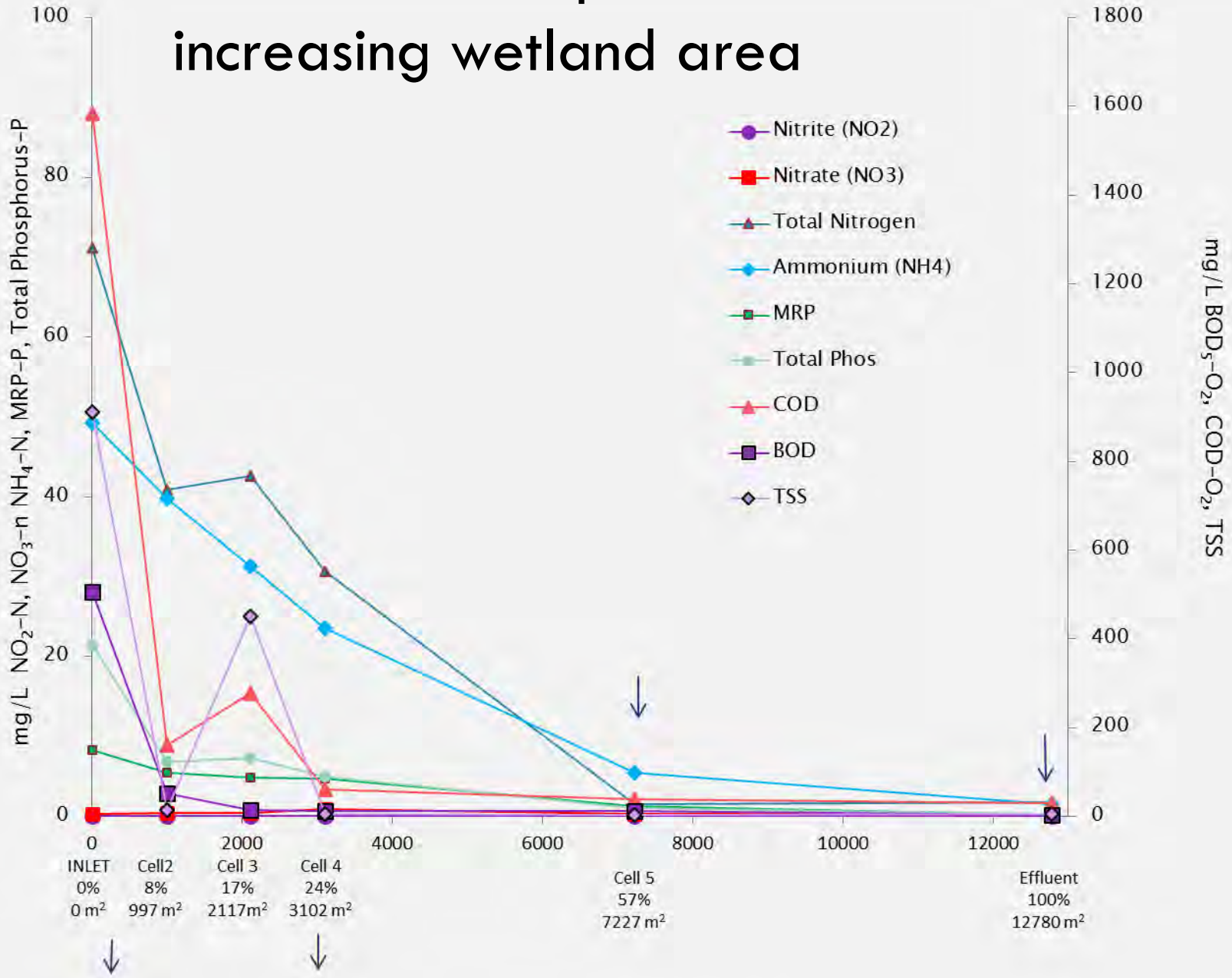
CELL NUMBER	SAMPLING POINT	**ECOLI (Fecal Coliforms) per 100 mls**	TOTAL COLIFORMS per 100 mls	**ACCUMULATIVE PERCENTAGE OF ICW AREA**
Sludge pond	INLET	**559950**	>1209800	**1.2**
1	INLET	**86640**	>241960	**15**
2	INLET	**20924**	48392	**29**
3	INLET	**292**	1074	**67.5**
4	INLET	**<10**	63	**96**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

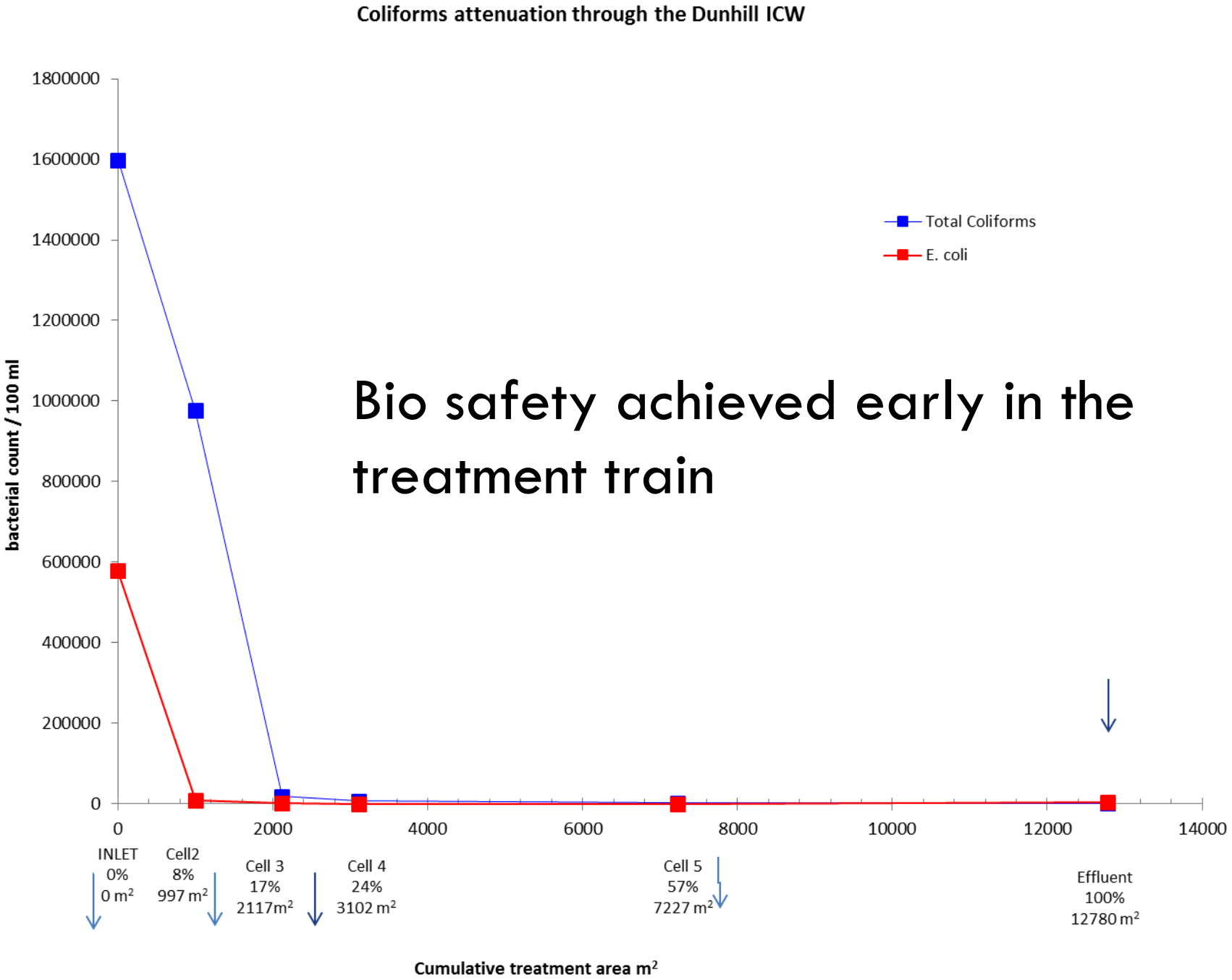
Lab#	Location	Sample date	COD	Ammonia-N	MRP-P	NO3-N	NO2-N	ToxN	Cl	Total coli	E.coli
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(/100ml)	(/100ml)
20160001	Dunhill ICW stormwater pond u/s of confluence with ww eff	04/01/2016	17	0.09	0.07	4.9	0.113	5.02	30.4	NT	NT
20160002	Dunhill ICW pond 5 effluent to SW pond	04/01/2016	45	5.8	0.95	<0.1	0.009	<0.1	32.5	2143	10
20160003	Dunhill ICW SW & WW combind dischage to river	04/01/2016	28	2.4	0.42	2.8	0.308	3.1	31.5	NT	NT
20160004	Annestown Stream at footbridge DS ICW	04/01/2016	25	0.24	0.11	5.9	0.228	6.17	34.7	3873	571
20160005	Dunhill ICW GW reference pond	04/01/2016	18	0.02	0.04	4.2	0.023	4.25	36.7	NT	NT
20160026	Annestown Stream Upstream of ICW outfall	08/01/2016	NT	0.17	0.13	5.6	0.056	5.69	33.9	NT	NT
20160027	Annestown Stream Downstream of ICW outfall @ footbridge	08/01/2016	NT	0.18	0.17	5.6	0.057	5.7	33.9	NT	NT

10

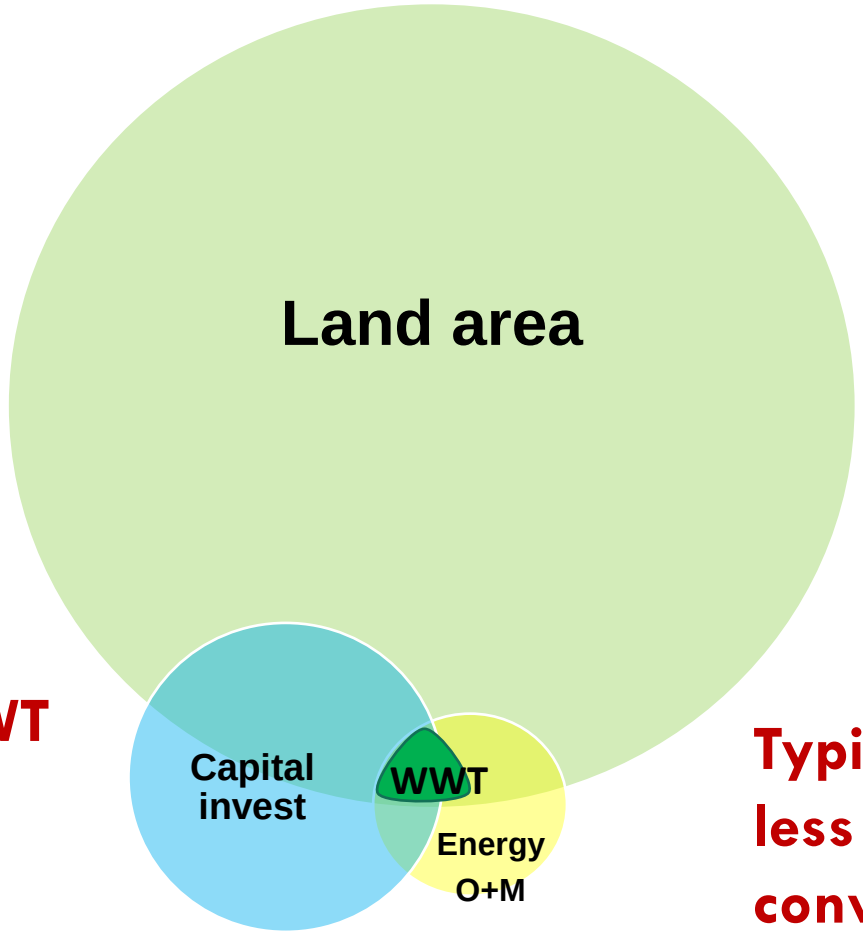
571

Performance improves with increasing wetland area




Coliforms attenuation through the Dunhill ICW
bacterial count / 100 ml
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
Total Coliforms
E. coli
Bio safety achieved early in the treatment train
0
2000
4000
6000
8000
10000
12000
14000
INLET 0% 0 m²
Cell2 8% 997 m²
Cell 3 17% 2117m²
Cell 4 24% 3102 m²
Cell 5 57% 7227 m²
Effluent 100% 12780 m²
Cumulative treatment area m²

Cost of Integrated Constructed Wetland (ICW) systems



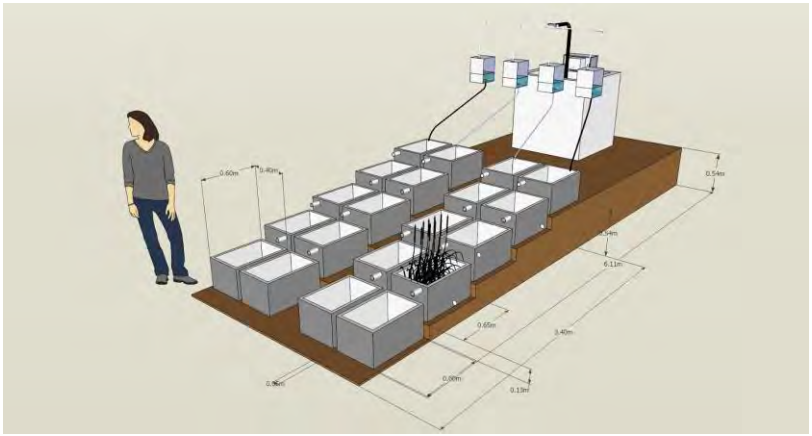
Typically 60 – 80% less than conventional WWT (including land cost)

Typically >90% less than conventional WWT

Scientific rigour

Experimental science approach:

- Replicated treatments
- Measurable dynamics of known and emerging contaminants



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

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

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

etc.....

Amenity & awareness values of ICWs

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

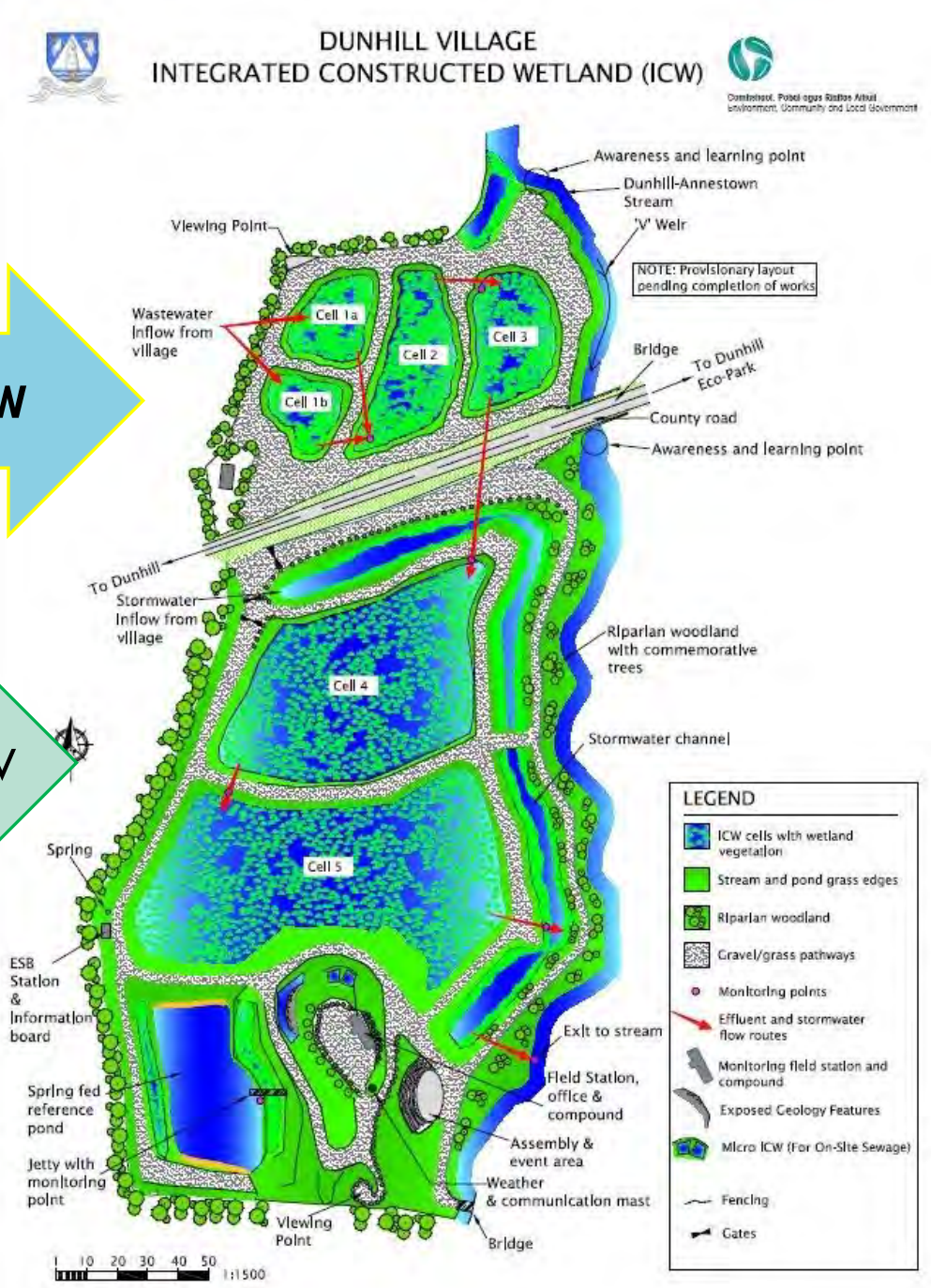
'Old' (1999) ICW

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)



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

European Commission - Press release

Closing the loop: Commission adopts ambitious new Circular Economy Package to boost competitiveness, create jobs and generate sustainable growth

Brussels, 2 December 2015

Today the Commission adopted an ambitious new Circular Economy Package to stimulate Europe's transition towards a circular economy which will boost global competitiveness, foster sustainable economic growth and generate new jobs.

ICWs sequester carbon, phosphorous and nitrogen

Improved biodiversity

Is change and implementation possible? …What if? …what if we do ……. what if we don't?

What are the roles of leadership, regulation and demonstration…….?

Understanding what makes people respond:

Is there awareness or understanding….?
Is there cohesion or differentiation……?
What values are held, is empathy possible…?
What are the cultural or social drivers……..?

Warning!!

The ICW concept and its objective to obtain multiple benefits must ***not be overtaken by formulaic engineered approaches*** that might compromise its site-specific creative philosophy and scientific depth.

Where formulaic engineered solutions are often applied, opportunities to deliver on multiple benefits (SE&E) are often missed due to a ‘tick-the-box’ approach to design, whereby the ‘little boxes’ are filled-in and the concept lost……..

ACKNOWLEDGEMENTS

- **Aila Carty and Caolan Harrington: VESI Environmental Ltd. Ireland**
- **Paul Carroll and Sue Cook: Waterford Council, Ireland**

Thank you for your attention