Franklin Vale Catchment

Restoration Plan 2021-2026

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For:

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Contents

1. Introduction

1.1 Context

The Franklin Vale catchment is a relatively small catchment (~ 138 km^2) situated approximately 35 km south-west of Ipswich in south-east Queensland. Franklin Vale Creek drains into the Bremer River (via Western Creek) which, in turn, is a tributary of the Brisbane River. The catchment is currently home to a small community of landholders and supports a range of land uses including grazing, cropping, forestry and conservation. Significant vegetation clearing has occurred in the catchment since it was settled by Europeans in the mid-1800s. A lack of vegetation, especially in riparian areas, in combination with steep slopes and grazing pressure have been associated with river bank instability and erosion in the catchment's waterways, as well as gully erosion in the broader catchment (Alluvium, 2014a, b). While bank instability in the catchment was identified as being high compared to other catchments within the Ipswich City Council (Council) area, such instability is unlikely to be major contributor to sediment loads in the lower Bremer River (Alluvium, 2014a, b).

To address concerns associated with the degradation of water quality and the ecological values of the Franklin Vale catchment and its receiving waters, as well as the catchment's agricultural productivity, Council has established the *Franklin Vale Creek Catchment Initiative*. This programme seeks to restore and enhance the ecological condition of the Franklin Vale Creek and catchment by working with landholders to mitigate threats and rehabilitate and renew degraded areas through the implementation of on-ground actions (e.g., revegetation). The Initiative is funded by Council's stormwater quality offsets scheme.

In late 2020, Council engaged a project team from the Australian Rivers Institute at Griffith University to develop a catchment restoration plan to inform the design and development of the *Franklin Vale Creek Catchment Initiative*.

1.2 Purpose

The main purpose of the *Franklin Vale Creek Catchment Restoration Plan* is to support decision-making regarding the selection, prioritisation and implementation of restoration actions in the Franklin Vale Creek catchment. More specifically, the aims of the plan are to:

- synthesise existing knowledge concerning the ecology of the Franklin Vale catchment;
- assess current ecological conditions of the Franklin Vale catchment, including its key values and threats to these;
- provide a strategic plan for prioritising on-ground actions; and
- identify monitoring and evaluation needs to assess the effectiveness of these interventions and guide future adaptive management.

1.3 Approach

To develop a catchment restoration plan for the Franklin Vale catchment, three work packages were completed as follows:

1. *Catchment condition assessment:*
    - compilation of an information log for the catchment
    - synthesis of available relevant knowledge
    - an evaluation of key ecological values of the catchment
    - an assessment of the major risks and vulnerabilities facing the catchment

2. *Strategic Restoration Plan development:*
    - co-design of restoration objectives for the Franklin Vale catchment
    - compilation of a catalogue of potential on-ground interventions
    - identification of priority actions to address restoration goals

3. *Monitoring and Evaluation guidelines:*
    - design and testing of rapid field condition assessment methods
    - intervention monitoring methodology
    - water quality monitoring protocols
    - longer-term catchment-scale condition monitoring and evaluation

To support the development of this catchment restoration plan, thorough literature searches of published and unpublished literature were conducted and existing sources of relevant regional data (e.g., LiDAR, satellite imagery, regional ecosystem mapping) were identified. This knowledge was then synthesised and analysed to describe the status of key catchment components with respect to five themes (land, water, plants, animals and people) and to identify appropriate restoration approaches. A comprehensive information log and detailed methods of the spatial data analysis is provided in the *Catchment Condition Assessment* package, Appendices 1 and 2.

Additionally, field surveys were conducted at 30 sites along Franklin Vale Creek and main tributaries to provide a rapid condition assessment of these waterways including bank condition and erosion, riparian vegetation cover and condition (including exotic species), water quality and stream condition (sedimentation, aquatic vegetation), animal habitat (instream and terrestrial) and infrastructure. Detailed methods are provided in the *Catchment Condition Assessment* package, Appendix 3.

Two community workshops were also held during the project to ascertain community values and collate local knowledge regarding the condition of the catchment and its vulnerability as well as interest and support for various management approaches. A summary of each event is provided in the *Catchment Condition Assessment* package, Appendix 6.

It should be noted that this project was initially designed during the 2020 Covid-19 lockdown period. Consequently, neither field work nor face to face community events were included in the budget or timeline but were conducted as the opportunity arose.

1.4 Structure of this document

This document presents the outputs of the second work package – a strategic restoration plan for the Franklin Vale catchment. As per the accompanying *Catchment Condition Assessment* report, this plan is presented in relation to five broad themes – land, water, plants, animals, and people.

The first section describes restoration goals for each of these five themes as determined through a combination of community and stakeholder consultation during this project as well as drawing on the project team's expertise and the knowledge gleaned during the catchment condition assessment and associated knowledge reviews.

The second section provides a catalogue of candidate on-ground interventions that could be implemented to address bank erosion and declining water quality as well as an overview of various approaches to riparian vegetation restoration. A selection of catchment restoration case studies discussing the effectiveness of such approaches are also presented as an Appendix to this plan.

The third section identifies possible actions in relation to the restoration goals of the Franklin Vale catchment. As per the restoration goals, these actions reflect ideas raised at community engagement activities held during this project as well as the expertise of the project team.

Finally, some key recommendations for priority actions under the *Franklin Vale Creek Catchment Initiative* are presented.

2. Restoration goals

Restoration goals for the Franklin Vale Creek catchment were co-developed for each of the five themes through a combination of community and stakeholder consultation, the project team's expertise and knowledge gleaned from the catchment condition assessment and associated knowledge reviews (Table 1).

Table 1. Restoration goals for the Franklin Vale Creek catchment

Goal	Rationale	Priority
1. Land		
1.1 Maintain bank stability and minimise further bank erosion	Reduce sediment loads into waterways, protect habitat stability, protect agriculturally productive land	High
1.2 Reduce current areas of bank erosion	Reduce sediment loads into waterways, improve stability of aquatic habitats, protect agriculturally productive land	High
1.3 Protect geomorphic stability of catchment (e.g., prevent further gully erosion)	Reduce sediment loads into waterways, protect habitat stability, protect agriculturally productive land	High
1.4 Promote the resilience of landforms to large flood events	Protect landform and habitat stability, protect agriculturally productive land	Moderate
2. Water		
2.1 Protect and enhance flowing water in the creek	Maintain habitat for aquatic species, provide a water source to terrestrial species and people	High

2.2 Maintain and improve water quality within waterways and wetlands	Protect water availability and condition for biodiversity and human uses, limit impacts on downstream, receiving waters	High
2.3 Slow down and disperse floodwaters	Reduce flood damage to landforms, vegetation, crops and infrastructure	Moderate
2.4 Maintain wetlands, seeps and other wet catchment areas during droughts	Hydrate the landscape, maintain vegetation health, promote agricultural sustainability	Moderate
2.5 Maintain and restore healthy and stable billabongs/pools	Protect aquatic biodiversity, especially during droughts	High
2.6 Protect water security	Support agricultural productivity	High
2.7 Improve understanding of water quality in the catchment, particularly during high flow events	Support adaptive catchment management	High
3. Plants		
3.1 Protect remnant vegetation	Protect biodiversity and ecosystem functions, promote geomorphic stability	High
3.2 Restore degraded riparian vegetation	Improve and maintain bank stability, provide a buffer to waterways, restore biodiversity habitat and connectivity	High
3.3 Increase the cover and diversity of native understorey and groundcover vegetation	Protect biodiversity and ecosystem function, protect soils, support agricultural productivity (e.g., pasture growth)	Moderate

3.4 Restore floodplain woodlands and open forests	Enhance biodiversity and ecosystem function, promote geomorphic stability	Moderate
3.5 Reduce and control herbaceous and woody weeds	Protect biodiversity and ecosystem functions	High
4. Animals		
4.1 Limit stock access to waterways and riparian buffers	Protect bank stability, reduce sediment loads from heavy stock access, promote vegetation regrowth	High
4.2 Protect waterholes / aquatic refuges	Protect aquatic habitat and biodiversity	Moderate
4.3 Protect and maintain aquatic fauna (e.g., fish)	Protect catchment biodiversity	High
4.4 Improve understanding of native wildlife in the catchment	Improved understanding for better management of native and exotic populations	Moderate
4.5 Reduce or maintain stable feral dog and fox populations in the catchment	Improve understanding of pest prevalence and hotspots to inform management. Protect native animal populations, livestock and domestic pets	Low
4.6 Improve connectivity of remnant vegetation habitat	Enhance catchment biodiversity, promote resilience of biodiversity	Moderate
5. People		
5.1 Get 100 % of landowners onboard with *Franklin Vale Creek Catchment Initiative*	Build momentum and cohesion in actions to protect and maintain the quality of the catchment and water quality	Moderate

5.2 Maintain and enhance community engagement in catchment restoration and governance	Build on the successes of community events and to build and maintain relationships between landholders and Council	High
5.3 Promote continuity of catchment history and environmental knowledge in the community	Encourage sharing and knowledge stewardship	Moderate
5.4 Maintain current population density	Maintain sustainable population levels	Low
5.5 Promote and enhance recreation opportunities in the catchment (e.g., picnic spots by the creek)	Acknowledge and celebrate the natural environment	Low
5.6 Promote sustainable agricultural productivity	Ensure that land practices benefit both the landholders and the environment	Moderate
5.7 Prevent division of properties in the catchment into smaller plots	Maintain land management practices at larger scales and enhance cohesion across generations	Moderate

3. Overview of catchment restoration approaches

3.1 Potential on-ground actions for catchment restoration

A wide range of on-ground interventions are possible to address concerns related to bank instability and erosion and water quality degradation (Table 2). While some of these involve the use of physical structures (e.g., rock walls), many potential restoration actions addressing catchment degradation aim to increase vegetation in the catchment and riparian buffers especially. There is significant evidence demonstrating the importance of vegetation to bank stability and water quality (Capon & Pettit, 2018). Additionally, riparian vegetation restoration has a strong potential to provide multiple and far-reaching benefits to biodiversity and people and its value is likely to become more important under a changing climate (Pusey and Arthington 2003; Capon et al., 2013). Table 3 summaries key approaches to vegetation restoration applicable to both riparian and upland habitats. A series of catchment restoration case studies are also presented in the Appendix.

Table 2. Catalogue of potential on-ground interventions to address erosion and water quality decline

Problem	Solution	Short description	Possible complications	Links and references
Erosion/Water quality	Cattle exclusion: fencing, riparian buffers	Reduce the negative impact of cattle on water quality, particularly for sediment and faecal indicator bacteria	Landowners may not agree with fencing if they do not have a dam or other source of water for their cattle; alternative water sources have to be provided	Butler DR, 2013; Miller et al., 2014; Grudzinski et al., 2020
Erosion	Recontouring/ bank reprofiling/ terracing	Soil reprofiling. Addition or removal of soil to lessen the slope, reduce erosion, and disperse water to creation of a new channer. Stabilizes channel and increases its capacity	During a construction phase, sediment can be release into a waterway; therefore, freshly disturbed soil needs immediate protection. Depending on the scale, can be affected by climate, soil properties, topography and other factors	Richardson et al., 2011; Brown et al., 2013; Lawrence, 2008; Sonnenberg, 2008; Fox et al., 2016
Erosion	Erosion barriers: coir logs, hay bales, silt fences, trenches	Reduce erosion; some structures may promote groundcover growth	Area has to be accessible; traps and design have to be chosen according to a location, water velocity, presence of animals, otherwise they may fail	Kimiti et al., 2017; Morris et al., 2008; Fernández et al., 2016
Erosion	Riparian planting	Effective when successful, addresses more than one problem at the same time (improves water quality, has positive effect on macroinvertebrate communities)	No immediate result, may take up to several years; requires maintenance, risk of failure; difficult to evaluate effectiveness on a watershed scale	Arnaiz et al., 2011; Parkyn et al.,2003; Jowett et al., 2009; Wilcock et al., 2009; Yuan et al., 2009
Erosion	Grass barriers	Effective in trapping sediment, fast growing	Some grasses are more effective than the others; appropriate species need to be chosen	Van Dijk et al., 1996; Pan et al., 2010; Fisseha et al., 2011

Problem	Solution	Short description	Possible complications	Links and references
Erosion	Bank reinforcement: geotextiles	Effectively reduce soil erosion and slope degradation processes	Jute and coir matting may reduce vegetation growth; can be costly if large areas affected	Álvarez-Mozos et al., 2014a,b; Wu et al., 2020
Erosion	Rock structures: rock chutes, rip-raps, riffles	Stabilise erosion in channel bed	Possible negative consequences include: weed infestation, rocks lost, damaged abutment	Ladson et al., 2006; Keller, 2004; Shilton et al., 2015
Erosion	Zuni bowls	Addresses head-cut erosion	New method, no academic studies, but there is a case study on Water by Design, Baron Catchment	Barron Catchment Care, 2021
Sedimentation / water velocity	Small rock weirs/leaky rock weirs	Slow water down, disperse water, create pools upstream, collect sediment	Can be damaged if not well designed, can impede fish passage if too high, collect sediment	Southern Rivers Catchment Management Authority (2011); Shields et al., 1995.
Water velocity and habitat	Re-snagging, log jams, rock vanes	Introduction of rock or wood in stream to decrease water velocity and create habitat	Need to be carefully designed and secured to avoid failure	Erskine & Webb, 2003; Moore & Rutherfurd 2014; Linohss et al., 2012; Sonnenberg, 2008).
Sedimentation	Riparian planting	Reduces fine sediment and nutrient input by cattle activity	Effectiveness depends on a buffer's width and type; takes a few years to become effective; maintenance required	Feld et al., 2018; Leguédois et al., 2008; Vought et al., 1994; Collins et al., 2013; Yuan, 2009

Problem	Solution	Short description	Possible complications	Links and references
Sedimentation	Tree belts for non-riparian areas	Trap most of the sediments even for extreme conditions	Takes a few years to become effective, maintenance required	Leguédois et al., 2008; Vought et al., 1994
Sedimentation	Structural improvement of a stream bed	Creates new interstitial habitats, improves the quality of bottom sediments, creates habitat for taxa which prefers coarse sediments	Not always successful; heavy machinery maybe destructive for existing species	Sarriquet, 2007; Muotka & Laasonen, 2002
Water quality	Riparian buffers	Effectively address multiple problems including nutrient excess problem and sedimentation. Mitigate the impacts of land use activities on water quality and aquatic ecosystems	Buffers must be 10-20m wide; takes a few years to become effective; maintenance required	Feld et al., 2018; Vought et al., 1994; Collins et al., 2013
Water quality	Grass buffers	Fast growing; nutrient reduction in stream	Some grasses are more effective than the others; different level of performance at different times of the year; no ability to remove dissolved pollutants; additional engineering solutions might be required	Van Dijk et al., 1996; Pan et al., 2010; Fisseha et al., 2011; Ou et al., 2021

Table 3. Key approaches to vegetation restoration

Restoration types	Short description	Possible complications	Links and references
Passive restoration	Cost-effective; labour-efficient; restoration success is higher in natural regeneration than in active restoration	Slower ecosystem recovery compared to active restoration methods; restoration success varied and depends on precipitation, temperature, past disturbance; requires seeds present in the soil; weed management often necessary - competition with introduced species; longer recovery time can be seen as failure	Brancalion et al., 2016; Zahawi et al., 2014; Meli et al., 2017; Prach et al., 2019; Crouzeilles et al., 2017; Lopez-Barrera et al., 2006
Active restoration: direct planting	Establish rapidly, increase the chances of restoration success; develop a broader range of forest-like soil functions about a decade sooner than when passive method is used	Can be costly and labour-intensive if big areas are to be restored; maintenance required; past land use, natural resilience of the area should be evaluated prior decision making	Benayas et al., 2008; Ruwanza et al., 2013; Meli et al., 2017; Shoo et al., 2016
Active restoration: direct seeding	The cost is much lower than the cost of direct planting; emerged species have a higher survival rate;	Low seedling emergence and establishment for most species	Raupp et al., 2020; Sampaio et al., 2019; de Souza & Engel 2018
Active restoration: Islands/islets planting	"Nucleates" across degraded area, source of seeds for surrounding area. Might be good when resources are limited, and area is big. Can act as shelter for livestock. Due to size easier to maintain	Strong edge effect	Benayas et al., 2008; Bender et al., 1998; Hulvey et al., 2017; Bodin et al., 2006

4. Restoration actions for the Franklin Vale catchment

4.1 Potential restoration actions

Restoration actions for the Franklin Vale catchment were co-developed for each of the five themes through a combination of community and stakeholder consultation, the project team's expertise and knowledge gleaned from the catchment condition assessment and associated knowledge reviews (Table 4). To determine priorities amongst these, restoration actions were assessed in relation to the goals they addressed, potential to generate perverse outcomes or to fail and their potential to generate multiple benefits.

Please note that although the *Franklin Vale Creek Catchment Initiative* is funded by the Stormwater offsets program, it requires collaboration from a range of Council team and programs to implement associated recommendations.

Table 4. Co-designed restoration actions for the Franklin Vale catchment

Action	**Considerations**	**Risk of perverse outcomes / failure**	**Priority**
1. Land			
1.1 Detailed local evaluation of erosion hot spots	Consider prioritisation of hot spots	Low	High
1.2 Promote sustainable riparian zone and property management practices	Promote landholder involvement in Council's partnership programmes and encourage attendance at NRM workshops	Low	High
1.3 Riparian fencing and/ or stock management in riparian buffers	Consider positioning of gates to enable efficient management of stock/human access, fencing must be maintained, consider removal of fencing once vegetation is well established	Low – Moderate	High
2. Water			
2.1 Riparian fencing and/ or stock management in riparian buffers	Consider positioning of gates to enable efficient management of stock/human access, fencing must be maintained, consider removal of fencing once vegetation is well established	Low – moderate	High
2.2 Conduct water quality monitoring	Potential to include citizen science monitoring; potential to link with ICC Waterway Health Strategy actions	Low	High
2.3 Protect water levels in refuge pools	Particularly important during droughts	Low	High
2.4 (Re)introduce aquatic plants in waterways	Needs to be supported by research to understand feasibility and benefits to water quality, bed and bank stability and biodiversity	Moderate	Low - moderate

Action	Considerations	Risk of perverse outcomes / failure	Priority
2.5 Slow flows at the top of the catchment through (re)introduction of large wood	Needs to be supported by research to understand, catchment hydrology feasibility and potential benefits	Moderate	Low - moderate
2.6 Manipulate aquifer recharge	Needs to be supported by research to understand, catchment hydrology feasibility and potential benefits	Moderate	Low
2.7 Understand effects/risks of weirs in the channel	Size of weirs matters	Low	Low - moderate
2.8 Improve physical structure of road crossings	Prioritise road culverts associated with current erosion hot spots	Low – moderate	Moderate
2.9 Diversion of flood waters into constructed wetlands	Needs to be supported by research to understand, catchment hydrology, feasibility and potential benefits	Moderate	Low
3. Plants			
3.1 Riparian fencing and/ or stock management in riparian buffers	Mainly important for areas that are regenerating, consider positioning of gates to enable efficient management of stock/human access, fencing must be maintained, consider removal of fencing once vegetation is well established	Low – Moderate	High
3.2 Active restoration of degraded riparian buffer strips	Provide incentives for riparian replanting, prioritise areas associated with erosion hot spots and that improve connectivity	Moderate – High	High
3.3 Protect woody regrowth (e.g., she-oaks and bottlebrush) in channels and riparian buffers	Provide incentives for protecting regrowth, related to fencing and stock management	Low	High

Action	Considerations	Risk of perverse outcomes / failure	Priority
3.4 Protect and promote vegetation regrowth on floodplains	Prioritise areas that improve connectivity, provide incentives for protecting regrowth, related to fencing and stock management	Low – Moderate	Moderate - High
3.5 Develop catchment weed management strategy	Need to understand risks and weed dynamics as well as most effective management strategies, consider role of cattle in weed management	Low	High
3.6 Develop catchment fire management strategy	Need to understand risks associated with fire and fire management strategies	Low	Moderate
4. Animals			
4.1 Riparian fencing but keep stock access to water	Mainly important for areas that are regenerating, consider positioning of gates to enable efficient management of stock/human access, fencing must be maintained, consider removal of fencing once vegetation is well established	Low – Moderate	Moderate
4.2 Protect and maintain waterholes / refuges and aquatic biodiversity	Need to identify key refuges in catchment, riparian fencing / stock management will be important	Low	High
4.3 Design and commence citizen science monitoring of fauna	Establish web portal for fauna observations / rapid riparian assessment reporting, conduct a catchment biodiversity 'blitz'	Low	Moderate
4.4 Conduct monitoring to assess presence and abundance of native and invasive freshwater species	Information is required to address critical knowledge gaps for freshwater biodiversity and inform restoration goals.	Low	High
5. People			
5.1 Document and publish oral history of Franklin Vale catchment	Link to ICC's history team	Low	High

Action	Considerations	Risk of perverse outcomes / failure	Priority
5.2 Establish Franklin vale catchment community committee	Consider registering as an official Franklin Vale Catchment Authority, consider various working groups (e.g., catchment weed management group)	Low	High
5.3 Conduct regular Franklin Vale catchment community meetings and other communications (e.g., newsletter)	Need to ensure this is equitable, transparent, and consultative	Moderate	High
5.4 Establish and maintain a Franklin Vale catchment web portal	Could be set up to incorporate citizen science projects (e.g., biodiversity blitzes)	Low	Moderate

4.3 Spatial prioritisation for on-ground interventions

The key on-ground interventions recommended to address bank stability and water quality concerns in the Franklin Vale catchment, as well as generating multiple beneficial outcomes for biodiversity and ecosystem function, are mainly concerned with improving the cover and condition of vegetation within riparian buffers in the catchment (Table 4). Ecological benefits are likely to accrue from actions that protect and restoring riparian vegetation in any parts of the catchment that currently have low levels of canopy cover (Figure 1). Within these zones, revegetation efforts could be prioritised from upstream to downstream. This assessment therefore suggests that riparian revegetation should be prioritised in the Upper Alluvium zone as well as on streams in the surrounding Foothills.

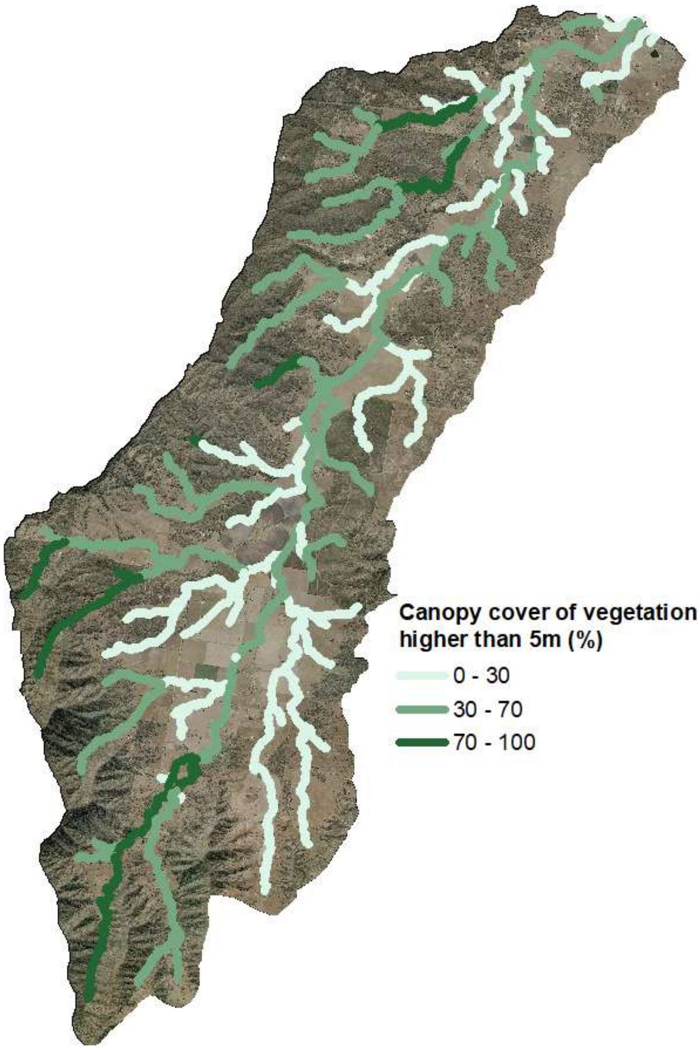

Figure 1. Riparian buffers within the Franklin Vale catchment with low (< 30 %) canopy cover (of vegetation > 5 m in height; see accompanying Catchment Condition Report for more details).

As not everywhere will respond to vegetation loss in a similar way, due to variation in flow energy and resistance of channel banks, we also used current erosion levels as a primary factor guiding the identification of priority areas for on-ground interventions. In some instances, the erosion estimates from LiDAR were affected by dense vegetation cover or the presence of water in channels or farm dams (see accompanying Catchment Condition Assessment report). Therefore, erosion hotspots were visually inspected to determine results which reflected true erosion.

Within the higher eroding segments, current vegetation extent was used to further refine priority areas for on-ground intervention. High priority areas are presented in Figure 2. These priority areas reflect:

- Substantial erosion and low to moderate vegetation cover along stream segments in the Upper Alluvium zone; and
- Substantial erosion and moderate vegetation cover along stream segments in the Lower Alluvium zone.

It should be noted that some successful interventions have already been implemented in the priority area of the Lower Alluvium zone. The effectiveness of these interventions would benefit from expanding efforts to adjacent properties.

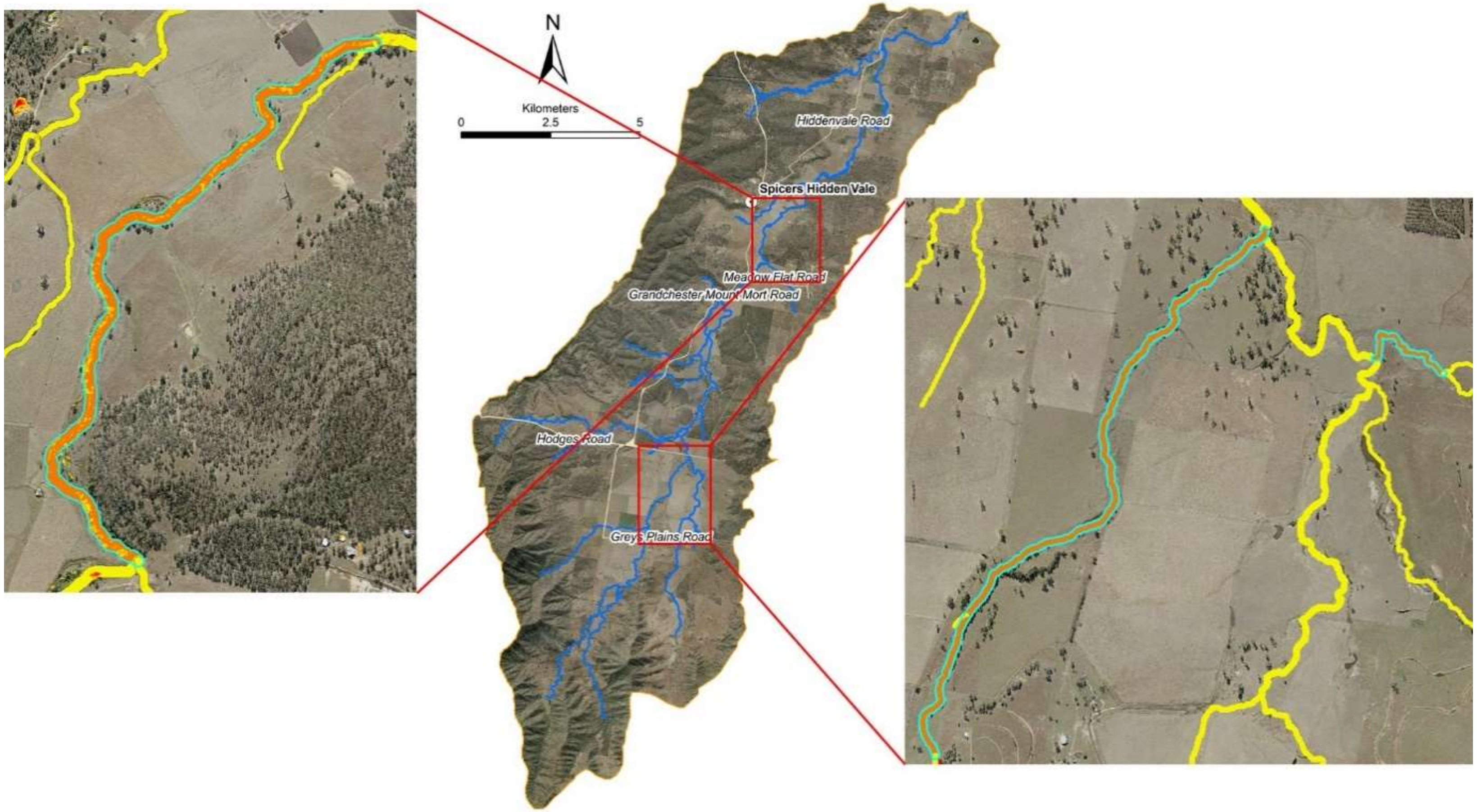

Figure 2. Summary of identified priority areas for on-ground restoration interventions in the Franklin Vale catchment. Note: The inset on the left illustrates high priority areas in the Lower Alluvium zone (orange creek segment highlighted in blue) and the inset on the right illustrates high priority areas in the Upper Alluvium zone (orange creek segments highlighted in blue).

5. Recommendations

The following recommendations are made to Ipswich City Council to consider in the ongoing development and implementation of the *Franklin Vale Creek Catchment Initiative* based on the catchment condition assessment and restoration plan generated in this project as well as the community engagement events conducted. These include on-ground interventions as well as priorities for governance and research.

On-ground interventions

- Prioritise revegetation interventions in erosion hotspots (see Figure 2) in the Upper Alluvium zone and Lower Alluvium zone
- Expand existing on-ground interventions into neighbouring properties
- Implement on-ground actions to promote revegetation of riparian buffers in areas with low canopy cover, prioritising Upper Alluvium zone and adjacent Foothills
- Ensure a suite of complementary on-ground interventions are implemented in each area to maximise benefits and reduce the risk of perverse outcomes and failure, e.g., planting in association with fencing / stock management

Stakeholder participation

- Establish a Franklin Vale Creek catchment community association to enable effective communication and participatory management, research and decision-making
- Implement a citizen science catchment monitoring programme (see accompanying Monitoring & Evaluation plan)

Knowledge needs

- A comparative analysis of all the catchments draining into the Bremer River (not only those within the Ipswich City Council area) to identify regional erosion hotspots. Once identified collaborative work with regional bodies, such as the Resilient Rivers Initiative or Healthy Land and Water, could be undertaken to improve the targeting of water quality interventions.
- Monitor water quality and hydrology in the catchment, with a focus on the downstream end, and responses to high rainfall events. This will provide baseline data, help assess the effectiveness of interventions to improve water quality and guide decision making around the feasibility and location of future interventions.
- Improve understanding of the regenerative capacity of key vegetation communities in the catchment including riparian forests and woodlands, extirpated floodplain woodlands, as well as that of weeds (e.g., propagule pressure, seed banks)
- Improve understanding of wildlife in the catchment, including aquatic fauna, and habitat quality

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Appendix. Catchment restoration case studies

Case study 1. Riparian Restoration of Lake Ellesmere Catchment, New Zealand

Catchment description

Lake Ellesmere is part of a 256,000 hectare catchment. The lake traps nutrients and sediments from the land use practices.

Riparian buffers of its four reaches - Boggy Creek, Harts Creek downstream of The Lake Road, Harts Creek downstream of Lochheads Road and Birdlings Brook - have been planted, and various restoration planting projects have been happening in the catchment for two decades.

Figure 1. Planted riparian buffer at Birdlings Brook site, typical of restored areas in the Lake Ellesmere catchment (from Collins, 2011).

Degradation level

Locals noticed that the health of the lake and its tributaries has declined in the last years. The main concerns were that the fish numbers are dropping, and cattle grazing on the margins was causing erosion.

Improvements

Riparian zones were fenced off to prevent cattle entering the stream, native vegetation planted to filtrate the surface runoff, stabilize the banks, reduce flood flow, and to create habitat. The planting width was less than 10 meters.

Stock was excluded at Boggy Creek and Birdlings Brook, but not at Harts Creek sites. Lochheads Road part of Harts Creek was not grazed during the study while the Lake Road stretch was actively grazed until the area was fenced off mid-way during the data collection.

Sites for planting were chosen largely on the basis of landholders' willingness to participate.

Evaluation

The effect of the riparian buffers on the creeks' water quality was evaluated. Water samples for testing were taken from restored buffer zones that were best restoration examples in the catchment. Some control sites were not located upstream of the buffered area, as not all landholders were prepared to give access the creek from their properties. Control sites did not have any planted native vegetation.

This study found that riparian restoration in the Lake Ellesmere catchment positively affected water quality, as dissolved oxygen was found to be higher in planted areas, and turbidity lower. However, levels of nutrients, salts and bacteria did not change significantly, most likely due to the fact that the vegetation width was less than 10 m. Water temperature did not change and macrophytes did not die off, as there was no or limited amount of closed canopy.

Case study 2. Tullstorp Stream Restoration Project (ongoing)

Catchment description

Tullstorp Stream flows through fertile agricultural lands of Sweden. In the 20th century the stream was channelized, and the area of wetlands surrounding it decreased. Groundwater supply reduced and was not meeting irrigation needs.

Figure 2. Part of Tullstorp Stream during and after restoration works (from The Tullstorp Stream Project, 2020).

Degradation level

As 85% of the area is agricultural land, there was a problem with nutrients leaching into the Baltic Sea, as well as problems with flooding during big rain events. The stream condition was classified as 'bad'.

Improvements

A pilot project was run to demonstrate to catchment landholders what can be achieved, which was successful and sparked a lot of interest.

The stream was then divided into three parts, between 5 and 10km long, and re-meandered. The bottom of the stream was restored to various depths, the banks were flattened and revegetated. Buffer zones, flood zones and wetlands were created along the stream.

Evaluation

Since 2009, 10km of the stream have been rehabilitated, 39 wetlands were constructed, and thousands of plants put in the ground. The stream condition has changed to 'moderate'. Positive results have been reported for bird-associated wetlands. The amount of phosphorus leaking into the sea has significantly reduced.

Case study 3. Mulloon Creek Restoration Project

Catchment description

The Mulloon Creek is located in Southern Tablelands, in New South Wales, with an average rainfall in the catchment of 650-750mm a year. The creek is a tributary of the Shoalhaven River and is about 50km long, while the project site is 2.4km.

Mulloon Creek restoration is a Natural Sequence farming Pilot project, and its goal is to rehydrate the creek's catchment.

Figure 3. Part of Muloon Creek before and after restoration works (from Southern Rivers Catchment Management Authority (2011)

Degradation level

After the introduction of farming in 1820, the hydrology of the lower reaches of Mulloon creek has dramatically changed, including catchment clearing, swamp and wetland drainage, as well as straightening of the channel. All these created bank erosions, channel incision, reduction in water holding capacity, as well as other problems.

Improvements

The main goal of the project was to slow and de-energize the water flow, raise its level, and bring the floodplains back. Several structures were installed in the creek: rock weirs, log sills, rock/gravel sills, flow diffusing cobble bars, and rock baffles. Various designs and materials were used, including rocks, gravel, and vegetation. Fences were installed to exclude stock and wildlife.

Evaluation

Parts of the creek that used to be dry most of the time now often have water, which has created a habitat for aquatic plants and animals as well as a drought refuge. While this is an ongoing project and more monitoring is required, there has been an improvement in the creek's health, according to the results of biomonitoring of aquatic macro-invertebrates. Multiple benefits of installing leaky weirs were also identified, and landholders are reporting a better water flow as well as increase in agricultural productivity.

Case study 4. Riparian Protection and best management practices (BMPs) for restoration of Waiokura Stream, New Zealand

Catchment description

The 2100 ha Waiokura catchment is located in Taranaki, New Zealand. The Waiokura is a 3rd level stream, well-aerated and shaded, with high density.

There are 44 dairy farms in the area, all located on a 0.5-20% slope. There are 107 bridge crossings and culverts in the catchment.

Degradation level

Several Waiokura stream tributaries are accessible to cattle, which was considered to be a big contributor for poor water quality in the area. Nitrogen, phosphorus, suspended solids, and faecal bacteria levels were high prior the treatment, yet approximately 40% of the stream had livestock permanently excluded before 2001.

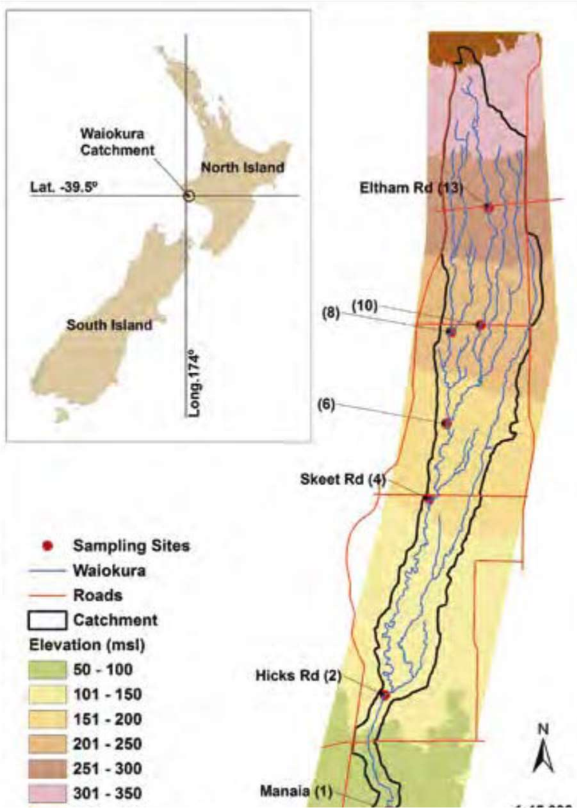

Figure 4. Waiokura Catchment (from Wilcock et al., 2009)

Sediment and phosphorus particulate inputs to the stream during winter and spring were mostly coming from stream banks, livestock trampling, channel straightening, the removal of sediment and the removal of riparian vegetation.

Improvements

Farms were selected for the study for an even representation of various practices, such as fertilizer application, grazing intensity, and waste management.

The links between water quality and land use were examined. The best performing BMPs were identified. The best management practices were: livestock exclusion from the streams, riparian planting (about 5 km stretch on middle reaches) for filtering particulate contamination, deferred irrigation dairy shed effluent to land, phosphorus levels reduction. Less than half of the stream was protected.

Evaluation

Waiokura Stream flow and water quality have been monitored between 2001 and 2008 at three sites. It was tested for pH, conductivity, temperature, turbidity, dissolved oxygen, suspended solids (SS) and volatile SS, E. coli, nitrate plus nitrite N (NOX-N), ammoniacal N, total nitrogen (TN), filterable reactive phosphorus (FRP) and total phosphorus concentrations (TP).

Despite that fact that the water quality in the stream was still found to be poor, it was considered to be significantly improved. There was a reduction in shed effluent discharge, with riparian planting and fencing being the main reason. There were also trends of decreasing concentrations and yields for TP, SS, FRP and turbidity. Yet, median concentrations of total phosphorus, nitrogen, FRP, NO_X-N and turbidity were between 3 and 7 times higher than the default trigger values. Median *E.coli* concentrations were also 5 to 11 times higher than outlined in the guideline for livestock drinking water, which was possibly attributed to numerous stream crossings and high stream density.

Macroinvertebrate communities have not improved. Possibly, for the improvement to happen the established vegetation has to mature and source populations have to be able to recolonise the area.