# Improving the design of urban stormwater ponds

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# Acknowledgements


- Scottish Water and Heriot-Watt University funded Catherine Morgan's PhD research
- Adolf Spitzer for Linburn Pond data
- British Atmospheric Data Centre for rainfall data

# Urban stormwater ponds (retention basins)

- Permanent pool of water
- Flow attenuation
- Water quality enhancement occurs primarily by sedimentation
- Different design aims affect pond performance

# Design for flow attenuation *vs.* water quality enhancement

| Pond design | Radius (m) | Inflow | Peak inflow ($L\ s^{-1}$) | Peak inflow reduction (%) | Inflow sediment mass settled (%) |
|---|---|---|---|---|---|
| Flow attenuation | 75 | Q90 | 28.7 | 94 | 98 |
| Flow attenuation | 75 | 1 in 2 year | 125 | 69 | 78 |
| Water quality | 16.45 | Q90 | 28.7 | 4.0 | 48 |
| Water quality | 16.45 | 1 in 2 year | 125 | 2.0 | 21 |

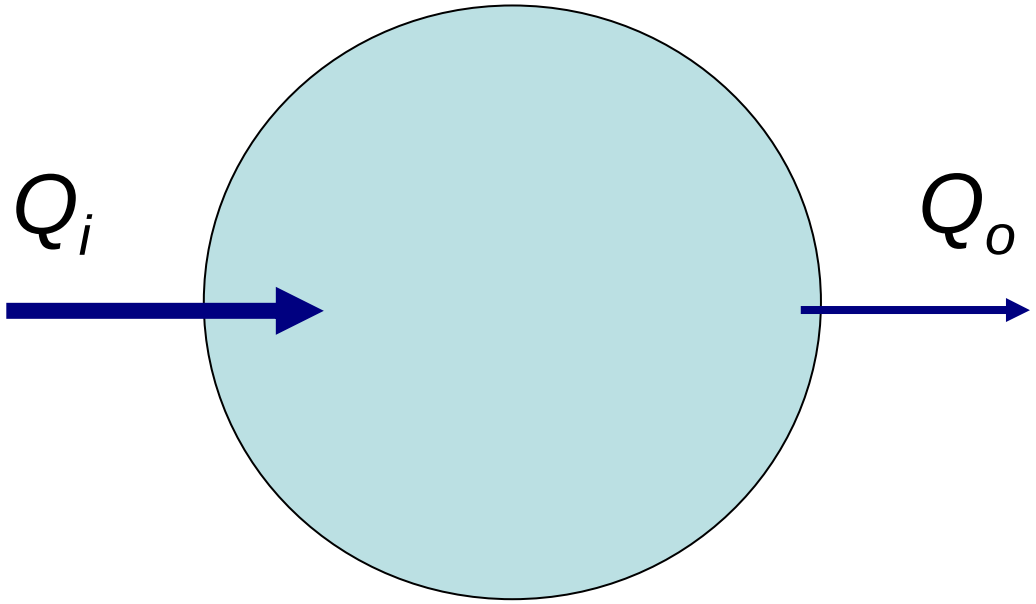
Morgan, C.T., Heal, K.V., Wallis, S.G. and Lunn, R.J. (2007). Assessing the effects of design and climate change on sediment removal in urban stormwater ponds. In: Webb, B. W. and de Boer, D. (Eds.), *Water Quality and Sediment Behaviour of the Future: Predictions for the 21st Century,* IAHS Publication no. 314, pp.71-78.

Higher peak inflow reduction and sediment mass settled in ponds designed for flow attenuation

# Presentation aim

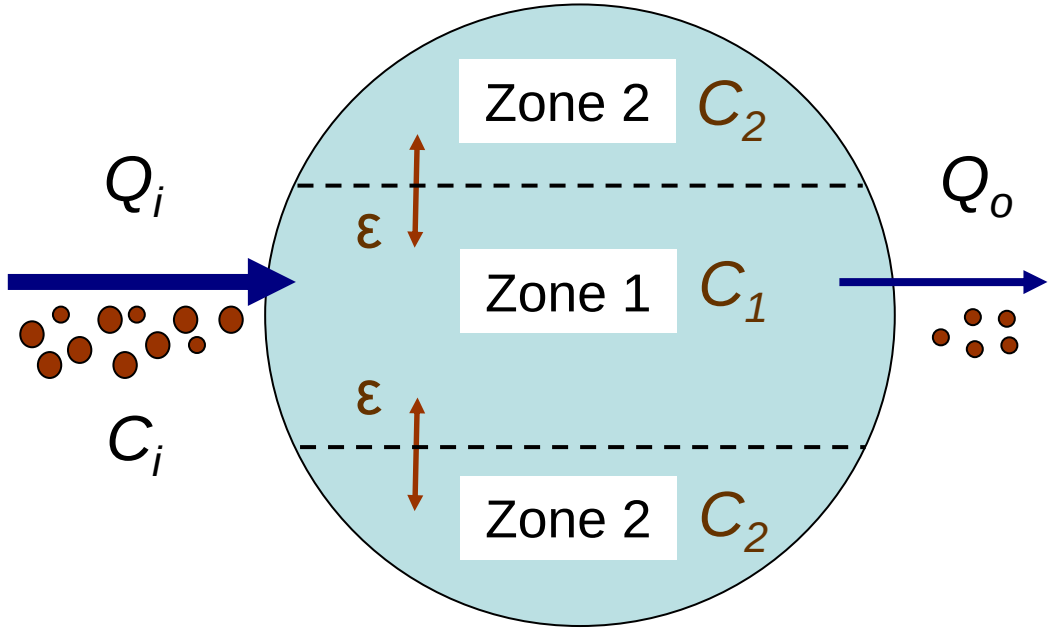
To demonstrate, using a similar generic modelling approach, how the use of a dual outlet for retention ponds can resolve potential design conflicts in an efficient manner

# Flow model




Conservation of water volume: $$\frac{dV}{dt} = Q_i - Q_o$$

# Sediment transport model




- Zone 1:
  - short-circuiting
  - flow-dependent settling (from Hjulström curve)
- Zone 2:
  - quiescent settling (values from Ellis *et al.*, 1995)

# Linburn Pond, DEX, central Scotland

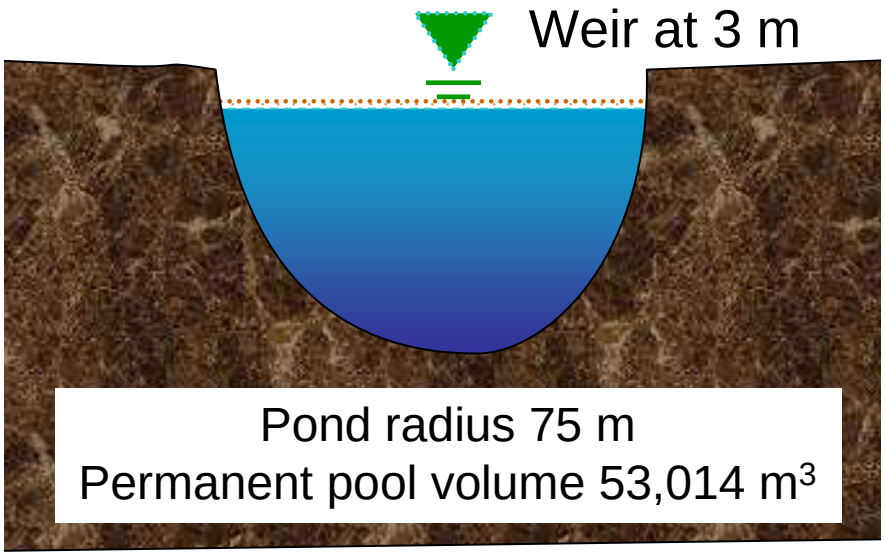
# Simulations

- Inflow hydrographs and sedigraphs triangular and symmetrical
- Peak inflow from analysis of 30-year daily rainfall record
- 5 sediment size classes
- Water level at weir crest at start of all simulations
- 0.24 h timestep
- Ponds sized to reduce the peak outflow to 50% or less of the peak inflow for the 1 in 25 year inflow event

## Single outlet

Maximum TSV

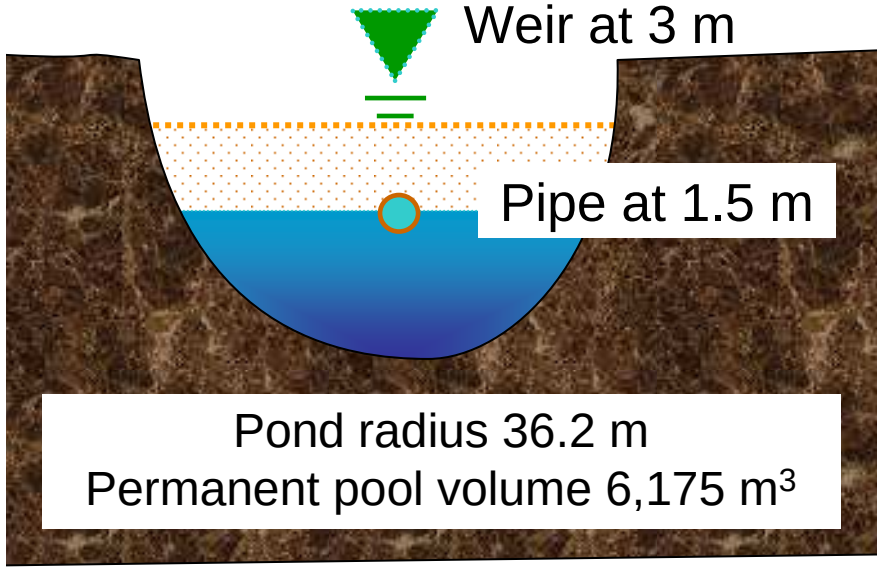
Permanent pool



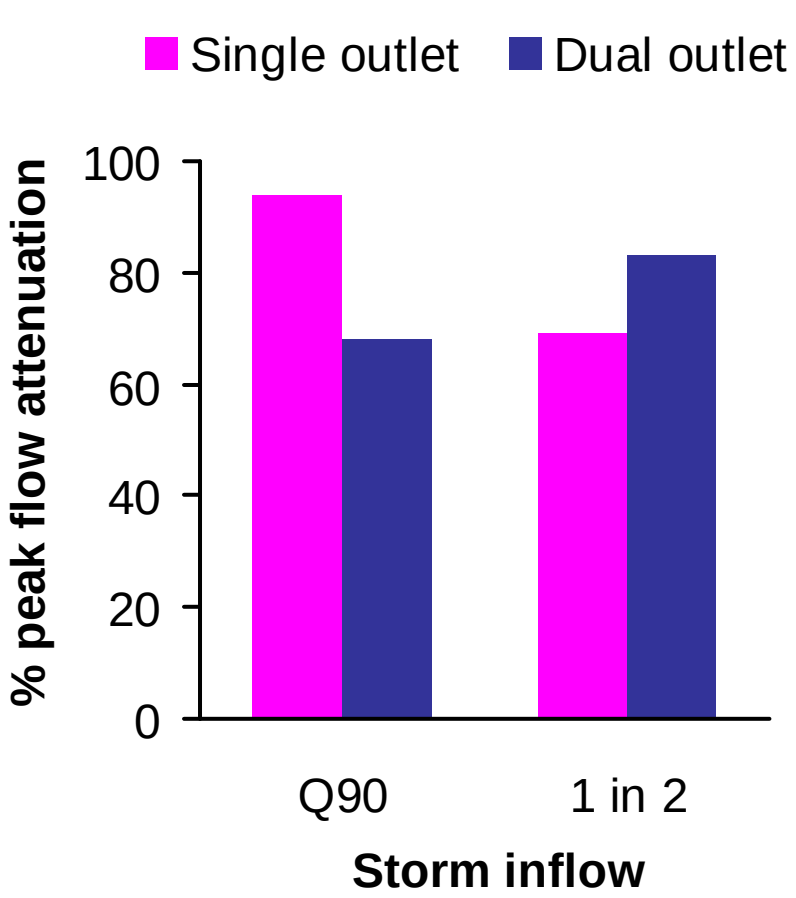

## Dual outlet

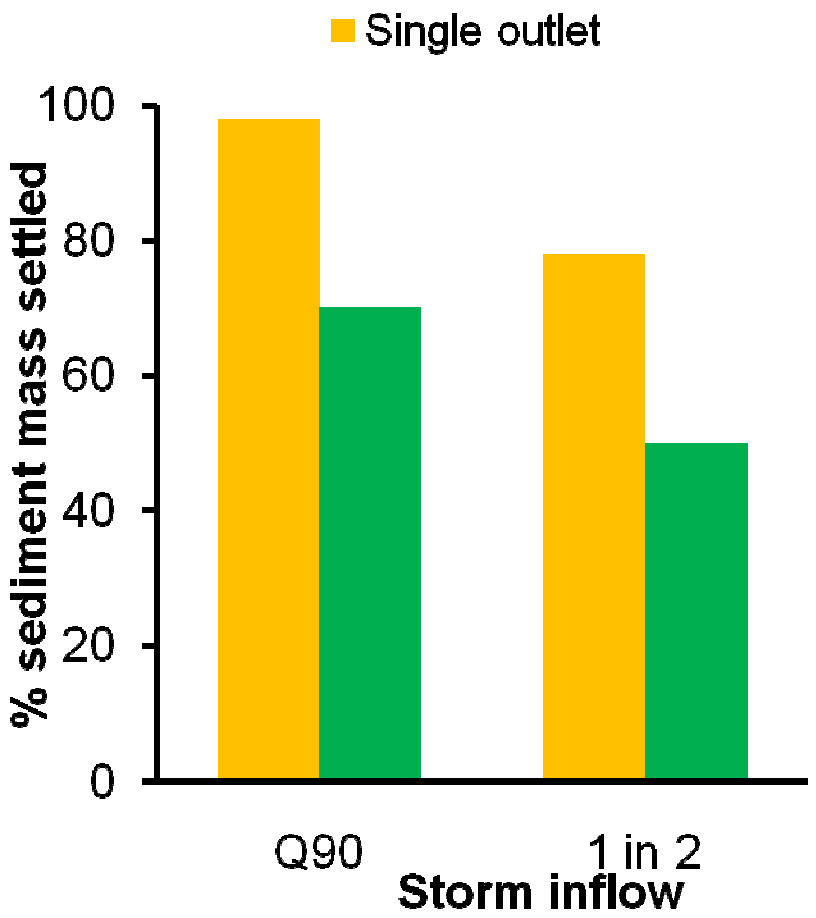
Sensitivity analysis showed pipe diameter of 0.1 m and 1.5 m above pond base most favourable for attenuating peak flow and sediment settlement

Wallis et al. (2006) *Wat. Sci. & Technol.* 53(10), 229-236



# Generic pond simulations



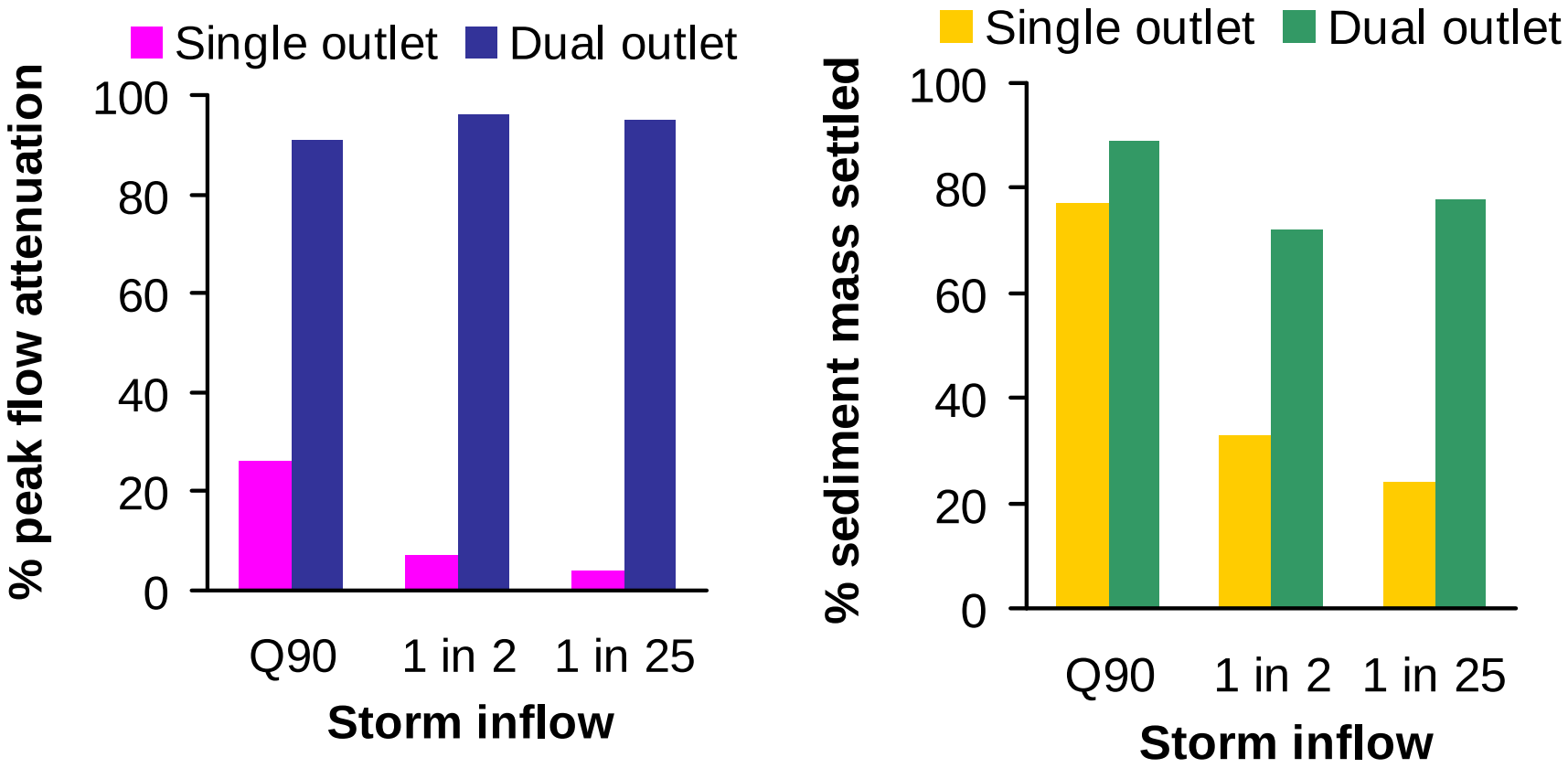

Dual outlet pond most effective as storm inflow increases

Single outlet pond most effective due to much larger permanent pool volume

# Optimising the design of Linburn Pond

- Keep radius of 40 m
- Current single-level outlet: 4 x 90$^{o}$ V-notch weirs at 2.8 m above pond base
- Optimised dual outlet design for flow attenuation and sediment settlement
  - Weir crest at 3 m (max for health and safety)
  - Pipe elevation 1 m above pond base (1 m elevation min to sustain aquatic plant and animal communities and minimise bed scour)
  - Pipe diameter 0.05 m

# Linburn Pond simulations




Dual outlet pond provides increases in % peak flow attenuation and % sediment mass settled

# Conclusions

- The design of urban stormwater ponds has a significant effect on performance
- Benefits of multi-level outlet devices
  - Improved performance for flow attenuation (and sometimes sediment settlement)
  - Smaller pond footprint/permanent pool volume => reduced cost