World Water Day 2019

Resilience to drought and low flow conditions in Scotland

The effects of drought on freshwater fish and river restoration options to mitigate impacts

Hamish Moir & Chris Conroy

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The effects of drought on freshwater fish and river restoration options to mitigate impacts

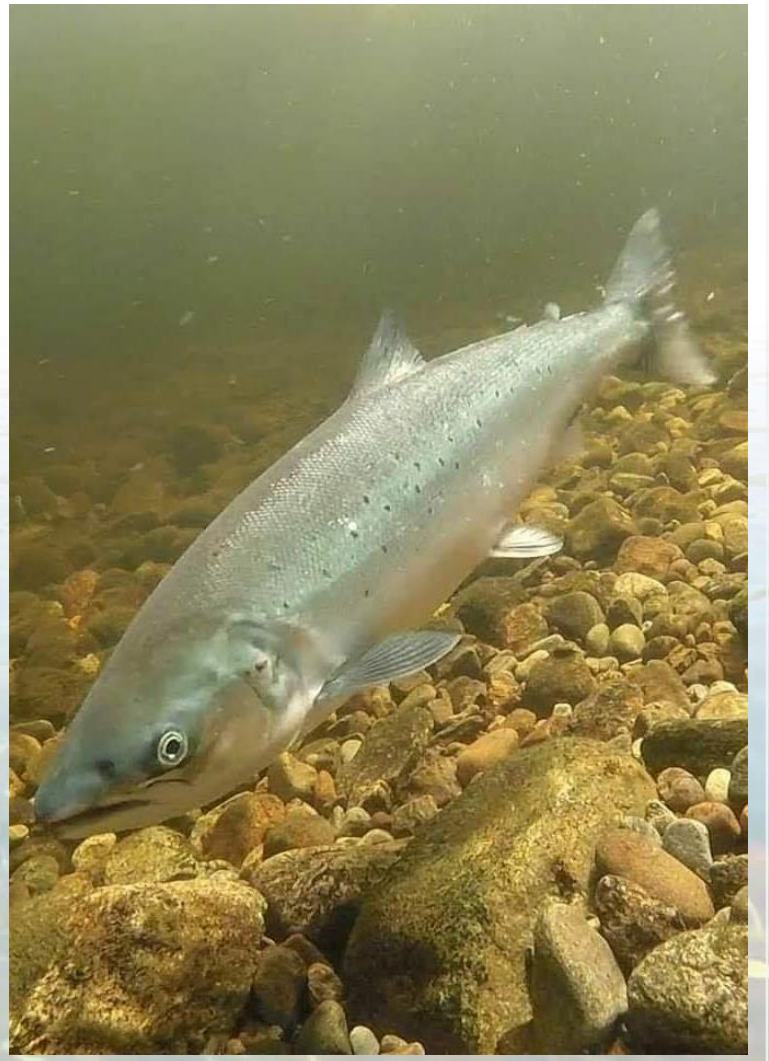
Talk outline:

- Effects of drought/ low flows on fish and their habitats (Chris Conroy)
- Catchment and floodplain scale methods to add low flow resilience to river environments (Hamish Moir)

Effects of Drought

General flow requirements of Atlantic salmon

- Flows must be of sufficient quantity and quality to stimulate the ‘primary’ migration of adult salmon through the tidal reaches and into the freshwater environment.
- Natural freshets must be of sufficient quantity and quality to provide access for adults to spawning and nursery areas during their late summer/autumn ‘secondary’ migrations.
- Summer flows must be sufficient to maintain adequate quality, depth and velocity in juvenile nursey areas with the availability of suitable habitat maximised.
- Natural freshets must be sufficient to stimulate and facilitate the downstream migration of juvenile salmon ‘smolts’ during the spring period.



Effects of Drought

Primary Migration - entry into freshwater

- The flow required to encourage migration from the sea into the freshwater reaches varies from river to river.
- The percentage of the Q95 required to provide a threshold migration flow at the tidal limit tends to be higher in smaller rivers.
- Temperatures exceeding around 16°C can be associated with reduced migration in estuaries and rivers, with very little migration above about 20 to 23°C.
- Lack of flow and elevated water temperatures associated with drought can result in a delay of fish entering the river.
- Increased predation, poaching, stress and subsequently disease.

Effects of Drought

Secondary Migration

- As adult fish moved further upstream the percentage of the Q95 required to maintain migration also increases.
- Natural or artificial freshets can be important in facilitating the upstream passage of fish over barriers.
- Increased effort required to negotiate obstacles in low flows can divert reserves from gonad development - lower quality eggs and survival of adults.
- Lower water levels reduces availability of pre-spawning refuge/cover for adults = increase predation, poaching, stress and subsequently disease.

Effects of Drought

Spawning and nursery areas

- Low flows associated with drought can result in sedimentation of spawning substrate.
- Exposure of ‘redds’ (or nests) can lead to reduced survival or total loss of eggs.
- Reduced wetted area results in a decrease in juvenile habitat = increased competition for territory food and predation.
- Low flow can result in higher water temperatures - over 25°C can be lethal for salmon.
- Higher river temperatures = increased growth rates = younger smolts and earlier migration to sea.

Effects of Drought

Downstream migration of salmon ‘smolts’

- Major physiological and behavioural changes juvenile salmon prepare for life at sea.
- Less territorial, gather in schools and exhibit increased downstream orientation.
- Drift passively and have a very limited period of readiness in which they must enter the sea.
- Freshet flows help the smolts make the journey downstream, drought can delay the process.
- Increased predation at ‘bottle-necks’ with the ‘window’ of opportunity missed.

Effects of Drought

Worst case scenario - Total loss of flow

Salmonid fish species require lots of good quality, cool water to survive and thrive!

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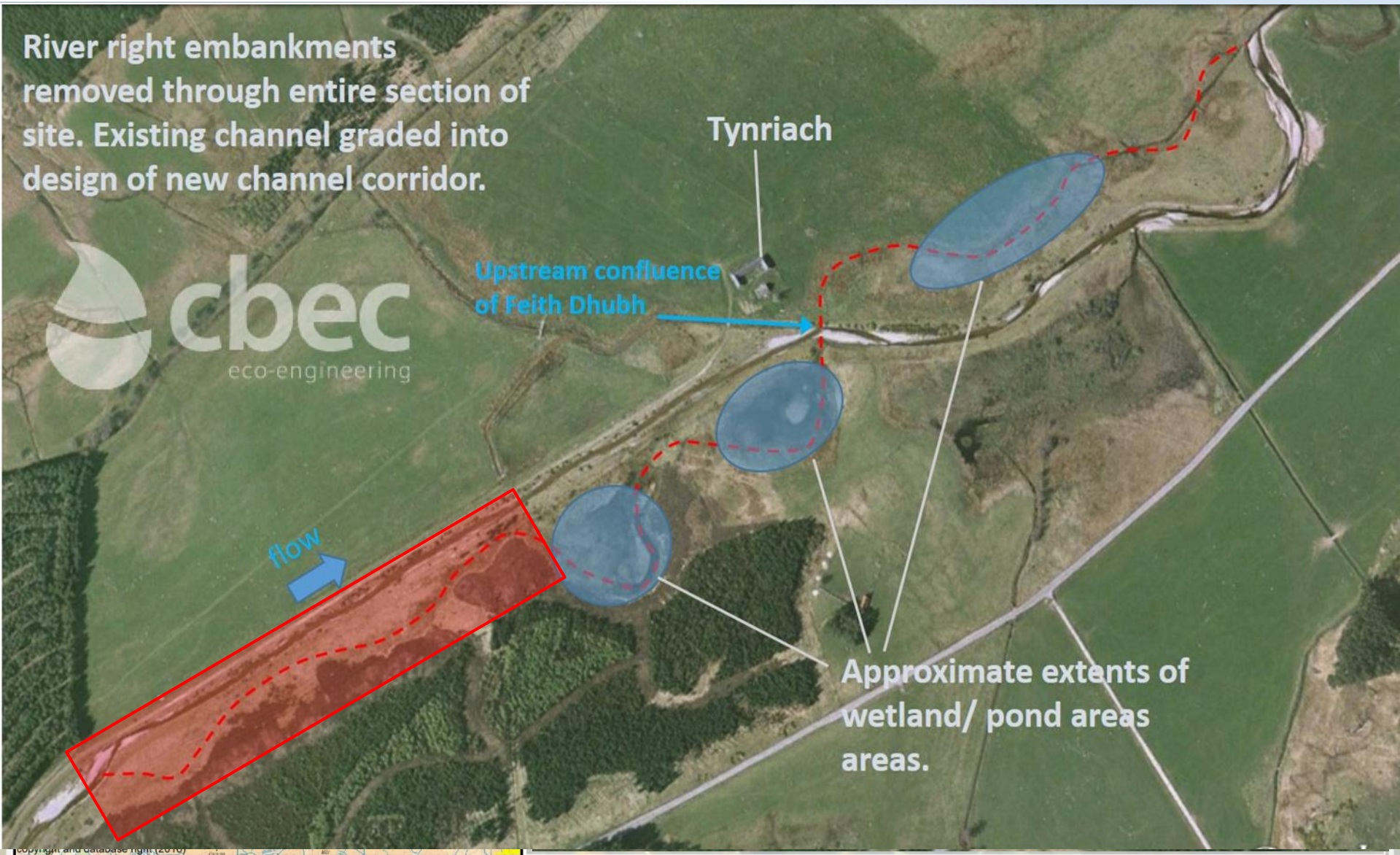
Adding low-flow resilience to instream ecology through catchment-scale re-naturalisation of physical processes

- All river catchments physically impacted by human activity (land-use, river engineering etc) – increases their 'ecological sensitivity' to both high and low flows
- Significant potential through sustainable catchment management/ river restoration to improve resilience to extreme flow conditions
- Most sustainable approach is catchment scale reinstatement of natural physical processes – 'let the river do the work'

Restoration of natural channel-floodplain processes

- Reinstate natural processes of supply, transport and storage of water, sediment and large wood
- Provides ecological resilience by enhancing physical diversity and providing habitat refugia to extreme hydrological conditions (River Nairn case study).
- Specifically relating to fishery, barriers to movement of fish (e.g. weirs) will become more significant in extreme drought situations –management of barriers also provides increased resilience.


River right embankments removed through entire section of site. Existing channel graded into design of new channel corridor.
Tynriach
Upstream confluence of Feith Dhubh
flow
Approximate extents of wetland/ pond areas areas.

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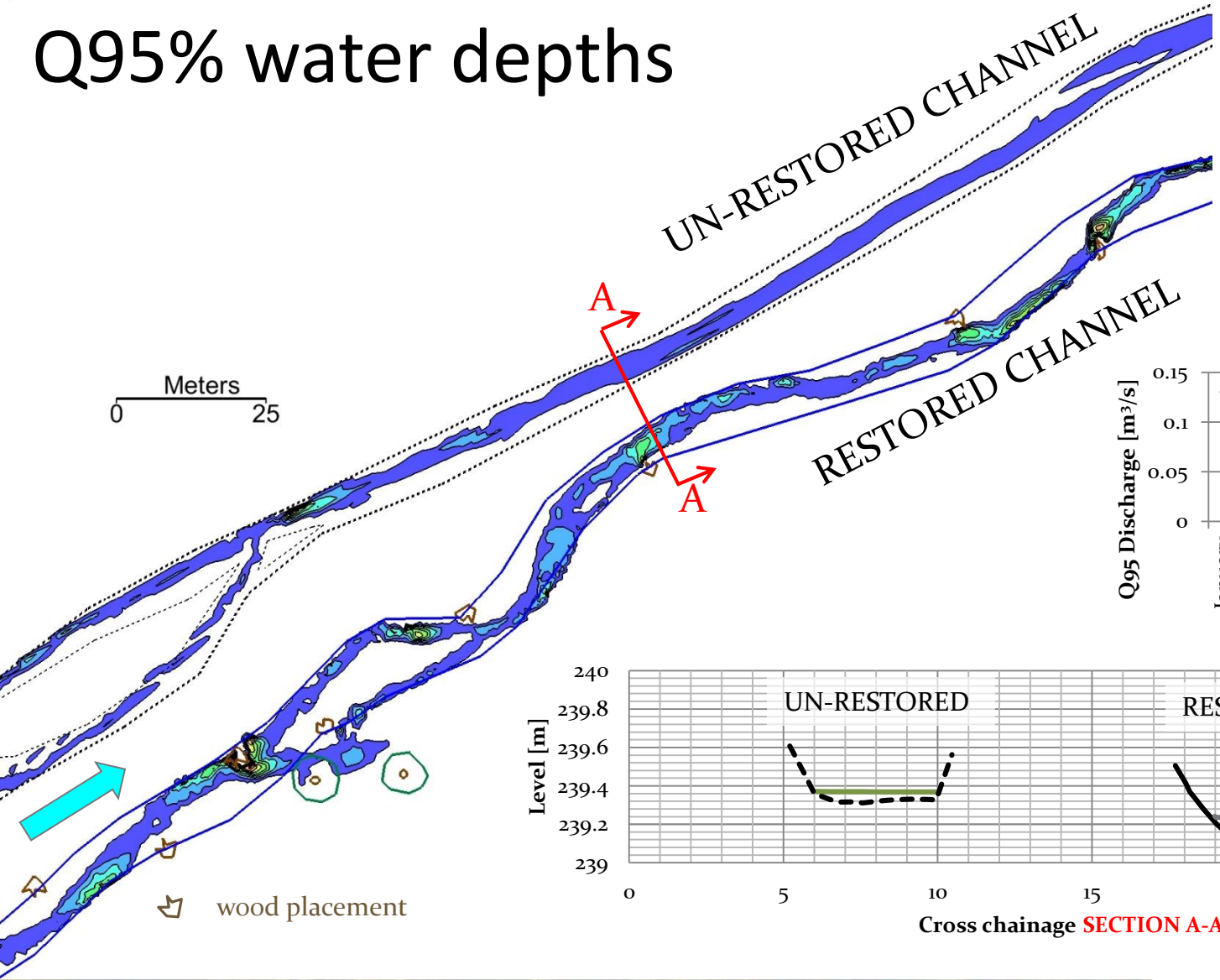
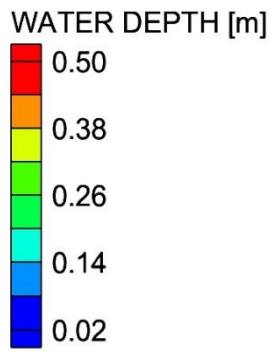
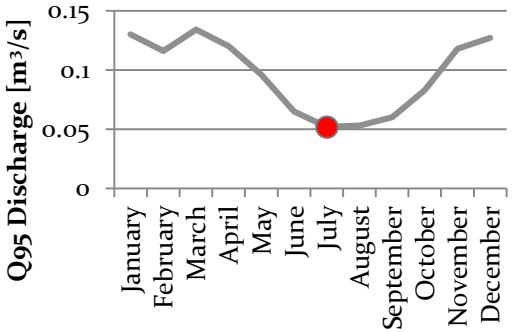
Q95% water depths







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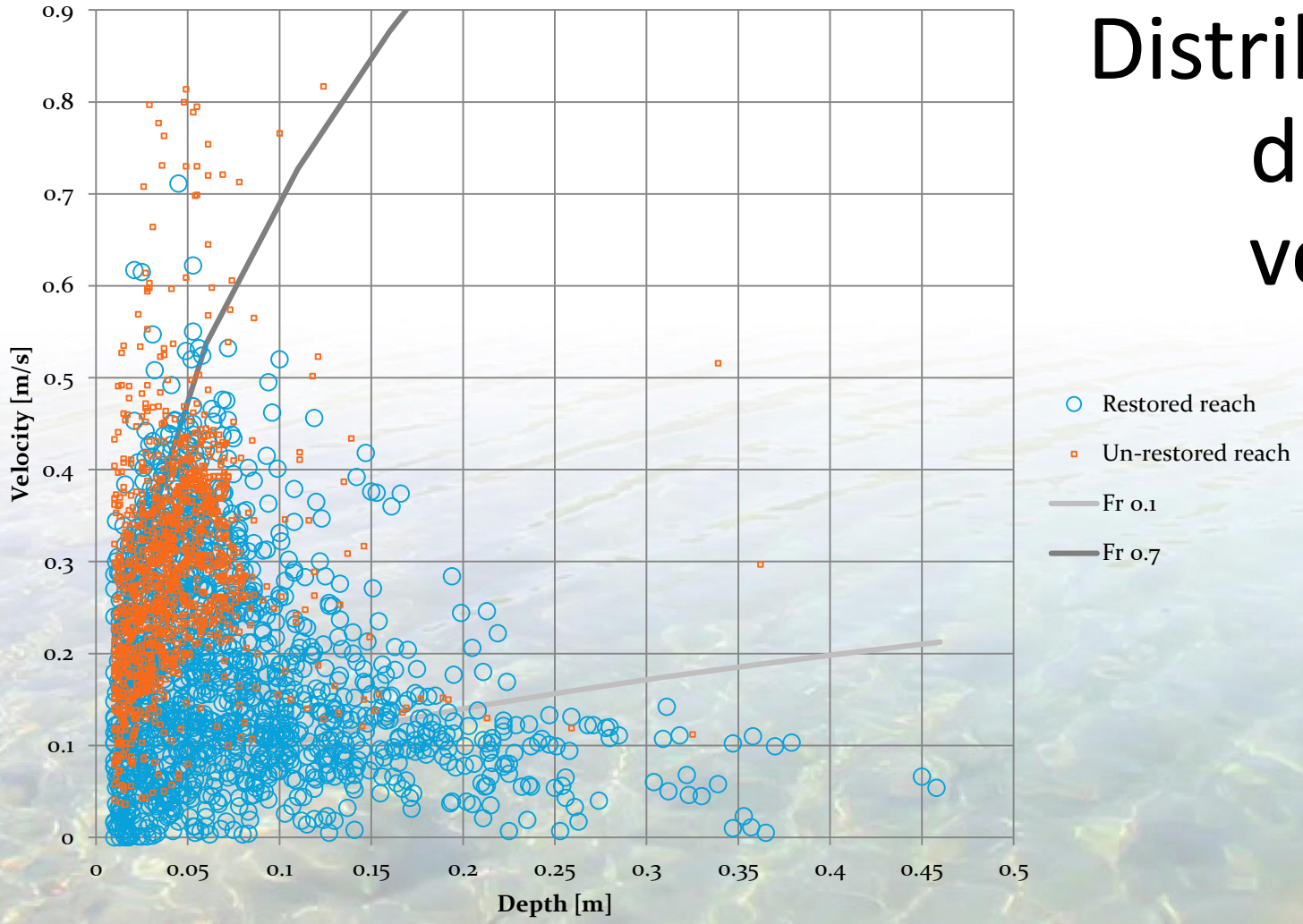
Distribution of depth and velocity at Q95%



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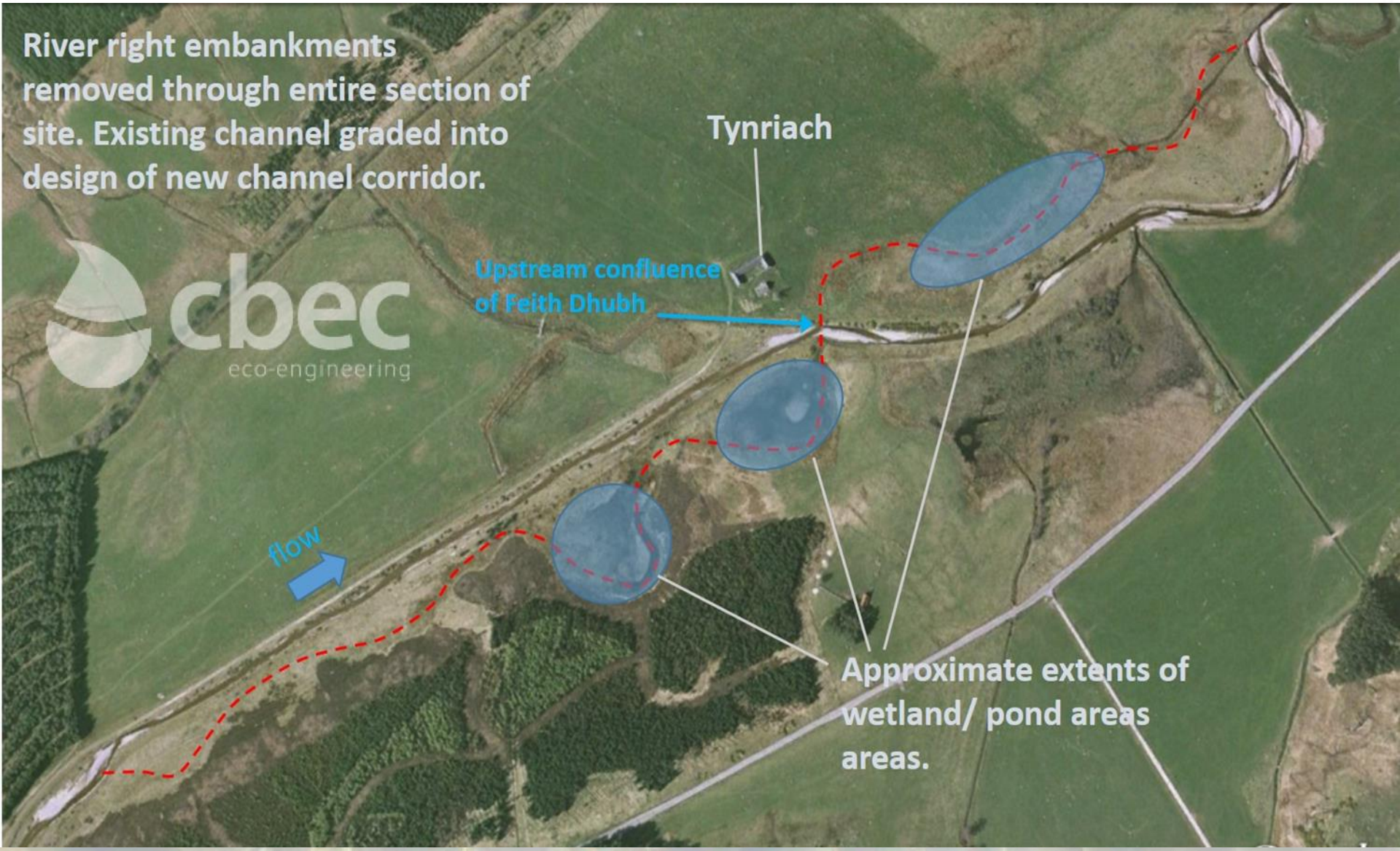

Ecological Benefits of Wetlands:

- Wetlands/ connected floodplains significantly reduced through river management practices
- Refugia from high and low flows - maintaining baseflows in summer
- Potentially important in controlling water temperatures
- Management/ storage of fine sediment

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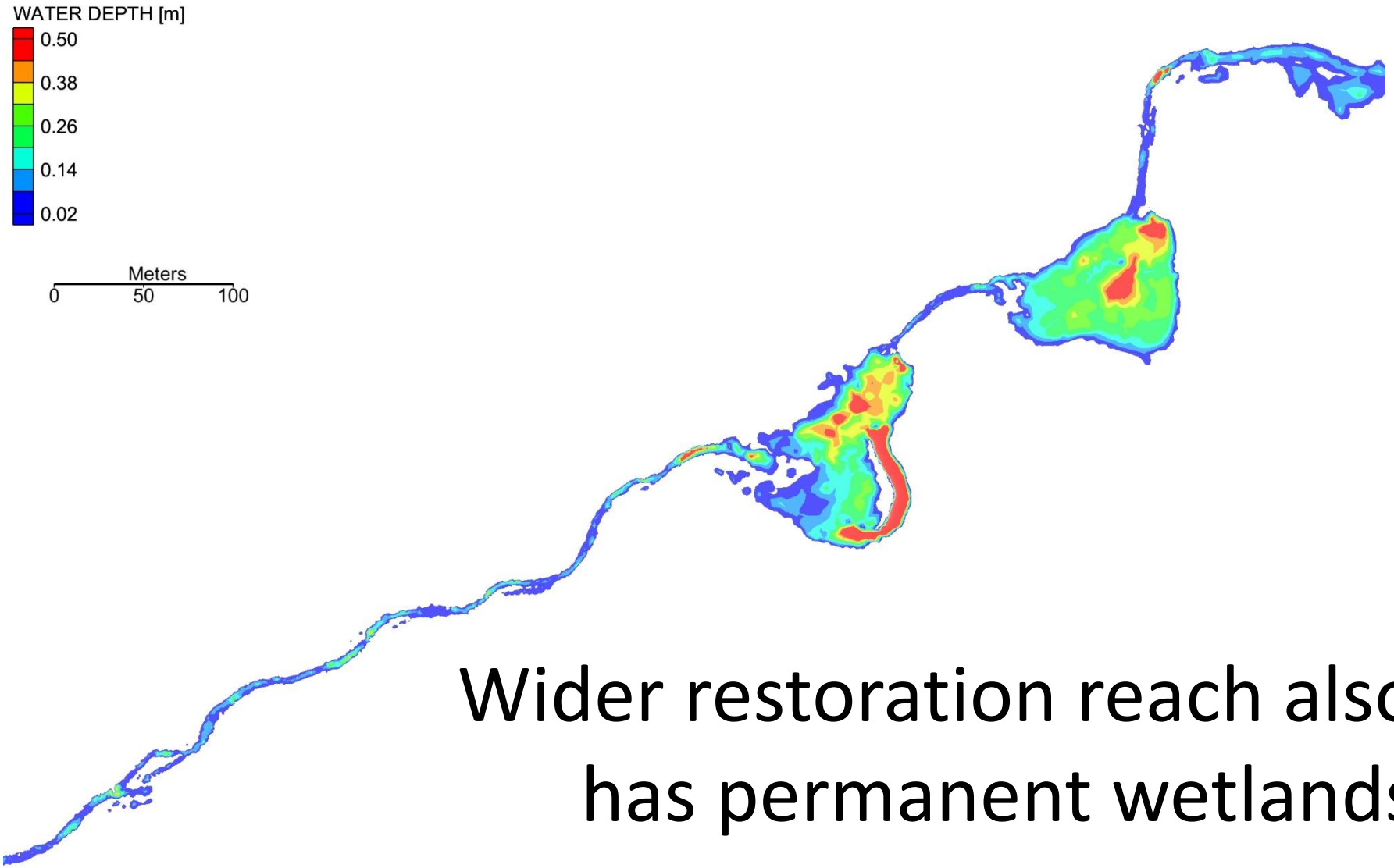

Wider restoration reach also has permanent wetlands

Conclusions

- Drought flows significantly impact all species and life stages of fish and their habitats
- Ecological effects of droughts exacerbated by human impacts to the river environment (land-use and river engineering)
- Significant potential to improve ecological resilience through reinstatement of natural physical processes
- Process-based river restoration adds physical diversity to the river environment, partly mitigating impacts of drought flows
- Wetland enhancement has a potentially very significant benefit to mitigation of the ecological impacts of drought

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THANK-YOU FOR YOUR ATTENTION!

Catchment-scale management of run-off

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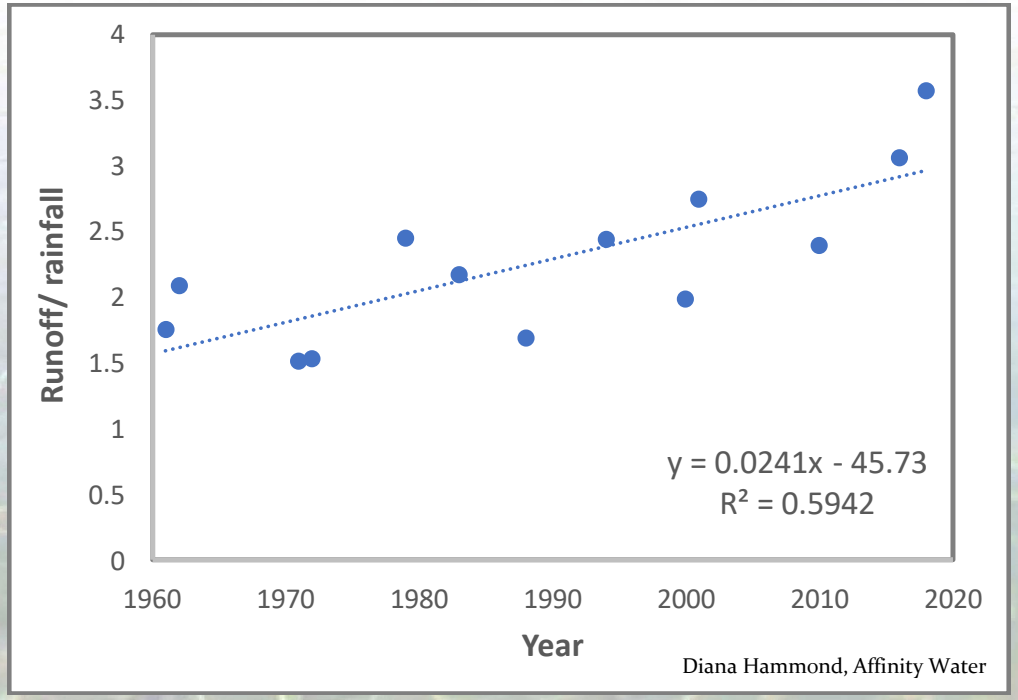
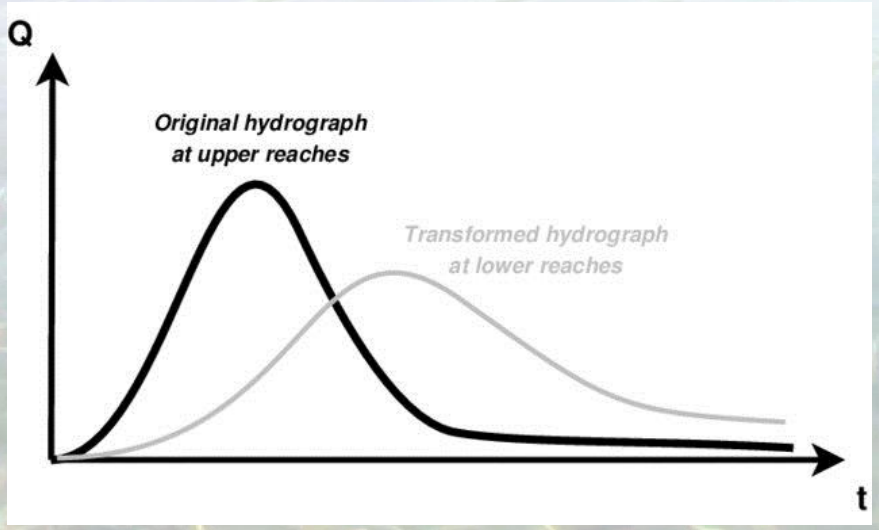


Catchment-scale management of run-off

- run-off rates generally increased due to land management practices (e.g. deforestation, enhanced drainage, grazing pressure etc).
- NFM aims to re-naturalise catchment hydrology – primarily for flood risk but also enhances base flows.



Catchment-scale management of run-off

- run-off rates generally increased due to land management practices (e.g. deforestation, enhanced drainage, grazing pressure etc).
- NFM aims to re-naturalise catchment hydrology – primarily for flood risk but also enhances base flows.
- NFM measures will provide climate change resilience for both floods AND droughts.

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