Catchment Carbon Offset Trial

Goulburn Broken CMA

Catchment carbon offsets trial: Gellibrand River case study

IS190600-4-1 | RevC

29 March 2018

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Supporting implementation of the Victorian Government's water plan, Water for Victoria

GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

CORANGAMITE CMA

Glenelg Hopkins CMA

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Catchment Carbon Offset Trial

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A	12 Feb 18	Working draft for Steering Committee comment	KM		
B	15 Mar 18	Draft for Steering Committee and Working Group review	KM	CC	CC
C	29 Mar 18	Final following Steering Committee and Working Group review	KM	CC	CC

Contents

Executive summary

The catchment carbon offsets (CCO) concept has been developed as a potential approach for Victoria's water sector to progress their emissions reductions obligations, while delivering complementary catchment and social benefits. A "virtual" case study was undertaken, to design and test the feasibility and likely outcomes of such a project. The case study was also intended to provide a replicable method for further case studies or actual CCO projects.

This report describes the process for undertaking a case study of the CCO concept in the Gellibrand River catchment of south-west Victoria and its main findings. The case study design involves restoration of woody vegetation cover along waterways in the catchment upstream of Wannon Water's Otway South water offtake, which provides raw water for Warrnambool and nearby towns. If the case study was subsequently implemented, these works would be expected to improve water quality in the Gellibrand River and provide river health, biodiversity and other cultural and social benefits.

The case study considered five CCO options or configurations (Figure ES.1):

- Environmental plantings (comprising locally indigenous native tree and shrub species) in a 20 m buffer on either side of catchment waterways (*20 m waterway buffer*, abbreviated as 20 m EP);
- Environmental plantings in a 100 m buffer on either side of catchment waterways (*100 m waterway buffer*, abbreviated as 100 m EP);
- Environmental plantings in the 20 m adjacent to either side of the waterways, with farm forestry plantings on the remaining 80 m of the 100 m buffer area (20 m EP + 80 m FF);
- Environmental plantings in a 20 m buffer on either side of catchment waterways and in all areas flooded in a 1% annual exceedance probability (AEP) flood event (i.e. floodplain areas; *floodplain + 20 m buffer*, abbreviated as 20 m + FP EP); and
- Environmental planting in a 20 m buffer on either side of catchment waterways with farm forestry plantations established across the remainder of the 1% AEP floodplain (20 m EP + FP FF).

20 m waterway buffer | **100 m waterway buffer** | **Floodplain + 20 m buffer**

Note: Brown lines and areas mark the extent of revegetation under each of the configurations. The location of the waterway is shown for the 100 m waterway buffer and floodplain+20 m buffer configurations. The illustration shows the Gellibrand River floodplain at the junction between the Gellibrand and Carlisle Rivers and does not differentiate between environmental and farm forestry plantings in the 100 m and floodplain + 20 buffer configurations.

Figure ES.1 : Representations of the case study's main catchment carbon offset configurations.

Carbon sequestration for each configuration (averaged over 50 years) was calculated using the Australian Government's carbon accounting model FullCAM. Each option was also evaluated against financial, environmental, socio-economic and governance metrics or criteria, as summarised in Table ES.1.

CCO project options were compared with "doing nothing new" to change the condition of catchment waterways or water treatment processes (*base case*)[1] and a "business-as-usual" option, where UV treatment capacity would be constructed at the five water treatment plants drawing water from the Gellibrand River (*engineered WQ treatment*).

Table ES.1 : Summary of case study results

Effect[1]	Base case	Engineered WQ treatment	Riparian buffer			Floodplain + 20 m	
			20 m EP	100 m EP	20 m EP + 80 m FF	20 m + FP EP	20 m EP + FP FF
Generation of certified carbon offsets							
Average yearly sequestration (tCO_2-e)	0	0	7.8k	40k	35k	17k	16k
Financial costs and benefits[2]							
Present value: cost	0	-\$8.3M	-\$6.2M	-\$79M	-\$113M	-\$36M	-\$46M
Present value: benefit	0	-	\$1.8M	\$6.9M	\$70M	\$3.3M	\$21M
Net present value	0	-\$8.3M	-\$4.4M	-\$72M	-\$43M	-\$32M	-\$25M
Environmental costs and benefits							
Non-certified GHG emissions abatement (t CO_2-e/y on average)	0	-0.46k	0	20k	21k	8.9k	9.1k
Treatment of causes of water quality impairment (% reduction in effect of main causes)	-ve	-ve	56%	90%	85%	80%	80%
Change in length of waterway with connected vegetation (% increase)	-ve	-ve	13%	13%	13%	13%	13%
Additional area of connected terrestrial vegetation (ha)	0	0	356 ha	391 ha	391 ha	356 ha	356 ha
Change in river flow regime (% mean annual flow)	0	0	-0.4%	-1.7%	-2.7%	-0.8%	-1.1%
Socio-economic costs and benefits[3]							
Waterway cultural values[4]	-1	-1	1	1	1	1	1
Waterway social values	-1	-1	3	2	1	2	1
Bushfire risk	0	0	0	0	-1	0	-1
Governance benefits[3]							
Confidence in level of implementation	0	4	3	1	2	1	2
Development of community partnerships	0	0	3	3	2	3	2

[1] The "base case" is unlikely to allow Wannon Water to meet emerging health-based water quality targets and is therefore untenable. It is only a base case for the purposes of this analysis. The engineered water quality treatment option is the more likely, "business-as-usual" scenario that would be implemented by a water corporation in the absence of a CCO project.

Notes:

1. Descriptions of effect criteria and metrics are given in Section 4.
2. Present value of financial costs and benefits was calculated assuming a 7% discount rate.
3. Socio-economic and governance criteria were assessed on a scale ranging from -4 (very much worse than current base case) – 0 (current base case conditions) -+4 (very much better than current base case).
4. The cultural values assessment is preliminary only and based on the kinds of features which characteristically have higher cultural value. A full assessment would be undertaken with Traditional Owner representatives.

Overall, the evaluation suggests that the 20 m waterway buffer option is the most cost-effective approach to achieving the case study's design objectives. It could be implemented at lower cost than the engineered water treatment plants, provide significant water quality improvement with relatively high implementation confidence and most likely eliminate the need for the engineered water quality treatment option. Environmental plantings configured in this way would also provide a range of other complementary environmental and socio-economic benefits.

If implemented in compliance with NCOS integrity requirements, the 20 m waterway buffer option could generate sufficient certifiable offsets to satisfy Wannon Water's requirements under its *Statement of Obligations* to the Victorian Government.

Conclusions

The case study designed and evaluated several options for a catchment carbon offset project in the Gellibrand River catchment in south-west Victoria. The case study found that, at least in this catchment, a CCO project provides a cost-effective option to generate certifiable carbon offsets to help a Water Corporation meet its emissions reduction obligations[2], while improving catchment water quality, river health, biodiversity and other environmental, cultural and social benefits. The case study demonstrated that the characteristics or design principles for CCOs which were developed by the project's steering committee and a broader stakeholder group were appropriate and workable.

A replicable method for designing and evaluating potential catchment carbon offsets projects was developed. The process and tools could be applied to potential catchment carbon offsets projects in other settings and at different scales.

The case study found that configuration of the catchment carbon offset as a 20 m wide waterway buffer (on each side of the stream) was the most cost-effective option to provide the required carbon offsets and achieve the project's other design objectives, including water quality improvement. In other settings, different designs may be more appropriate and a catchment carbon offset project may be more or less cost-effective.

The case study also found that the concept of flexible offsets – those which are associated with measurable, but uncertified greenhouse gas abatement – has application in CCO projects. With some project designs, it is possible to generate significant non-certifiable abatement that would contribute towards the achieving the State's net zero emissions target. However, flexible offsets could not be used by Water Corporations to help meet emissions reduction targets under their *Statements of Obligations*.

[2] Under their *Statements of Obligations*, Water Corporations all have obligations to achieve agreed emissions reduction targets. Some of these targets may be achieved by "self-generated offsets", which are offsets created by or for a Water Corporation or CMA from activities undertaken in Victoria. Self-generated offsets must satisfy National Carbon Offset Standard methodological and integrity requirements.

1. Introduction

The Catchment Carbon Offsets Trial (CCOT) seeks to complement Victorian government policies and strategies relating to climate change, water, catchment management and biodiversity by demonstrating how projects may deliver emissions reductions, climate resilience and improve catchment management outcomes. The project is intended to enhance understanding of carbon offset opportunities and help align water sector emissions abatement activities with regional natural resource management (NRM) plans and strategies. The project is a collaboration involving Victorian Catchment Management Authorities (CMAs), Water Corporations (WCs) and the Department of Environment, Land, Water and Planning (DELWP). It was funded through the Victorian Government's Our Catchments-Our Communities initiative.

Jacobs Group Australia Pty Ltd (Jacobs) was engaged to support its development and implementation.

The CCOT project commenced in January 2017 and is due for completion in March 2018. It is being implemented in four stages, as depicted in Figure 1.1.

- Stage 1 established the framework for the project, including defining what the key attributes of catchment carbon offsets were (Table 1.1).
- Stage 2 included a major stakeholder workshop (in March 2017) and the production of a discussion paper on the catchment carbon offsets concept, which was circulated to CMA and Water Corporation stakeholders. The workshop extended the original CCO concept to include the features or principles reproduced in Table 1.1.
- Stage 3 was a detailed appraisal of the CCO concept. The appraisal was structured around the evaluation framework for the project and explored the various types of carbon offset project through their appropriateness, effectiveness and legacy. The outcome of the appraisal was that the carbon offsets most closely aligned with the CCO concept are environmental plantings and natural regeneration.
- Stage 4 explored the application of the CCO concept to a virtual case study, based on a set of real integrated catchment management challenges and opportunities. The case study was undertaken in the Gellibrand River catchment of south-western Victoria, in conjunction with Wannon Water, Corangamite CMA, Glenelg Hopkins CMA and the Centre for eResearch and Digital Innovation (CeRDI).

This document summarises the process and findings of Stage 4 of the project.

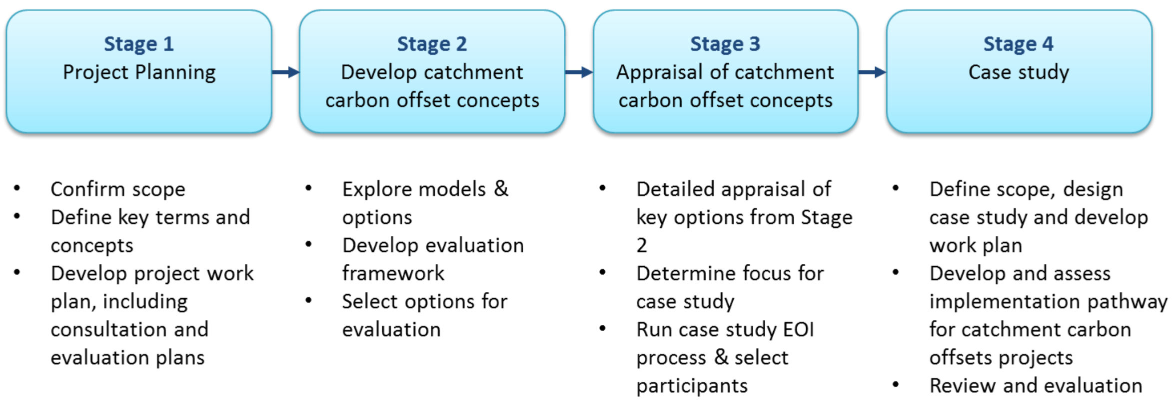


Figure 1.1 : Catchment carbon offsets trial: overview of approach

A second major stakeholder workshop was held in February 2018 in which outcomes of the case study were presented and discussions held on future opportunities to apply the CCO concept.

Table 1.1 : Characteristics of catchment carbon offsets projects

Original Steering Committee definition of the key features of catchment carbon offsets	Extended definition of catchment carbon offset characteristics – following the March 2017 stakeholder workshop
• Projects result in the retention of carbon stocks in the landscape and further carbon sequestration. • Projects provide environmental benefits which are consistent with regional NRM planning frameworks, programs and targets.	• Offset projects increase landscape carbon stocks, resulting in real and additional reductions in atmospheric CO_2. • Carbon sequestration is credible, quantified and verified. • Carbon is "permanently" sequestered. • Stable and resilient with climate change. • "Protected" from ownership and policy change. • Offsets projects provide environmental, social, cultural and/or economic benefits which are consistent with: - Regional NRM planning frameworks, programs and targets; - Water Corporation objectives; - State Government policy. • Project benefits and outcome can be owned and transferred. • Non-carbon benefits are visible, certain and clearly defined. • Build or result from stable, long-term relationships within water sector: CMA(s)-Water Corporation(s). • Local to Water Corporations and CMAs. • Offset projects are scalable up and down.

2. Case study approach

The case study took the form of a virtual trial to explore the implementation pathway of potential CCO projects. As a virtual trial, the case study will not directly result in new catchment carbon offset plantings being undertaken. However, the case study may be a catalyst for the case study participants, particularly Wannon Water and Corangamite CMA to initiate an actual catchment carbon offset project.

The project team invited expressions of interest from CMAs and Water Corporations, to nominate a project and team for the case study. The nominated project or priority area was assessed for consistency with the CCO concept (Table 1.1).

The successful project was centred on the Gellibrand River in south-western Victoria (Figure 2.1). The project partners were: Wannon Water, Corangamite CMA, Glenelg Hopkins CMA and Federation University's Centre for eResearch and Digital Innovation (CeRDI). The main focus of the project was on improving water quality and river health through riparian revegetation. Inclusion of CeRDI in the partnership also offered the chance to explore the potential role of spatial data and analysis in planning CCO projects and engaging stakeholders.

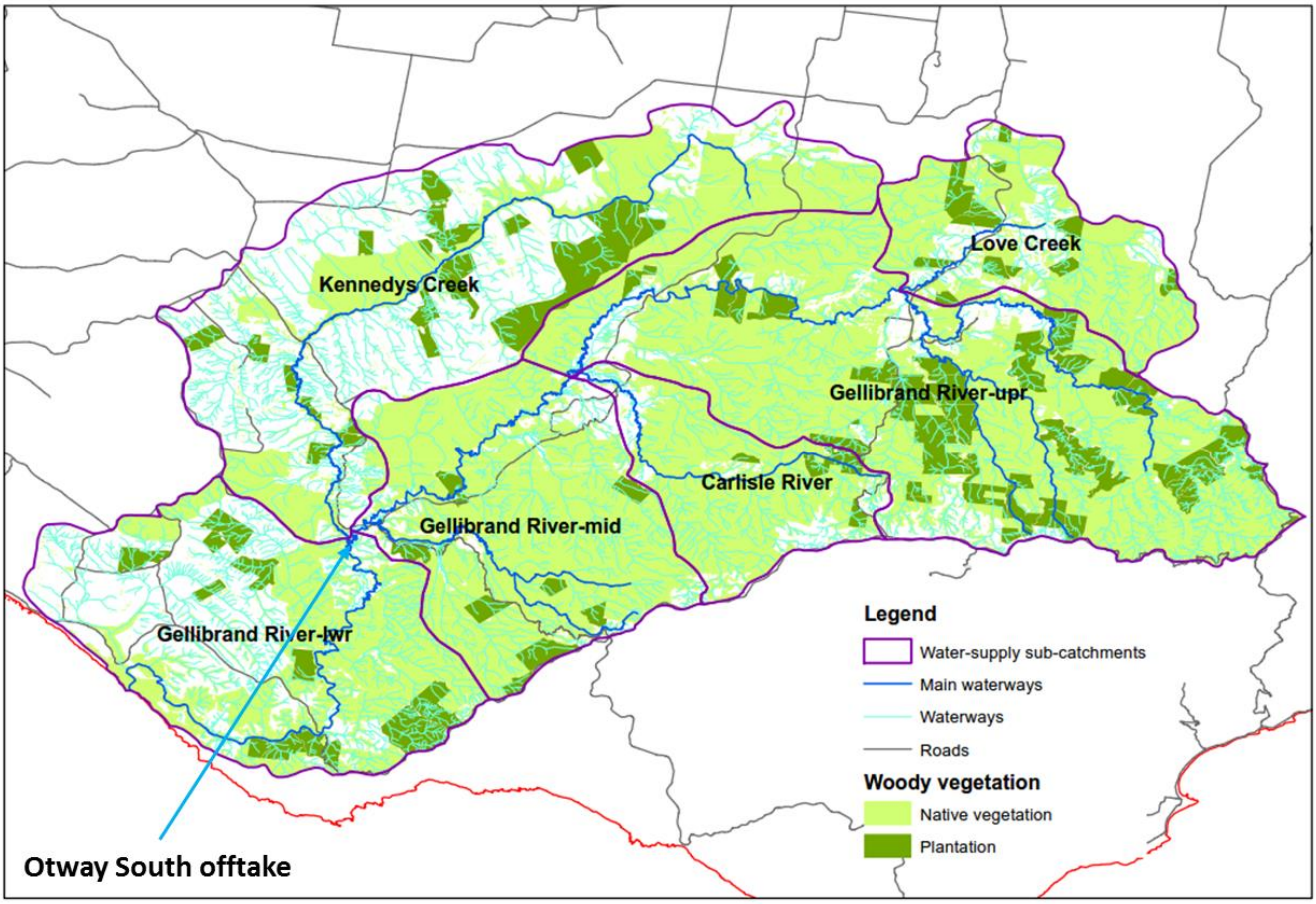


Figure 2.1 : The Gellibrand catchment. The case study considered the catchment upstream of the Otway South water offtake, which includes the mid and upper Gellibrand River, Carlisle River and Love Creek sub-catchments.

The case study included three full day workshops, supported by out-of-session work by the consulting team from Jacobs. Content covered during each workshop and a description of supporting work is summarised in Table 2.1.

Table 2.1 : Case study format and program of activity

Workshop	Focus of agenda	Follow on work by consultant
1. Case study design – October 2017	• Building shared language and understanding about catchment carbon offsets concept • Case study scope and objectives • Case study context – issues, (conceptual) project area • Case study design • Work planning, including communications and stakeholder engagement • Governance and management arrangements • Tour of case study area	• Case study work plan • Project planning documentation – for certified and flexible options • Develop case study evaluation framework • Characterisation of the catchment carbon offset project (based on the catchment carbon offset appraisal).
2. Implementation pathway – December 2017	• Review of catchment carbon offsets concept • Conceptual design for the Gellibrand catchment carbon offsets project • Analysis of potential project legacies • Analysis of potential project costs • Governance options • Community and landholder engagement • Environmental Impact Bonds: a potential funding model for environmental works	• Further analysis to support documentation of implementation pathway • Case study reporting • First pass case study evaluation

3. Review and evaluation – February 2018	• Presentation and review of case study:
	  ▪ Evaluation of the Gellibrand CCO project: financial, environmental, socio-economic and governance costs and benefits
	  ▪ Lessons learned and key messages
	• Next steps for region and partners
		• Finalisation of case study report
		• Incorporation of case study report into final project report

3. Case study design

3.1 Objectives

Project steering committee objectives

The Catchment Carbon Offsets Trial's steering committee's aspiration for the case study was that it would explore the CCO concept in a real project context, with the types of stakeholders who would implement such a project. The objective was that the case study would demonstrate how CCO projects could simultaneously deliver:

- Emissions reductions – particularly as offsets for intractable emissions
- Climate resilience
- Better catchment health
- Alignment between regional NRM plans and water sector emissions abatement.

Project partner's objectives

The main project partners described a project which would improve water quality in an important drinking water catchment and improve river health in a key waterway and catchment area. The Gellibrand catchment is the main source of the potable water Wannon Water supplies to Warrnambool and surrounding towns.

Specific objectives for the case study included:

- Integrate existing regional NRM mapping, soil and landscape databases and investment priority weightings with carbon farming by leveraging the South West Climate Change Portal (www.swclimatechange.com.au) to assist stakeholders;
- Identify gaps in formal carbon offset methods for the Victorian context;
- Explore how realistic it may be to expect formal carbon sequestration projects to also deliver co-benefits;
- Clarify cost of carbon, and compare to relative cost of other outcomes;
- Explore where CCO projects could be realised in the region;
- Develop a framework for including carbon credits in business-as-usual operations by Wannon Water;
- Demonstrate excellent cross-agency relationships, including building relationships with innovators at CeRDI;
- Build internal capability to participate in emissions reduction action at a local scale.

The project would also align with corporate commitments and strategies.

For Wannon Water, these include:

- Carbon Emission Reduction Pledge and Action Plan;
- Environmental and carbon neutrality policies;
- Community Strategy;
- Water quality objectives, specifically for catchment improvements along the Gellibrand River;
- Biodiversity and natural asset management objectives;
- Vision 2023 of enhancing regional prosperity and community partnerships.

For the CMAs, these include:

- Regional Catchment Strategies;

- Climate Change-NRM Plans;
- Waterway Strategies;

The case study was also intended to align with DELWP *Our Catchments-Our Communities*-funded projects in the region

3.2 Cause and effect relationships

A fishbone diagram (Figure 3.1) was used to explore the main causes and drivers of poor water quality in the Gellibrand catchment (Figure 3.2). This fishbone diagram is a simple conceptual tool that assists in the identification of the causes of an "effect" (in this case, poor water quality in Gellibrand catchment water offtakes), as well as in determining where responses to the "effect" or issues should be targeted (Table 3.1).

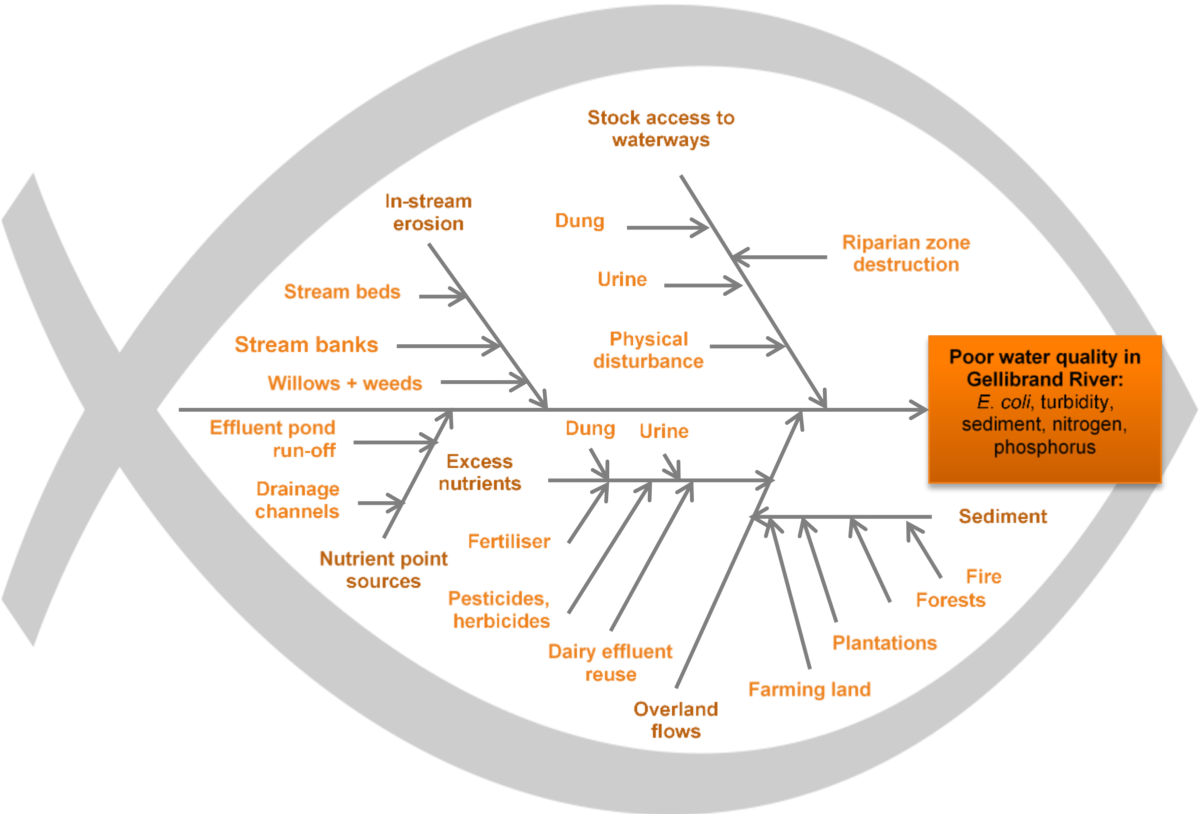


Figure 3.1 : Cause-effect diagram for water quality impairment in the Gellibrand River catchment

Table 3.1 : Major causes or drivers of water quality issues in the Gellibrand catchment and responses included in the catchment carbon offsets case study

Cause	Estimated contribution to water quality issues	Responses
Stock access to waterway	30%	Riparian fencing, stock exclusion, off-stream watering.
In-stream erosion	15%	Riparian fencing, stock exclusion, off-stream watering, riparian revegetation.
Nutrient point sources	15%	Relocate dairy effluent reuse systems away from waterways.
Overland flows: • Sediment • Excess nutrients	40% *12%* *28%*	Riparian vegetation restoration, grassed filter strips, riparian fencing and stock exclusion.

Wannon Water's Otway South water offtake on the Gellibrand River. Livestock have unimpeded access to the river at this point.

At least 20 m wide buffers with environmental plantings would be established on either side of these waterways under the CCO options considered in the case study

Figure 3.2 : Gellibrand River catchment, south-west Victoria.

3.3 Catchment carbon offset scenarios

3.3.1 Characteristics of the Gellibrand River catchment

The Gellibrand River catchment is located on the western side of the Cape Otway and drains an area of some 115,000 ha. The catchment upstream of Wannon Water's Otway South offtake is 66,442 ha (Table 3.2). Unlike the Kennedy's Creek and Lower Gellibrand River sub-catchments, the catchment area upstream of the Otway South offtake is largely forested (Figure 2.1, Table 3.2). Just 13% of this area (8,319 ha) supports agricultural land and is potentially available for revegetation. A similar area is occupied by commercial forestry plantations.

A small area of Crown water frontage is contained within each of the sub-catchments, most of which is located within areas of native forest (Table 3.2). About 200 ha of Crown water frontage is potentially available for revegetation.

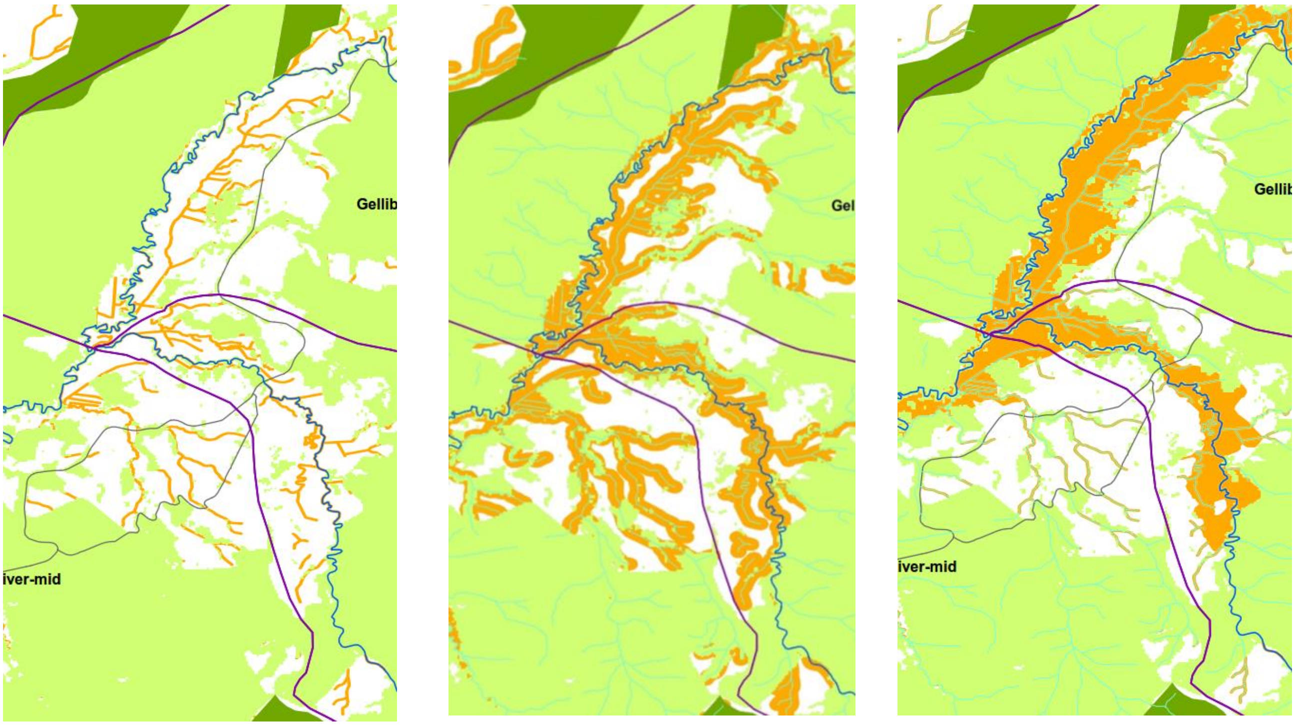
3.3.2 Revegetation configurations

This case study considered three main revegetation configurations for the CCO project (Figure 3.3), including:

- *20 m waterway buffer:* 20 m revegetated buffer both sides of all defined waterways within the case study catchment[3]. This represents what is considered to be the minimum width of revegetated buffer to materially improve water quality in the main waterways and catchment.
- *100 m waterway buffer:* 100 m revegetated buffer both sides of all defined waterways within the case study catchment. This represents what is assumed to be the plausible upper limit of revegetation in the catchment.
- *Floodplain + 20 m buffer:* 20 m revegetated buffer both sides of all defined waterways, with further areas of revegetation occupying all of the floodplain for a 1% annual exceedance probability (AEP) flood event (or 100 year average recurrence interval flood).

[3] The Gellibrand River catchment upstream of the Otway South offtake, near the junction of Kennedy's Creek and the Gellibrand River.

20 m waterway buffer **100 m waterway buffer** **Floodplain + 20 m buffer**



Note: Brown lines and areas mark the extent of revegetation under each of the revegetation configurations. The location of the waterway is shown for the 100 m waterway buffer and floodplain+20 m buffer configurations. 100 m buffer and floodplain options include farm forestry plantings in some configurations.

Figure 3.3 : Examples of the main revegetation configurations, mid and upper Gellibrand and Carlisle River floodplain

In each configuration, the 20 m buffer either side of the waterway was assumed to be revegetated with locally indigenous species of trees and shrubs (called *environmental plantings*; EP). In the 100 m waterway buffer and floodplain+20 m buffer configurations, the plantings outside the 20 m riparian buffer were either environmental plantings or farm forestry plantings (FF; assumed to be *Eucalyptus globulus*).

Environmental plantings would remain unharvested through their life. The farm forestry plantings were assumed to be harvested for pulpwood on a 15 year rotation and then replanted (within 18 months of harvest).

The limited area of Crown water frontage within the Gellibrand catchment (Table 3.2) means that none of the revegetation projects could be fully implemented on such land.

Managed natural regeneration was initially considered as an option for achieving the three main CCO configurations. This could be used as a means to establish riparian or floodplain buffers within about 50 m of existing native vegetation (with fencing, livestock exclusion and development of off-stream watering), with the latter providing the seed source. However, natural regeneration was not considered in the final CCO configurations due to several limitations on its practicability, including:

- *Competition from dairy pastures:* this would limit the likely success of natural regeneration or require that high levels of grass control would be maintained for several years to achieve adequate levels of recruitment;
- *Limited extent:* the limited extent of remnant vegetation patches in the target areas for the three main CCO configurations would mean that most of the plantings would need to be in the form of environmental or farm forest planting;
- *Carbon accounting:* areas of managed natural regeneration would need to be accounted separately to the environmental and farm forestry plantings under the methodologies for generating carbon offsets. This

would increase transaction costs associated with claiming the carbon offsets (i.e. costs associated with monitoring, carbon stock modelling and measurement, reporting and verification)[4].

Table 3.2 : Characteristics of the case study area, the Gellibrand River catchment upstream of Wannon Water's Otway South offtake.

	Love Creek	Carlisle River	Upper Gellibrand	Mid Gellibrand	Total
Area (ha)	9,510	7,991	32,031	16,911	66,422
Native vegetation (ha)	6,564	6,290	22,995	14,189	50,038
Plantations (ha)	1,036	365	5,648	1,036	8,086
Agriculture (ha)	1,910	1,336	3,388	1,686	8,319
Area of new environmental or farm forestry plantings (ha and % agricultural land):					
100 m EP	846 (47%)	590 (47%)	1,302 (42%)	696 (43%)	3,435 (42%)
20 m EP	168 (9%)	128 (10%)	267 (8%)	157 (9%)	720 (9%)
20 m + FP EP	170 (9%)	312 (23%)	825 (24%)	322 (19%)	1,629 (19%)
Crown water frontage (ha):					
Total	61	71	501	224	856
Native vegetation	42	39	388	184	653
Agriculture	19	32	113	39	203

3.3.3 Alternative projects

In evaluating the potential legacies of the CCO project (see section), the case study considered two alternatives to the planting designs described in the previous section. These included:

- *Base case:* this was a "do nothing" option in which no new action was taken to manage source water quality upstream of the Otway South offtake or to improve river health. Treatment of drinking water (by Wannon Water for Warrnambool and surrounding areas) would continue and would meet current standards.
- *Engineered water quality treatment:* in this option, rather than treat the catchment source of water, ultra-violet (UV) treatment would be introduced at each of the five plants treating water from the Gellibrand River. This will allow Wannon Water's drinking water supplies to meet evolving health-based water quality targets and to treat growing levels of *Cryptosporidium* and *Giardia* in the source water – without treating the catchment[5].

3.4 Legacies

One intent of the case study was to test approaches to evaluating the various potential legacies of CCO projects. These were identified using a fishbone diagram (as per Figure 3.4) and grouped into four main categories:

- *Emissions:* in addition to sequestering carbon in the new vegetation, the CCO project could reduce emissions associated with dairy production in the planted area (from livestock, nitrogenous fertiliser use and manure management). Improving source water quality may also reduce emissions associated with water treatment. Establishment and management of the CCO plantings may slightly increase emissions associated with vehicle use, particularly during the establishment phase and harvesting of trees in the farm forestry configurations;

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[4] Note that the managed natural regeneration methodology (under the Commonwealth Emissions Reduction Fund) has also been criticised for overstating the amount of carbon sequestered (Climate Change Authority 2017. *Review of the Emissions Reduction Fund*, http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/CFI%202017%20December/ERF%20Review%20Report.pdf, Section 3.4.1.

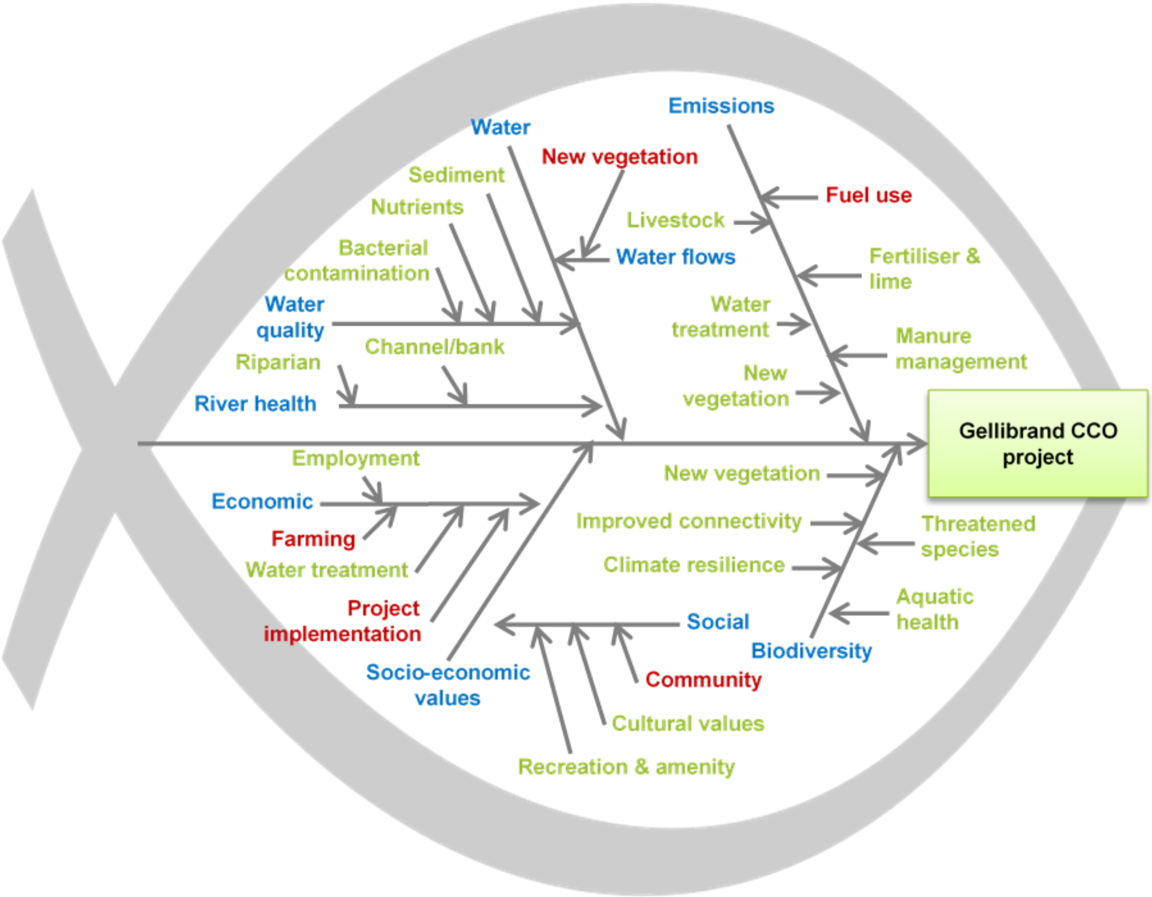
[5] Note that this is one of a range of engineered water treatment options potentially available to Wannon Water.

- *Water:* the CCO plantings were designed to address the main causes of water quality issues in the catchment and hence this should be an important beneficial legacy of the case study. Establishment of new vegetation in the catchment is likely to intercept water flows and reduce average catchment water yield. The net effect of the project on river health should be positive, with the adverse effect of reduced flows offset by improved water quality and riparian and aquatic habitat.
- *Socio-economic values:* the CCO plantings would likely have both positive and negative socio-economic legacies. Displacement of dairy production would reduce income from farming, particularly for the 100 m waterway buffer and floodplain + 20 m buffer options. This would be at least partly offset by revenue from farm forestry production, the value of carbon credits generated and/or reduced water treatment costs incurred by Wannon Water (depending on the planting configuration). Costs would be incurred in implementing the project, but this would generate employment during establishment (and harvesting for the farm forestry options).

  Riparian revegetation should also improve social and recreational values associated with the Gellibrand River, its tributaries and estuary. It should also help to protect or enhance Indigenous cultural values. Increasing vegetation cover in the catchment may increase bushfire risk to residents.

  The 100 m waterway buffer configuration would, if fully implemented, occupy about 40% of the remaining agricultural land in the Gellibrand catchment (upstream of the Otway South offtake). As this option would displace agricultural land use and the contraction of farming in the catchment, it may also lead to the loss of farming families and a decline in social values associated with the local community.

  Implementing the CCO project as a partnership between Corangamite CMA, Wannon Water and local landholders may help to strengthen relationships and build collaboration and community capacity within the catchment.
- *Biodiversity:* the CCO plantings would enhance vegetation connectivity along waterways and improve aquatic, riparian and terrestrial habitat. This may help to protect populations of threatened aquatic and terrestrial species and improve environmental conditions within the estuary of Gellibrand River. Improving vegetation connectivity and water quality by implementing the CCO project should also improve climate resilience within the catchment.



Note: Green indicates a likely positive legacy from the project. Red indicates a likely risk or adverse legacy from the project. Blue indicates the main groupings of legacy.

Figure 3.4 : Potential project legacies associated with catchment carbon offsets designs in the Gellibrand River catchment

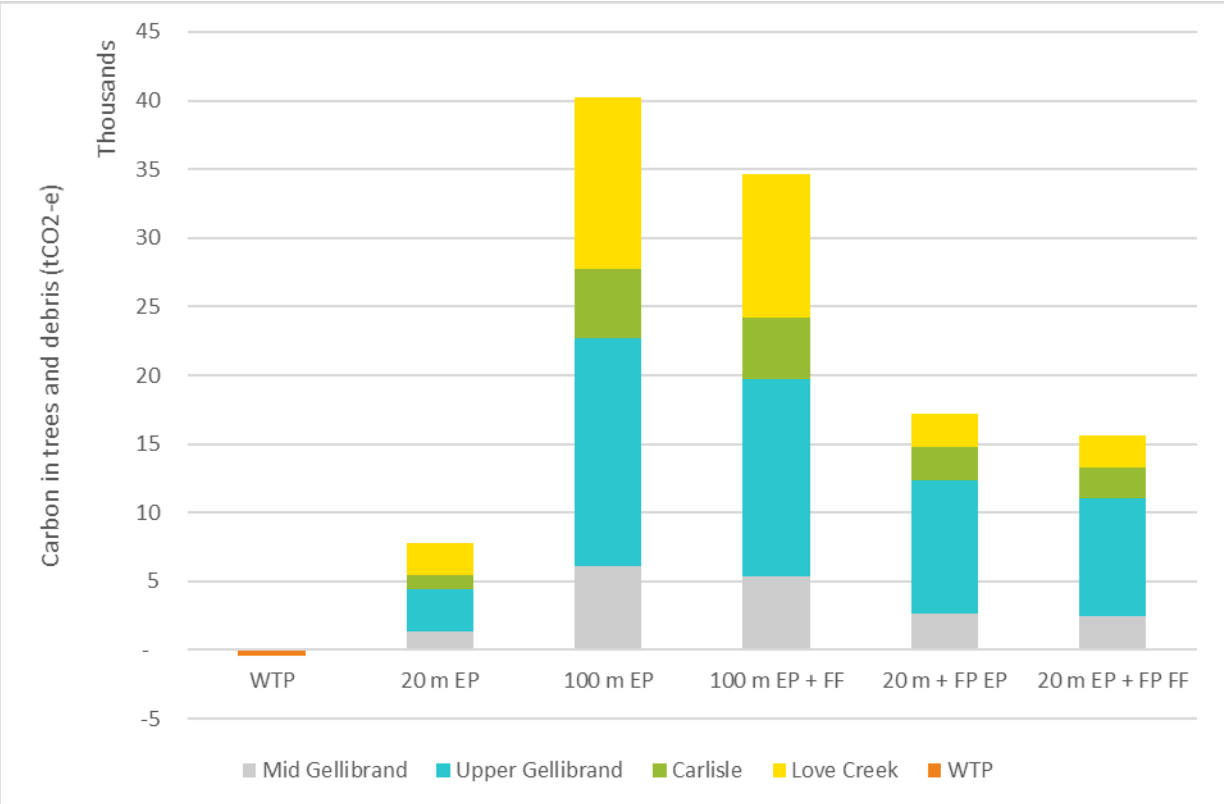
4. Case study results

The case study was designed to evaluate as many of the project legacies as possible – for each of the CCO configurations and, where relevant – the alternative scenarios. This section provides a summary of those assessments.

4.1 Certified carbon offsets and offset requirements

Certified carbon abatement offsets could be generated by the various CCO options, including both the environmental planting and environmental planting plus farm forestry configurations (Figure 4.1). The planting projects would need to be established and carbon accounted for according to the applicable Emissions Reduction Fund (ERF) methodologies and comply with National Carbon Offset Standard (NCOS) integrity requirements[6].

Given the energy intensive nature of engineered water treatment, any emissions associated with the engineered water treatment option (WTP) may be expected to generate an additional offset requirement[7].



Note: WTP – engineered water treatment plant alternative to CCO projects; EP – environmental planting CCO options, FF – farm forestry CCO options; FP CCO options involving environmental or farm forestry plantings on 1% AEP floodplain areas (in addition to 20 m waterway buffer environmental plantings.

Figure 4.1 : Average yearly carbon sequestered for each project option by sub-catchment

Carbon sequestration was estimated for each of the CCO configurations using FullCAM, the Australian Government's carbon accounting model (see Appendix A). Model runs were undertaken for environmental plantings and harvested farm forestry (*E.globulus*) plantations. Emissions associated with new UV water treatment plants were also estimated.

[6] If the offsets are to be credited against Wannon Water's offset requirements. Under Water Corporations' *Statements of Obligations*, any offsets used to contribute towards emissions reduction targets must comply with NCOS requirements.
[7] If the water treatment plant is powered by non-renewable energy.

Average annual sequestration or emissions (over 50 years) for each of the project options and Gellibrand sub-catchments is shown in Figure 4.1. Average annual carbon sequestration ranged between about 7.8 kt CO_2e/y for the 20 m waterway buffer option and about 40 kt CO_2e/y for the 100 m waterway buffer option entirely comprise of permanent environmental plantings. While the *E.globulus* trees in the farm forestry plantings grow rapidly and sequester large amounts of carbon, average long-term rates of sequestration are significantly diminished by harvesting (at 15 year intervals). All of the CCO project options are able – averaged over 50 years – to satisfy Wannon Water's current carbon offset requirements (of approximately 7,000 t CO_2-e/y).

Where the CCO options provide carbon credits beyond Wannon Water's internal requirements, these could be traded to other Water Corporations or sold into carbon markets.

The engineered water quality treatment option would generate carbon emissions due to its energy use and – unless energy was provided by renewable sources – would add to Wannon Water's offset requirements (Figure 4.1).

Although the environmental plantings projects continue to accumulate carbon over the modelled project timeframe, the FullCAM model estimates that maximum carbon sequestration occurs at approximately year 13 (Figure 4.2).

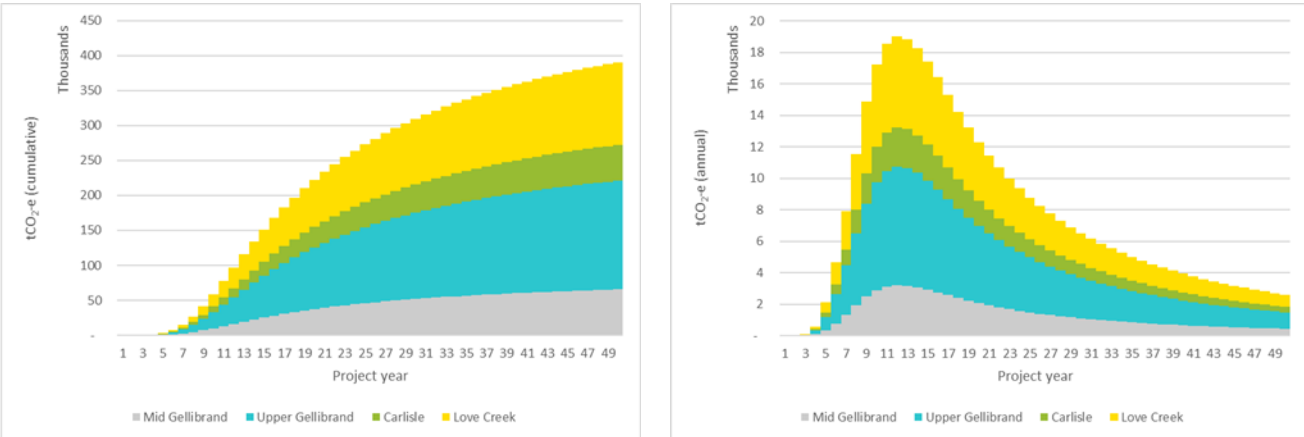


Figure 4.2 : Cumulative and annual carbon sequestration: 20 m waterway buffer environmental planting

Cumulative and annual carbon accumulation in trees and debris for the farm forestry projects are dominated by the harvest/replanting cycle (Figure 4.3). The cycle length (15 years of growth followed by an 18-month rest period) captures the peak tree growth period. Much of the carbon accumulation in the years following harvest results from carbon sequestration in the 20 m waterway buffer environmental planting buffer, which remains unharvested.

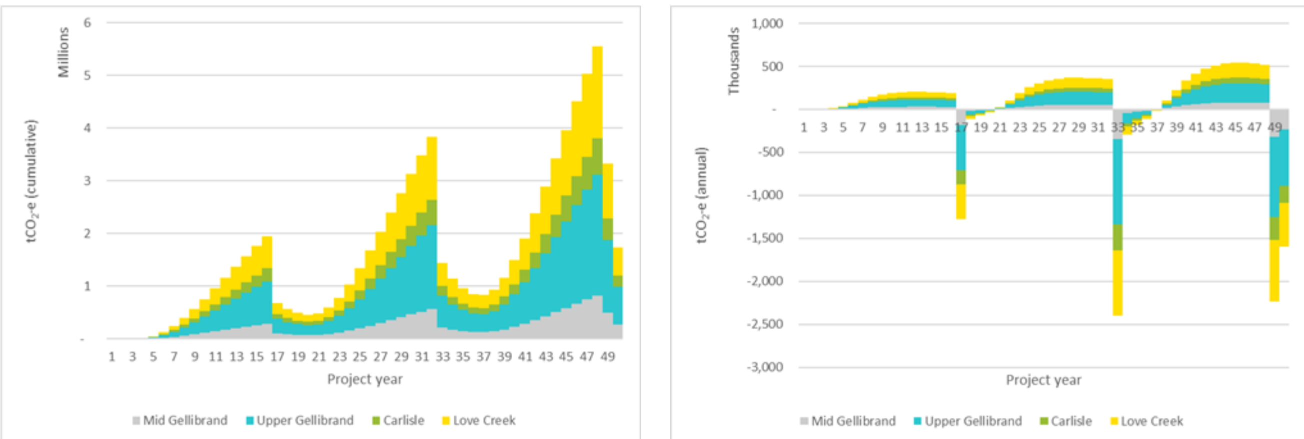


Figure 4.3 : Cumulative and annual carbon sequestration: 100 m waterway buffer, with farm forestry

4.2 Financial costs and benefits

The financial assessment considered the costs involved in establishing and running the different CCO project options and the engineered water treatment plant alternative (see Appendix A for details of the assessment). Costs also include the value of foregone dairy production where the CCO project displaces agriculture[8]. It also includes the revenue which could be generated by the sale of carbon credits, as well revenue from the sale of timber produced in farm forestry areas. Any potential savings in water treatment costs resulting from improvement in source water quality as a result of the CCO projects were also estimated.

Costs and revenue were all discounted (using 7% discount rate) and the net present value (NPV) calculated for each option. NPV was calculated assuming a carbon price of $11/tCO_2$ (Table 4.1), although a "break-even" carbon price was also calculated (the carbon price required for zero NPV for each option).

The overall costs and benefits are divided into normal project costs (i.e. the costs associated with establishment and running of any environmental planting or farm forestry project of this type) and the costs and benefits specifically associated with running the project as a carbon offset.

Table 4.1 : Financial assessment summary: all costs and revenues discounted to present values

Effect	Engineered WQ treatment	20 m EP	100 m EP	20 m EP + 80 m FF	20 m + FP EP	20 m EP + FP FF
Overall						
Present value of costs	-$8.3M	-$6.2M	-$79M	-$113M	-$36M	-$46M
Present value of benefits	-	$1.8M	$6.9M	$70M	$3.3M	$21M
NPV	-$8.3M	-$4.4M	-$72M	-$43M	-$32M	-$25M
Break-even carbon price	n/a	$51	$140	$97	$146	$122
"Normal" project costs and revenues: non-carbon elements of project						
Establishment and management of plantings	n/a	-$5.9M	-$79M	-$110M	-$35M	-$46M
Water quality treatment savings	n/a	$0.57M	$0.68M	$0.65M	$0.41M	$0.62M
Pulpwood revenue	n/a	-	-	$64M	-	$18M
Costs associated with participation in carbon markets						
Operation as a carbon offset	n/a	-$0.20M	-$0.46M	-$0.58M	-$0.41M	-$0.39
Carbon credit revenue[1]	n/a	$1.2M	$6.2M	$5.6M	$2.6M	$2.5M

Note:

1. Carbon credit revenue, assumes that all offsets are valued at $11/t CO_2e$, regardless of whether they are retained by Wannon Water or on-sold.

Capital cost estimates for the engineered water quality treatment option are based on the cost to install gravity UV systems at each of the five water treatment plants (according to their size and capacity; see Appendix A). Water treatment savings are based on average running costs at the five water treatment plants serviced by the Gellibrand catchment, assuming that a 1% reduction in turbidity (see Section 4.3.2 for calculations) can result in a 0.1% reduction in treatment cost[9].

[8] Based on local anecdotal evidence (Chris Pitfield, personal communication), there is assumed to be no net loss of agricultural production from the first 20 m either side of a waterway.

[9] Heberling MT, Neitch CT, Thurston HW, Elovitz M, Birkenhauer KH, Panguluri S, Ramakrishnan B, Heiser E, Neyer T (2015) 'Comparing drinking water treatment costs to source water protection costs using time series analysis', *Water Resources Research*, vol. 51, no. 11, pp 8741-8756.

Further details on the financial assessment, including the assumptions and baseline conditions, are given in Appendix A.

None of the CCO options break even at the assumed carbon price of $11 per t CO_2-e and all, including the engineered water treatment plant alternative, had negative net present values (over 50 years; Table 4.1). The option with the smallest negative NPV was the 20 m waterway buffer option. This reflects the lower costs of establishment and management with this option and that has the least impact on revenues from agriculture.

The larger-scale CCO options (100 m buffer, floodplain options) incur more costs in establishment and on-going management, have greater impact on dairy production and hence increased cost overall. These costs are not fully offset by the increased value of sequestered carbon, or in the case of the farm forestry options, the value of pulpwood produced. Revenue from the sale of pulpwood means that the farm forestry options have less negative NPVs that the corresponding option with only environmental plantings.

The financial results for CCO options are sensitive to the agricultural opportunity cost. This was assumed to be 80% of the previous revenue for 100 m buffer and floodplain projects. However, if this was reduced to 40%, the NPV for the 100 m waterway buffer option would increase to -$12M. If the opportunity cost was just 20%, the NPV would be +$3.9M. Revenue from farm forestry options does not fully offset the lost value of dairy production.

The NPV of the 20 m waterway buffer options is superior (less negative in this instance)[10] to the engineered water treatment plant.

Table 4.1 shows that the cost of participating in carbon markets is estimated to range between about $0.2 and $0.4 million over 50 years. Even with carbon prices as low as $11/t CO_2-e, these costs are significantly exceeded by the revenue that could be generated.

4.3 Environmental legacies

The case study was designed to provide a variety of environmental legacies, including greenhouse gas emissions abatement and improving catchment water quality, river health and terrestrial biodiversity. As the case study options include the establishment of new areas of woody vegetation, they have potential to intercept catchment run-off and pose a risk to flow regimes in the Gellibrand River catchment.

Metrics have been developed to evaluate the performance of the CCO options and each of the project alternatives against each of these potential environmental legacies, as discussed below.

4.3.1 Greenhouse gas emissions

CCO projects are likely to displace existing agricultural land uses and their associated emissions. As there is no mechanism for these emissions reductions to be certified, they cannot generate revenue and are unable to be considered in the financial analysis. However, these emissions reductions could be considered as “flexible offsets” (as defined for the CCO concept[11]), as they can be calculated using established methods, are permanent and meet at least some of the CCO principal characteristics (Table 1.1).

Avoided agricultural emissions would result (for some options) from reduced livestock numbers and area of dairy pasture. These would lead to reduced livestock methane emissions, as well as fertiliser and manure-related emissions of nitrous oxide. Given the scale of the case study project (if implemented), these changes could be detectable in Victoria’s greenhouse gas accounts.

[10] Note that the NPV calculation has not valued community benefits associated with maintaining or improving drinking water quality or meeting health-based water quality targets. Were these to be included, the NPV of the engineered water treatment and 20 m waterway buffer options would most likely have differed to those presented here.
[11] See Jacobs 2018. Catchment Carbon Offsets Trial. Final report. Report to Goulburn Broken CMA. Report is190600-4-2.

This source of abatement was counted as an environmental effect for each CCO option, where applicable[12]. The sum of certified and flexible offsets generated by each of the CCO options are shown in Figure 4.4.

For this case study, the assumptions about foregone revenues from dairying from the financial analysis can be used to estimate the change in agricultural emissions. For the 20 m waterway buffer option, all livestock are assumed to be retained by the landowner and hence there is unlikely to be any reduction in agricultural emissions. For the CCO options occupying larger areas (100 m buffer, floodplain), it was assumed that 80% of dairy production would be displaced. Agricultural emissions are assumed to be reduced by this amount.

For the larger CCO options, flexible offsets from displacement of dairy production may add a further 50% to the certified emissions (Figure 4.4). This equates to an average of about 20 kt CO_2-e/y for the 100 m waterway buffer options and about 10 kt CO_2-e/y for the floodplain + 20 m buffer options.

Greenhouse gas emissions may also be avoided due to reduced water quality treatment requirements (see sections 4.3.2 and 4.2), however, these changes have not been estimated[13]. The change in greenhouse gas emissions associated with fuel use for the establishment and management of any of the CCO options are considered to be marginal and have also not been included in this analysis.

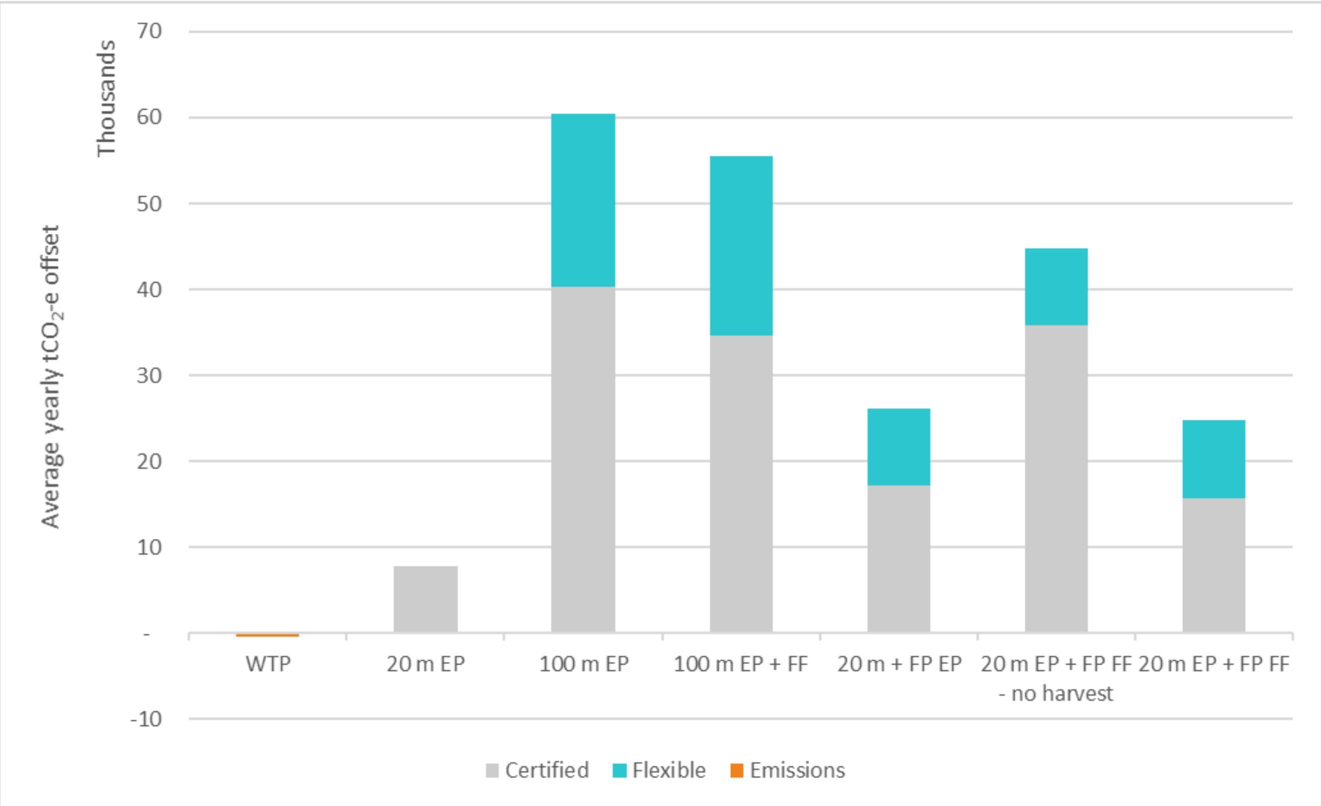


Figure 4.4 : Certified and flexible carbon: carbon sequestered and greenhouse gas emissions avoided per project

4.3.2 Source water quality

The CCO options in this case study were designed to improve the quality of water taken by Wannon Water from the Gellibrand catchment. This would have both financial and environmental benefits, with the former considered in the financial analysis in Section 4.2 and the latter considered here. Environmental benefits associated with improved water quality could be reflected in improved habitat and populations of aquatic flora and fauna, as well as in broader measures of river health.

12 As previously noted, the 20 m waterway buffer option was not considered to lead to reduced agricultural production and hence it was assumed that there would be no agricultural emissions abatement.

13 They are also partly reflected in the reduced water treatment cost for the CCO options in the financial analysis.

The four main causes of poor water quality were identified during the problem definition stage (see Figure 3.1). These are: stock access to waterways; in-stream erosion; nutrient point sources (i.e. dairy effluent); and overland flows transporting sediment and excess nutrients into the waterways. The effect of each CCO option on individual causes was modelled (Table 4.2) to estimate the overall potential impact on water quality (Figure 4.5). Under this analysis, if the CCO options were to be fully implemented, they would treat between 55% and 90% of the causes of water quality impairment. The options occupying larger land areas would provide the greatest water quality improvement.

More detailed modelling than was possible for this case study would be required to estimate the actual improvement in water quality that could be expected if 55-90% of the underlying causes of water quality impairment were addressed by a CCO project and the timeframe over which it would be achieved..

For the purpose of this analysis, each of the options was assumed to be fully implemented as per Table 3.2 and that each of the potential causes of water quality impairment (Figure 3.1) were operating along the full length of the waterways[14]. However, it is likely that the larger environmental plantings (only) options would be less attractive to land owners (due to greater establishment and agricultural revenue costs) than the 20 m waterway buffer option and may not be implemented to the extent that has been assumed. In this case, these options would be less effective than indicated in Figure 4.5.

Table 4.2 : Water quality cause-effect assumptions

Cause of water quality impairment (% contribution)	Catchment carbon offset option – effect on water quality cause if fully implemented				
	20 m EP	100 m EP	20 m EP + 80 m FF	20 m + FP EP	20 m EP + FP FF
Stock access to waterways (30%)	100%	100%	100%	100%	100%
In-stream erosion (15%)	55%	90%	70%	80%	65%
Nutrient point sources (15%)	0%	90%	90%	75%	75%
Overland flows (40%):					
• Sediment (12%)	30%	60%	50%	50%	40%
• Excess nutrients (28%)	50%	90%	90%	75%	75%

[14] Given the configuration of existing vegetation within the case study area, this is likely to overstate the effect of the treatments on the causes of water quality impairment.

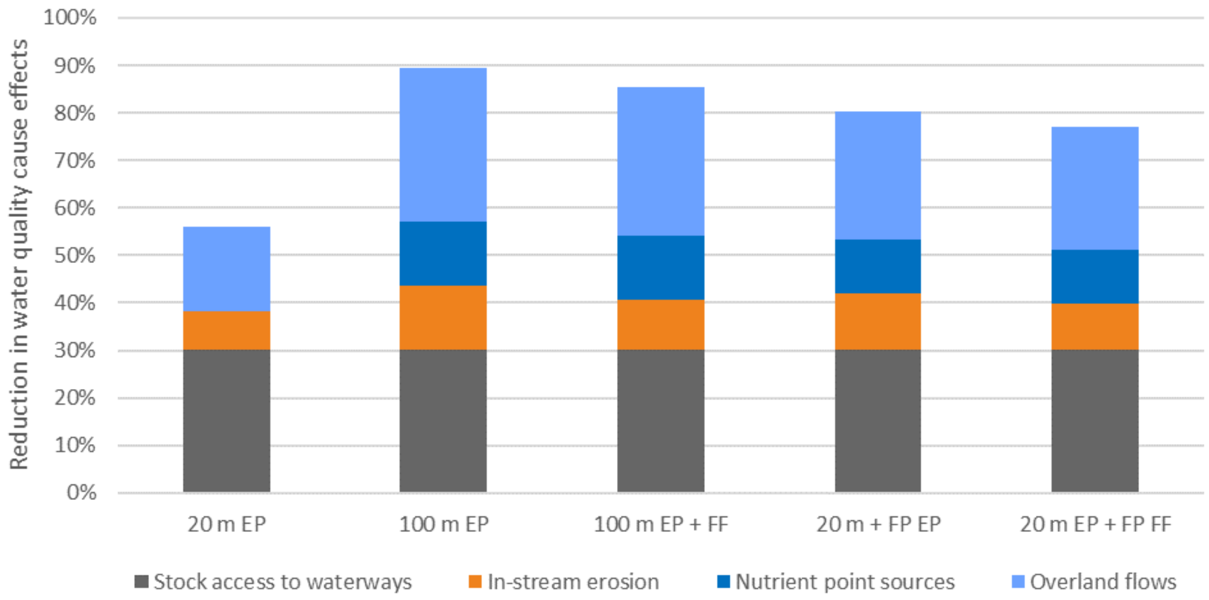


Figure 4.5 : Effect of catchment carbon offset options on causes of water quality impairment in the Gellibrand catchment

4.3.3 River health

River health is typically characterised using the Index of Stream Condition (ISC). The most recent assessment involving the Gellibrand catchment was ISC3 (DELWP, 2010; Table 4.3), which charactered river health using indices of:

- Physical form: bank condition, instream woody habitat
- Streamside zone: riparian zone width, fragmentation, tree/shrub cover, structure, large trees, weeds
- Water quality: total phosphorus, turbidity, electrical conductivity, pH
- Aquatic life.

Reflecting the relatively high level of retained native vegetation in much of the upper Gellibrand catchment, ISC scores typically rate waterways to be in moderate to excellent condition (Table 4.3). This limits potential improvements from implementation of a CCO project involving riparian vegetation restoration in this part of the Gellibrand catchment.

The CCO options considered in this case study have potential to influence all four of the ISC metrics listed above, although their most direct effects will be on streamside zone metrics. While there are limited opportunities for improvements against this metric (Table 4.3), each of the CCO options will increase the connectivity and width of native vegetation along waterways and contribute to improvements in river health in sections of waterway reaches which currently have limited vegetation cover.

Table 4.3 : ISC3 results for project reaches[15]

Basin	Reach	Reach Length (Km)	River	Hydrology	Physical Form	Streamside Zone	Water Quality	Aquatic Life	ISC Score	Condition
35	13	37.5	Gellibrand River	3	9	8	6	7	28	Moderate
35	14	41.5	Gellibrand River	5	7	8	6	9	32	Moderate
35	15	19.5	Gellibrand River	2	7	7		8	26	Moderate
35	16	15.7	Gellibrand River	2	9	9	8	8	31	Moderate
35	19	22.6	Chapple Creek	9	10	9		9	45	Excellent
35	20	13.8	Sandy Creek	9	10	9		8	44	Excellent
35	21	20.9	Carlisle Creek	3	9	9	9	8	34	Moderate
35	22	8.1	Gum Gully Creek	10	10	10		9	48	Excellent
35	23	17.9	Lardner Creek	8	10	9		8	42	Excellent
35	24	13.5	Love Creek	7	5	8	4	9	29	Moderate
35	25	13.1	Love Creek	7	9	10		6	37	Good

The additional length of waterway with connected native vegetation cover is shown in Table 4.4. Since each of the options provides at least a 40 m wide riparian corridor, the change in length of connected riparian vegetation is the same for each option. Overall, an additional 174 km of waterway would have connected native vegetation, an improvement of about 13% for the Gellibrand catchment upstream of the Otway South offtake.

Table 4.4 : Change in length of waterway with connected vegetation.

Sub-catchment	Current km	CCO options	Total km	% change
Carlisle River	176	32	207	18%
Gellibrand River-mid	376	38	409	10%
Gellibrand River-upper	610	63	673	10%
Love Creek	159	41	200	26%
Catchment total	**1,315**	**174**	**1,490**	**13%**

Improvements in water quality within the case study area as a result of implementing one of the CCO options could also help to improve water quality and river health in downstream reaches and the Gellibrand River estuary.

4.3.4 Biodiversity

Habitat fragmentation is a key risk factor for terrestrial biodiversity and a common feature of agricultural areas. While native vegetation has been retained on about 75% of the land upstream of the Otway South offtake, CCO options have potential to connect fragmented vegetation in farming areas (e.g. Figure 4.6) and lead to potential improvements in terrestrial biodiversity.

Figure 4.7 compares how much additional vegetation would be connected for each CCO option. Only planting floodplain areas would reconnect very disconnected patches of native vegetation. Most connections could be

[15] DEPI (2013) *Third Index of Stream Condition Report*: *Corangamite Region*, Victorian Government, available at https://www.water.vic.gov.au/__data/assets/pdf_file/0024/34818/ISC_Part10_Corangamite.pdf.

achieved with 20 m waterway buffers; these would connect about 90% of the area of native vegetation that would be connected with 100 m waterway buffers. However, their reduced width means that the 20 m waterway buffer plantings would provide less value in connecting habitat patches than wider buffers. For example, the vulnerable yellow-bellied glider (*Petaurus australis*), which is present in the case study area, is considered to require 60 m wide vegetation corridors to move between habitat patches and so may not move along the 20 m buffers.

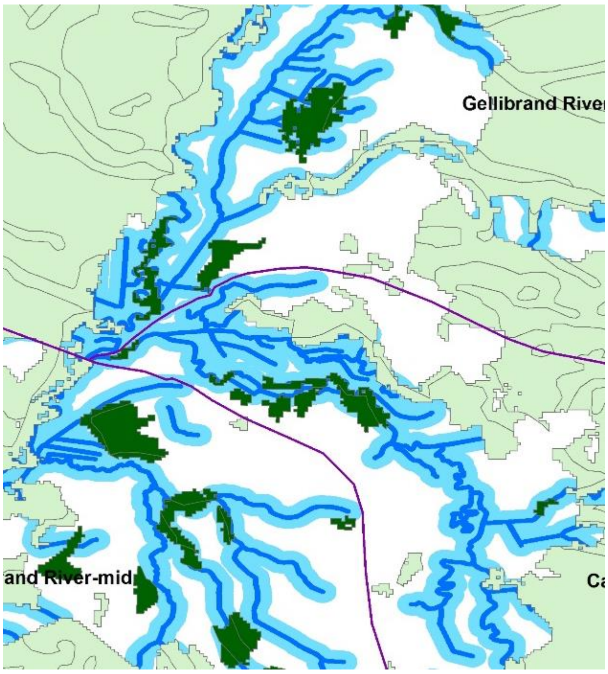


Figure 4.6 : Connecting existing vegetation patches (dark green) with larger habitat areas (light green) with 20 m (dark blue) and 100 m (light blue) waterway buffer plantings.

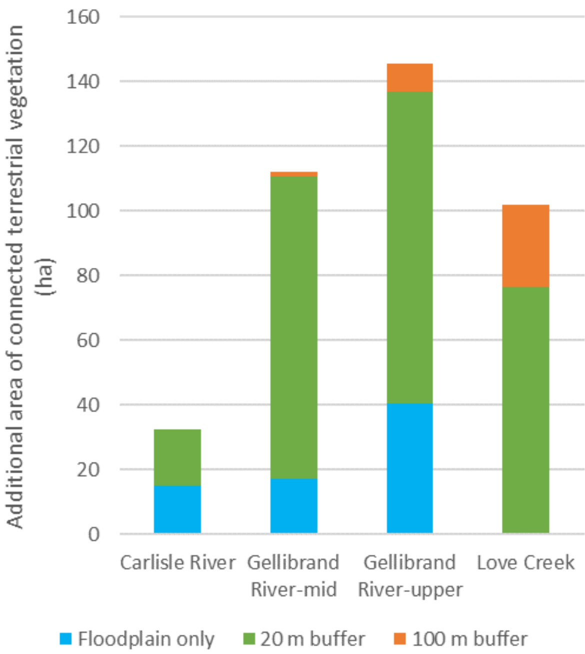


Figure 4.7 : Area of additional connected vegetation with catchment carbon offset options.

A number of reaches of the Gellibrand River are vital habitat for the River Blackfish (*Gadopsis mamoratus*), a species that declining in both abundance and distribution in Victoria. The preferred habitat of this species is clean, well oxygenated flowing streams with high timber debris. The River Blackfish also requires hollow logs to deposit their eggs. Revegetating key reaches of the Gellibrand River will hopefully lead to better quality habitat for this threatened fish species.

4.3.5 River flow regime

Tree plantings use more water than agricultural pastures and hence the CCO options have potential to intercept water which would otherwise have flown in the Gellibrand River. The impact of the project options on river flow was calculated using data from the South-west Victoria Water and Land Use Change Study[16] (Figure 4.8). The estimated reduction in mean annual flow with the CCO options varies between about 1,000 ML/y for the 20 m waterway buffer option and almost 8,000 ML/y for the 100 m waterway buffer with environmental and farm forestry plantings.

Since mean annual flow in the Gellibrand River exceeds 280,000 ML, the CCO options would account for between 0.4-2.8% of flow within the catchment.

[16] Clifton C, Daamen C, Home A (2008) *Water and Land Use Change Study: Changes in hydrology and flow stress with land use change in south west Victoria: Final technical report*, Sinclair Knight Merz, report for Glenelg Hopkins CMA.

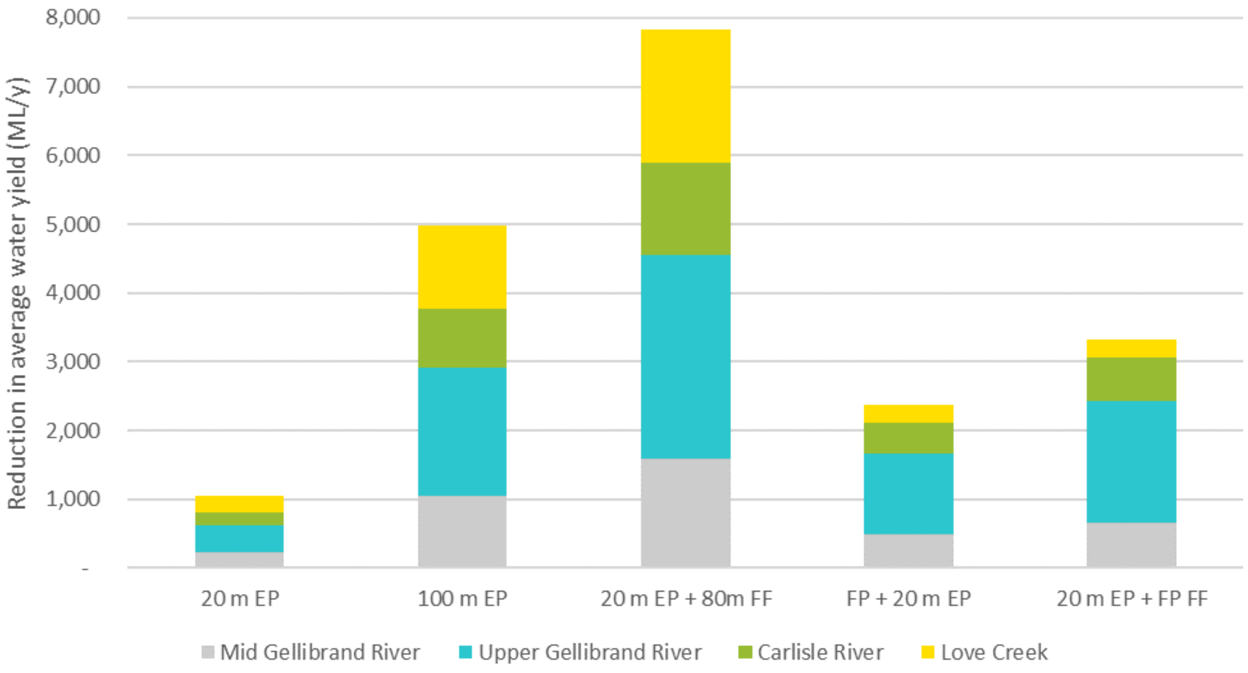


Figure 4.8 : Reduction in average water yield from catchment carbon offset options

4.3.6 Climate resilience

CCO projects are intended to contribute to climate resilience in landscapes and natural resource management. Climate resilient landscapes are characterised, among other things, by connectivity between patches of remnant vegetation, continuity of vegetation cover along waterways, good water quality and healthy river flow regimes. As each of these elements has been considered individually as part of the environmental assessment, it would be inappropriate (for reasons of double counting) to consider climate resilience as a separate metric for CCO options.

While it is not assessed specifically, it is clear from discussions through this environmental assessment that each of the CCO options would help to improve climate resilience. The Corangamite CMA's *NRM Plan for Climate Change* found that the Gellibrand River is considered a high priority to the region due to its high resilience capacity due to large areas of streamside still vegetated and its close proximity to one of more high rainfall catchments in Victoria.

4.4 Socio-economic impacts

The provision of social and cultural benefits to communities is an important design consideration for CCO projects (as per Table 1.1). This section considers three areas of potential socio-economic legacy of the CCO options considered by the case study. These have been assessed qualitatively, as there are no readily useable metrics for the assessments. Effects of each of the CCO options and the engineered water treatment plant project alternative have been considered on a scale of -4 (highly adverse effect of the option) to +4 (highly beneficial effect of the option), with a score of zero being the current base case situation.

4.4.1 Waterway cultural values

Recognising and managing to maintain Indigenous cultural values is embedded in policies and strategies governing water and catchment management. *Water for Victoria*[17] mandates that Aboriginal values and objectives for water be included in planning and that traditional knowledge is incorporated into water

[17] DELWP (2016) *Water For Victoria: Water Plan*, Victoria State Government, available at https://www.water.vic.gov.au/__data/assets/pdf_file/0030/58827/Water-Plan-strategy2.pdf.

management. *Water for Victoria* also requires increased Indigenous participation in water management and access to water for economic development for Aboriginal enterprises.

The *Corangamite Waterway Strategy 2014 – 2022*[18] notes that Traditional Owners support the planting of endemic species of Indigenous significance along the region's waterways. This aspiration could be incorporated into the establishment of the CCO options considered in the case study, particularly within the environmental planting components.

Changes in Indigenous cultural value associated with the CCO options were assessed qualitatively due to the lack of specific metrics. The assessment considered the changes in protection provided to riparian land by the CCO options and the extent of native vegetation restoration – all within the context of a case study catchment area which retains large amounts of connected, remnant vegetation. The assessment was undertaken by the case study working group (Table 4.5), based on their experience in working with Traditional Owners. It should be taken to be an indicative figure which would be revised following discussion with Traditional Owner representatives.

Table 4.5 : Assessment of socio-economic legacies of case study options

Effect	Base case	Engineered WQ treatment	Riparian buffer			Floodplain + 20 m	
			20 m EP	100 m EP	20 m EP + 80 m FF	20 m + FP EP	20 m EP + FP FF
Waterway cultural values	-1	-1	1	1	1	1	1
Waterway social values	-1	-1	3	2	1	2	1
Bushfire risk	0	0	0	0	-1	0	-1

Note: Socio-economic legacies were assessed qualitatively on a scale on -4 (very adverse impact, option makes the condition very much worse) to +4 (very positive impact, option makes the condition very much better). 0 represents the current base case. If conditions under the base case are projected to decline (or improve) over the life of the project, the base case alternative may be assessed to have a non-zero score.

4.4.2 Waterway social values

Community values for waterways in the Gellibrand catchment are described in the *Corangamite Waterway Strategy 2014 – 2022* and include:

- *Biodiversity:* fish (including the River Blackfish), birds, native vegetation, platypus and other flagship species;
- *Recreation*: picnics, swimming holes, camping, fishing, boating, holidays, kayaking, canoeing;
- *Local history:* with known significant sites, including sites with Aboriginal artefacts;
- *Stock and domestic water uses:* use of waterways for stock watering and to provide water for other agricultural uses, firefighting etc.

The Rural Community and Land Use Profiling report[19] highlighted that community values such as, "living in a rural environment" and "being able to contribute to the environmental health of the area" were held by most landholders. Other key values include "family" and "long-term investment". These values are generally consistent with the characteristics of catchment carbon offsets (Table 1.1). However, the large scale of some of the options for this case study (particularly 100 m riparian buffer) is not necessarily consistent with commercial-scale farming operations on some properties and may therefore provide a challenge to values based on the maintenance of family farming.

As with cultural values, there is no clear metric for the social values associated with waterways and hence this criterion was assessed qualitatively (Table 4.5). The base case and engineered WQ treatment options were

[18] Corangamite CMA (2013) *Corangamite Waterway Strategy 2014 – 2022*, Corangamite CMA and Victoria State Government, available at http://asp-au.secure-zone.net/v2/index.jsp?id=402/439/6793&lng=en/

[19] Corangamite CMA (2013) *Rural Community and Land Use Profiling: Summary 2013*, Corangamite CMA.

considered to have a small negative effect on the social value of the waterways, as they would not address declining waterway condition and the associated recreation and biodiversity values. The environmental plantings were assigned a moderate positive impact, with the 20 m waterway buffer option having better alignment with social values than the 100 m and floodplain options. Options incorporating farm forestry were assessed to have a small positive impact on social values (due mainly to the environmental plantings component).

4.4.3 Bushfire risk

One potential legacy associated with CCO projects is increased bushfire risk associated with the restoration of native vegetation cover. For this case study, a key consideration in the assessment of any change in bushfire risk is the existing extent of native vegetation and forestry plantations in the case study area. As the CCO options add between 1% and 6% to the area of woody vegetation within the case study area, the likely change in bushfire risk is considered to be small.

Further, environmental plantings (using locally indigenous species of trees and shrubs) along waterways will generally be somewhat less flammable than other types of vegetation and will be in wetter, lower slope areas that typically have lower bushfire risk than other parts of the landscape.

While there are metrics available for bushfire risk (e.g. bushfire consequence of loss, based on Phoenix Rapidfire modelling) it was beyond the scope of the case study to assess these. Change in bushfire risk was therefore assessed qualitatively (Table 4.5). Consistent with the small proportional change in woody vegetation cover with CCO options and the location of the plantings, the change in bushfire risk was assessed to be zero for all options except the options incorporating farm forestry. These were assessed to have slightly higher risk because their understorey is likely to be drier and more open than in environmental plantings.

4.5 Governance

The final aspect of the case study evaluation considers criteria which are relevant to governance of the project. The first concerns the likelihood of the CCO option being implemented successfully, so that the anticipated benefits are achieved. The second criterion concerns the community and agency partnerships that could be developed through implementation of the project. This criterion reflects the principle that CCO projects should build on collaborative relationships between Water Corporations, CMAs and other stakeholders (Table 1.1).

As with the socio-economic legacy assessments, these assessments of governance legacies have been undertaken qualitatively on a scale ranging from 0 (no change to current conditions) to +4 (high likelihood, high value).

4.5.1 Implementation

The assessments of financial, environmental and socio-economic legacies of each of the case study options have assumed that each option is fully implemented – to the extent indicated (for CCO options) in Table 3.2. However, as discussed previously, not all of the CCO options are likely to be equally attractive to current landholders in the case study area, nor are they likely to be implemented to the same extent if a CCO project was to proceed.

The risk that full project implementation may not be achieved is considered to vary with the project size and type (Table 4.6). Since Wannon Water has direct control over the implementation of the engineered water quality treatment project alternative, it has been assumed that full implementation has a very high likelihood. Of the CCO options, the 20 m waterway buffer project is assumed to have the highest level of confidence in full implementation. This reflects its: lower cost; capacity to complement, rather than compete with dairy production; and its environmental benefits. The CCO options with larger footprints may be more difficult to implement due to their greater cost and the level of displacement of dairy production. Incorporation of farm forestry into the 100 m waterway buffer and floodplain options – with their additional revenue streams – may be more readily implementable than options solely established with environmental plantings.

Table 4.6 : Assessment of governance legacies of case study options

Effect	Base case	Engineered WQ treatment	Riparian buffer			Floodplain + 20 m	
			20 m EP	100 m EP	20 m EP + 80 m FF	20 m + FP EP	20 m EP + FP FF
Project implementation risk	0	4	3	1	2	1	2
Community and stakeholder partnerships	0	0	3	3	2	3	2

Note: Governance legacies were assessed qualitatively on a scale on 0 (no change to current conditions) to +4 (high likelihood of implementation, strong, broad partnerships established).

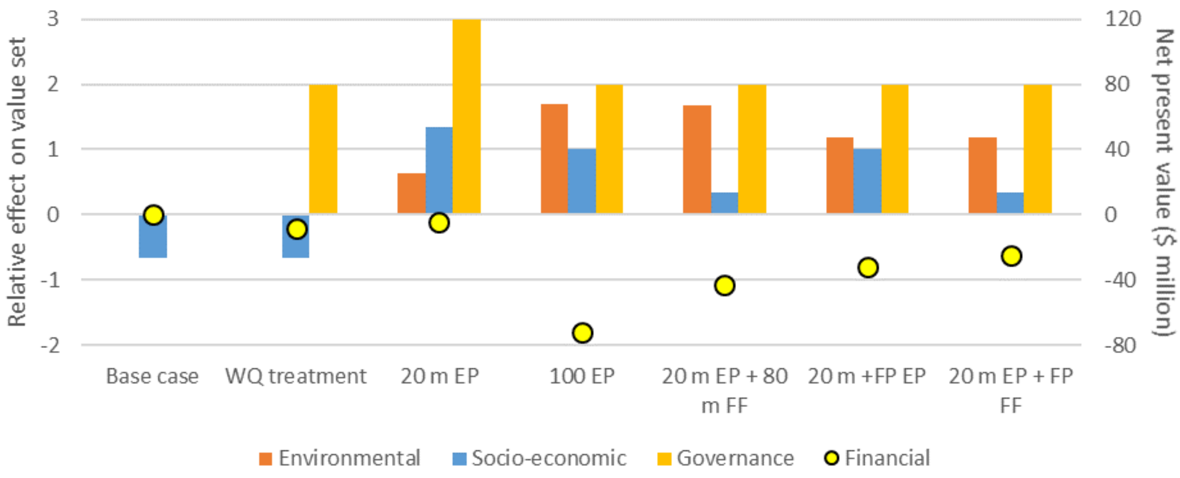
4.5.2 Community and stakeholder partnerships

CCO projects are intended to involve collaborative relationships between CMAs, Water Corporations and other relevant stakeholders. This criterion should to assess the extent to which the option would help to build and maintain partnerships with the community and among the key stakeholders, in this case Water Corporations and CMAs (Table 4.6).

Neither the base case nor engineered water treatment plan option would assist in developing partnerships within the water sector or with the community. All of the CCO options were assessed to be likely to contribute to the strengthening of relationships between Wannon Water Corangamite CMA and between these and the local community. Environmental plantings (only) options were considered to be likely to develop somewhat stronger and more effective partnerships than those involving farm forestry plantings.

4.6 Overall evaluation of case study options

Results of the evaluation of case study options against financial, environmental, socio-economic and governance criteria are reproduced in Table 4.7. The overall evaluation of case study options has been synthesised into a single graph (Figure 4.9). This shows the actual financial analysis results ($ NPV) and consolidates the remainder of the assessment into overall relative scores for environmental, socio-economic and governance criteria.



Note: Values for individual environmental assessment criteria were scaled -4 to 4 and then averaged for each option. Qualitative assessments for socio-economic and governance criteria for each option were averaged.

Figure 4.9 : Synthesis of case study option evaluation.

Table 4.7 : Case study option overall scorecard.

Effect	Base case	Engineered WQ treatment	Riparian buffer			Floodplain + 20 m	
			20 m EP	100 m EP	20 m EP + 80 m FF	20 m + FP EP	20 m EP + FP FF
Certified carbon							
Average yearly sequestration (tCO_2-e)	0	0	7,800	40,000	35,000	17,000	16,000
Financial							
Net present value[1]	0	-$8.3M	-$4.4M	-$72M	-$43M	-$32M	-$25M
Environmental							
Non-certified GHG emissions abatement (t CO_2-e/y on average)	0	-460	0	20,000	21,000	8,900	9,100
Treatment of causes of water quality impairment	-ve	-ve	56%	90%	85%	80%	80%
Change in length of waterway with connected vegetation	-ve	-ve	13%	13%	13%	13%	13%
Additional area of connected terrestrial vegetation (ha)	0	0	356	391	391	356	356
Change in river flow regime (% mean annual flow)	0	0	-0.4%	-1.7%	-2.7%	-0.8%	-1.1%
Socio-economic[2]							
Waterway cultural values[3]	-1	-1	1	1	1	1	1
Waterway social values	-1	-1	3	2	1	2	1
Bushfire risk	0	0	0	0	-1	0	-1
Governance[2]							
Confidence in level of implementation	0	4	3	1	2	1	2
Development of community partnerships	0	0	3	3	2	3	2

Notes:

1. Present value of financial costs and benefits was calculated assuming a 7% discount rate.
2. Socio-economic and governance criteria were assessed on a scale ranging from -4 (very much worse than current base case) – 0 (current base case conditions) -+4 (very much better than current base case).
3. The cultural values assessment is preliminary only and based on the kinds of features which characteristically have higher cultural value. A full assessment would be undertaken with Traditional Owner representatives.

The overall assessment suggests that the 20 m waterway buffer option is the most cost-effective approach to achieving the case study design objectives. It could be implemented at lower cost than the engineered water treatment plant, provide significant water quality improvement with relatively high implementation confidence and provide a range of other complementary environmental and socio-economic benefits. It could also satisfy Wannon Water's certified offset requirements.

While the environmental benefit provided by the 20 m waterway buffer option is assessed to be lower than is the case for other CCO options, this is largely due to reduced effect on the causes of water quality impairment (relative to other options; Table 4.7). However, this option poses the lowest implementation risk of any of the CCO options and so it is more likely to achieve the estimated water quality effect than the other options. Its smaller footprint means that this option has lower costs – in terms of establishment, management and foregone value of agricultural production – and better socio-economic and governance legacies.

The CCO and engineered water treatment plants are presented in the case study as alternative potential investments. Further analysis – potentially including the consideration of other catchment-based source water or engineered treatments – is required before confirming an investment choice. The case study has provided a *prima facie* case for catchment carbon offsets being a valid option in such analyses.

5. Assessment against the catchment carbon offset evaluation framework

The evaluation framework defined in Stage 2 of the project considers each CCO options for their *appropriateness* (consistency with the characteristics of the CCO concept, and the needs, objectives, policies and strategies of the key stakeholders), *effectiveness* (inputs and immediate outputs of the project) and *legacy* (long-term benefits and risks which may accrue over a project's life). The CCO options which were shortlisted for consideration in the case study were identified using this framework. This section revisits the evaluation framework for CCO options, based on learnings and results from the case study (as described in Section 4).

5.1 Appropriateness

Appropriateness criteria included in the evaluation framework consider alignment of a CCO option or project with:

- Key stakeholder needs;
- CCO concept principles (as per Table 1.1);
- Relevant Victorian Government and Corangamite CMA policies, strategies and objectives;
- NCOS offset integrity requirements;
- Requirement for clear property rights.

Each of the CCO options considered in the case study were found to be broadly appropriate, in terms of alignment with the CCO key characteristics (Table 1.1) and the environmental and social outcome requirements of the key project and case study stakeholders (Wannon Water, Corangamite CMA). The larger scale environmental plantings options (100 m waterway buffer, floodplain plantings) align better with environmental and some social objectives of these stakeholders than the 20 m waterway buffer option. However, as they are likely to displace farming operations, they may generate community resistance and be less consistent with stakeholders' objectives for building community partnerships.

All of the options would be implemented, evaluated and verified in accordance with Commonwealth Emissions Reduction Fund methodologies and would satisfy NCOS offset integrity requirements. Whether the revegetation was carried out on Crown water frontage or private land, property rights could be clearly established for the trees and the carbon they sequestered under the *Climate Change Act 2017*.

As highlighted in the case study, inclusion of farm forestry as an option in CCO projects adds a potential source of revenue and contributes to some aspects of a project's environmental legacy. This is particularly the case if (as in this case study) they were to be combined with environmental plantings along waterways. However, farm forestry is generally less well-aligned with CCO principles (Table 1.1) or key stakeholder objectives or strategies, relative to environmental plantings.

5.2 Effectiveness

Effectiveness criteria included in the evaluation framework consider the relative inputs and outputs of a CCO option or project. A brief narrative in relation to each of the main effectiveness criteria is given below:

- *Inputs to a CCO project*
  - *Land:* the CCO concept does not specify the types of land on which CCO projects would be undertaken. This will depend on the design objectives of each project. Based on the case study, the suggested minimum and maximum sizes of CCO projects was increased (to a minimum of 100 ha and maximum of 5000 ha) to provide greater confidence that projects could achieve material improvements in environmental condition and sufficient carbon credits over the project life.
  - *Cost:* costs for establishing and maintaining each of the CCO options were estimated in present value terms (Table 4.7).

- *Skills:* the financial evaluation of the CCO options considered the range of relevant input skill requirements (e.g. landholder engagement, project management, legal, site establishment and maintenance, participation in carbon markets).
- *Investment-funding sources:* it was anticipated that environmental plantings (and associated fencing and off-stream watering provision) could be funded by Wannon Water (if the project was to proceed). Farm forestry plantings would likely be funded by landholders.
- *Stakeholder engagement:* the case study did not engage beyond the key stakeholder group (of Wannon Water, Corangamite and Glenelg Hopkins CMAs). If the project was to go to detailed design and then implementation, it would be essential to engage with other stakeholders, including landholders, Traditional Owners and DELWP.
- *Governance:* the project would be implemented under a memorandum of understanding between Wannon Water and Corangamite CMA, with Wannon Water owning sufficient carbon credits to satisfy their offset requirements.

- *Outputs:*
  - *Project narrative:* a narrative for the case study has been developed which reflects on its design objectives and outcomes (Box 1). The case study developed approaches to characterise and evaluate key aspects of the project narrative.
  - *On-ground works:* under the options considered in the case study, between 720 and almost 3,500 ha of new environmental and/or farm forestry planting would be established.
  - *Partnerships:* the case study helped to develop relationships between Wannon Water and Corangamite CMA. If the case study was to proceed to implementation, further relationships would need to be developed, for example with DELWP, Traditional Owners and catchment landholders.

Box 1: Gellibrand River Catchment Carbon Offset project narrative

Wannon Water and Corangamite CMA could collaborate to deliver a catchment carbon offsets project in the Gellibrand River catchment that would satisfy Wannon Water's carbon offset requirements, while improving water quality, building resilience in farming landscapes and improve river health and terrestrial and aquatic biodiversity.

The project partners would work with landholders and Traditional Owners to fence and revegetate a 20 m buffer along waterways in the Gellibrand catchment upstream of Wannon Water's Otway South offtake. The 20 m waterway buffer would be planted with locally indigenous native trees and shrubs. The plantings would occupy approximately 720 ha of land (depending on landholder uptake), which is less than 10% of the cleared farming land in the target area. Livestock would be excluded from the plantings and all waterways in the target area.

The plantings would sequester carbon and provide certified carbon offsets using a methodology which has been approved for use under the National Carbon Offset Standard. They would remain in place permanently.

Small tributaries of Gellibrand River. These would be revegetated with 20 m environmental plantings under the preferred CCO option from the case study.

As well as sequestering carbon, the plantings would provide habitat and migration corridors for the native fauna, help to connect fragmented patches of native vegetation, improve vegetation connectivity along waterways and provide better habitat for aquatic species. River health and biodiversity would be improved. Vegetation restoration and livestock removal would address several major drivers of deteriorating water quality in the catchment. This would help to improve the health of downstream reaches and the estuary of the Gellibrand River and may remove the need for Wannon Water to add to its engineered water quality treatment facilities.

The catchment carbon offset project would improve cultural and social values associated with waterways in the target area. Water yields may decline slightly with the establishment of the plantings. Bushfire risk may marginally increase. Overall dairy production should remain largely unaffected by the project, with stock accessing water via off-stream watering.

The 20 m waterway buffer option – employing only environmental plantings – was assessed to be the most cost-effective of the CCO options considered in this case study. It is the least cost method of achieving or advancing the full suite of case study design objectives. It requires the least area of land, is likely to be the most attractive option for landholders and generally has similar or better environmental, socio-economic and governance legacies that other options. While it most likely provides reduced source water quality benefit compared with other options, it greater adoptability means that it is more certain of achieving the projected benefits than other CCO options.

Inclusion of farm forestry with environmental plantings in waterway buffers increases the cost-effectiveness of the larger scale CCO options (100 m buffer, floodplain + 20 m buffer). The potential financial advantage offered by farm forestry was diminished in this case study because of the relatively high value of the land use it displaced.

Corangamite CMA is currently implementing a project with landholders in the Gellibrand River catchment which seeks similar water quality benefits to the case study (e.g. through improved management of dairy effluent ponds). Such work would complement a CCO project based on the designs developed for the case study.

5.3 Legacy

Legacy criteria included in the evaluation framework consider the relative benefits and costs or risks of a CCO option or project. A summary of the most legacy elements is given in the case study scorecard (Table 4.7). A brief narrative in relation to each of the main legacy criteria is given below:

- *CCO project benefits:*
  - *Carbon sequestration:* each of the CCO options was able, on average, to at least satisfy Wannon Water's expected carbon offset requirements. Sequestration would range between 7,800 and 40,000 t CO_2-e/y over the 50 year project life. All but the 20 m waterway buffer options were anticipated to result in up to 20,000 t CO_2-e/y in uncertified greenhouse emissions reduction.
  - *Non-carbon environmental, social and/or environmental benefits:* these are described in the CCO case study score card (Table 4.7) and include changes in river health, biodiversity, cultural and social value of the Gellibrand River, as well as the development of community and agency partnerships.
- *CCO project risks:*
  - *Bushfire:* bushfire risk in the Gellibrand River catchment was not considered likely to be materially affected by the CCO case study project, if it was implemented – due to the high level of existing native vegetation and plantation forestry cover.
  - *Land use change inflexibility and population and demographics:* these criteria were not considered in detail in the case study. It is clear that these potential legacies of a CCO project would be much greater for the 100 m waterway buffer and floodplain + 20 m buffer options than the preferred 20 m buffer option. The former would occupy up to 40% of agricultural land within the catchments, compared with less than 10% for the 20 m buffer option.
  - *Organisational risk:* this was assessed to be lower for the 20 m waterway buffer option, due to its smaller footprint on the landscape and much lower impact on agricultural production. Since the option was assessed to be more readily implemented than other CCO options it was considered to offer the lowest organisational risk.
  - *Pests:* the effect of the CCO options on weeds and pest animals was not considered in the case study.
  - *Water interception:* each of the CCO options would see new perennial vegetation established upstream of Wannon Water's Otway South offtake. This would be expected to reduce mean annual flows by between 0.4 and 2.7%. Flow reductions would be lowest for the 20 m waterway buffer option.

Inclusion of farm forestry plantings as part of the larger-scale CCO options reduced most aspects of their legacy, although this effect is diminished by the inclusion of 20 m waterway buffers.

Some aspects of the options' environmental and socio-economic legacies were constrained by the existing high level of vegetation cover within the case study area. Had the case study been conducted in an area with less intact waterways and native vegetation, the opportunity for improvement in river health and biodiversity may have been greater.

6. Case study evaluation

6.1 Case study partners' objectives

This first component of the case study evaluation addresses the objectives nominated by the working group, which comprised representatives of the main partner organisations, Wannon Water, Corangamite CMA and Glenelg Hopkins CMA (Section 3.1). The objectives and the consultants' evaluation against them are given in Table 6.1

Table 6.1 : Evaluation against project partners' objectives

Objective	Evaluation
Overall objective: Design and evaluate a project which would improve water quality in an important drinking water catchment and improve river health in a key waterway and catchment area	The case study successfully designed a potential CCO project which would address key causes of water quality impairment and provide a wide variety of beneficial environmental and social legacies. The CCO project (for the preferred 20 m waterway buffer option) should, if fully implemented, address water quality issues for lower cost than an engineer water treatment approach while providing complementary environmental and social benefits.
Other objectives:	
• Integrate existing regional NRM mapping, soil and landscape databases and investment priority weightings with carbon farming by leveraging the South West Climate Change Portal (www.swclimatechange.com.au) to assist stakeholders	The case study used available spatial and other data, as appropriate to the intended effects and evaluation framework. Selection of the Gellibrand River catchment was based on regional climate change-NRM planning processes. This case study report is to be loaded onto the South West Climate Change Portal.
• Identify gaps in formal carbon offset methods for the Victorian context	The case study found that formal (or certified) carbon offset methods were adequate for the CCO concept as designed. Certified offset methods are available for environmental plantings and harvested, farm forestry plantings – both of which have potential application in CCO projects. Farm forestry plantings provide fewer environmental and social benefits that environmental plantings, however they may generate additional revenue, on top of that provided by carbon.
• Explore how realistic it may be to expect formal carbon sequestration projects to also deliver co-benefits	The case study was designed to achieve various environmental and social co-benefits (Figure 3.4). The evaluation framework was developed to assess the extent to which such benefits would be provided by various CCO designs or configurations. The evaluation found that for a project of the scale of the case study, material improvements in environment metrics (river health, biodiversity, emissions abatement) could be achieved, with modest additional risk (from bushfires and changes in water flows).
• Clarify cost of carbon, and compare to relative cost of other outcomes;	The case study found (Table 4.1) that the marginal cost of transforming a catchment project akin to the case study into a CCO project was returned six to tenfold from the value of carbon offsets, even at a price of $11/t CO_2-e for carbon. The case study also developed a replicable process for evaluating the financial and non-financial benefits and costs associated with a CCO project.
• Explore where CCO projects could be realised in the region.	This was not dealt with by the case study. Corangamite CMA's Climate change-NRM plan deals with this issue.
• Develop a framework for including carbon credits in business-as-usual operations by Wannon Water.	The case study demonstrated how Wannon Water could use CCO-style projects to manage water quality and catchment health issues, while contributing carbon credits for internal offsets or sale to third parties.

Objective	Evaluation
• Demonstrate excellent cross-agency relationships, including building relationships with innovators at CeRDI;	The case study helped to strengthen relationships among partner organisations, particularly Wannon Water and Corangamite CMA. CeRDI were engaged late in the case study. A role was identified for CeRDI in developing a web-based tool to support the roll out of the CCO concept. Additional case studies and further development of some of the tools may be required (and additional funding secured) before this could proceed.
• Build internal capability to participate in emissions reduction action at a local scale	The project helped to develop a common language about the CCO project amongst working group participants and built the capacity of all involved – including the consultants.
• Undertake a case study which aligned with key Wannon Water and CMA corporate commitments and strategies.	The case study strong aligns with CMA Regional Catchment Strategies, Climate Change-NRM Plans and the Corangamite Waterway Strategy. It shows how Wannon Water's offset requirements (under its carbon emissions reduction pledge and action plan) could be secured, while providing various complementary environmental and social benefits and improving water quality inputs to its drinking water system.
• Align with DEWLP *Our Catchments-Our Communities* funded projects in the Gellibrand River catchment.	The case study complements work in the catchment to reduce nutrient inputs from dairy farms into waterways.

6.2 Catchment Carbon Offsets Trial evaluation framework

At the conclusion of the third case study workshop, participants were engaged in an evaluative discussion about the project. The discussion covered learnings from the project and addressed specific questions which related to the CCOT's evaluation framework.

6.2.1 General learnings

- This process uses a new methodology and fresh approach, considering the whole of the catchment and appreciation of the viewpoints of all stakeholders, beyond water and plants. These projects could result in win-win situations for all stakeholders.
- This has been a useful exercise, of facilitated learning. Gathered a group with diverse expertise across different aspects of this issue, and all learnt from each other.
- Opportunity for next time: include community members in the workshops (farmers, Agriculture Victoria)
- Getting policy into practice. Carbon policy is very complex, and this process is a pathway to apply on the ground.
- Farm forestry can be a useful tool in the carbon context.
- Blue gums maybe not the best solution for this area – would be good to think about other commercial pursuits (e.g. Blackwoods). This project's messaging around blue gums will be very important. Recommend using the term 'farm forestry' rather than 'blue gum'.
- Planting for carbon is complex. This project accepts the complexity and works with it.
- We started from a gut feel that there is value here. This project helps us learn how we would do this. This has been a process of taking the wild ideas that may or may not have been implementable, and converting them into a hard analytical model, coming out at the end with meaningful comparisons.
- Creating momentum for the CCO concept, and the transition from focus on carbon to focus on multi-benefits.
- Combing policy, modelling and the reality of on ground outcomes was crucial for this project and it looks like it has delivered – such a hard thing to do. The key test for it however will be if Wannon Water and the CMAs can work with landholders and investors (DELWP) to deliver.
- The project tools used during the process were very useful.

6.2.2 The catchment carbon offset concept

The case study has clearly shown that projects designed along the CCO concept can demonstrate multiple benefits and outcomes. It's part of integrated catchment management, and many stakeholders can benefit.

The CCO characteristics, originally defined at the first stakeholder workshop (Table 1.1), have held up well throughout this process. One change would be to extend "Build or result from stable, long-term relationships within water sector: CMA(s)-Water Corporation(s)" to other stakeholders, as these projects have the potential for wide-reaching benefits.

6.2.3 Certified and flexible models of catchment carbon offset

The certified models of carbon offsets are clearly real. Flexible offset models were intended to allow a broader range of options and/or cheaper implementation, and potentially to make the case to the State Government that carbon sequestration could be achieved through lower-cost methods. However, it was clear at the first workshop that the WCs wanted carbon abatement to be real and credible. This set the bar very high for flexible models, resulting in very little differences (including time cost) between certified and flexible approaches.

6.2.4 Carbon abatement options

It is clear that both environmental plantings and farm forestry have a role to play in sequestering carbon in this catchment. However, the environmental planting projects are much more strongly aligned to the CCO principles. Note that blue gums are not planted in wet areas, so the floodplain forestry option may not work (albeit factoring in the 20 m distance from the river)

Natural regeneration wouldn't work in the Gellibrand catchment, but may have an important role in other areas. It is important to note recent published concerns from the Climate Change Authority that the method (including carbon modelling) overestimates the amount of carbon sequestered by this approach[20]. There are so many variables determining whether or not you get a good result with this method – seed bank, weeds, rain, natural events etc. Uncertainty is too high.

With environmental plantings, you have the option of choosing climate change-resilient species (while still complying with the requirements that they be native to the region).

6.2.5 Thinking and analysis tools used in the case study

Another case study might not have had another clear "problem" to address in addition to carbon. Could look at biodiversity, social license etc. The fishbone diagrams used here would still be useful in defining and exploring these problems.

The evaluation tool (scoring system) was difficult, as it is hard to consider all the complexities in the short timeframe required, and you ended up going with a gut feel. There may be easy ways to get some of this information. It is very subjective – if we'd had community members in the group, we may have ended up with different outcomes. Strengths are that it allows you to be explicit about how you arrived at your outcomes, and that there is no better way to do this. Important to have the right people in the room when using this approach.

6.2.6 Evaluation against CCOT key evaluation questions

Responses to key evaluation questions during or following the third case study workshop are collated below.

Were the catchment carbon offset models and options considered in the trial relevant to the needs of CMAs and Water Corporations? Why/why not?

[20] Climate Change Authority (2017) *Review of the Emissions Reduction Fund*, http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/CFI%202017%20December/ERF%20Review%20Report.pdf, Section 3.4.1.

Yes, the first workshop invited all organisations to put forward their needs and explored the areas of overlap and shared benefits. Both the carbon offset models and options presented were the same or with similar NRM options that the Corangamite CMA has for improving the catchment health and achieving specific NRM outcomes for the Gellibrand River, both within and outside the project area.

Were the processes to engage case study participants (over the 3 workshops) appropriate for the objectives of the case study and interests of participants and effective? What was done well and what could have been improved?

The workshops were very interesting, and an example of excellent collaboration. Clear intent was set at the beginning of the process, defining the areas of interest for different stakeholders; framing the project around the key stakeholders.

We need to have space for incorporating previous studies and supporting data (such as the catchment works and water quality data drawing on Brad Clingin's work). It was good to bring some of this previous work to a wider forum.

The scoring system for co-benefits was difficult, as it is hard to consider all the complexities in the short timeframe required, and you ended up going with a gut feel. Some queries raised in one workshop were not addressed with the entire project team either in-between workshops or at the workshops.

Jacobs' expertise in carbon offset markets, policy, modelling and NRM in general was evident throughout this project.

Have the case study workshops appropriately valued participants' time by (e.g.) providing good information, getting the right people together and working through the process in a time efficient manner? What might have been done differently?

Overall, yes. It might have been good for everyone to have tasks between workshops, to keep momentum and be involved in the full process. Others felt this was covered by Jacobs to deliver on specific task/seek further information quite well. Start of workshop 2 included an extensive recap and rehashing of the project to date – this was not optimal but normal for a complex process. Might have been avoidable if people were engaged between workshops.

We had a core group attend all three workshops, and additional people attend one or two. This worked well, although it would have been better to have consistent representatives from participating stakeholders.

It does not seem that the period of time to complete the project could have been shortened in any way. The workshops moved through content well. Particularly enjoyed have the field trip component and the variety of locations for the workshops to ensure partner ownership in the process.

Were the key case study deliverables consistent with the questions asked of the case study and the needs of the project partners? Why/why not?

Yes, as the deliverables were framed around the questions asked in the first workshop and the needs of the project partners. With more time, the trial and team of participants could build on the framework to allow a more tangible tool for use by an implementation team, leading to a web tool

Has the project been delivered with the level of collaboration sought? Explain. What lessons about collaboration might be learned for any future case study or actual catchment carbon offset project?

Would have liked more collaboration with GHCMA but understand the circumstances with respect to their involvement. The fact that there is now an example of a NRM/carbon offset model that has been applied to a real case study is a great platform for any other similar project in Victoria and indeed Australia. It might have been interesting to get some feedback from farmer's groups or a few landholders to get an idea of how much frontage might be picked up.

Do you think the case study has provided appropriate value for the resources invested in it? What more (if anything) would you have liked it to achieve?

Yes, having a confined catchment with existing NRM modelling data (i.e. from Wannon Water) as well as a strong relationship between the agencies and landholders was crucial for the project to succeed.

The key thing will be the next steps, what happens from here. If it becomes an implementation tool or web tool then yes, it has been worth it. It has been a good thought provoker for participants. If nothing happens, then no, not worth the resources spent.

What do you think will form the main legacies of the case study?

A coherent way forward for carbon sequestration implementation. Wannon Water and Corangamite CMA now have a blueprint to attract investment to achieve both carbon offset and NRM outcomes. The working relationship between the two agencies has been strengthened despite the outcomes of the project as well. It was good to see the different agencies working together and hopefully there’s to be more of it.

7. Case study conclusions

The case study designed and evaluated several options for a catchment carbon offset project in the Gellibrand catchment in south-west Victoria. The case study found that, at least in this catchment, a catchment carbon offset project provides a cost-effective option to generate certifiable carbon offsets to help a Water Corporation meet its emissions reduction targets, while improving catchment water quality and providing other complementary environmental and social benefits. The case study demonstrated that the characteristics or design principles for catchment carbon offsets which were developed by this project's steering committee and a broader stakeholder group were appropriate and workable.

A replicable method for designing and evaluating potential catchment carbon offsets projects was developed. The process and tools could be applied to potential catchment carbon offsets projects in other settings and at different scales.

The case study found that configuration of the catchment carbon offset as a 20 m waterway buffer (on each side of the stream) was the most cost-effective option to provide the required carbon offsets and achieve the project's other design objectives, including water quality improvement. In other settings, different designs may be more appropriate and a catchment carbon offset project may be more or less cost-effective.

The case study also found that the concept of flexible offsets – those which are associated with measurable, but uncertified greenhouse gas abatement – has application in catchment carbon offset projects. With some project designs, it is possible to generate significant non-certifiable abatement that would contribute towards the achieving the State's net zero emissions target.

A key feature of the catchment carbon offset concept is collaboration. This was an important feature in the design and execution of this case study and would be in the delivery of any project resulting from it.

Recommendations arising from the case study and overall Catchment Carbon Offsets Trial are given in the project's final report[21].

[21] Jacobs 2018. Catchment Carbon Offsets Trial. Final Report. Report is190600-4-2.

8. Acknowledgements

The case study was undertaken with a working group drawn from Wannon Water, Corangamite CMA, Glenelg Hopkins CMA and the CCOT's project steering committee. The contributions of working group members (below) is greatly appreciated:

- Wannon Water: Julie Rissman, Ian Bail, Brad Clingin, Ben Pohnler, Murray Dancey, Tim Harrold;
- Corangamite CMA: Chris Pitfield, Gene Gardiner, Amy Leith;
- Glenelg Hopkins CMA: Marty Gent;
- CCOT Steering Committee and Goulburn Broken CMA: Kate Brunt.

Appendix A. Catchment carbon offset financial analysis methodology

A cost benefit analysis (CBA) was conducted to evaluate the economic efficiency of developing catchment carbon offset (CCOT) options. The CBA converts future flows of monetised benefits and costs to a comparable basis through discounting. The costs and benefits are those experienced by society for the project. The prime decision rule in CBA is that a project should, subject to budget constraints, be accepted if the present value of the benefits exceeds the present value of its costs, that is, the project's net present value (NPV) is greater than zero. This decision rule indicates that an investment generates positive economic returns. Projects with a higher net present value provide greater economic returns.

A.1 Catchment carbon offsets

The project options were modelled using FullCAM software (Australian Government, 2016) to characterise per hectare carbon accumulation in each of the four sub-catchments, then converted to CO_2 equivalents and multiplied up to the full project area in each catchment. Environmental plantings were characterised in FullCAM by "Mixed species environmental planting temperate, geometry block, stocking <500, prop tree <0.75", and farm forestry plantations by "*Eucalyptus globulus*", normal stocking.

The environmental planting projects were modelled as being rolled out over five years, with one fifth of the total available area for that project (see Table 3.2) planted each year. The farm forestry projects were modelled with the full project area being planted or harvested in a single year. The project was set to run for 50 years. Environmental plantings were assumed to continue to generate carbon credits over the project lifespan, in accordance with the CCO principle of permanence. Carbon accumulation in farm forestry systems was calculated as an average over 100 years (the predicted project average carbon stock, PPACS), following the *Measurement Based Methods for New Farm Forestry Plantations Methodology Determination 2014*.

The model was used to calculate carbon sequestered and/or offset through displaced agricultural land use, costs and income over the 50-year lifespan of the project (including the 5 years to set up the project).

The model was built to explore the effect of changing elements on the project. Adjustable elements and their values used to model the project results are described in Table A.1.

Table A.1 : Carbon and financial model parameters

Adjustable parameter	Modelled condition	Other options
Discount rate (base year 2019)*	7%	4%, 10%
Number of blue gum seedlings per ha	1100	User defined
Number of blue gums harvested per ha	1000	User defined
Number of environmental planting seedlings per ha	500	User defined
Off-stream watering required	'Yes' for 20 m buffer projects, 'no' for other project options	Yes, No
Per km cost of off-stream watering	$7500 (if 'Off-stream watering required' = Yes)	User defined Effectively 0 if Off-stream watering required' = No
Agricultural opportunity cost	0% for 20 m buffer projects, 80% for other project options	0%, 20%, 40%, 60%, 80%, 100%
Destructive sampling required	Yes	No
Potential increase to claimable carbon due to destructive sampling	0	10%, 25%
Carbon price	$11 per tCO_2-e	User defined

Adjustable parameter	Modelled condition	Other options
Permanence period	100 years	25 years (results in 20% loss of carbon credits)
Blue gum chip price	$198 per bone-dry tonne (source: Australian Bluegum Plantations, pers. comm. 2017)	User defined

* A 7% discount rate is consistent with Victorian Department of Treasury and Finance guidelines.

Estimates for the engineered water quality treatment option are based on the estimated cost to install gravity UV systems at each of five water treatment plants (according to plant size and capacity).

The CBA for the project options involved:

1. Calculating the costs for establishment of the land use (fencing, purchase and planting of seedlings, weed control, maintenance, harvesting, opportunity cost for foregone agricultural production);
2. Calculating the costs associated with managing the project as a carbon offset (engaging with the carbon market, five-yearly modelling, measurement, reporting, auditing);
3. Calculating the carbon financial benefits from the option (income earned from selling the carbon credits);
4. Calculating the non-carbon financial benefits from the option (sale of pulpwood); and
5. Comparing the present value of the costs (1 and 2 to the present value of benefits (2 and 3) to calculate the net present value of the options. This approach also allows comparison of the costs and benefits of engaging with the carbon market.

The tables below provide costs and benefits incorporated into the financial analysis.

Table A.2 : Costs applied to the case study

Cost and timeframe	Value for environmental planting	Value for farm forestry	Basis
Establishment costs (first year of project)			
Project management and governance	$8,000	$8,000	Site planning and consultation together is about $12,000 - NRM Review and Price Guide for Significant Environmental Benefits, Government of South Australia, 2016
Stakeholder engagement	$4,000	$4,000	
Aggregator (farm coordinator)	$4,000	$4,000	Jacobs estimate
Project registration on ERF	$5,000	$5,000	Jacobs estimate
Participation in ERF auction	$3,000	$3,000	Jacobs estimate
Site preparation – ripping the land (per ha)	$275	$275	The cost of revegetation, Final Report, Jacki Schirmer and John Field, ANU Forestry and FORTECH, Natural Heritage Trust, 2000; updated to $2017
Seedling purchase (per ha)	$2,000	$4,400	$4 per plant - Workshop 2; 500 seedlings for environmental planting, 1,000 seedlings for blue gum plantation
Seedling protection (tree guard and installation) (per ha)	$1,000	$2,200	$2 per plant - NRM Review and Price Guide for Significant Environmental Benefits, Government of South Australia, 2016; 500 seedlings for environmental planting, 1,000 seedlings for blue gum plantation

Cost and timeframe	Value for environmental planting	Value for farm forestry	Basis
Direct seeding cost (per ha)	$2,000	$2,000	Workshop 2
Weed control (per ha)	$1,000	$1,000	CCMA waterway frontage protection programme
Fencing (per km)	$5,000	$5,000	CCMA waterway frontage protection programme. Fencing requirements per ha based on spatial assessment of project area compared to perimeter, with correction factor for adjacency to land uses not requiring new fences,
Off-stream watering (per km)	$7,500	$7,500	CCMA pers.comm. $750 per ha used for 100 m buffer and floodplain projects. $375 per ha for 20 m buffer.
Operating costs of maintaining the vegetation and the carbon offset project (annual)			
Stakeholder engagement (per ha)	$5	$5	Jacobs estimate
Monitoring and maintenance (per ha)	Variable – high at first, declines over time	Variable – high at first, declines over time after each planting	Jacobs estimate
Reporting costs for carbon offset project (every 5 years)			
Project management	$1,000	$1,000	Jacobs estimate
Modelling (per ha)	$5	$5	Jacobs estimate
Reporting	$2,500	$2,500	Jacobs estimate
Reporting to project partners: MERI	$5,000	$5,000	Jacobs estimate
Crediting and verification (per ha)	$5	$5	Jacobs estimate
Stakeholder management – aggregator (farm coordinator)	$2,000	$2,000	Jacobs estimate
Destructive sampling	$20,000	$20,000	Jacobs estimate. Effort: establish plot, measure every tree, determine appropriate level of sampling, establish sampling plots, cut all trees in plot at base, measure all above-ground C (wet weight, dry weight --> moisture content --> carbon), derive and apply appropriate allometric equations. Model below-ground carbon. Requirements: cutting equipment, 2 personnel, access to lab equipment. Assume 2 weeks work for 2 people for whole project area.
The opportunity cost of using the land for grazing (annual)			
Foregone gross returns from using the land to graze dairy cattle	$1,493	$1,493	Gross margin per hectare, average for south-western victoria, Dairy Farm Monitor Project 2016-17
The costs of harvesting plantation trees			
Production (m^3 of timber per ha)		358	Based on a weighted average of per hectare harvested (FullCAM modelling), at a density of 540 kg/cubic m (McKinley et al 2002)
Harvesting (per m^3 per ha)		$17	Based on Farmforestline 2009, updated to $2017
Haulage (per m^3 per km)		$0.10	Farmforestline 2009, updated to $2017.

Cost and timeframe	Value for environmental planting	Value for farm forestry	Basis
Haulage travel (km)		110	Assume taken to Geelong
Snigging, sorting and loading (per m^3 per ha)		$10	Based on Farmforestline 2009, updated to $2017

Table A.3 : Benefits from the case study

Benefits	Basis
Carbon sequestration (annual)	Carbon dioxide equivalent sequestered under each project option multiplied by assumed price of $11 per tonne (or as user set).
Water quality treatment savings (annual)	Water treatment savings are based on average running costs at the five water treatment plants serviced by the Gellibrand catchment (2013/14 to 2016/17), the assumption that a 1% reduction in turbidity can result in a 0.1% reduction in treatment cost[22], applied to the water quality improvements presented in Section 4.3.2.
Wood revenue (in year of harvesting – year 15)	Tonnes of wood produced (bone-dry tonne) multiplied by assumed price of blue gum pulp price ($AUD/bone-dry tonne) of $198 (or as user set).

A.2 Assumptions

Other key assumptions:

- All project land is currently used for grazing dairy cattle;
- *Eucalyptus globulus* wood density of 540 kg/m^3;
- Water quality OPEX includes energy costs.

A.3 Engineered water quality treatment[23]

Outlined below are methods used to estimate water treatment costs for the Otway treatment system associated with improved water quality. The treatment plants for which this analysis was undertaken included the five main Otway system facilities - Simpson, Cobden, Camperdown, Terang and Warrnambool - excluding disinfection plants at Purnim and Noorat. The resulting data was used to determine costs associated with the engineered water treatment option and cost savings associated with source water quality improvement. Two approaches used to estimate treatment costs associated with water quality improvement follow.

A.3.1 Reduction in routine water treatment costs associated with water quality improvement

An average of actual costs for the last four years was calculated at all five treatment plants, using available CAPEX and OPEX data. Cost data was obtained from the Wannon Water Dashboard.

Assumption: The average routine CAPEX and OPEX spend from the last four years would reflect the average CAPEX and OPEX spend for the next 30 years. Jacobs used the data to model long term treatment costs. Published papers were used to estimate the expected improvement in water quality associated with vegetating riparian buffers and to estimate treatment costs associated with water quality improvement.

Calculated treatment costs associated with reductions in sediment input to the treatment system, using literature and Wannon Water's treatment costs.

- Literature indicates 0.1% reduction in cost associated with 1% reduction in turbidity[i]
- Studies found a 90% sediment reduction associated with 20 m riparian buffers on both sides of a river[ii]

[22] Heberling MT, Neitch CT, Thurston HW, Elovitz M, Birkenhauer KH, Panguluri S, Ramakrishnan B, Heiser E, Neyer T (2015) 'Comparing drinking water treatment costs to source water protection costs using time series analysis', *Water Resources Research*, vol. 51, no. 11, pp 8741-8756.
[23] This section was prepared by Julie Rissman of Wannon Water

- Assume a 90% reduction in sediment is associated with a 50% reduction in turbidity
- (50% reduction in turbidity x 0.1% reduction in costs = 5% reduction in treatment cost)
- Establish costs at each facility using dashboard data – subtract opex from capex/opex to find capex spend
- Subtract 5% from CAPEX and from OPEX
- The results were collated and sent to Jacobs (See Table A.4)

A.3.2 Reduction in regulatory compliance costs associated with water quality improvement

Optimiser is a software program developed within Wannon Water, by Treatment Engineer Jenith Jesuthasan, to calculate Log Reduction Values (LRVs) associated with different treatment systems. It can be run under different catchment classifications from level 1 to 4. The catchment classifications are defined by DHS Health Based Targets. The difference in each level is based on the level of catchment protection and associated water quality in each catchment. The "*Drinking Water Source Assessment and Treatment Requirements - Manual for the Application of Health-Based Treatment Targets* 2015[iii]" states:

"*Categories 3 and 4 can be split by the microbial indicator assessment. Any source which experiences greater than 2,000 E. coli per 100 ml should assign to Category 4 unless an explanation for the possible anomaly can be identified."*

Calculation of treatment required for the Otway system when the Gellibrand is classified as a level 3 vs level 4 catchment:

- Populated Optimiser for the five treatment plants in the Otways system: Simpson, Cobden, Camperdown, Terang and Warrnambool.
- Ran an Optimiser report which indicated the LRVs for each treatment plant given the source water was from a level 3 vs level 4 catchment.
- Used the report results to determine what additional treatment infrastructure was required at each plant when the catchment was classified as level 4 rather than level 3.
- The type of additional treatment required to meet HBTs was predominantly UltraViolet disinfection. The *Warrnambool Water Treatment Plant UV Business Case* for the 2018-23 pricing submission was used as the basis for treatment cost estimates. The annual inflow at each treatment plant requiring additional UV was determined. This was pro-rated against the CAPEX and OPEX costs estimated for the Warrnambool Water Treatment Plan (WTP) UV system to arrive at UV costs for each smaller plant.
- The projected costs for each plant were collated and sent to Jacobs (below)

A.3.3 Results

Reduction in routine water treatment costs associated with water quality improvement

Outlined below (Table A.4, Table A.5) are the OPEX and CAPEX costs at each facility over four years and a calculation of the reduction in expenses associated with improved water quality. Capital expenditure is variable and in some cases none is recorded.

Table A.4 : CAPEX costs($) at each treatment facility in the Otway System

Capex	13/14	14/15	15/16	16/17	Total	Average	5% reduction	30 years*
Simpson WTP	28,382	0	0	0	28,382	7,096	355	10,643
Camperdown WTP	61,291	100,299	7,137	0	168,716	42,179	2,109	63,269
Terang WTP	109,823	21,517	0	9	131,349	32,837	1,642	49,256
Cobden WTP	86,146	4,312	0	17,591	108,049	27,012	1,351	40,518
Warrnambool WTP	49,177	157,489	728,537	1,383,134	2,318,337	579,584	28,979	869,376

* No discount factor is applied here - for consistency that was done by Jacobs within their options analysis

Table A.5 : OPEX costs($) at each treatment facility in the Otway System

OPEX	13/14	14/15	15/16	16/17	Total	Average	5% reduction	30 years*
Simpson WTP	105,102	65,812	104,190	51,968	327,072	81,768	4,088	122,652
Camperdown WTP	158,997	138,765	156,722	143,599	598,083	149,521	7,476	224,281
Terang WTP	101,949	99,770	105,459	100,267	407,445	101,861	5,093	152,792
Cobden WTP	108,141	108,097	109,303	159,088	484,629	121,157	6,058	181,736
Warrnambool WTP	506,213	478,530	500,063	493,885	1,978,691	494,673	24,734	742,009

* No discount factor is applied here - for consistency that was done by Jacobs within their options analysis

Assumptions:

- 1 % reduction in turbidity can result in approx. 0.1% reduction in treatment cost
- 20 m planted riparian buffer can reduce sediment by 90%
- Assume 50% reduction in turbidity with planting of 20 m or more riparian buffers

OPEX is consistent between years at the larger WTPs with greater variation observed at Simpson and Cobden Water Treatment plants.

Improvement of water quality is likely to decrease costs associated with the distribution system, storages and the reticulation system. These were not included in this analysis.

Reduction in regulatory compliance water treatment costs associated with water quality improvement

Table A.6 : Cost estimate for the UV system at Warrnambool WTP[iv]

	Option 1: HBT Disinfection only	Option 2: Gravity UV System	Option 3: Pumped UV System
CAPEX			
UV (4 No in Filter Gallery)	$1.10 M	-	-
UV (larger UV system)	-	$1.9 M	$1.9 M
UV Civil Works	$0.10 M	$0.50 M	$0.50 M
UV Pump Station & Pipework	-	-	$0.40 M
Capex Subtotal	**$1.2 M**	**$2.4 M**	**$2.8 M**
Engineering, design, PM, CA (15%)	$0.2 M	$0.3 M	$0.4 M
Capex Subtotal (incl engineering & design)	**$1.4 M**	**$2.7 M**	**$3.2 M**
Contingency (30%)	$0.4 M	$0.7 M	$0.8 M
TOTAL CAPEX	**$1.8 M**	**$3.5 M**	**$4.0 M**
OPEX (per year)			
UV Power	$0.05 M	$0.05 M	$0.05 M
UV lamp replacement	$0.06 M	$0.03 M	$0.03 M
Additional Water Pumping	n/a	n/a	$0.04 M
Operator Attendance		$0.04 M	$0.04 M
Total OPEX	$0.11 M	$0.12 M	$0.16 M
OPEX with 20% Contingency	**$0.13 M**	**$0.14 M**	**$0.19 M**
Overall NPC	**$3.8 M**	**$5.6 M**	**$6.9 M**

DRAFT

Note: Refer to Section 5 below for opportunities to save on capex and for costs for staging of works.

Option 2 is the preferred option used as the basis of calculations in this analysis.

Not all water treatment plants in the Otway system required an upgrade with UV to meet the health based target treatment requirements. At Simpson WTP, the current treatment system was considered adequate whether the Gellibrand catchment was classified as level 3 or 4. Outlined below is the cost of installing UV treatment at each plant, extrapolated from the costing provided above for Warrnambool WTP using the maximum inflow at each plant.

Table A.7 :Cost estimate for UV in Otway system water treatment plants

Capex/Opex	Maximum Inflow (ML/y)	UV Cost ($m)
Warrnambool WTP	44	$5.60
Camperdown WTP	13	$1.65
Cobden WTP	5.2	$0.66
Terang WTP	4.8	$0.61
	Total	**$8.53**

A.3.4 References

1. Matthew T. Heberling, Christopher T. Nietch, Hale W. Thurston, Michael Elovitz, Kelly H. Birkenhauer, Srinivas Panguluri, Balaji Ramakrishnan,Eric Heiser. Comparing drinking water treatment costs to source water protection costs using time series analysis, Water Resources Journal, 5 November 2015

2. Cooper, J. and Gilliam, J. (1987). Phosphorus Redistribution from Cultivated Fields into Riparian Areas1. Soil Science Society of America Journal, 51(6), p.1600.

3. Drinking Water Source Assessment and Treatment Requirements - Manual for the Application of Health-Based Treatment Targets 2015

4. D2017/ 053572 UV Business Case for Warrnambool WTP, Nigel Johnston/Michael Kennedy GHD, Oct 2017

Appendix B. Guidelines for catchment carbon offset projects

This appendix provides a step-by-step guideline for assessing potential catchment carbon offsets (CCO) projects.

B.1 Review the CCO characteristics

CCO projects should be framed by the CCO characteristics (Table B.1). Revisit these characteristics before starting, and periodically during project design, planning and delivery.

Table B.1 : Catchment carbon offset characteristics

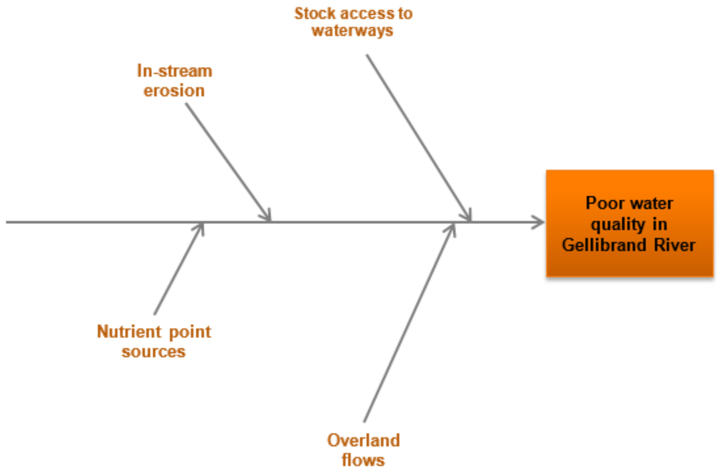
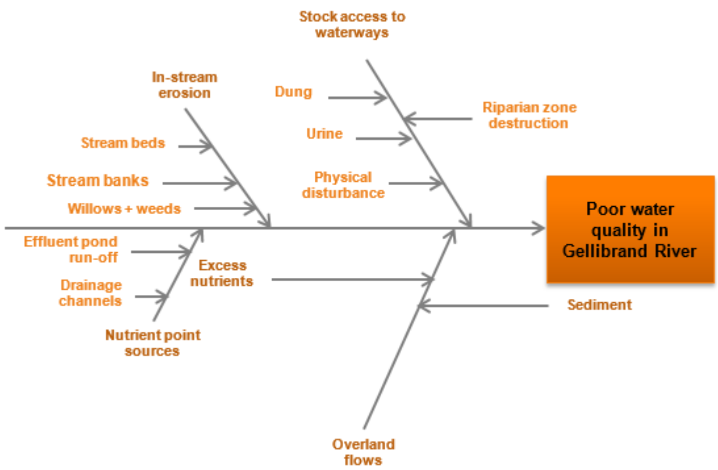
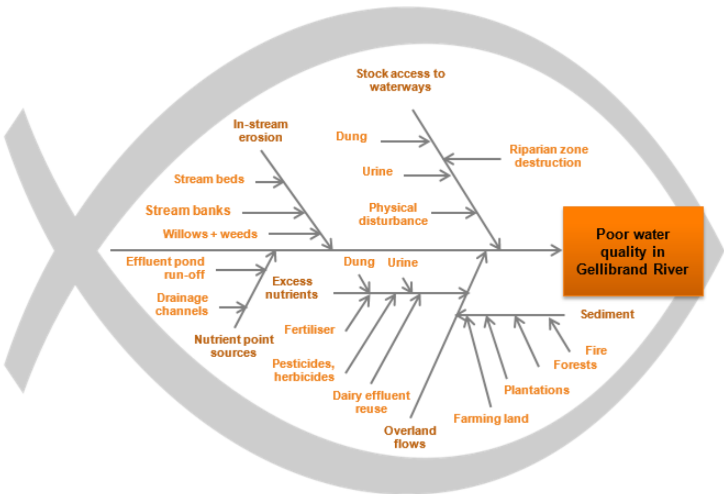
Original Steering Committee definition of the key features of catchment carbon offsets	Extended definition of catchment carbon offset characteristics – following the March 2017 stakeholder workshop
• Projects result in the retention of carbon stocks in the landscape and further carbon sequestration. • Projects provide environmental benefits which are consistent with regional NRM planning frameworks, programs and targets.	• Offset projects increase landscape carbon stocks, resulting in real and additional reductions in atmospheric CO_2. • Carbon sequestration is credible, quantified and verified. • Carbon is “permanently” sequestered. • Stable and resilient with climate change. • “Protected” from ownership and policy change. • Offsets projects provide environmental, social, cultural and/or economic benefits which are consistent with: - Regional NRM planning frameworks, programs and targets; - Water Corporation objectives; - State Government policy. • Project benefits and outcome can be owned and transferred. • Non-carbon benefits are visible, certain and clearly defined. • Build or result from stable, long-term relationships within water sector: CMA(s)-Water Corporation(s). • Local to Water Corporations and CMAs. • Offset projects are scalable up and down.

B.2 Define the problem

What other, non-carbon problem should the project address? What is the main driver for seeking co-benefits with a CCO project? For this step, the general project area should be identified, with known issues and limitations incorporated into the causes.

We recommend the use of a Fishbone Diagram (otherwise known as an Ishikawa Diagram) as a tool to identify the root causes of a problem. This is a visual tool to help organise critical thinking, and see past symptoms to the true root cause. The process to develop a Fishbone Diagram is provided below.

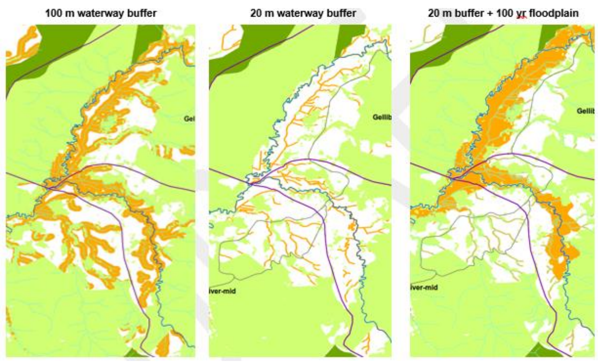
Steps	Example
Succinctly articulate the problem (effect).	Poor water quality in the Gellibrand River
Write the problem at the centre-right of the page, with an arrow pointing to it (the fish’s ‘spine’).	

Steps	Example
Brainstorm the main causes of the problem. Sort into groups if necessary, and feed into the 'spine'.	
Brainstorm the causes of each main cause. Feed into the main causes.	
Continue to identify potential causes in further sub-categories as appropriate.	

Project teams can use the completed diagram to identify the most material root causes, and consider design responses that directly and efficiently address these.

B.3 Identify potential legacies

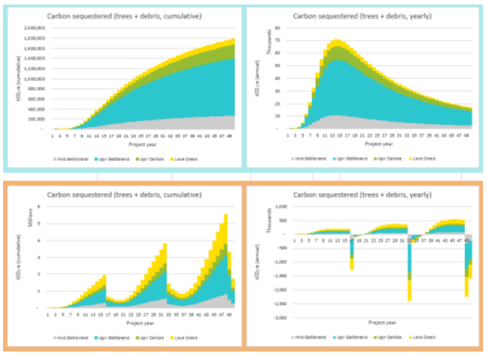
Drawing on the CCO characteristics and the root causes identified in the previous step, identify the potential project legacies. This can also be done as a Fishbone Diagram, with the CCO project as the effect, the main project legacies as the main branches, and contributing factors to each legacy as appropriate. Both positive and negative legacies should be included. These should again be relevant to the project area, incorporating local knowledge and values where appropriate.



B.4 Design the project

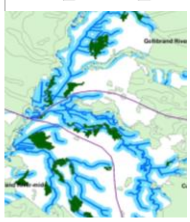
Define a set of project options that align with the CCO characteristics, address as many of the root causes (Step 2) as possible, and will result in as many of the positive project legacies (Step 3) as possible. Several of the vegetation methodologies certified under the National Carbon Offset Standard closely align with the CCO concept, and are a good place to start. Potential project areas, activities and timeframes will need to be defined. Set up the potential project areas in GIS, including current land uses.

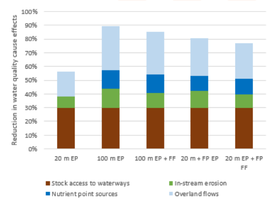
B.5 Calculate project impacts



Use FullCAM to calculate potential carbon sequestration over the course of the project.

Use appropriate available data to characterise other potential impacts (for example, we used the Water and Land Use Change Study to calculate likely impacts to flow, data from previous work by the Water Corporation to calculate the effectiveness of various interventions on improving water quality, and current land use data to calculate the increase in connected vegetation using ArcGIS).





B.6 Cost-benefit analysis

Compile project costs and benefits. Be sure to include:

- Costs of project start-up, including on-ground works
- Project management costs, including stakeholder engagement, at start-up and ongoing
- Ongoing monitoring and maintenance
- Costs of running the project for carbon offsets, such as regular reporting and certification requirements
- Opportunity cost of project land
- Income and savings from the change in land use

Project costs and benefits are compiled to calculate the net present value (NPV) of each project option, using an appropriate discount rate.

B.7 Evaluation framework

Compare the project options using a triple bottom line approach, including a ‘do nothing’ option. The detail of the evaluation framework will depend on the project type, its goals and legacies. The framework used in this case study is as follows:

- Carbon sequestered
- Financial impacts
- Environmental impacts
  - Greenhouse gas emissions sequestered/avoided (where not already covered by the ‘carbon sequestered’ measure)
  - Water quality
  - River heath
  - Terrestrial biodiversity
  - River flow regime
- Socio-economic impacts
  - Waterway cultural values
  - Waterway social and recreational values
  - Bushfire risk
- Governance
  - Confidence in level of implementation
  - Community partnerships.

Effect	Base case	Engineered WQ treatment	Riparian buffer			Floodplain + 20 m	
			20 m EP	100 EP	20 m EP + 80 m FF	EP	20 m EP + FP FF
Certified carbon							
Average yearly sequestration (tCO_2-e)	0	0	7.8k	40k	35k	17k	16k
Financial							
Financial cost	0	-$8.3M	-$6.2M	-$79M	-$113M	-$36M	-$46M
Financial benefit	0	-	$1.8M	$6.9M	$70M	$3.3M	$21M
NPV	0	-$8.3M	-$4.4M	-$72M	-$43M	-$32M	-$25M
Environmental							
Change in GHG emissions (flexible, average tCO_2-e pa)	0	-0.30k	0	20k	21k	8.9k	9.1k
Changed source/catchment water quality	-ve	-ve	56%	90%	85%	80%	80%
Change in river health increase in length of waterway with connected vegetation)	-ve	-ve	13%	13%	13%	13%	13%
Change in terrestrial biodiversity (additional area of connected vegetation)	0	0	356 ha	391 ha	391 ha	356 ha	356 ha
Change in river flow regime (ML/yr)	0	0	-0.4%	-1.7%	-2.7%	-0.8%	-1.1%
Socio-economic							
Change in waterway cultural values	-1	-1	1	1	1	1	1
Change in waterway social and recreational values	-1	-1	1	2	1	2	1
Change in bushfire risk with new plantings	0	0	0	0	-1	0	-1
Governance							
Confidence in level of implementation	0	4	3	1	2	1	2
Development of community partnerships	0	0	3	3	2	3	2

Where possible, the evaluation should be based on measured or calculated metrics. Where this is not possible, project options should be assigned a score based on their relative performance against that metric. This should be done in discussion with stakeholders representing different interests in the project; i.e. the CMA, Water Corporation, DELWP, Traditional Owners, local government, and/or members of the local community.

The evaluation framework should be constructed to avoid double counting of effects. All aspects which can readily be denominated in dollar terms should be included in the financial analysis/CBA.

If the evaluation does not result in a clear ‘best’ project choice (i.e. one with a positive NPV), project stakeholders will need to determine if the complementary benefits warrant the investment.

B.8 Craft the narrative

The outcomes of all of the previous steps should provide the project team with a compelling narrative to support the chosen project. Questions to guide a potential narrative structure are provided here:

- Set the context: CCO characteristics, problem to be addressed (Steps 1 and 2). Why is the project needed?
- What do you intend to do? (Best project option from Step 4)
- What will be the results? (Impacts and legacies, Steps 3 and 5)
- Why is this best option? (Overview of evaluation results, other options considered and their weaknesses from Step 7).

i Matthew T. Heberling, Christopher T. Nietch, Hale W. Thurston, Michael Elovitz, Kelly H. Birkenhauer, Srinivas Panguluri, Balaji Ramakrishnan,Eric Heiser. Comparing drinking water treatment costs to source water protection costs using time series analysis, *Water Resources Journal*, 5 November 2015

ii Cooper, J. and Gilliam, J. (1987). Phosphorus Redistribution from Cultivated Fields into Riparian Areas1. *Soil Science Society of America Journal*, 51(6), p.1600.

iii *Drinking Water Source Assessment and Treatment Requirements - Manual for the Application of Health-Based Treatment Targets* 2015

iv D2017/ 053572 UV Business Case for Warrnambool WTP, Nigel Johnston/Michael Kennedy GHD, Oct 2017