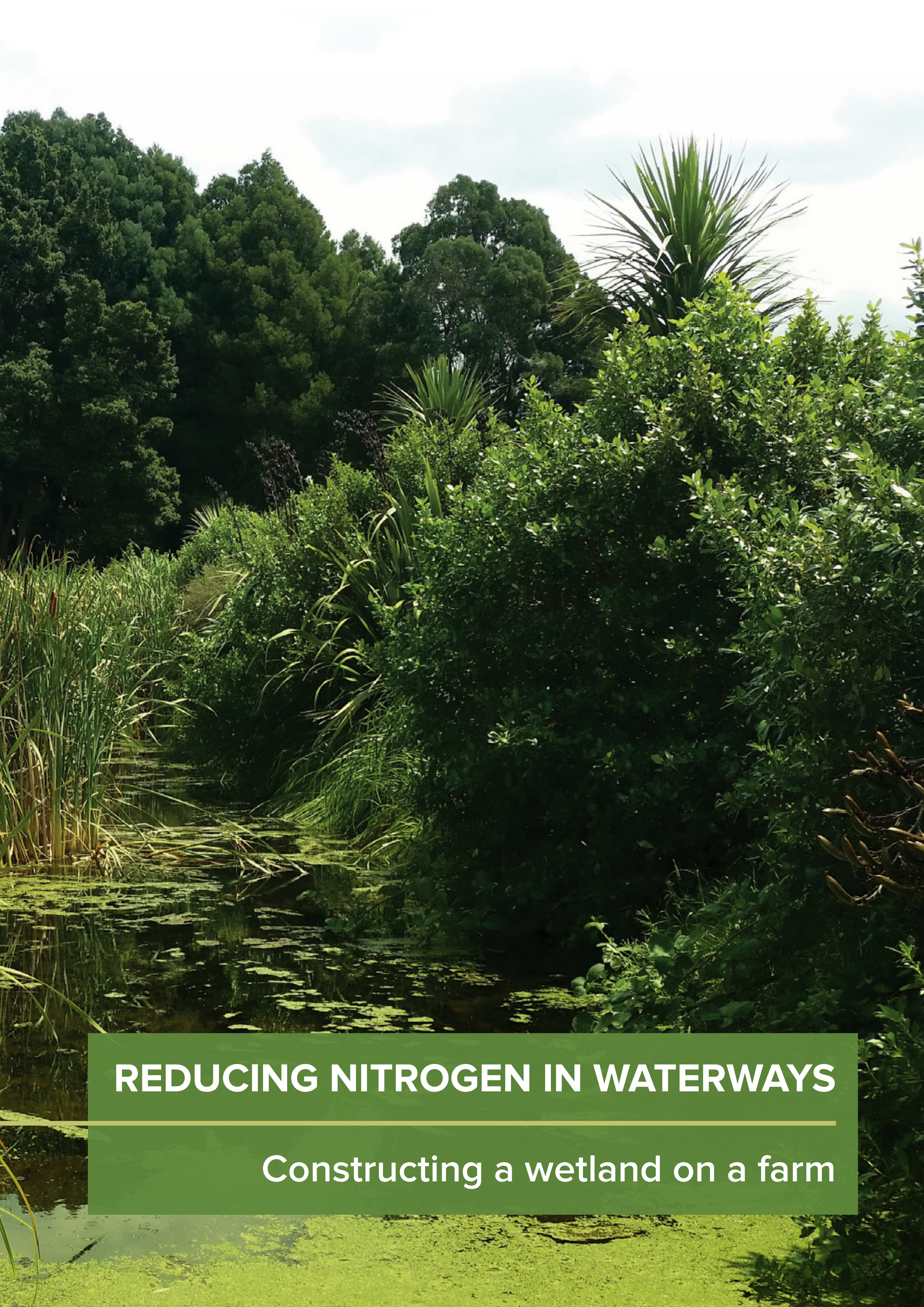


REDUCING NITROGEN IN WATERWAYS

Constructing a wetland on a farm

Thinking about creating a wetland on your property? This guide covers key aspects and some tips from on-farm experience over the last six years.

Natural wetlands were a common feature of the Ruamahanga river basin prior to European settlement. They provided a system for cleaning water on its way to Lake Wairarapa by removing sediment and some dissolved nutrients. Most of the wetlands have been drained and developed into productive pastoral farms, and few now remain on farms, but the sediment and dissolved nutrients remain.

In fact, the risk of contaminants such as nitrogen entering the waterways fed by farm drainage systems is recognised as an issue facing the agricultural industry. Tile (pipe) and open (surface) drain systems carry water away from the soil when the soil profile is saturated. The drainage water typically has elevated levels of Nitrate-Nitrogen (NO3-N) caused by urine patches[1] from sheep and cattle. NO3-N is an important plant fertiliser, but it is highly soluble and leaches through soils, particularly after heavy rainfall. Dairy cows deposit large quantities of urine onto pasture, equating to 700 to 1000 kg N/ha under a urine patch. Reducing nitrogen in the feed and/or removing cows from grazing when the soil is wet reduces the risk to waterways. However these options are not always available, practical or economic.

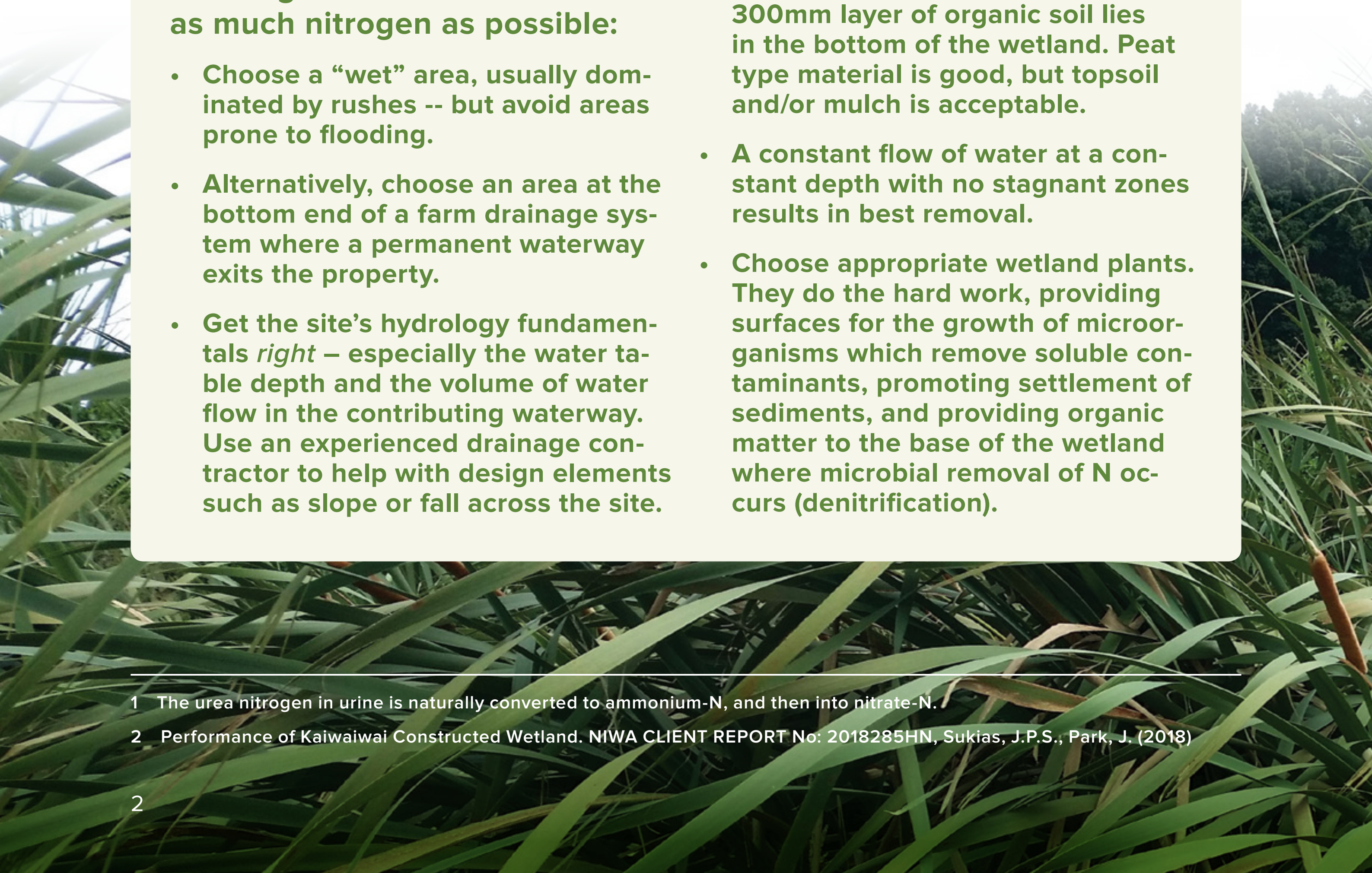
A well-designed wetland created and constructed on a farm in the Wairarapa has cost effectively reduced farm loss of nitrogen by as much as 10%[2].

To design a wetland to remove as much nitrogen as possible:

- **Choose a “wet” area, usually dominated by rushes -- but avoid areas prone to flooding.**
- **Alternatively, choose an area at the bottom end of a farm drainage system where a permanent waterway exits the property.**
- **Get the site’s hydrology fundamentals *right* – especially the water table depth and the volume of water flow in the contributing waterway. Use an experienced drainage contractor to help with design elements such as slope or fall across the site.**
- **Plan water levels so that a 100 to 300mm layer of organic soil lies in the bottom of the wetland. Peat type material is good, but topsoil and/or mulch is acceptable.**
- **A constant flow of water at a constant depth with no stagnant zones results in best removal.**
- **Choose appropriate wetland plants. They do the hard work, providing surfaces for the growth of microorganisms which remove soluble contaminants, promoting settlement of sediments, and providing organic matter to the base of the wetland where microbial removal of N occurs (denitrification).**

1 The urea nitrogen in urine is naturally converted to ammonium-N, and then into nitrate-N.

2 Performance of Kaiwaiwai Constructed Wetland. NIWA CLIENT REPORT No: 2018285HN, Sukias, J.P.S., Park, J. (2018)



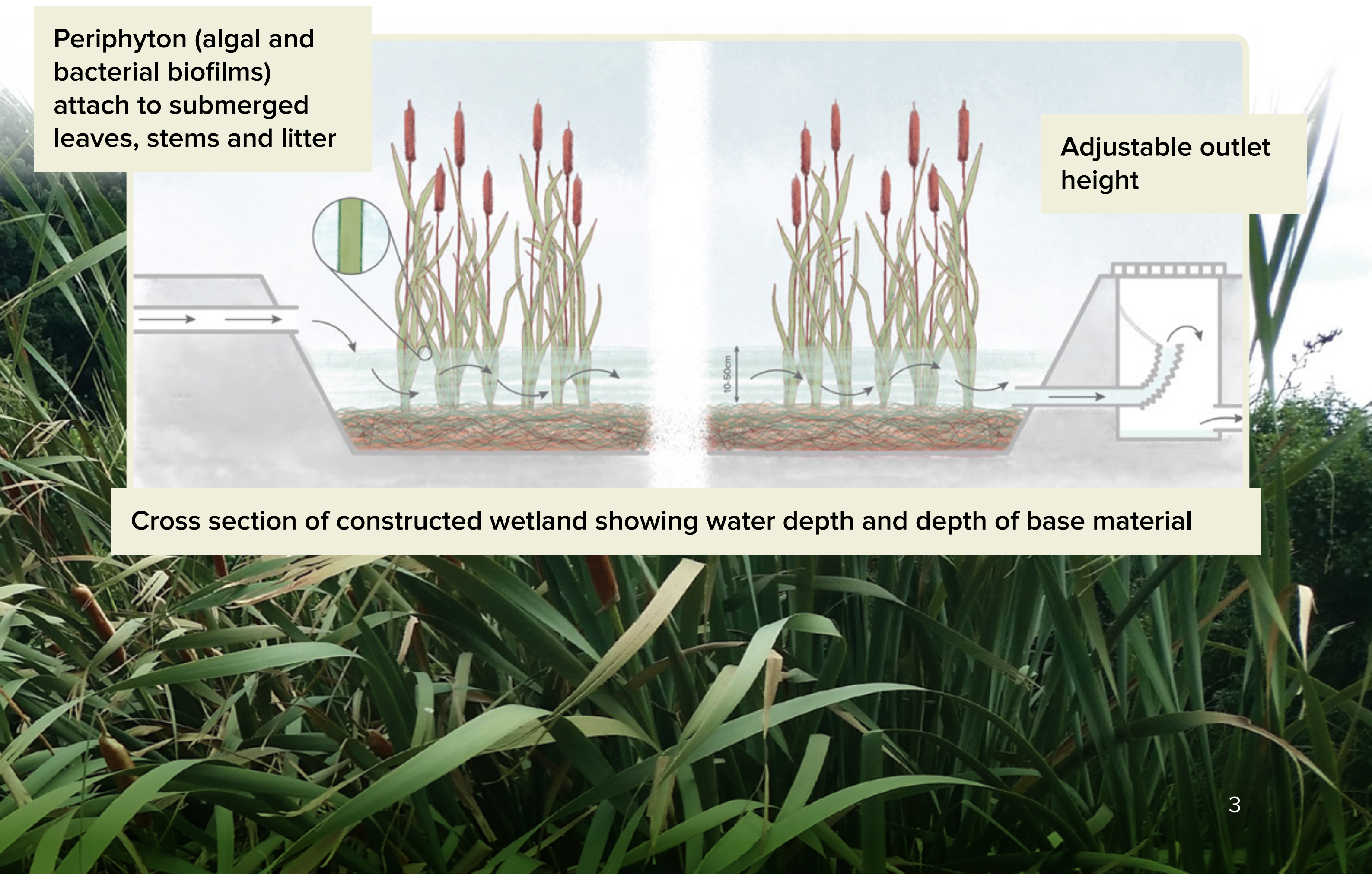
WATER FLOW AND DEPTH

Wetlands systems with a constant flow are the most efficient at removing nitrogen from water. Ephemeral wetlands which typically have no inflow during summer and may dry out, are about half efficient as constant flow wetlands. The aim is to provide a stable home for a thriving community of microorganisms (periphyton) to “treat” the inflowing water.

To maximise N removal, water depth in the main wetland area should be 0.3m with a maximum depth of 0.5m. Any shallower and pastural weeds can be a problem. Any deeper and growth of the plants that provide litter for denitrification will be inhibited. Stagnant zones should be avoided.

If N removal is not the only goal for constructing a wetland then a range of depths can be considered for diversity and function.

Creating a sediment trap, perhaps a deeper area (1.0-1.2m deep) at the inlet, will remove sediment, thus improving water quality. For example removing sediment reduces the phosphorous in water as P binds to soil particles. This is only necessary if inflows are from open drains or streams, as tile drains typically have low sediment loads. A deep sediment trap may have to be cleaned periodically with an excavator. An alternative technique has been used where the wetland has a solid (compacted gravel) bottom. In this case regular (annual) removal of sediment can be done by farm tractor loader.



Cross section of constructed wetland showing water depth and depth of base material

LOCATION

Choose a “wet” area, usually dominated by rushes. Pasture production is relatively poor in these wet areas anyway, and they are often the most expensive areas to drain on the farm. Alternatively you could construct a wetland at the bottom end of a farm drainage system, either where a permanent waterway exits the property or even maybe at the end of a tile drainage system. Avoid areas prone to flooding as this will disturb the ecosystem and will disrupt N removal.

Providing a permanently flowing supply of farm drainage water will result in the best performance of the constructed wetland. As long as the water directed through the wetland eventually flows back into the original waterway a resource consent is not normally required.

“Wet” areas which have poor pasture species are well suited to conversion to constructed wetlands. Poor pasture species and rushes are shown to the right.

STUDY THE WATER

Hydrology is the most important determinant of success in a constructed wetland system. Key aspects include: range of water table depth (summer vs winter), slope or fall across the site, volume of water flow in the contributing waterway[1], soil type and depth, depth to impervious soil layers, height of water in contributing waterway, soil surface heights, water height in receiving waterway.

Spend a bit of time with a laser level to investigate the potential site and discuss with an experienced drainage contractor who can advise on pipe sizes, expected flow, water levels and excavation volumes. Remember that the wetland will require a base of good quality soil between 100 and 300mm thick for the plants to root into. Topsoil from the site is generally suitable for this. However it MUST be free of pasture grasses, as unless the wetland is filled with water quickly these will establish in the wetland and prevent the wetland plants from establishing well.

1 Flow can be determined by measuring the speed of water flowing in a section of consistent width and depth. Time how long an apple or orange floats a known distance and calculate eg a 3m long section with average width of 0.4m and depth of 0.05m where the apple took 3 seconds to float that 3m equates to a flow of 20 litres/second (0.4m x 0.05m x 1m/s /1000 = 20 L/s)

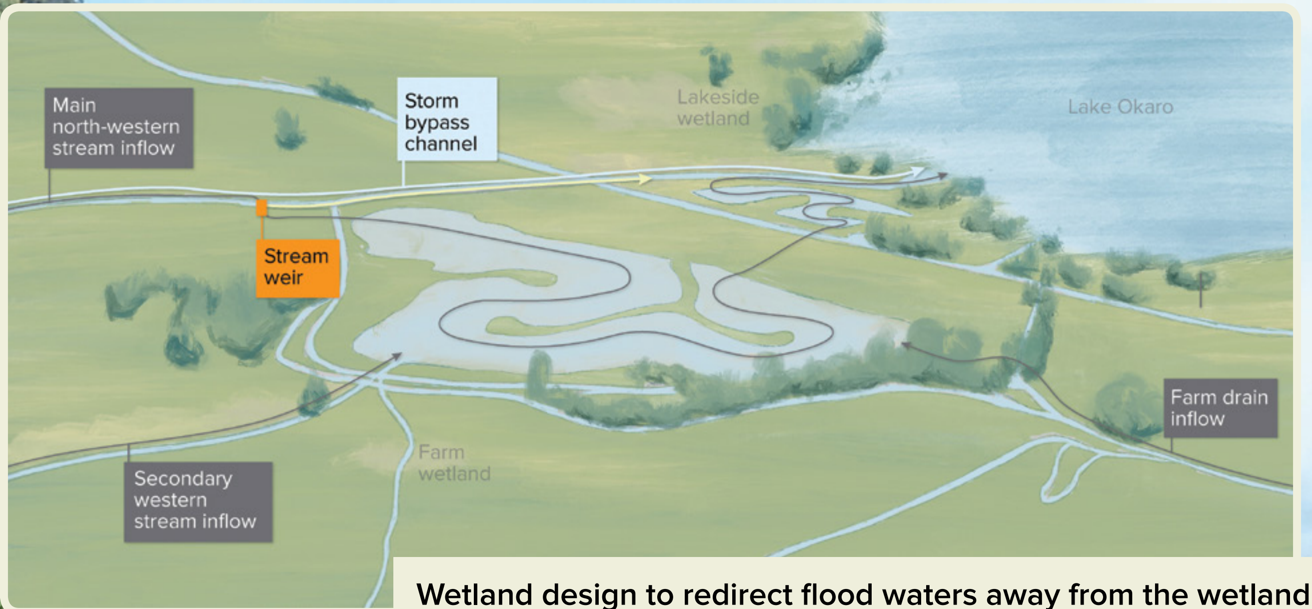
SCALE

For a wetland system to remove NO3-N the rule of thumb is each hectare of surface water in a wetland requires an inflow of 1000 to 1330 m3 of fresh water per day (which equates to an average of 48m3/hour, or a range of 11.5 to 15.4 litres/second)[1]. Generally the bigger the wetland the better the treatment achieved. One approach to sizing is to determine the project's main constraint – available land area or available water flow and scale the wetland from there based on the rule of thumb and experience above. For a more detailed calculation method see NIWA wetland guide 2010.

DESIGN

An example of a mini wetland at the end of a tile drain
Image courtesy of NIWA

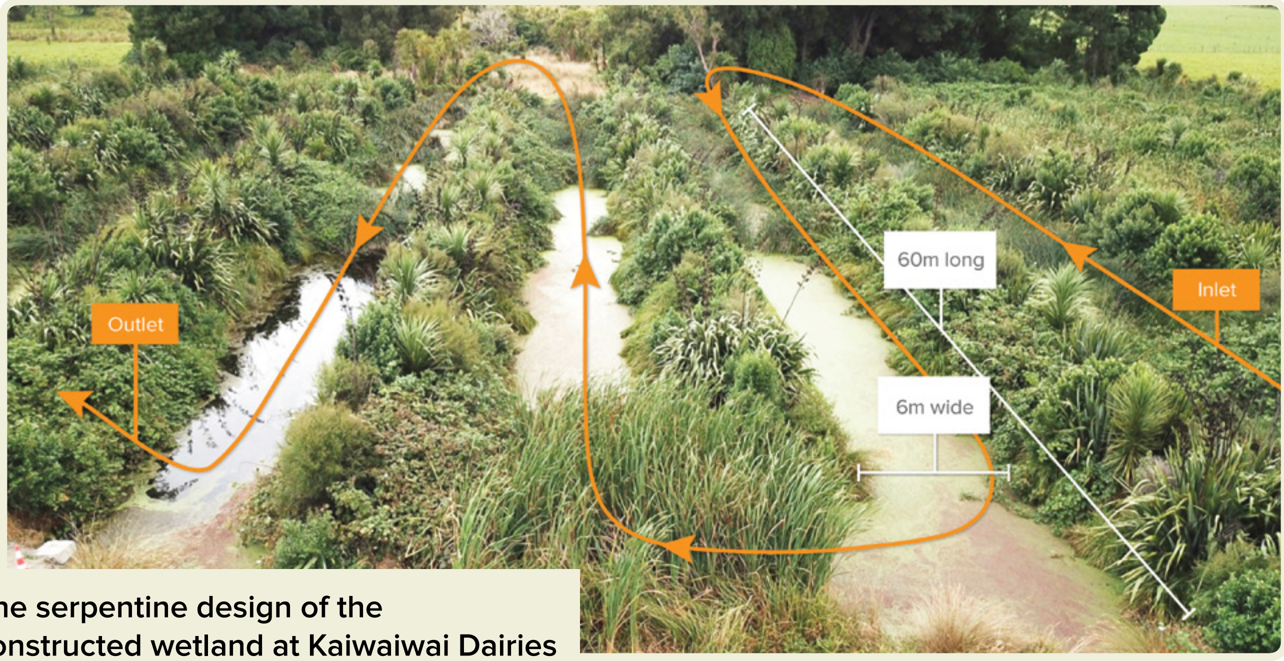
A wetland should have an elongated shape with a ratio of length-to-width of between 3:1 to 10:1. The inflow and outflow should be at opposite ends to promote even flow, reducing the opportunity for short-circuiting of flow or creation of dead zones. The design should take account of the goals of the wetland and the situation available. For example, to redirect water in case of a flood, the wetland at Lake Okaro incorporates a storm bypass channel (see following photo). Its curving shape gives a more natural appearance, and having multiple cells is beneficial on sloping sites as well as improving water quality treatment. To pursue its *dual* aims of maximizing N-removal and biodiversity, the wetland at Kaiwaiwai Dairies incorporates a high length-to-width ratio (10:1), a serpentine channel and multiple cells. Generally, good design can also help reduce construction costs, e.g. compatible widths and depths of channels will minimise double-handling of soil by excavators. Involve your contactor in the design process.



Wetland design to redirect flood waters away from the wetland
Image courtesy of NIWA

1 While these are the current recommendations, there are examples such as the Kaiwaiwai wetland where full removal of nitrate in summer was recorded at flows of 14L/s, but with only 0.5ha of water area. It should be noted that not all wetlands perform as well as this system.

DESIGN



The serpentine design of the constructed wetland at Kaiwaiwai Dairies
Photo courtesy of Neville Fisher

PLANTING THE WETLAND

Establishing appropriate plants in the wetland is crucial to effective N removal. These plants provide a habitat for periphyton, which in turn take up soluble contaminants and promote settlement of sediments. The fall of leaf litter into the base of the wetland provides organic matter where removal of NO3-N occurs.

Initial planting in about October or November is ideal. During planting, a shallow water depth of about 100mm softens the base material to make planting easier. However, deeper than this can make planting difficult. As plants become established and grow, increase the water depth to the target of 300mm in the main wetland area, but keep the water level below the tops of the plants by about 100mm. Planting desired (native) aquatic plants helps exclude weeds. Final planting density will depend on your budget and availability of suitable planting stock, however too low an initial planting density will allow weeds to enter. Four plants per square metre is appropriate for small plants, with a a minimum of one per square metre spacing using larger plants. In the Wairarapa you may be able to reduce costs by transplanting from existing wetlands. However it is essential that plants are clean of unwanted plant material, which can introduce weeds. Ask neighbouring farmers or a Land Management Officer from GWRC or DOC for help with this.

Suitable plants include:

Plant Species	Common Name
Schoenoplectus tabernaemontani	Kapungawha, Lake clubrush
Typha orientalis	Raupo
Machaerina articulata (previously *Baumea articulata*)	Mokuautoto, Jointed twig rush
Isolepis prolifera	None known
Eleocharis sphacelata	Kuta, Tall spike rush

INLET AND OUTLET STRUCTURES

There are many considerations in the design of inlet and outlet structures:

- potential for blockages by floating weed
- fish passage
- sediment buildup
- raising water level in the summer to maximise efficiency of N removal
- ability to control and measure flow easily and installation of monitoring equipment.

Examples from the Wairarapa are shown right.

If there is any free fall of water exiting a pipe, consider adding rocks beneath this to disperse energy and oxygenate water. Consider providing access for eels and other fish[1]. Sediment may accumulate in the wetland so provide a sediment trap and suitable access for equipment to remove sediment periodically.

Inlet structure with overflow

Submerged 160mm plastic inlet pipe with slots cut in

Wetland inlet, water height and orifice diameter control flow

Wetland outlet, flow measurement weir with height scale

COST EFFICIENCY

Experience in the Wairarapa indicates that for a wetland water surface area of 4000 to 5000m2, the cost of construction is between $40,000 and $55,000. Approximately 50% of the cost is for piping and excavator work, 25% for aquatic planting and 25% for planting the surrounding area. One way of reducing cost without compromising N removal is to leave the surrounding area unplanted and simply re-grass with a cheap pasture mix. GWRC have indicated that some funding is available for on-farm construction of wetlands.

Performance monitoring of the wetland at Kaiwaiwai Dairies shows that a constructed wetland can remove nitrate from farm drainage water for around $90/kg of Nitrogen. This is very cost competitive with other mitigation techniques. Given the other biodiversity and aesthetic benefits from having a wetland on the farm, constructing a wetland is a sensible investment for landowners seeking to improve the quality of the water leaving their farm.

1 See www.niwa.co.nz/fishpassage for guidelines on fish passes

FURTHER READING

New Zealand Guidelines: Constructed wetland treatment of tile drainage. NIWA Information series No. 75. Tanner, C.C., Sukias, J.P.S, Yates, C.R. (2010).

Greater Wellington Regional Council Wetland programme (www.gw.govt.nz/wetland-programme/)

TP10 Design guideline manual stormwater treatment devices. Chapter 6, Wetland design, construction and maintenance. Auckland City Council.

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