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QUANTIFYING AND DEMONSTRATING CONSTRUCTED WETLAND CONTAMINANT ATTENUATION FROM MIXED AGRICULTURAL RUNOFF

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Constructed wetlands (CWs) are a versatile and robust mitigation tool to complement on-farm nutrient management actions. Amongst the gamut of different edge-of-field mitigation options, CWs are one of the top contenders for widespread implementation in New Zealand (Tanner et al. 2020a). Surface-flow CWs, comprised of vegetated shallow channels or a series of impoundments, are the most suitable and lowest-cost type of wetland to construct for intercepting diffuse farm runoff. They function with water flowing slowly through beds of emergent aquatic plants such as sedges and bulrushes (Figure 1). Their simplicity and robustness under highly variable flow conditions make them widely applicable across a range of farm types and landscape settings.

Constructed wetlands can effectively reduce multiple contaminants from farm run-off. Provisional estimates for New Zealand suggest that, as their relative size increases from 1-5% of their contributing catchment, median annual removal efficacies will increase from ~50-90% for Total Suspended Solids, ~26-48% for Total Phosphorus, and ~25-53% in for Total Nitrogen in warm regions and ~17-38% for Total Nitrogen in cool regions (Tanner et al. 2020b). However, field-scale information to quantify their efficacy in relation to wetland size across different New Zealand landscapes, flow pathways, and climatic zones is limited (Woodward et al. 2020). To address these knowledge gaps, we are working in partnership with regional councils, industry, and farmers to quantify and demonstrate the field-scale performance of CWs for reduction of sediments, nitrogen, phosphorus and faecal microbial contaminants from mixed surface runoff and groundwater inflows. Our aim is to fill critical information gaps identified in a recent systematic review of local and international field performance data (Woodward et al 2020) to support development of comprehensive New Zealand guidelines for constructed wetlands (Tanner et al. 2020b; Tanner et al. 2022).

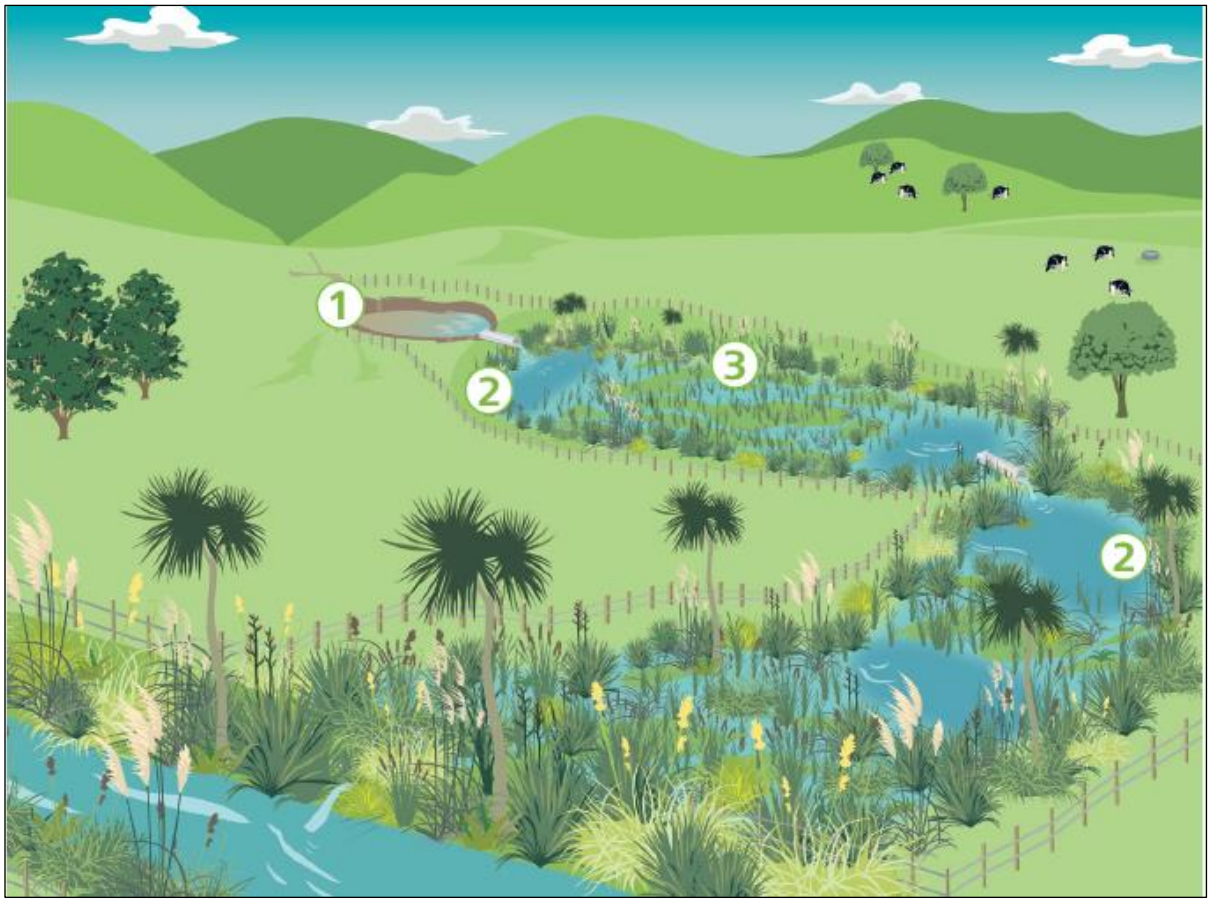

Figure 1. "Features of a surface flow constructed wetland on the landscape: (1) A deep sedimentation pond (more than 1.5m deep), size will depend on rainfall intensity and topography but generally up to 20% of wetland size, (2) Deep (over 0.5m) open water zones at the inlet of each cell to help dispersion and mixing, and even out the flow (3) Shallow (average 0.3m deep), densely vegetated zones (at least 70% of the total area). This is where most of the nitrogen removal happens via microbial denitrification, fuelled by decaying plant leaf litter. Maintain dense plantings in the outlet zone to limit faecal contamination by waterfowl (Tanner et al. 2022)."

Comprehensive monitoring of the performance of three recently constructed wetlands and three new CWs is being undertaken in five contrasting farmscapes. These CWs are located in Canterbury, Golden Bay, Hawke's Bay, Taranaki, and the Bay of Plenty (Figure 2).

Three years of telemetered, near-continuous flow, turbidity, and nitrate data and regular and event-based water quality data for Total Suspended Solids, Total Phosphorus, Dissolved Reactive Phosphorus, Total Nitrogen, Nitrate-N, Ammonium-N, and *Escherichia coli* are being collected and collated into a database with national coverage. We will use a range of modelling tools to integrate information from continuous flow, turbidity and nitrate measurements, and discrete monthly and event water quality sampling, to quantify annual treatment mass loading, export, and treatment performance for each wetland. Measured and flow-proportional concentrations and percentage reductions, mass removal (g m^{-2} yr^{-1}), and percentage mass removal will be used to assess CW treatment efficacy.

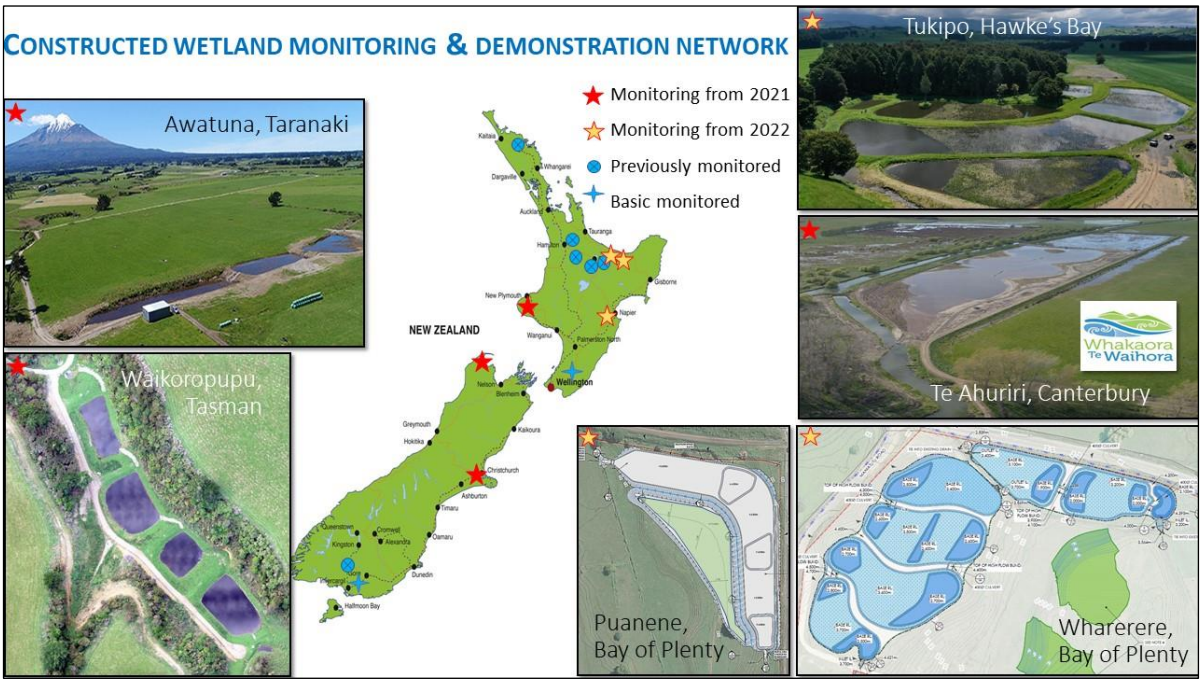

Figure 2. Locations and site photos of the six wetlands where comprehensive monitoring of diffuse pollution attenuation is underway.

Our project will establish a 'demonstration network' of CWs, showing how they can improve attenuation of diffuse runoff in pastoral landscapes. The six wetland demonstration sites established and promoted across the country will serve as educational platforms that showcase the practical application, benefits, and fit of wetlands within a range of diverse farm systems and landscapes. We are working with partner councils, DairyNZ and Beef + Lamb NZ and local catchment groups to run local field-days at each of the six demonstration sites.

Overall, building the scientific evidence base is crucial to provide farmers with reliable measures of CW efficacy so they can assess their cost:benefit as mitigation tools, apply and size them appropriately, and account for their contaminant load reductions in farm nutrient budgets and environment plans. Outcomes from this work will provide sufficient assurance for regulators to allow farmers to claim CW nutrient reductions to achieve required contaminant loss limits, and for industry and rural professionals to confidently promote their use.

Acknowledgements

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Councils and Tasman District Council, DairyNZ, Fonterra (Hawkes Bay site), and Beef+LambNZ.

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