

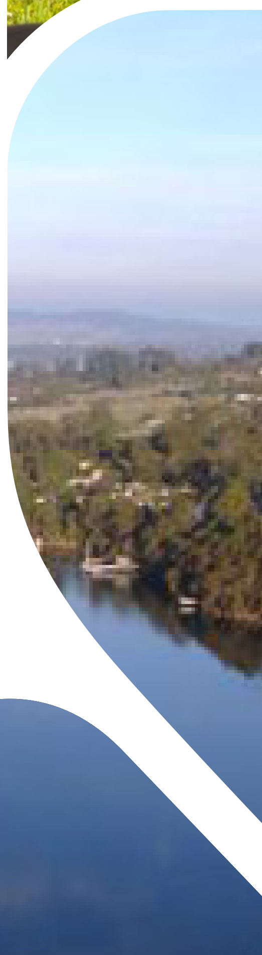
NRM North

Tamar Estuary and Esk Rivers

Natural Resource Management in Northern Tasmania

TAMAR ESTUARY & ESK RIVERS CATCHMENTS
WATER QUALITY IMPROVEMENT PLAN

2015



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The results displayed in this report are produced from a model and are therefore 'estimations' of the loads expected to be generated from the catchment areas. Users of this report should refer to the results as modelled or estimated amounts rather than actual amounts. Some caution should be used when interpreting the modelled loads for enterococci as due to lack of data, calibration of enterococci parameters was not possible using catchment monitoring data and so is based on literature including calibrated values from other catchments.

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EXECUTIVE SUMMARY

The Tamar Estuary and Esk Rivers (TEER) catchment area covers 10,000km^2 (approximately 15 percent of Tasmania). It supports urbanised areas, agricultural activities, industrial operations and recreational pursuits as well as having rich and diverse aquatic ecosystems. The estuary supports a diverse range of use and environmental values, including a large industrial area at Bell Bay, salmon farming operation, fishing, swimming, tourist boats and highly valued waterfront commercial and residential areas.

This Water Quality Improvement Plan (WQIP) has been developed for the greater Tamar Estuary and Esk Rivers (TEER) catchment area to:

- Provide a comprehensive whole-of-catchment picture of water quality in the Tamar River estuary and its tributaries;
- Develop an understanding of the drivers of any water quality issues and the levers that can be used to address these; and
- Identify priority activities to address water quality issues.

It is recognised that the WQIP will need to be implemented by a range of key stakeholders for water quality improvement so catchment stakeholders have been engaged throughout its development. This plan aims to provide direction to all catchment stakeholders on the role they can play in protecting and improving water quality in the Tamar Estuary and Esk Rivers catchments. It provides a framework and processes to report on progression towards achieving these targets and for updating them. Development of the plan has involved substantial consultation and engagement with the community and key stakeholders where those engaged could provide suggestions and feedback on the direction and content of the WQIP. Stakeholders were engaged through community forums, key stakeholder workshops, presentations to councils and industry, one-on-one meetings, emails and the TEER Program committees.

Current Loads, Condition and Sources of Pollutants

A major component of the TEER WQIP has been the development of a computer based decision support system, the TEER CAPER DSS, which allows the potential impacts of a range of management actions and possible land use changes on catchment loads and estuary water quality to be modelled. This DSS has been used throughout the plan to develop understanding of current sources of pollution, as well as the potential impacts of adoption of best management practice, dairy expansion and urban development under the Greater Launceston Plan. Unless otherwise stated, all loads, concentrations and estimated impacts in the plan are derived from this DSS.

Pollutant inputs into the Tamar River estuary are from both diffuse and point sources. Diffuse sources are pollutant loads carried by rainfall runoff from the land surfaces. In the greater TEER catchment, point sources include sewage treatment plants (STP), combined system overflows (CSO) from Launceston and aquaculture. Combined system overflows refer to discharges of a mix of sewage and urban stormwater that occur during high flow events from the combined sewage and stormwater system that services Launceston. At other times the combined sewage and stormwater is directed to the Ti Tree bend STP and is treated before being discharged to the estuary.

Diffuse sources are the dominant supply of flows and pollutants to the Tamar River estuary:

- Close to 100% of the flow and Total Suspended Solids (TSS) loads can be attributed to diffuse sources with a very small proportion of loads coming from point sources;
- For Total Nitrogen (TN), diffuse sources contribute approximately 70% of the total load with STPs and aquaculture making up the majority of remaining portion (22% and 6% respectively);
- For Total Phosphorous (TP), diffuse sources contribute to a lesser extent but are still a main source (~55%) of loads. STPs contribute approximately 35% and aquaculture 7% of loads, with a marginal portion (<1%) resulting from CSO; and
- Enterococci loads result mainly from diffuse sources (70%) with CSO contributing approximately 26% and STPs 4%.


NATURAL RESOURCE MANAGEMENT
in Northern Tasmania

Dominant land uses in the greater TEER catchment by land area are greenspace (~25%), grazing (~45%) and native production forest (~20%) with other land uses covering less than 5% of the total land area each.

- Flows to the Tamar River estuary mainly come from native production forest (~45%) and greenspace (~35%) with smaller but significant contributions from grazing (~5%), hardwood plantations (~5%), softwood plantations (~5%) and urban areas (<5%). The dominance of green space and native production forests in producing flows is due to their position in the catchment. These land uses tend to occur in high slope, high rainfall areas at the top of the catchment and so produce high flows relative to their areas. This higher relative contribution of flows also leads to a greater contribution of pollutants than for well covered lower rainfall and slope areas, particularly in terms of TP and TSS.
- Grazing areas represent a significant source of other diffuse pollutants, in particular enterococci. They produce only 4% of flows due to the relatively low rainfall in these areas, but 32% of TN, 13% TP and 50% enterococci.
- Dairy is a very small land use in the catchment, covering less than 1% of the land area but is estimated to contribute approximately 2% of the TN, 4% of the TP and over 20% of the enterococci load in the catchment
- Urban areas are a very small land use in the catchment, covering only 1% of the land area. They contribute substantially higher proportions of the total load than this relative area, ranging from 14% to 18% of nutrient and sediment loads.
- Cropping areas are a small land use in the catchment (3%) and produce a very small proportion of total loads (approximately 1% of nutrients and sediments). This is generally due to the lower rainfall and flows that occurs in these areas.

Pressures and Opportunities

Land use change can present both a threat and an opportunity to improve water quality. Two major land use changes are foreseen over the next 20 years: dairy expansion and urban development.

Dairy is currently a relatively small land use in the catchment covering less than 1% of the land area, but it is expected that this area will double in the medium term bringing with it an additional herd of nearly 40,000 cows.

The Greater Launceston Plan has been developed to guide urban development through to 2036. This plan envisages an additional 3.7% of the catchment under urban development.

Both these land uses could potentially lead to declining water quality, were they to occur without substantial adoption of best management practices (BMP). However, modelling presented in the plan shows that if these changes occur with high levels of adoption of BMP, then water quality can be protected. In some cases it may even be possible to improve water quality. These results demonstrate the importance of sustainable development and using change as an opportunity to improve environmental outcomes.

Load and Condition Targets

The WQIP develops a set of load and condition targets for the catchment and its estuary. Targeted load reductions presented in the plan are:

- 17% for Total Nitrogen
- 27% for Total Phosphorous
- 6% for Total Suspended Solids
- 24% for Enterococci.

These targets are based on analysis assuming future land use and population and feasible levels of adoption of best management practices outlined in the plan. The estimated potential impact of the current preferred option (as at May 2015) for the Launceston Sewerage Improvement Plan is also included in the target. Decreases in nutrients are largely due to decreases in point source loads while decreases in TSS and enterococci occur largely as a result of decreases in diffuse source loads.

Achieving targeted load reductions scenarios can be expected to lead to:

- Very substantial decreases in nutrient concentrations in the upper estuary, with changes in Zone 1 (Launceston to Legana) of 40% to 50% and 50% to 60% for TN and TP respectively; Relative changes in nutrient concentration decrease down the estuary until decreases in Zone 5 (Kelso to Low Head) are effectively zero;
- Smaller and more even changes in TSS down the estuary, with decreases of 12% to 13% in summer and 15% to 18% in winter; and
- Slightly greater in Zone 1 but relatively constant decreases in enterococci concentrations down the estuary at approximately 20%.

Recommendations

The greater TEER catchment covers a substantial proportion of the state and contains a very broad ranges of land uses and other point sources. Managing such a complex system to improve water quality means it will require action by a very broad section of the community. Recommended management actions to reduce pollutant loads in the catchment are summarised below.

Dryland grazing

- A major focus of management should be on improving groundcover management in the identified high and medium priority catchments emphasising productivity benefits to landholders.
    - In the short term emphasis should be placed on getting those landholders not yet meeting median groundcover levels to improve to this level before trying to improve the groundcover on other farms.
- Actions to reduce stock access to streams should focus on lower cost solutions that are flexible to physical constraints on specific farms as well as the needs and preferences of individual farmers:
    - In subcatchments where riparian revegetation is not a priority action or where there are significant physical constraints, simply excluding stock from the stream with narrow fenced buffers should be considered.
    - Options where the stock are restricted from entering most of the stream while still having limited hardened access for stock watering should be considered where this is the preference of the landholder to increase the adoption and lower the overall cost of this action.
    - The specific design of fencing (e.g. single wire fencing versus six wires fences) should be determined on a case by case basis with landholders depending on their preferences so long as the fencing adequately restricts stock access to the stream.
    - Incentives should focus on compensating for the initial costs of fencing out streams.
- The primary focus of efforts to revegetate the riparian zone in order to improve water quality (not including biodiversity outcomes) should be on establishing broadscale adoption of narrower buffers (5m). For example, it would be substantially more effective for a landholder to create a 200m long, 5m wide buffer than a 100m long 10m wide buffer. Where landholders are happy to establish wider buffers on the same length of stream this should be encouraged.
    - Limited stock access to riparian zones (e.g. crash grazing to keep weeds out) should not be actively discouraged except in sensitive areas where excluding stock has been identified as a priority.
    - Incentives for revegetating riparian zones should be developed to address both upfront and ongoing maintenance costs for at least the first five years of establishment.

Dairy management

- Sufficient effluent storage should be provided for on dairy farms. This storage should be well-designed and placed to ensure effluent can be applied to an adequate area of the farm, and storages are unlikely to leach or overflow effluent.
- Stock should be restricted from all streams on dairy farms wherever it is feasible. The inclusion of riparian buffers is likely to have very small benefits for water quality, however could be expected to benefit stream health through shading, increased bank stability, increased connectivity between vegetation remnants and provision of wildlife corridors. Creation of riparian buffers should be encouraged for these reasons, however the most important outcome for water quality in most cases is that stock are removed from streams. Therefore management should be flexible to allowing for this with either minimal or no buffers where this is likely to achieve greater adoption of this action.
- Irrigation scheduling should be managed to match irrigation to soil infiltration rates and pasture growth rates, and irrigation water reused to reduce drainage losses where possible.
- Drains need to be managed to minimise the transport of pollutants off the farm. This presents some practical challenges for dairy farmers and more consultation is needed to develop practical solutions for best management practice.

Crop management

- Fertiliser management is a key action in reducing nutrient losses from cropping areas. Adoption of enhanced efficiency fertilisers should be strongly encouraged as these are likely to have the greatest impacts on nutrient runoff.
- While fertiliser management is very effective for reducing nutrient runoff, improving water quality off cropping areas will require a more holistic approach to ensure sediment loads are reduced. Both improving groundcover and adoption of riparian buffers can improve water quality in terms of sediment loads, as well as having impacts on nutrient runoff. Narrow riparian buffers can be expected to have greater impacts than low levels of adoption of groundcover management.
- While the magnitude of impacts of riparian buffers are similar to those of groundcover management, groundcover management is likely to be significantly more cost effective than riparian buffers which achieve load reductions at a much greater cost per kg than the other management options. This emphasises the importance of focusing on these low cost options even where they are not very effective at a catchment scale at reducing pollutant loads as they represent economically efficient options for achieving some improvements in water quality.
- Narrower buffers have the potential to improve water quality at a catchment scale by more than wider buffers where these are seen as more adoptable. A flexible approach should be used in encouraging farmers to adopt riparian buffers with an emphasis on broadscale adoption of narrow buffers likely to be more effective than lower adoption of wider buffers. Greater incentives for farmers willing to adopt wider buffers may need to be provided. An emphasis on adoption of narrow buffers in the short to medium term with long term encouragement to expand these to wider buffers is likely to be more effective in terms of producing water quality benefits.
- Focusing extension efforts to emphasise the long term benefits of buffers in reducing streambank erosion and subsequent losses of productive land are also expected to be more effective in increasing the adoption of buffers rather than a focus on the environmental benefits, given that the loss of productive land to buffers was identified as a key impediment to their adoption. Upfront incentives are required for any level of adoption of buffers. Maintenance incentives shouldn't be a focus of programs given feedback that these are unlikely to have any impact on the adoption of buffers.

Forest management

- The Forest Practices Code has been essential in improving water quality from production forest areas. It is important that this continues to be implemented in the future.
- Any areas that are pre-code in the catchment should be identified and, where possible, streamside reserves should be created in these areas prior to harvesting activities.

Stormwater management

- Household scale WSUD devices such as plumbed in rainwater tanks and rain gardens should be encouraged using a combination of incentives and education focused on both environmental benefits and those directly experienced by the householder. In particular, these devices have the potential to be very effective at reducing overflows from the combined system in Launceston. It is recommended that City of Launceston and TasWater look to household scale devices such as these to assist in the management of combined system overflows.
- Large scale retrofit options are much more difficult to adopt broadly across the catchment. Opportunities should be sought by councils to identify 'win-win' opportunities for retrofitting WSUD – for example as a feature of green space areas, or by including quality management in existing flow detention systems.
- The Northern Stormwater Working Group should continue to work together to build the capacity of councils to develop and maintain large scale WSUD systems. Opportunities should be sought to fund ongoing maintenance of systems as this is a key impediment to broad scale retrofitting of WSUD identified by stakeholders.
- Councils should work proactively with the community, in particular local businesses, to identify small scale WSUD options that can be incorporated in refits and redevelopments, for example, to treat or reduce pollutant exports from commercial car parks and other hard surfaces.
- The NRM North Stormwater and Catchments Officer and councils should engage with the community and provide education about the sources of pollutants in urban areas, the role and advantages of WSUD and actions they can take to improve stormwater quality. This may include but not be limited to school education programs, workshops with developers and builders and education of home owners on the potential benefits of household scale WSUD options.

Urban expansion in the Greater Launceston area

- Water sensitive urban design should be broadly adopted in all new development areas where on-site constraints allow this to occur. Specific treatment trains will need to be designed subject to site specific constraints using expert assistance to ensure they provide the greatest benefit at the lowest cost. In order to be effective, WSUD devices need to be properly maintained.
- While erosion and sediment controls can be seen to have a relatively small impact catchment wide, they still represent an important action in preserving and improving water quality. These controls should be used and properly managed on all new development sites to minimise soil erosion from new developments.
- The Northern Tasmanian Stormwater Program should facilitate the development of templates for incorporating WSUD into Development Control Plans (DCPs) and Local Environment Plans (LEPs) for new developments to assist councils in their efforts to implement WSUD in future developments.

TasWater

- TasWater should continue to investigate and refine options for improving sewage discharges in the Launceston area through the Launceston Sewerage Improvement Plan.

Heavy metals

Heavy metals were raised by the community as a serious water quality concern. These were not modelled in the CAPER DSS because: diffuse loads are unlikely to be a major source of metals – these are likely to be sourced primarily from historic mine sites and urban areas; and insufficient information was available to model these at the catchment scale. Management options outlined in this plan for improving stormwater quality in terms of nutrients, sediments and pathogens are likely to also produce benefits in terms of reducing heavy metal exports from these areas. Resuspension of contaminated sediments in the estuary is also an issue that needs to be considered in managing pollution from metals.

- Historic mine sites leaching metals should be identified and where possible remediated to manage potential future discharges of heavy metals.
- The impacts of resuspension of contaminated sediments particularly in Zone 1 of the estuary should be investigated.

Scientific investigations, modelling and monitoring

This plan relies on the best available science to evaluate the potential benefits of proposed management actions. In collating and integrating this information, several weaknesses in current data and information were identified. Priorities for scientific investigations, modelling and monitoring to fill these gaps are:

- The TEER Tamar Estuary Ecosystem Health Assessment Program (EHAP) should continue to collect monitoring data for the Tamar River estuary. This data is essential to understanding the current condition of the estuary and identifying changes into the future.
- Further agricultural trials should be conducted to collect more locally sourced data on the impacts of management actions such as improvements to groundcover, impacts of fertiliser management and the impacts of drain management on dairy farms. Costing actions and identifying barriers to their adoption as part of these trials would also be useful.
- Collection of disaggregated data on the adoption of management actions. In most cases current rates of adoption of various management actions have been obtained either through state-wide surveys of land holders, or in discussion with key stakeholders. Very little data is collected to help quantify the current rates of adoption of specific management actions within regions of the state or catchments.
- Continued monitoring of pollutant concentrations and flows in stream systems in Tasmania is vital to understanding current condition and pressures on water quality in these systems. Monitoring of instream water quality, collocated with flow measurements should be continued and where possible expanded in areas where land use and management is likely to be having impacts. Ideally, other ecological monitoring such as AUSRIVAS data collection should be conducted where stream monitoring is available to allow linkages between water quality, flow and ecological health to be investigated.
- Monitoring of overflows from the combined system should be undertaken, including locations, flows and concentrations of overflows. These should be collected to allow comparison with rainfall and antecedent conditions.
- The Source Catchments model used to underpin the CAPER DSS has been calibrated to flow, nutrient and sediment data. Literature values are used to model enterococci loads. Ideally, the Source Catchments model will be refined and calibrated to include pathogens in future revisions.
- The CAPER DSS should be updated as new information and modelling becomes available. This includes: revised versions of the Source Catchments and receiving water quality modelling; improved land use data; improved information on adoption rates of current practices; improved information on the effectiveness and costs of proposed management actions; and additional MUSIC modelling of WSUD options which are based on local data, including for household scale options such as raingardens and rainwater tanks.

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GLOSSARY OF TERMS AND ABBREVIATIONS

AMT	Accepted modern technology. Standards agreed to within the sewage industry. These standards set maximum acceptable concentrations of various pollutants which STPs should not exceed in their discharge to fresh and marine waters.
AUSRIVAS	Australian River Assessment System. An approach for assessing river health using macroinvertebrates.
BMP	Best management practice.
CAPER DSS	A computer based modelling system that can be used to assess 'what if' type questions related to the impact of management actions on catchment pollutant loads and receiving water quality.
CSO	Combined system overflow. Discharges of mixed stormwater and raw sewage from Launceston's combined sewer-stormwater system during high flow events.
Diffuse loads	Pollutant loads from land based sources delivered the surface and groundwater systems through the actions of rainfall runoff.
DSS	Decision support system.
Enterococci	A bacteria found in water that correlates with other enteric pathogens that are detrimental to human health. It is used as an indicator of levels of pathogen pollution that would limit human activities such as boating or swimming. In monitoring programs, enterococci is generally reported and used as a concentration and is normally elevated for several days after a rainfall event. While loads would not generally be used in monitoring enterococci for human health, modelled enterococci load is used in this WQIP as an indicator to allow the relative benefits of various actions in reducing risk from pathogen pollution to be assessed. This assumes that actions that reduce total loads of enterococci will also reduce concentrations during high flow periods.
FCR	Food conversion ratio. The kg of fish produced for every kg of feed input in salmon production.
Flow	Volume of water discharged through a stream over a given period of time.
GLP	Greater Launceston Plan.
Greater Tamar Estuary and Esk Rivers catchment	Areas draining into the North and South Esk rivers and the Tamar River estuary.
Green space	Land use consisting of conservation and natural environments including national parks, conservation areas, nature reserves and other protected areas.
Highlands	Areas in the catchment above 400m.
LFA	Launceston Flood Authority.
LGA	Local Government Area.
Lowlands	Areas in the catchment below 400m.
LSIP	Launceston Sewage Improvement Plan.

PEV	Protected Environmental Value. The values or uses of a waterbody for which it should be protected.
Point source loads	Pollutant loads discharged from a single identifiable source such as a sewage treatment plant.
Sewage	Water carried waste from households and businesses.
Sewerage	The pipes, channels and other infrastructure used to transport sewage.
STP	Sewage Treatment Plant, where sewage is treated before being discharged either to land through for example, reuse such as irrigation, or into a receiving water body.
Tamar River estuary	Tidal areas of the Tamar River extending from Bass Strait upstream to First Basin in the Cataract Gorge on the South Esk and Hoblers Bridge on the North Esk River.
TEER	Tamar Estuary and Esk Rivers.
TN	Total nitrogen.
TP	Total phosphorus.
TSS	Total suspended solids.
WQIP	Water Quality Improvement Plan.
WSUD	Water Sensitive Urban Design. Integrating water cycle management in an urban environment through devices designed to increase the effective perviousness of a catchment or treat stormwater to remove pollutants before it is discharged.
Zones	A connected region of the estuary within which the estuary functions in a similar way, for example in terms of salinity or habitat.

section 1

INTRODUCTION

1.1 Purpose and Scope of the Plan

This Water Quality Improvement Plan (WQIP) has been developed for the greater Tamar Estuary and Esk Rivers (TEER) catchment area to:

- Provide a comprehensive whole-of-catchment picture of water quality in the Tamar River estuary and its tributaries;
- Develop an understanding of the drivers of any water quality issues and the levers that can be used to address these; and
- Identify priority activities to address water quality issues.

It is recognised that the WQIP will need to be implemented by a range of key stakeholders for water quality advancement so catchment stakeholders have been engaged throughout its development. This plan aims to provide direction to all catchment stakeholders on the role they can play in protecting and improving water quality in the Tamar Estuary and Esk Rivers catchments. It provides a framework and processes to report on progression towards achieving these targets and for updating them.

1.2 TEER Program

The Tamar Estuary and Esk Rivers (TEER) catchment area covers 10,000km^2 (approximately 15 percent of Tasmania). It supports urbanised areas, agricultural activities, industrial operations and recreational pursuits as well as having rich and diverse aquatic ecosystems.

To provide a coordinated management approach and guide for investment in activities to protect, maintain and restore the health of the catchment, NRM North established the Tamar Estuary and Esk Rivers Program (TEER) in 2008. A key goal of the TEER Program is to improve scientific understanding of the issues impacting upon the health of waterways so that priority areas requiring investment in on-ground works can be better identified and targeted.

The TEER Program is a regional partnership between the agencies with a statutory responsibility for waterway management and includes local and state governments, Hydro Tasmania and TasWater. The TEER Program also fosters collaborative partnerships and works closely with a range of industry, government, business, research partners, and community groups to coordinate activities to reduce pollutants entering waterways and to monitor and report on waterway health.

1.3 Plan Development Process

This WQIP for the greater TEER catchment has been developed over three main phases: Initial scoping; Decision Support System (DSS) and scenario development and; WQIP and recommendations. Each phase of the plan involved consultation and engagement with the community and/or key stakeholders where those engaged could provide suggestions and feedback on the direction and content of the WQIP.

1.3.1 Scoping Phase

The main direction and development of the TEER WQIP was determined as part of the initial scoping phase. This involved the establishment of a WQIP Working Group, one-on-one meetings with selected stakeholders, key stakeholder workshops, community forums and an online survey.

In October 2013, three community forums and an online survey were conducted to inform the community of the development of a WQIP for the greater TEER catchment area and seek feedback on community priorities. Community forums were held in Launceston, Westbury and Campbell Town on consecutive nights with the aim to educate the community about the WQIP objectives and to seek community input on scenarios, impacts and management actions to be considered in the plan. Facilitated discussions at the workshops were based on three main themes:

- Values
  - What do you most value about the catchment, rivers and estuary?
  - What do you use them for?
  - What attributes would you like to see protected?
- Impacts
  - What are you most concerned about in terms of the future health of the river and estuary?
  - What changes do you see could harm the estuary and rivers?
  - What changes do you see that could benefit the estuary or rivers?
- Management actions
  - What opportunities do you see to improve and protect our rivers and estuary?
  - What actions do you think should be taken to protect and enhance water quality in the rivers and estuary?

Four key stakeholder workshops involving participants with interests in forestry, primary industry and land conservation, health and ecology of the Tamar and the Northern Tasmanian Stormwater Working Group were also held in October 2013. These workshops were designed to:

- Ensure members were aware of the nature of the reference group, its terms of reference and the likely level and timing of commitment required;
- Give participants an overview of the WQIP and timeframes;
- Seek comment on possible management actions and scenarios to be considered in the pan and how these will be handled in the DSS; and
- Determine subcatchments and estuary zones to be used in the DSS and the plan.

One-on-one consultations were also held with key stakeholders as required. The scoping workshops and community forums identified a range of actions and potential sources of pollutants to the TEER waterways. This feedback was used to develop a set of management modules in a decision support system, the TEER CAPER DSS, constructed to support the development of this plan. The role of the DSS is to assess the impacts of various management actions, future land use and population scenarios on catchment and estuary water quality.

Scientific investigations and modelling were conducted and meta-models were developed for particular components of the TEER. Metamodels were developed based on detailed calibrated models previously developed for the catchment, monitoring data (e.g. for STPs) and literature.

Management modules underwent review by four independent peer reviews conducted to ensure they captured the best available science and understanding of processes.

A preliminary set of spatial scales was also developed for subcatchments to align with key planning reports and literature available in Tasmania. These were further refined using comments from key stakeholders before being used in the DSS. Subcatchments used in the modelling and analysis underpinning this WQIP are shown in Appendix 3.

Following this, the interface of the DSS was developed and text documents collated. Scenarios suggested by key stakeholders were evaluated in the DSS. Workshops were run in September 2014 to provide DSS training to key stakeholders, seek feedback on preliminary results and to determine the scenarios to be included in the plan, including feasible adoption rates for various management scenarios. Outcomes from these discussions are summarised in Appendix 4.

1.3.2 WQIP and Recommendations

Scenarios selected by key stakeholders for inclusion in the WQIP were analysed in the DSS and included in drafts of the plan along with preliminary recommendations before being circulated to key stakeholders for comment. The selected scenarios were used to illustrate the effects of management actions and pressures on water quality and to develop WQIP recommendations in consultation with key stakeholders. Negotiations of recommendations in light of scenario impacts were undertaken with stakeholders before being included in this plan.

1.4 The Tamar Estuary and Esk Rivers

1.4.1 Physical Description

The Tamar river estuary is located in north eastern Tasmania. It extends on a south-east to north-west axis for approximately 70km following a meandering path from Launceston to its mouth into Bass Strait at Low Head on Tasmania's north coast. The river is formed through the convergence of the North Esk and South Esk rivers at Launceston. At 214km, the South Esk River is the longest river in Tasmania. The South Esk basin, consisting of Macquarie, Brumbys-Lake, Meander and South Esk catchments, is the main source of freshwater flows and sediments to the Tamar; the North Esk is considerably smaller. The topology of the catchment varies from low hills and plains characterised by agriculture in the Northern Midlands, to plateaus of the Western Tiers, Ben Lomond and Eastern Highlands. Together the Tamar and its tributaries drain a catchment area of approximately 10 000 km^2 or 15% of the state of Tasmania. Nine local government areas are responsible for this region (Figure 1).

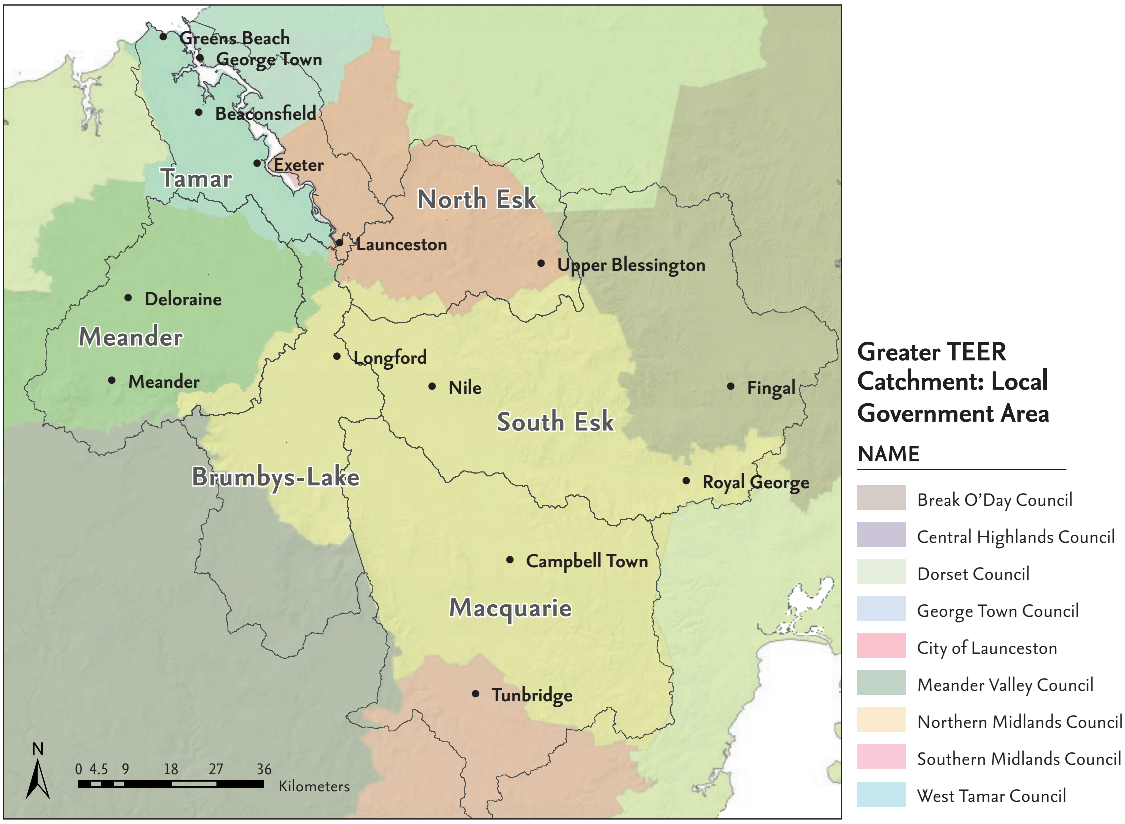


Figure 1. Greater TEER catchment showing local government areas (LGA)

The Tamar River estuary is a mesotidal drowned river valley, the only estuary of this type in Tasmania. It is tidal for its whole length to the First Basin on the South Esk and on the North Esk to St Leonards, with a 3.5 metre tide occurring twice a day in Launceston. The water in the Tamar River estuary gradually becomes less saline with distance upstream and is generally well mixed vertically with little salinity variation from surface waters to the bed. However, in high river flow periods, the lower salinity zone moves further downstream and salinity stratification, where freshwater is at the surface and seawater is near the bed, can occur. This causes variation in flow profiles and the density of currents, conditions which are conducive to flocculation and settling of suspended sediments, both significant drivers of siltation processes.

While the lower reaches of the estuary still exhibit characteristics of a drowned valley, the upper reaches above Swan Bay have been gradually infilling with sediment brought down the rivers and creeks (particularly the North and South Esk rivers) since sea level reached its present height. On the North Esk at Cora Linn, all sediments are transported as suspended load but tend to settle out a short distance downstream. Trevallyn Dam on the South Esk reduces freshwater flows, attenuates flood flows and passes suspended loads which enters the Tamar River estuary. Hence, the sediment in the upper estuary is very fine silt and clay lacking in any course fluvial sands. It has accumulated to a nine metre thickness in some areas of the upper estuary (GHD, 2009a).

High flows are responsible for the net removal of sediment in the upper Tamar through central channel bed scouring and downstream transport. Silt and clay that travels suspended through the rivers and creeks during and after floods typically deposits rapidly in locations that have slow current velocities and are exposed to high suspended sediment concentrations (e.g. Home Point and the Yacht Basin). In dryer periods, salinity zones extend further upstream to near Launceston City and, because flows are predominantly tide-induced, sediment transport is in an upstream direction. During low flow conditions, tidal flows can move sediment to upstream parts of the estuary where it settles out in areas where currents are too weak to keep sediments mobilised.

Studies on river sediment have identified an average annual deposition of sediment in the upper reaches of the Tamar River to be around 30,000m^3 per annum. Low river flows, dredging and flooding events can vary this annual average amount of sediment deposited up to more than 100,000 m^3 per annum, sometimes reaching as high as 200,000m^3 per annum. Over the past 20 years, nearly 1,000,000m^3 has been dredged from the river (GHD, 2009b).

Natural processes and dredging are not the only drivers of sedimentation in the upper Tamar. The construction of jetties and the introduction of several weeds and pest animal species such as rice grass and Pacific oysters have also influenced alterations to the channel's natural state. Land reclamation has occurred in areas around the estuary, in particularly around Royal Park. A growing urban population, intensive agriculture, industrial development and land clearance are also key pressures on the health of the estuary.

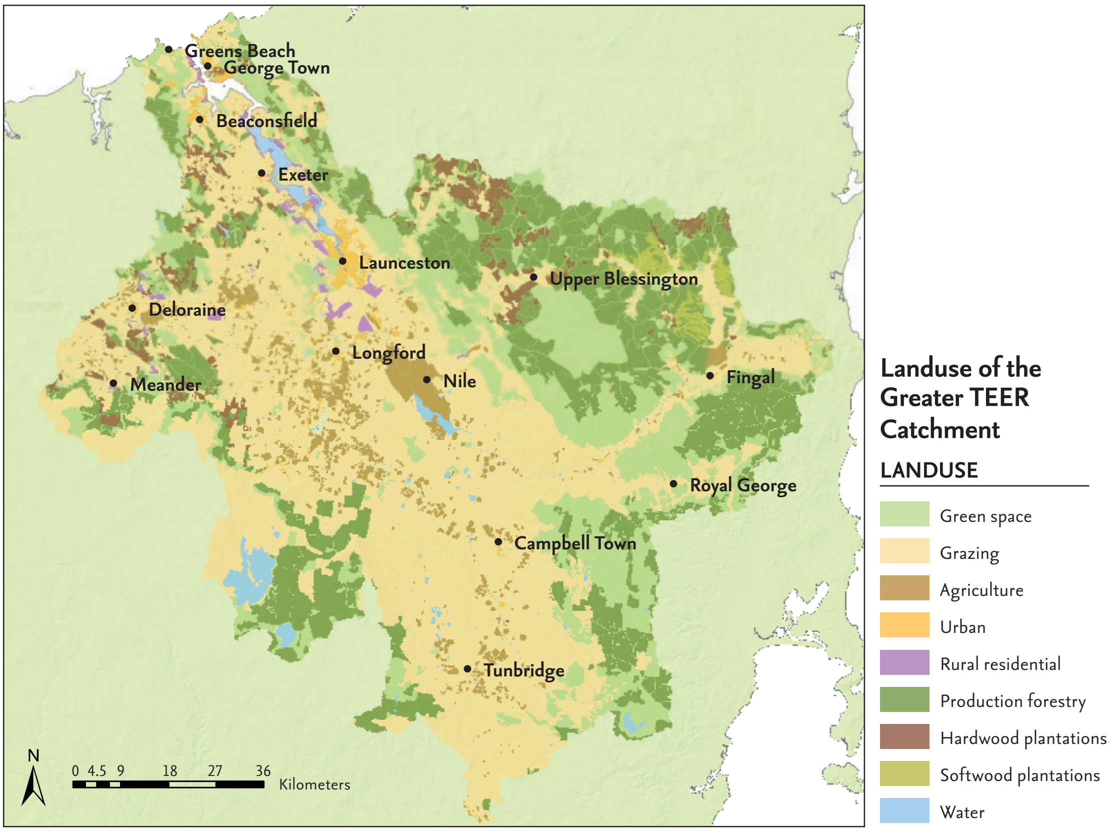


Figure 2. Major land uses un the greater TEER catchment

Land use in the greater TEER catchment is shown in Figure 2. The percentage of the greater TEER catchment under each land use is given in Table 1.

Table 1. Land use area as a proportion of the greater TEER catchment

	Proportion of catchment area
Green space	24%
Grazing	45%
Dairy	1%
Broadacre cropping	3%
Intense cropping	<0.1%
Horticulture	<0.1%
Rural residential	1%
Hardwood plantations	3%
Softwood plantations	1%
Native production forests	21%
Urban	1%

Pollutant inputs into the Tamar River estuary are both diffuse and point-source, including high levels of turbidity, nutrients, bacteria and metals. Metal contamination of water, sediments and biota is a legacy from old mining operations (Beaconsfield and abandoned mining operations near South Esk River catchment), trade waste, industrial activities in Bell Bay/ George Town and disturbance of acid sulphate soils from dredging. Additional nutrients and bacteria are added to the estuary water and sediments from agricultural runoff and Sewage Treatment Plants (STP) throughout the catchment.

There are 26 STPs within the greater TEER catchment. Of these, 13 are located near the Tamar River, discharging effluent into the estuary or its close tributaries. Four sewage treatment facilities are located in the Launceston municipality. These facilities are located within the city and surrounding suburbs at Norwood, Hoblers Bridge, Newnham, and Ti Tree Bend. The adjoining Launceston suburbs of Prospect also have treatment plants in the upper Tamar area (Figure 3).

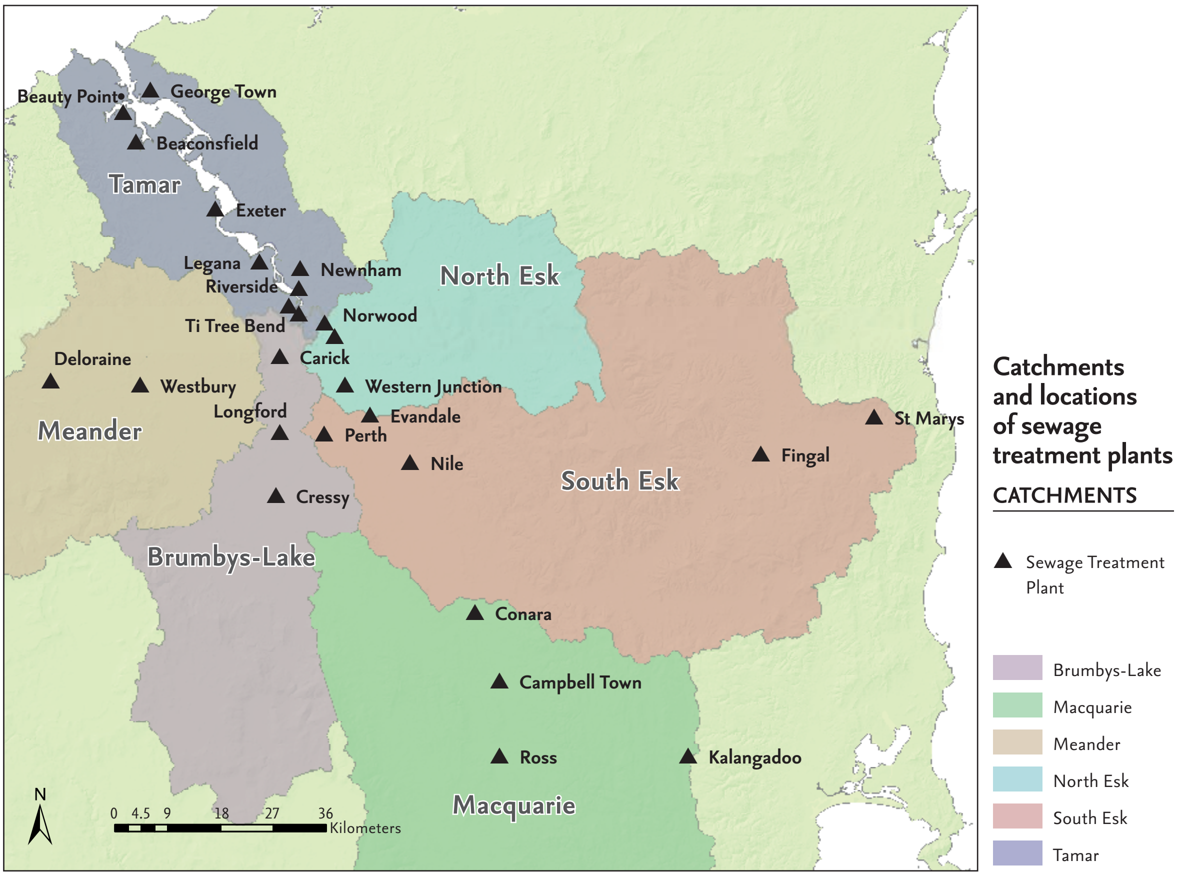


Figure 3. Greater TEER catchment: catchments and locations of sewage treatment plants

1.4.2 Values

Despite degradation of the upper Tamar River estuary, the Launceston community acknowledges the river as an iconic feature of the city, valued for commercial activities and tourism as well as recreational uses (e.g. boating, rowing, fishing, socialising), and aesthetic qualities.

The environmental health and water quality of the Tamar River estuary and its freshwater tributaries are highly valued by the community. The Tamar River estuary possesses extremely high plant, invertebrate and fish species diversity, many unique to the area. The area around the estuary mouth is considered to have High Conservation status. The estuarine and coastal ecosystems provide many important habitats including sand and soft muddy bottoms, wetlands, soft corals and rocky reefs, open ocean environments and sandy beaches. The estuary supports a wide range of both resident and migratory species and there have been more than 60 bird species and 110 species of finfish and macroinvertebrates recorded. The Tamar is also home to a number of protected species (at a state, national and international level) and fifteen threatened fauna species visit or inhabit the estuary. These include protected Syngnathidaes (pipefishes, seahorses, and sea dragons), the vulnerable listed Australian Grayling, the white-bellied sea eagle and the endangered humpback and southern right whales. There are also a number of threatened vegetation communities along the shores of the Tamar, including swamp paperbark (*Melaleuca ericifolia*) forests and saltmarsh communities.

Protected Environmental Values (PEVs) have been set for Tasmanian surface waters, including estuarine and coastal waters, under the State Policy on Water Quality Management 1997. With the exception of the waterways in forested areas with their headwaters in forest reserves or conservation areas, the majority of waterways in the greater TEER catchment are managed to support a healthy modified aquatic ecosystem that can support harvesting of edible fish, irrigation, stock and domestic use and secondary and aesthetic recreation values. In addition, some locations need to provide drinking water through town water supplies and provide for primary contact recreation. There are a number of highly valued swimming sites throughout the greater TEER catchment waterways flowing through forested areas with their headwaters in forest reserves or conservation areas represent pristine or near pristine aquatic ecosystems and are considered to have high conservation status. A full description of the protected environmental vales relevant to the greater TEER catchment can be found in DPIWE (2005a,b).

1.4.3 Current Loads

The TEER CAPER DSS is an integrated model that has been used to explore pollutant loads and flow in the greater TEER catchment and estuary as well as consider the effect of land use and management on these loads. Unless otherwise stated, all water quality estimates, analysis and results in this plan are based on this model. This section describes the modelled key pollutant loads to the Tamar River estuary which include total suspended solids (TSS), total nitrogen (TN), total phosphorus (TP) and enterococci as well as flow.

1.4.3.1 Current Loads

There are six catchments of the greater TEER catchment: North Esk River; South Esk River; Macquarie River; Meander River; Brumbys-Lake River; and the Tamar foreshore (Figure 3).

Estimated current average annual loads from each of these catchments as well as loads discharged directly to the estuary from point sources are given in

Table 2. These loads represent the expected load during a year with average climate conditions assuming current land use. TSS, TN, TP and flows have been derived using modelled data where model parameters have been calibrated and verified using catchment monitored data. Calibration of enterococci parameters was not possible using catchment monitoring data and so is based on literature including calibrated values from other catchments.

Table 2. Estimated Average Annual Catchment Loads

Catchment	TN (KG/YR.)	TP (KG/YR.)	TSS (T/YR.)	FLOW (ML/YR.)	ENTEROCOCCI (CFU/YR.)[1]
Brumbys-Lake	149,730	22,736	5,453	197,487	1.7E+14
Macquarie	75,846	16,867	4,647	75,285	2.9E+14
Meander	252,828	26,614	10,609	471,228	4.9E+14
North Esk	207,653	42,738	10,470	357,359	2.5E+14
South Esk	668,599	87,590	43,543	2,145,837	8.1E+14
Tamar	158,371	18,946	7,636	152,629	1.0E+15
Direct discharge to estuary	454,182	97,540	440	11,048	1.2E+14
Total	1,967,209	313,031	82,798	3,410,873	3.2E+15

1.4.3.2 Where do pollutants come from?

Pollutant inputs into the Tamar River estuary are from both diffuse and point sources. Diffuse sources are pollutant loads carried by rainfall runoff from the land surfaces. In the greater TEER catchment, point sources include sewage treatment plants (STP), combined system overflows (CSO) from Launceston and aquaculture. Combined system overflows refer to discharges of a mix of sewage and urban stormwater that occur during high flow events from the combined sewage and stormwater system that services Launceston. At other times the combined sewage and stormwater is directed to the Ti Tree bend STP and is treated before being discharged to the estuary.

Figure 4 shows the estimated relative contribution of diffuse sources and each main point source to the Tamar River estuary for the pollutants: total suspended solids (TSS), total nitrogen (TN), total phosphorus (TP) and enterococci as well as flow.

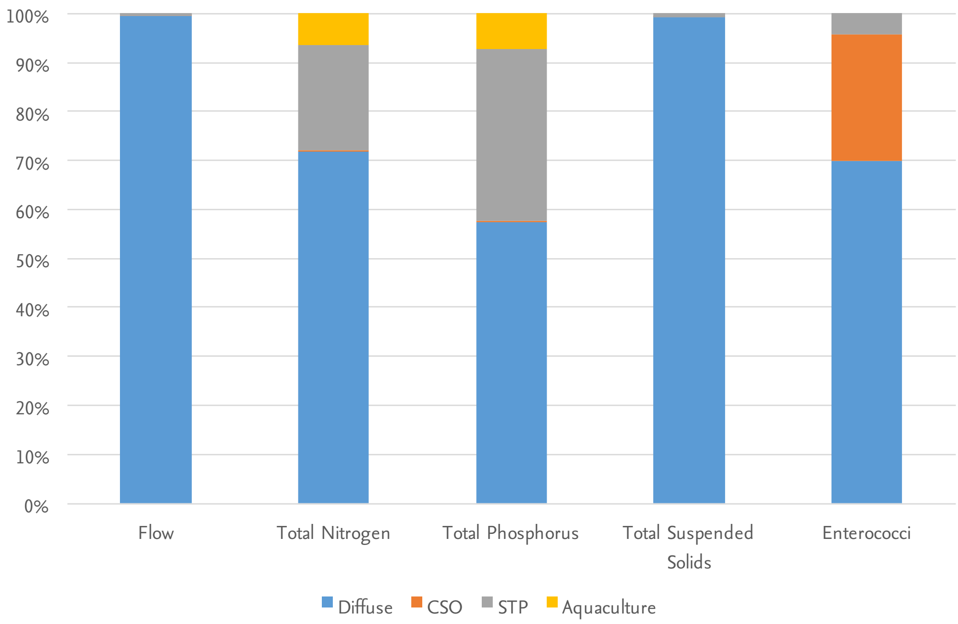


Figure 4. Modelled pollutant loads and flows into the Tamar River estuary from diffuse and point sources

1 A bacteria found in water that correlates with other enteric pathogens that are detrimental to human health. It is used as an indicator of levels of pathogen pollution that would limit human activities such as boating or swimming. In monitoring programs, enterococci is generally reported and used as a concentration and is normally elevated for several days after a rainfall event. While loads would not generally be used in monitoring enterococci for human health, modelled enterococci load is used in this WQIP as an indicator to allow the relative benefits of various actions in reducing risk from pathogen pollution to be assessed. This assumes that actions that reduce total loads of enterococci will also reduce concentrations during high flow periods.

Diffuse sources are the dominant supply of flows and pollutants to the Tamar River estuary. Close to 100% of the flow and TSS loads can be attributed to diffuse sources with a very small proportion coming from point sources. For TN, diffuse sources contribute approximately 70% of the total load with STPs and aquaculture making up the majority of remaining portion (22% and 6% respectively). For TP, diffuse sources contribute to a lesser extent but are still a main source (~55%) of loads. STPs contribute approximately 35% and aquaculture 7% of loads, with a marginal portion (<1%) resulting from CSO. Enterococci loads result mainly from diffuse sources (70%) with CSO contributing approximately 26% and STPs 4%.

Figure 5 shows the contribution of different land uses to diffuse pollutant loads and flows from the catchment. It also shows the proportion of the total catchment area of each land use so that the contribution of each land use can be considered relative to their land area.

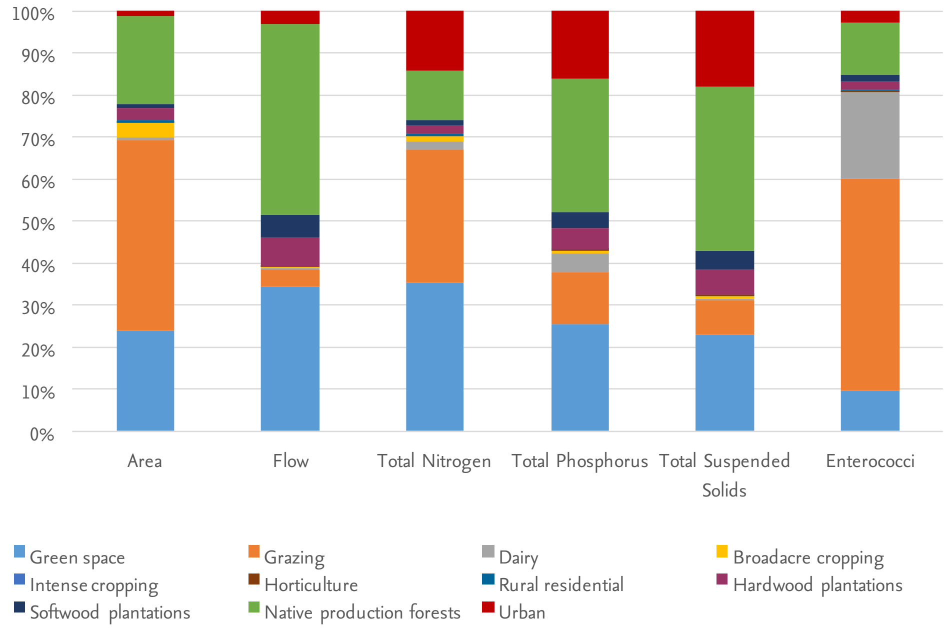


Figure 5. Diffuse pollutant loads and flow versus land use area

Dominant land uses in the greater TEER catchment by land area are greenspace (~25%), grazing (~45%) and native production forest (~20%) with other land uses covering less than 5% of the total land area each. Land uses which contribute the most flow to the Tamar River estuary are native production forest (~45%) and greenspace (~35%) with smaller but significant contributions from grazing (~5%), hardwood plantations (~5%), softwood plantations (~5%) and urban areas (<5%). The dominance of green space and native production forests in producing flows is due to their position in the catchment. These land uses tend to occur in high slope, high rainfall areas at the top of the catchment and so produce high flows relative to their areas. This higher relative contribution of flows also leads to a greater contribution of pollutants than for well covered lower rainfall and slope areas, particularly in terms of TP and TSS.

Grazing areas represent approximately 45% of the land area of the catchment but only 4% of the total flows, due to being located in much lower rainfall areas of the catchment. Despite this small contribution of flow, these areas can represent a significant source of other pollutants, in particular enterococci. This can indicate the potential for enteric pathogens such as Campylobacter, Salmonella, Cryptosporidium, Giardia and E.coli but the extent to which these are a problem will depend on the level of shedding from infected stock. Dairy is a very small land use in the catchment, covering less than 1% of the land area but is estimated to contribute approximately 2% of the TN, 4% of the TP and over 20% of the enterococci load in the catchment. As was the case with grazing, dairy areas produce well below their relative land use area in flows due to their location in the catchment.

Urban areas are a very small land use in the catchment, covering only 1% of the land area. They contribute substantially higher proportions of the total load than this relative area, ranging from 14% to 18% of nutrient and sediment loads.

Cropping areas are a small land use in the catchment (3%) and produce a very small proportion of total loads (approximately 1% of nutrients and sediments). This is generally due to the lower rainfall and flows that occurs in these areas.

The topology of the greater TEER catchment varies from plains and low hills characterised by agriculture, to plateaus of the Western Tiers, Ben Lomond and Eastern Highlands (GHD, 2009a). Land cover is a significant factor for contributing runoff that enters the system however slope and rainfall are also important contributing factors. High rainfall areas tend to be at the top of the catchment and hence tend to produce higher flows and potentially higher loads compared to their area. This helps to explain estimates of significant pollutant load contributions from land uses such as greenspace and native production forest shown in Figure 5. While groundcover in industries such as intensive agriculture, broadacre cropping, dairy and grazing can be managed, higher flows from high rainfall forested slopes are largely 'uncontrollable'. For activities located lower down in the catchment such as agriculture and urban land, high loads produced from smaller land areas are associated with land clearing as well as land and water management.

1.4.3.3 How do loads now differ from natural loads?

It is to be expected that the changing nature of land use throughout the greater TEER catchment since European settlement has resulted in increased rainfall-runoff and pollutant loads compared to what would naturally occur in the system. Figure 6 shows an estimate of the increase in flows and loads likely to have resulted by European settlement and subsequent land clearing and development in the catchment. Note that this is a rough modelled estimate based on the impact of land use changes on rainfall runoff and pollutant concentrations only and does not consider the effects of any inter-basin transfers of water or flow regulation by dams.

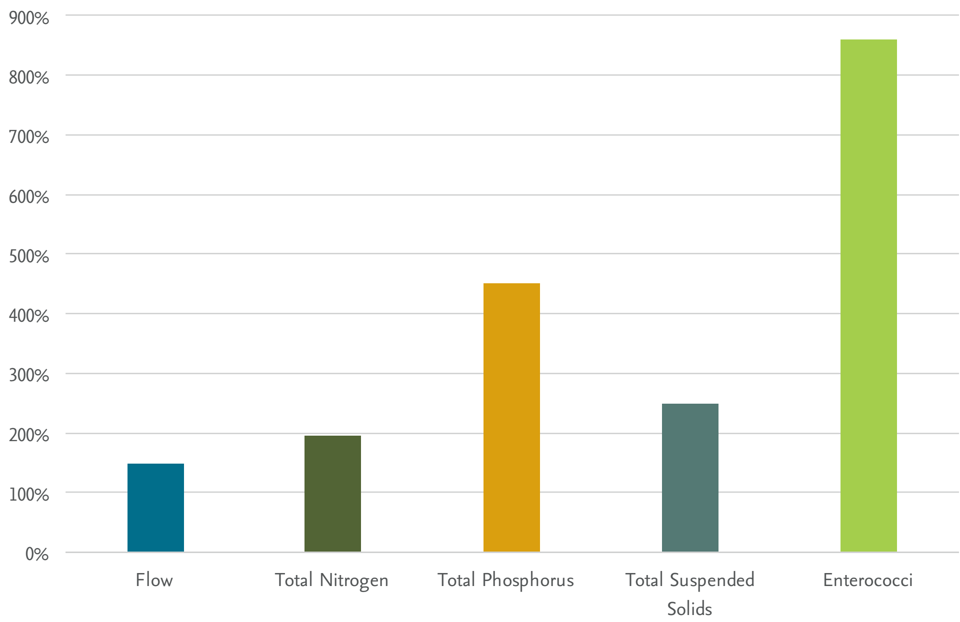


Figure 6. Modelled increase in pollutant and flow from natural loads

This figure shows significant increases in all pollutants and flow from what would be expected naturally in the greater Tamar Estuary and Esk Rivers catchment. The greatest pollutant increase has been in the enterococci load which is about 10 times greater than would be expected naturally. This increase can be attributed to introduced stock in dairy and grazing areas as well as to sewer overflows. There has been approximately a 450% increase in TP loads, 250% increase in TSS and 200% increase in TN in the system compared to estimated pre-European loads. Current flows are approximately 150% higher than pre-European flows due to increased imperviousness of the catchment and reduced filtering and buffering of flows associated with land clearing.

1.5 Spatial Analysis and Geographic Areas Adopted in the Plan

1.5.1 Freshwater Reporting Zones

The WQIP has adopted the TEER Freshwater Report Card reporting zones as the spatial area for analysis and reporting of results for freshwater. Figure 7 shows the TEER Freshwater Report Card major water catchments which have been split into two reporting zones for highlands shaded green (typically above 400m above sea level); and, lowlands shaded yellow (typically below 400m above sea level).

The split in catchment elevation at 400m above sea level corresponds largely to land use, with highland areas consisting mostly of undeveloped and forested areas, while lowlands generally contain a mix of agricultural and urban landscapes. Overall, highland areas were found to be in good condition as a result of being relatively undeveloped. Lowland areas are generally impacted from land clearing and the loss of vegetated riparian zones due to agricultural and urban development.

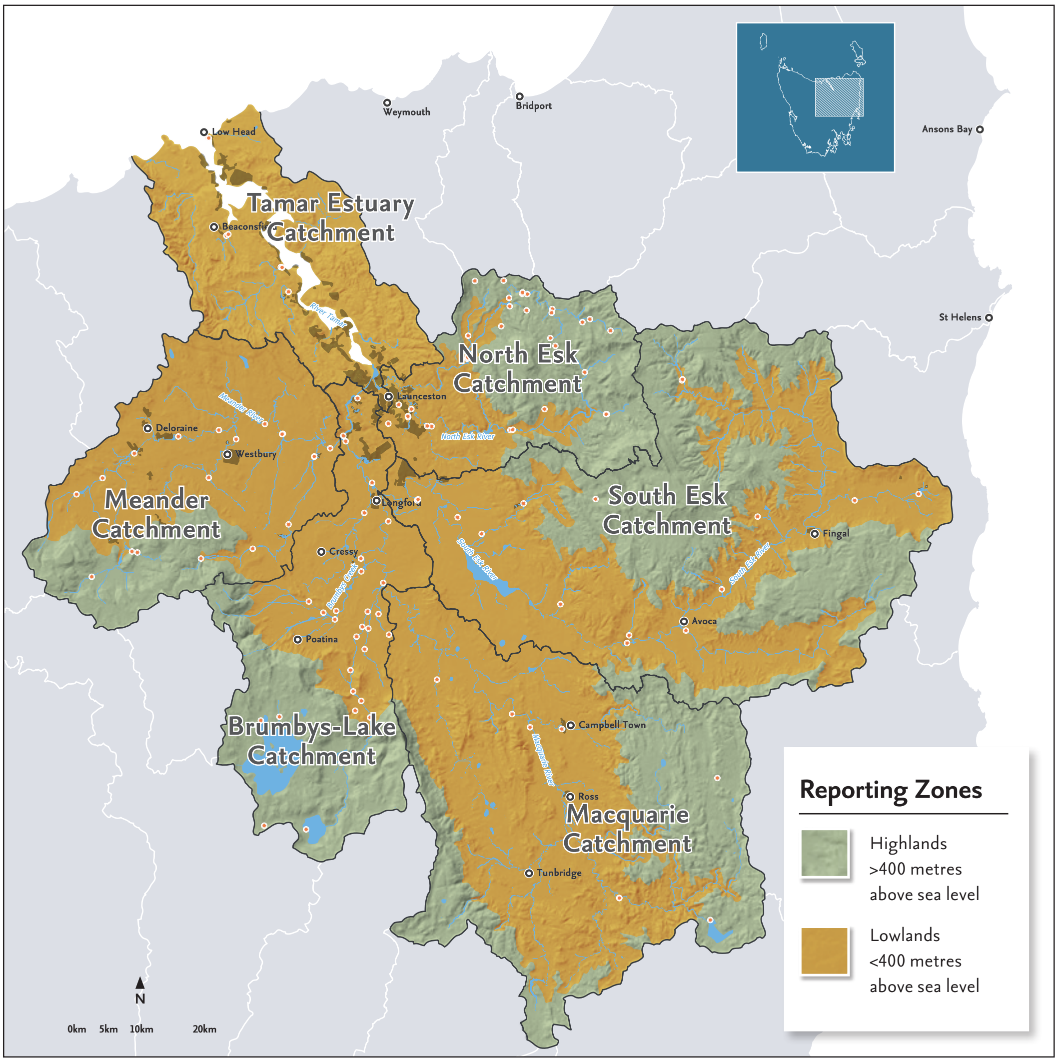


Figure 7. Greater TEER catchment freshwater report card catchments and reporting zones

1.5.2 Estuary Reporting Zones

The WQIP has adopted the TEER Tamar Estuary Report Card zones as the spatial area for analysis and reporting of results for the estuary. The Tamar River estuary has been divided into five functional zones that reflect differences in critical habitats, key processes and anthropogenic impacts of the estuary (Figure 8). A functional zone is defined as a geographic entity with common structural and functional characteristics which can be defined in a conceptual model and quantified by measurement (Dennison *et al.*, 1999). The zones provide a focus for management actions and future research (Pantus and Dennison, 2005). The five functional zones define clear boundaries through which change can be measured over time along the length of the estuary.

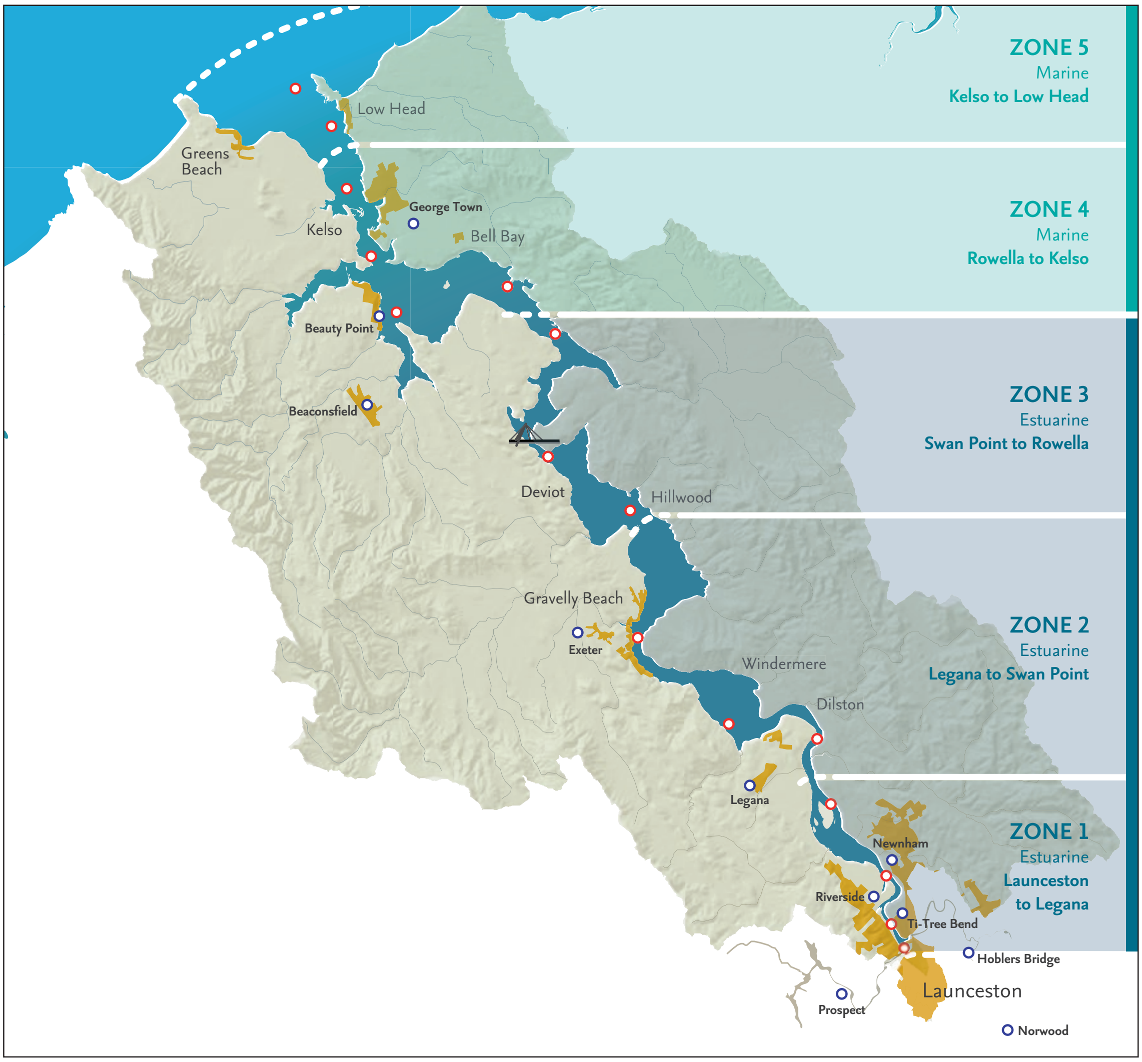


Figure 8. Five functional zones of the Tamar River estuary

Zones 1 to 3 are in the upper estuary and are considered estuarine. Zones 4 and 5 are strongly influenced by the ocean and tidal flushing and are considered to be marine zones. In general the condition of the estuary improves as you move downstream.

More information related to the condition and health of the Tamar Estuary and Esk Rivers waterways can be found in the TEER Freshwater and Estuary report cards available online via www.nrmnorth.org.au/teer.

section 2

POTENTIAL IMPACTS OF LAND USE CHANGE AND MANAGEMENT

This Section provides numerous stories around land use and point source contributions to pollutant loads as well as the effectiveness of potential management actions to address these. These stories were based on feedback from stakeholder workshops held throughout the plan development and rely on analysis of results from the TEER CAPER DSS. Stories have various purposes:

- To demonstrate the benefits of past management actions;
- To explore the impacts of potential future land use change with and without best management practices; and
- To assess the leverage and effectiveness of potential management actions on current land uses to prioritise management actions. These scenarios assume different levels of adoption for different incentive and education programs, based on key stakeholder feedback on rates of adoption.

These stories are used to develop a set of load targets presented in Section 3. These load targets are based on feasible levels of adoption of Best Management Practices (BMP) across all land uses, using both the current land use configuration and population as well as potential future land use and population.

2.1 Grazing Management in the Tamar Estuary and Esk Rivers Catchment

Dryland grazing accounts for just under half (45%) of the total area of the Tamar Estuary and Esk Rivers catchment. These areas contribute substantial proportions of the diffuse loads generated in the catchment, with one-third of the diffuse total nitrogen and 50% of the diffuse enterococci coming from grazing areas (see Figure 5). While high rainfall in upper forested areas of the catchment supply the largest proportion of sediments and phosphorus, grazing areas are a significant controllable source of these pollutants.

Figure 9 shows the relative contribution of grazing areas to loads and area for each of the catchments of the greater TEER catchment. This figure shows that grazing areas are a significant contributor to pathogen loads in all catchments except the Meander highlands. They make a substantial contribution (32%) to enterococci loads in the Meander lowlands although dairy areas contribute a greater total proportion (48%). Grazing areas make varying contributions to nutrient and sediment loads in other subcatchments:

- They are the main controllable source of TN from the Tamar catchment (39%), the Brumbys-Lake (47%), South Esk (22%) and North Esk (46%) highlands as well as from the Macquarie (61% and 66%) and Meander (31% and 38%) highlands and lowlands.
- They are the main controllable source of TP in the Macquarie highlands (56%) and lowlands (28%), and in the North (12%) and South Esk (8%) highlands.
- They make relatively small relative contributions to TSS except in the highlands of the Macquarie (25%), North Esk (10%) and South Esk (5%) where they are the main controllable source of TSS (equal with urban areas in the South Esk highlands).

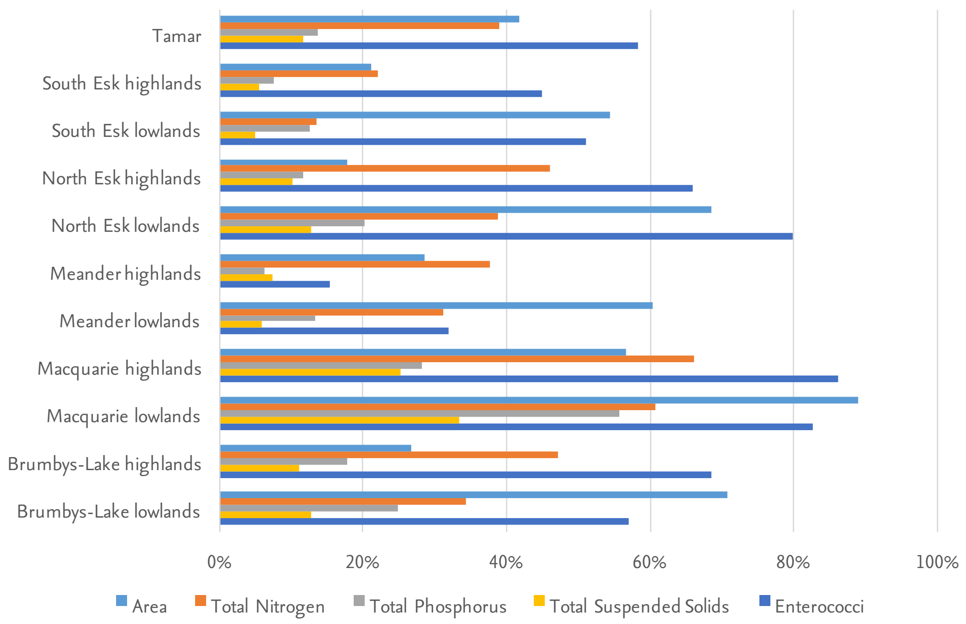


Figure 9. Relative contribution of grazing to loads and area by catchment

Grazing management is an important component of improving water quality both at the greater TEER catchment scale and in individual catchments and subcatchments. This section describes the potential for 3 grazing management options to improve water quality in the greater TEER catchment:

- Groundcover management;
- Restricting stock access to streams; and
- Creating vegetated riparian buffers.

This analysis has been undertaken using the TEER CAPER DSS that has been constructed to support the development of this plan. All estimates of adoption for best practice management actions were obtained using key stakeholder feedback from a facilitated workshop discussion, summarised in Appendix 4.

2.1.1 Groundcover Management

Groundcover management has the potential to substantially improve water quality at a whole-of-catchment scale. Good groundcover management is seen by key stakeholders as being a highly adoptable management option given it is largely a win-win option, leading to long term productivity improvements through a decrease in the loss of productive soils and improved fertility and production. Stakeholders indicated that management should aim to achieve current maximum or greater levels of groundcover across the catchment over the medium to long term. Key stakeholders indicated that the level of adoption of good groundcover management practices would be 85% or more with well-designed extension programs.

Several options for improved groundcover were analysed based on ideas provided by key stakeholders. These are:

- Groundcover is lifted to at least the current median groundcover level across all subcatchments;
- Groundcover is lifted to at least the 90th percentile of groundcover level across all subcatchments;
- Groundcover is lifted to at least the 95th percentile of groundcover level across all subcatchments; and
- Groundcover is lifted to the current maximum groundcover level across all subcatchments.

Figure 10 shows the impact of these options on total diffuse loads (not including loads from the combined system in Launceston) from the greater Tamar Estuary and Esk Rivers catchment. This shows that groundcover management has the potential to improve water quality, with decreases in nutrients and sediments of roughly 2% for the maximum groundcover option and 11% in enterococci. The most modest option, raising groundcover in areas where it is low up to the median groundcover level, achieves reductions of between 0.2% and 1.2% of diffuse pollutant loads.

Figure 10. Impacts of groundcover management on dryland grazing (including rural residential) areas on diffuse loads

The relative costs per unit load of each of these options have also been compared. For ease of comparison these are shown in Figure 11 relative to the cost per unit load of TN (i.e. per kg) for the option which raises groundcover to at least median levels. Note that relative costs per unit load reduced of other pollutants are very similar to those for TN. This figure shows that the average cost of each additional unit of load reduction decreases moving from the median to 90th percentile options, and then stays relatively stable. Further investigation at a subcatchment scale indicates this pattern is not generally the case – for most subcatchments the relative cost of each option increases as the level of groundcover being established increases. Results at the subcatchment scale reinforce the importance of focusing first on the areas with the poorest groundcover and achieving small to moderate improvements on these areas before focusing on improving areas where groundcover is already relatively good compared to the catchment average.

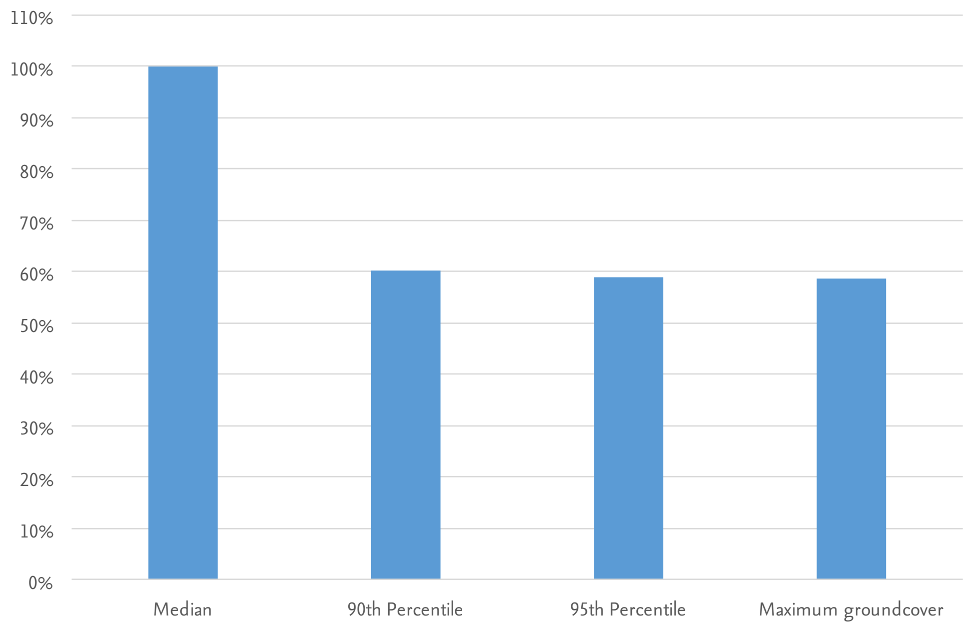


Figure 11. Relative costs per unit load reduction of options for groundcover management

2.1.2 Stock Access to Streams

Stock accessing streams leads to bank erosion as well as direct deposits of pollutants through manure and urine from stock to the stream. Two separate management options have been considered for excluding stock from streams, based on suggestions by key stakeholders:

- Stock are excluded from streams entirely and provided with off-stream water troughs to access water; and
- Stock are excluded from streams for almost their entire length, with relatively small hardened access points provided for stock water access. Fencing would be needed into the stream to stop stock accessing the broader riparian zone. For the purposes of this analysis it has been assumed that these gaps in riparian fencing would cover 5% of the total length of streams from which stock are being excluded.

Note that this analysis considers only the impacts of direct deposits of manure and urine to the stream and excludes the benefits of reduced bank erosion and reduced stirring up of bottom sediments. This means it will significantly underestimate the impacts of stock exclusion on TSS and to a lesser extent, nutrients.

The total impact on pollutant loads considering 100% adoption of each management action is analysed below before limitations on the adoptability, and consequent achievable load reductions are considered. Figure 12 shows the potential decreases in pollutant loads achievable for the greater TEER catchment if these stock exclusion actions were adopted by 100% of landholders not currently restricting stock access to streams. This figure shows that total stock exclusion is slightly more effective at reducing loads than limited hardened access, in line with the assumption that stock retain access to 5% of the stream under this option. These actions have the greatest potential impact on enterococci loads when compared with groundcover management and revegetation of the riparian zone, potentially leading to reductions of up to 10% of total diffuse catchment loads. Nutrient loads could be expected to decrease by 3 to 4% respectively, while a smaller reduction of TSS in the order of 1% can be expected. As previously discussed, it should be noted that the impact on TSS here is underestimated as it does not consider changes in stream bank erosion resulting from restricting stock access to streams.

Figure 12. Modelled potential change in diffuse loads if 100% adoption of stock access management actions were achieved

Feedback from stakeholders indicates that there are physical constraints that make provision of off-stream water difficult in some cases, and that often, limited hardened access points in these areas are a good compromise which improve water quality while addressing landholder needs. Landholders recounted their experience that cattle will move away from narrow watering areas after getting a drink to avoid overcrowding in these areas, rather than congregating in and around the stream. It was also suggested that maintenance of troughs and pumps, the natural movement of streams and issues with lost infrastructure during flooding can make management options designed to exclude stock from streams less adoptable by landholders than other options such as groundcover management. It should be noted that providing limited hardened access is likely to come with its own difficulties as fencing would need to extend into the stream and is likely to be affected by flooding and high flows in many areas.

Scenarios have been analysed considering two different levels of adoption:

- Based on a situation where no incentives are provided to landholders to undertake the works; and
- Based on the provision of reasonable upfront financial incentives to undertake works.

A third option to also provide some funding incentives to cover ongoing maintenance costs was not considered as stakeholders did not feel this would increase adoption rates for these options. Assumed levels of adoption of these options provided by key stakeholders are given in Table 3.

Table 3. Assumed rates of adoption of stock exclusion scenario options

	Without incentives	With incentives
No access with off-stream water provided	5%	15%
Small areas (5%) of hardened access only	10%	25%

These scenarios have been analysed to consider their impact on diffuse pollutants generated from the greater TEER catchment. Figure 13 shows that if these adoption rates are assumed, the most effective option for all pollutants is to provide incentives to allow landholders to fence off the majority of the stream with limited access provided for watering. Feedback from key stakeholders indicates that this option may be significantly more adoptable than the other options. This means that even though pollutant reductions per kilometre of stream fenced are not as great as for the option to allow no access, the net effect on streams of more landholders adopting the option still provides overall better water quality outcomes at the catchment scale. However, it should be noted that there may be physical constraints in some areas that make this option difficult to adopt. In particular, the need to fence into the stream and issues around loss of fencing during floods would need to be considered.

The second greatest impact is seen for no access allowed where incentives are provided. This shows the importance of providing incentives to achieve reasonable adoption of these actions and greater improvements in water quality regardless of the specific practice being adopted.

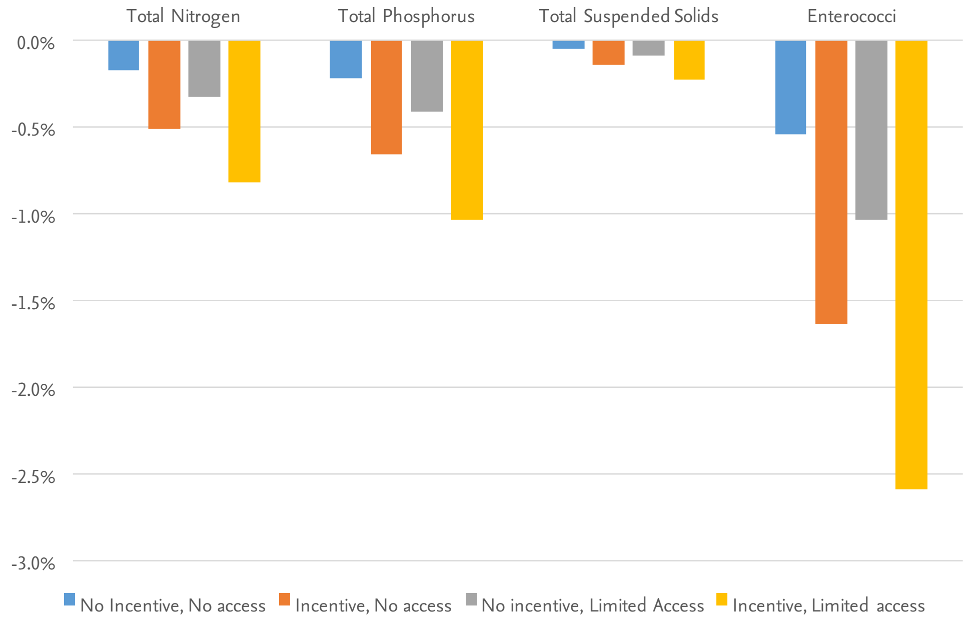


Figure 13. Modelled impacts of stock access on total diffuse catchment pollutant loads

Impacts are greatest on enterococci for all options and smallest on TSS as manure is a significant source of pathogens but a relatively small source of sediments. The estimated reductions in TSS are likely to be very conservative as this analysis doesn't account for the benefits of reduced bank erosion, which would be a significant source of sediments to streams where stock access occurs.

Benefits from reduced stock access are significantly smaller than for improvements in groundcover at the catchment scale in part because of the relative levels of adoption of each action. Reducing stock access to streams is expected to have much lower levels of adoption than improving groundcover due to landholder preferences, for example due to: issues with weeds, pests and flooding associated with limiting stock access to streams; perceived productivity benefits of improved groundcover; and higher costs associated with fencing streams relative to improving groundcover. One issue with improving groundcover management is the relative difficulty of designing incentives suitable to increasing the adoptability of this action.

The relative costs per unit load reduced of the 'No access' option relative to the 'Limited action' option are shown in Figure 14. Note that these use indicative costs that don't vary across regions or streams. In reality, it can be expected that costs will differ from one farm to another depending on the specific requirements of the individual farm and stream. This figure shows that the cost per unit load reduction of excluding stock entirely from the stream is nearly 10 times higher than allowing for limited access for stock watering. This is due in part to the costs associated with providing off-stream water points where stock have no access to the stream. These cost differences are a large part of the reason that landholders are more likely to adopt an option which allows limited hardened access to the stream for stock watering. These costs are on top of other physical and management constraints associated with needing to adequately locate troughs and manage pumps and other infrastructure. Other reasons relate to the need for ongoing maintenance and more time consuming day to day management of troughs and pumps providing off-stream water.

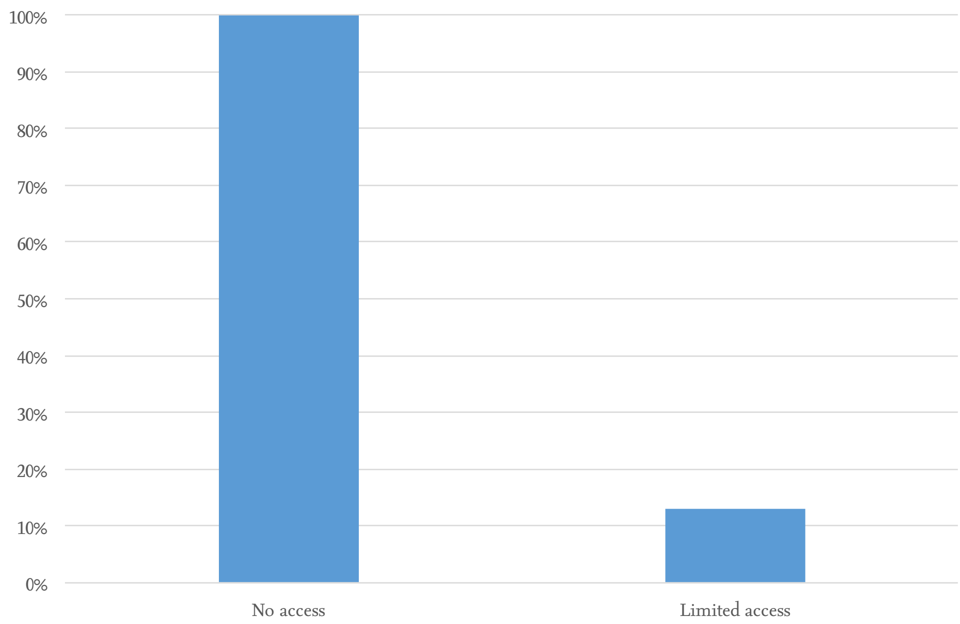


Figure 14. *Relative costs per unit load reduction of options for reducing stock access to streams*

2.1.3 Riparian Buffers

The final management option available for managing dryland grazing areas is the use of vegetated riparian buffers. These buffers act to capture pollutants from sheet flow that passes through the buffer on their way to the stream. They are generally not effective for removing pollutants from channelized flows. Figure 15 shows the modelled potential change in total catchment pollutant loads if these differing widths of riparian zone are implemented for all areas currently unvegetated in grazing landscapes. This figure shows that 20m buffers are nearly twice as effective at removing pollutants as 5m buffers. Reductions vary by pollutant and width, with 5m buffers being most effective for reducing sediments compared to other pollutants, while 20m buffers remove proportionally more TN. Overall if 100% adoption of vegetated riparian buffers could be achieved on areas where no buffers currently exist then loads could be reduced by roughly 1.5% with a 5m buffer, 2 to 2.5% with a 10m buffer and 2 to just over 3% with a 20m buffer.

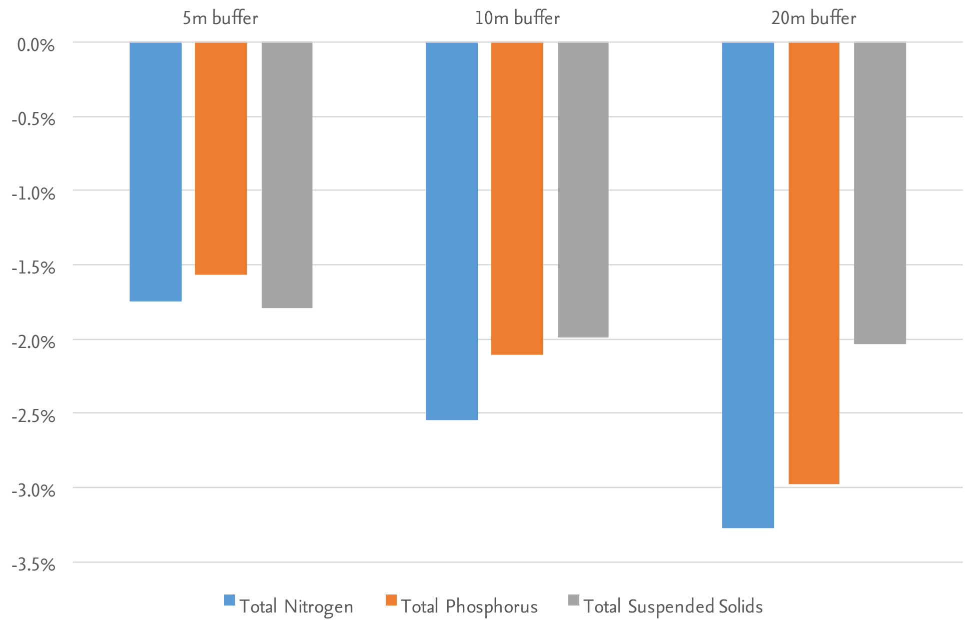


Figure 15. Modelled potential change in diffuse loads if 100% adoption of riparian buffer actions were achieved

Feedback from key stakeholders indicates that landholders are more likely to adopt vegetated riparian buffers than restricting stock access to streams. They are also more likely to adopt this action for narrower buffers and where incentives are provided for both upfront costs and maintenance of plantings for the first 10 years while these buffers are being established. Relative adoption rates for these options provided by key stakeholders are provided in Table 4. Values given in brackets are those used in the analysis below.

Table 4. Assumed rates of adoption of riparian buffer scenario options

Buffer size	Without incentives	With upfront incentives	Upfront incentives + maintenance funding 10 years
5m	<5% (3%)	50-60% (55%)	70-80% (75%)
10m	<5% (3%)	30-40% (35%)	50-60% (55%)
20m	<5% (3%)	10-20% (15%)	30-40% (35%)

Impacts on total diffuse catchment pollutant loads for these options are given in Figure 16. This figure shows that even though wider buffers reduce pollutant loads more per kilometre than narrower buffers, the increased adoptability of narrower buffers means that, so long as some incentives are offered, water quality outcomes at the catchment scale can be optimised with narrower rather than wider buffer widths. For TSS, a 5m buffer (with incentives) produces better outcomes than both 10m buffers and 20m buffers with the same type of incentives. For TP, there is little difference between 5m and 10m buffers where maintenance costs are provided but 5m buffers are more effective when incentives for only upfront costs are provided. For TN, where maintenance costs are provided, 10m buffers produce a slightly greater benefit than 5m buffers, with this relationship reversed when only upfront cost incentives are provided. Note that in all cases where incentives are provided, 20m buffers produce the worst water quality outcome of the various options at the catchment scale because of their lower adoptability. Incentives of some sort are necessary to get any substantial benefits to water quality. Providing incentives to assist with maintenance costs can boost water quality benefits to range from nearly 0.7% to 1.4% versus 0.4% to 1% where incentives are provided for upfront costs only.

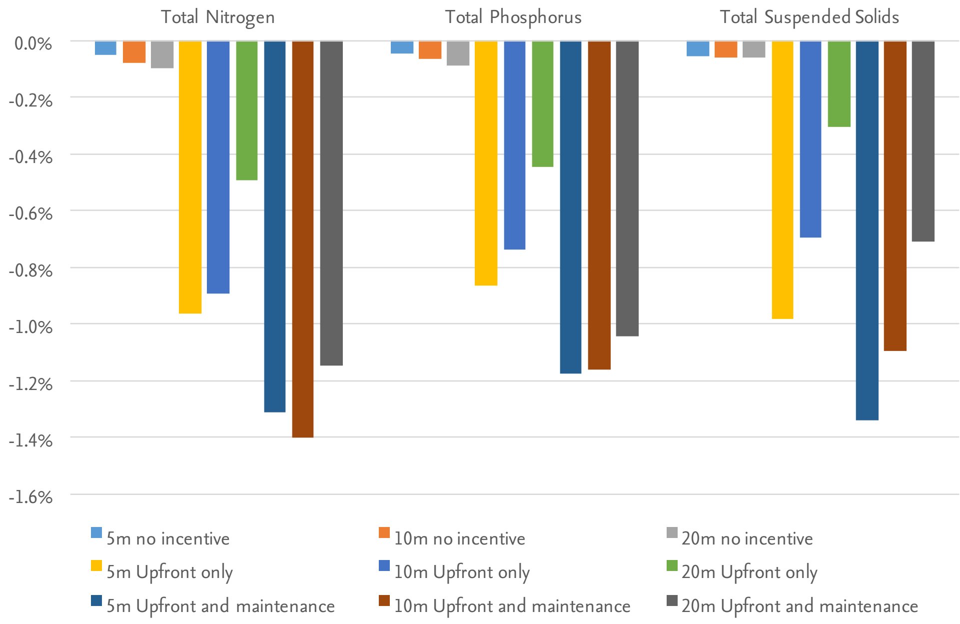


Figure 16. Modelled impacts of riparian buffers on total diffuse catchment pollutant loads

The relative costs per unit load reduced of the different buffer widths are shown in Figure 17 (note there are no differences between relative unit costs for different incentive levels). This figure shows the costs per unit load reduced of 10m buffers are between 1.4 and 1.8 times that of a 5m buffer, and for 20m buffers are between 2 and 3.5 times higher than for 5m buffers depending on which pollutant is used in the analysis. This only accounts for the costs of revegetation and so is likely to be further exacerbated by costs to landholders including the loss of productive land due to wider buffers and issues of weed and pest management in wider buffers. These increased costs are offset to some degree by the improved biodiversity outcomes and benefits provided by establishing wider buffers in terms of improved stream stability.

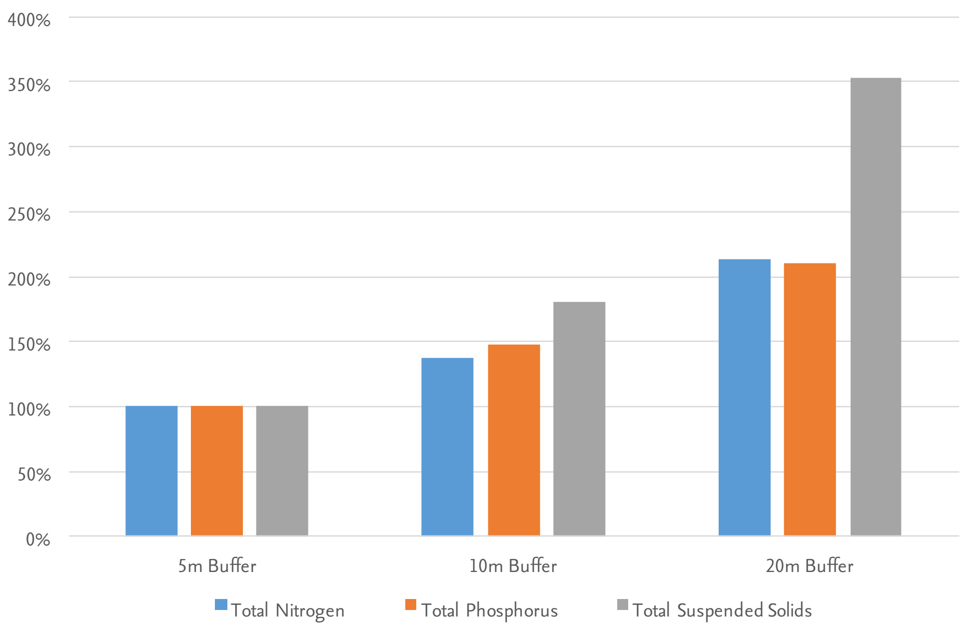


Figure 17. Relative costs per unit load reduction of options for incorporating vegetated riparian buffers

2.1.4 Recommendations

Based on this analysis and feedback from key stakeholders, recommendations for managing dryland grazing areas are:

- A major focus of management should be on improving groundcover management in identified high and medium priority catchments emphasising productivity benefits to landholders.
  - In the short term emphasis should be placed on getting those landholders not yet meeting median groundcover levels to improve to this level before trying to improve the groundcover on other farms.
- Actions to reduce stock access to streams should focus on lower cost solutions that are flexible to physical constraints on specific farms as well as the needs and preferences of individual farmers:
  - In catchments where riparian revegetation is not a priority action or where there are significant physical constraints, simply excluding stock from the stream with narrow fenced buffers should be considered.
  - Options where the stock are restricted from entering most of the stream while still having limited hardened access for stock watering should be considered where this is the preference of the landholder to increase the adoption and lower the overall cost of this action.
  - The specific design of fencing (e.g. single wire fencing versus six wires fences) should be determined on a case by case basis with landholders depending on their preferences so long as the fencing adequately restricts stock access to the stream.
  - Incentives should focus on compensating for the initial costs of fencing out streams.
- The primary focus of efforts to revegetate the riparian zone in order to improve water quality (not including biodiversity outcomes) should be on establishing broadscale adoption of narrower buffers (5m). For example, it would be substantially more effective for a landholder to create a 200m long, 5m wide buffer than 100m long 10m wide buffer. Where landholders are happy to establish wider buffers on the same length of stream this should be encouraged.
  - Limited stock access to riparian zones (e.g. crash grazing to keep weeds out) should not be actively discouraged except in sensitive areas where limiting stock access has been identified as a priority.
  - Incentives for revegetating riparian zones should be developed to address both upfront and ongoing maintenance costs for at least the first five years of establishment.

2.2 Future Land Use Change: Potential Dairy Expansion

Dairy areas are currently a very small part of the greater TEER catchment, covering less than 1% of the total area of the catchment (0.6%). As such they contribute a very small proportion of the total nutrient and sediment loads generated in the greater TEER catchment. They produce below their relative areal contribution of diffuse TSS loads (0.4%) but above their areal weight of nutrients (1.8% TN, 4.2% TP) and substantial proportion of enterococci (21%).

Figure 18 shows the relative intensity of dairy farming in the catchment, showing dairy as a percentage of catchment area. This figure shows that dairy farms are concentrated in the Meander River catchment, and to a lesser extent in the Brumbys-Lake catchment. Relatively low intensity dairying is also found in the Tamar catchment and the Macquarie catchment.

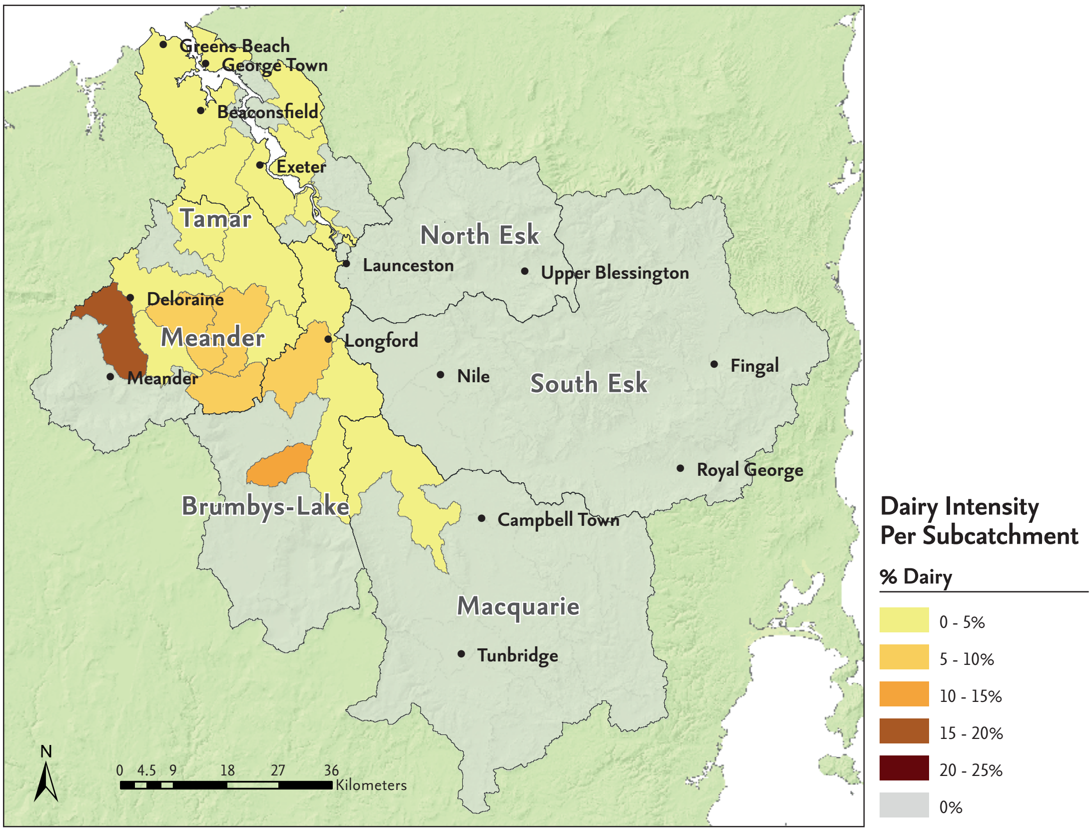


Figure 18. Intensity of dairy farms in the greater TEER catchment

Figure 19 shows the relative contribution of dairy to loads from each of the catchments of the greater TEER catchment. Dairying currently has its greatest impact on diffuse loads in the Meander highlands, where it is estimated that 10% TN, 32% TP, 3% TSS and 72% of enterococci are generated from dairy areas. It contributes much smaller proportions of the total loads to the Tamar catchment, Macquarie, Brumbys-Lake and Meander lowlands (1-2% TN, 1-9% TP, <1% TSS and 8 to 48% enterococci).

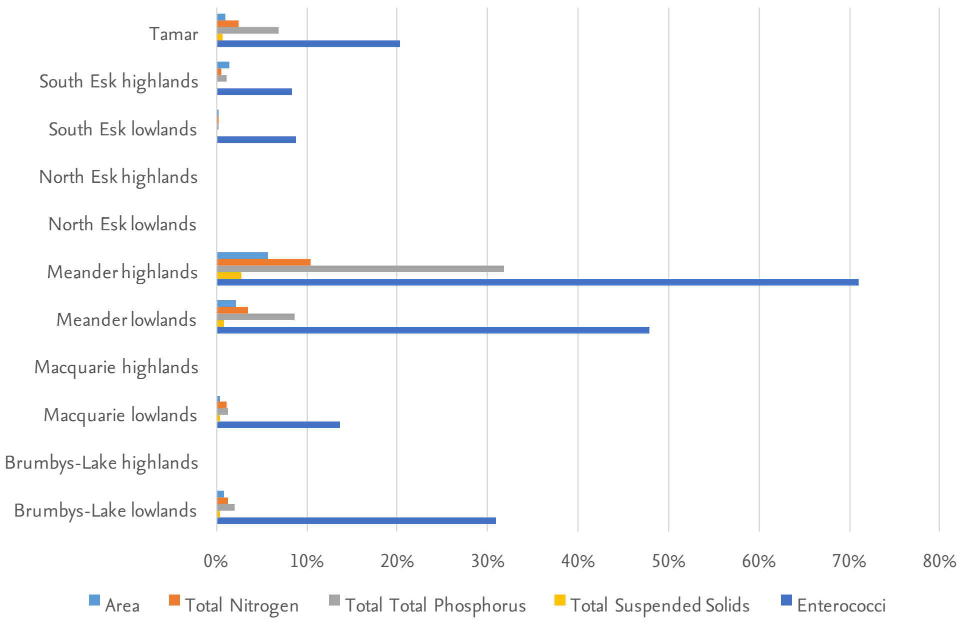


Figure 19. Relative contribution of dairy to catchment loads and areas

Over the coming years, substantial increases in dairy areas and dairy cow numbers are expected to be seen in the greater TEER catchment. While dairying currently contributes relatively small proportions of the total loads generated in the greater catchment, this expansion has the potential to lead to significant declines in water quality in some catchments if expansion occurs without adequate adoption of best management practice (BMP).

Analysis has been undertaken using the TEER CAPER DSS to explore the impacts of potential options for expansion, considering varying levels of adoption of BMP to show both the potential threats and opportunities to water quality associated with dairy expansion. A more detailed analysis of the potential leverage of specific management actions in reducing catchment loads is then provided.

2.2.1 Potential Impacts of Dairy Expansion on the Greater TEER Catchment

Four different dairy expansion options have been analysed to test whether they significantly affect the impacts of dairy expansion. All options considered the scenario where an additional 38,000 dairy cows are incorporated in the greater TEER catchment. Assumptions for where expansion would occur and its impacts on areas and stocking rates in these subcatchments have been provided by Dairy Tasmania:

- Broadscale expansion on 11,000 ha
  - Entirely on existing grazing areas.
  - Preferentially on cropping areas (up to 80% of the existing cropping area in a catchment) followed by grazing areas where additional area is required.
- Intense expansion on 9,150 ha
  - Entirely on existing grazing areas.
  - Preferentially on cropping areas (up to 80% of the existing cropping area in a catchment) followed by grazing areas where additional area is required.

These potential futures were then considered with three levels of management practices:

- 'No BMP' - New areas have no BMP implemented (no change in practice on existing areas);
- 'Current BMP' - New areas have BMP applied to the same extent as current areas; and
- 'All BMP' – New areas have 100% BMP applied (no change in practice on existing areas).

Management practices tested on dairy areas are:

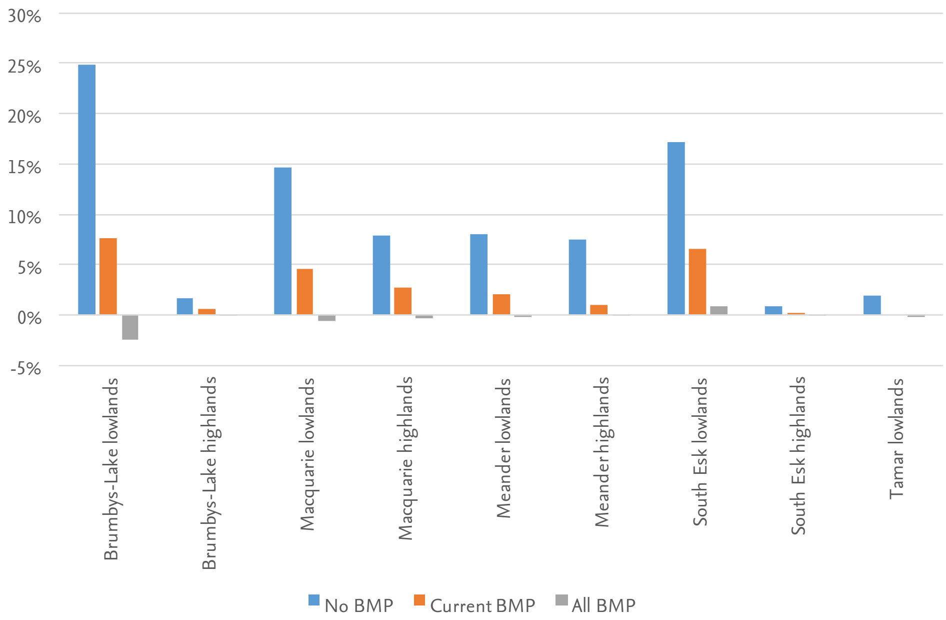
- Sufficient effluent storage is available;
- Stock are excluded from streams with off-stream water provided;
- 20m wide riparian buffers are created along all streams;
- Drains are vegetated to capture pollutants;
- Irrigation is managed to minimise pollutant loss;
- Fertiliser use is managed using nutrient budgets, with timing and application rates designed to minimise pollutant runoff; and
- Laneways are managed to reduce manure accumulation and runoff.

Figure 20 to Figure 23 show the impacts of these management scenarios on the various expansion options on TN, TP, TSS and enterococci loads from the freshwater report card zones in the greater TEER catchment as well as on pollutant loads from the whole catchment.

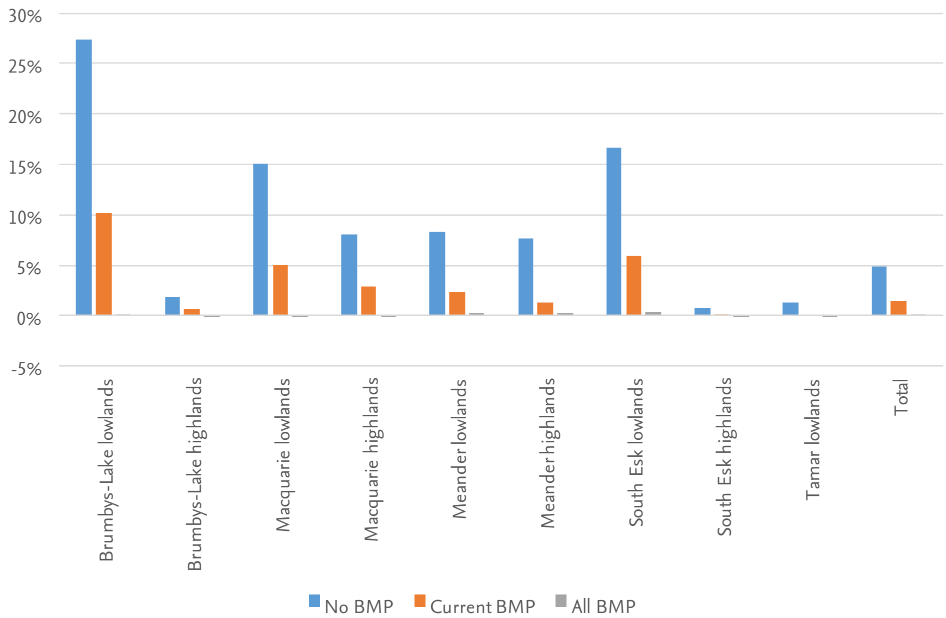
Overall this figure shows:

- Substantial increases in the loads of all pollutants can be expected from all scenarios where 'No BMP' are applied to expansion areas, with increases to pollutant loads from the greater TEER catchment ranging as follows: TN – ~ 5%; TP – ~9%; TSS – 1 to 6%; Enterococci – 100%
- In general, the greatest impacts of expansion are to be expected in the lowlands of the Brumbys-Lake catchment, followed by the Macquarie lowlands, Meander lowlands, South Esk lowlands and the highlands of the Meander catchment (with differing order depending on the pollutant and specific scenario).
  - Without BMP, increases in loads in the Brumbys-Lake catchment would be expected in the order of 25% TN, 45% TP, 9% TSS and 600% enterococci.
- Expansion with 'Current BMP' can be expected to reduce the impacts of expansion greatly below the 'No BMP' increases in load, although in many cases substantial increases in catchment loads can still be expected.
- Expansion with 'All BMP' has the potential to lead to no net increase and in some cases improve water quality compared to current loads.

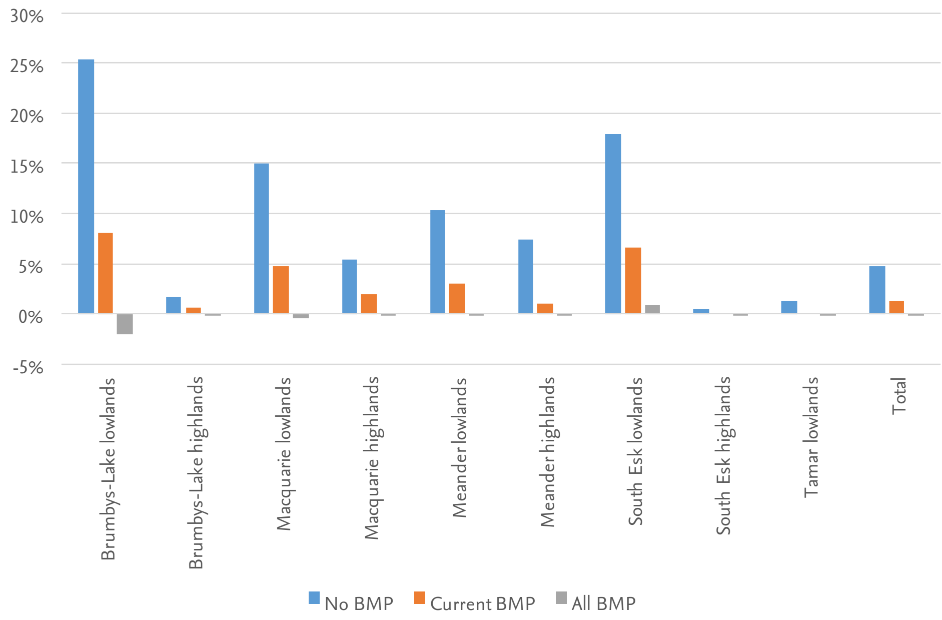
20A Grazing only, broadscale expansion



20B Cropping then grazing, broadscale expansion



20C Grazing only, intense expansion



20D Cropping then grazing, intense expansion

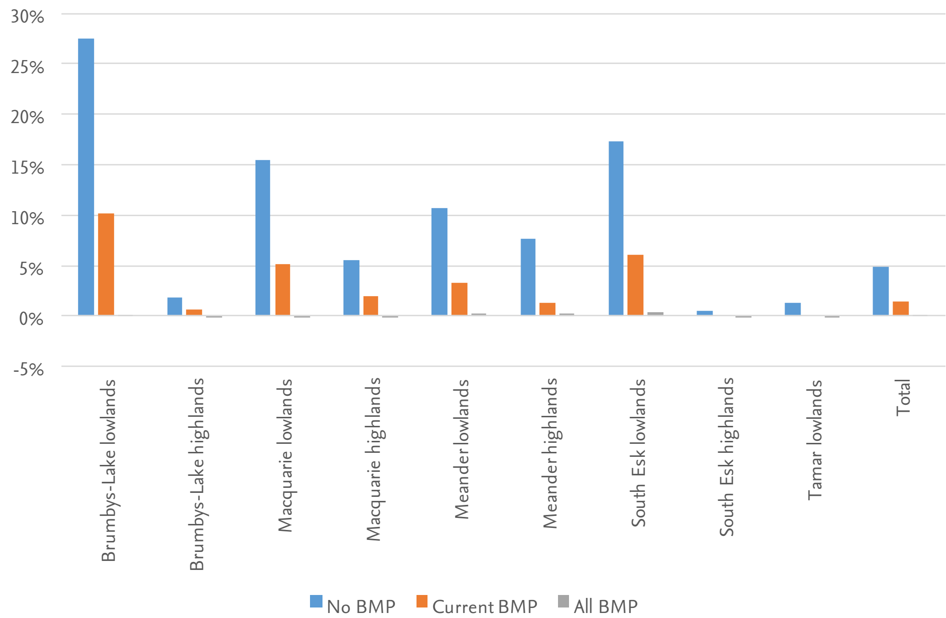
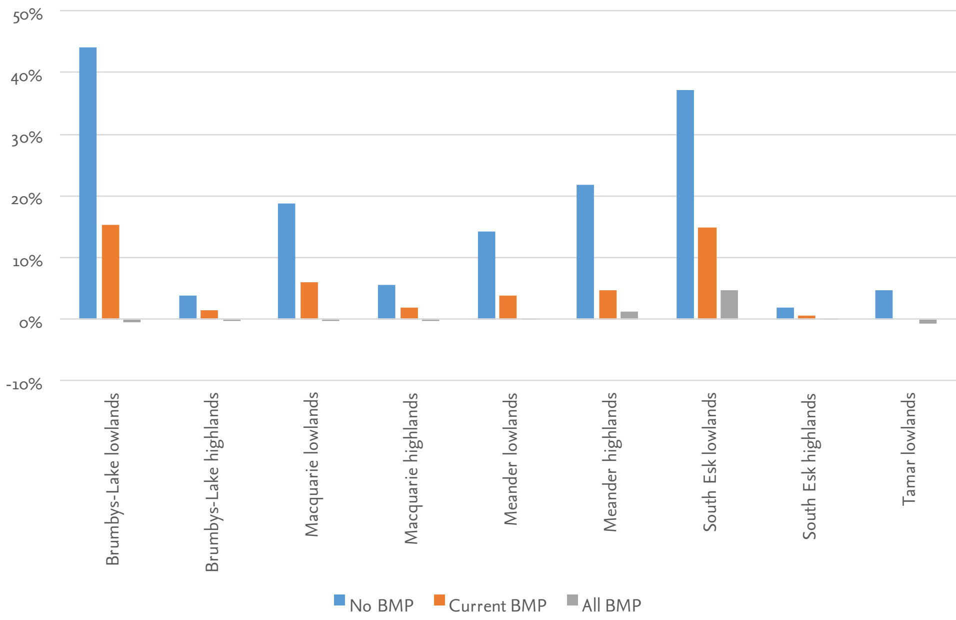


Figure 20. Modelled impacts of various dairy management practice options and expansion scenarios on total nitrogen

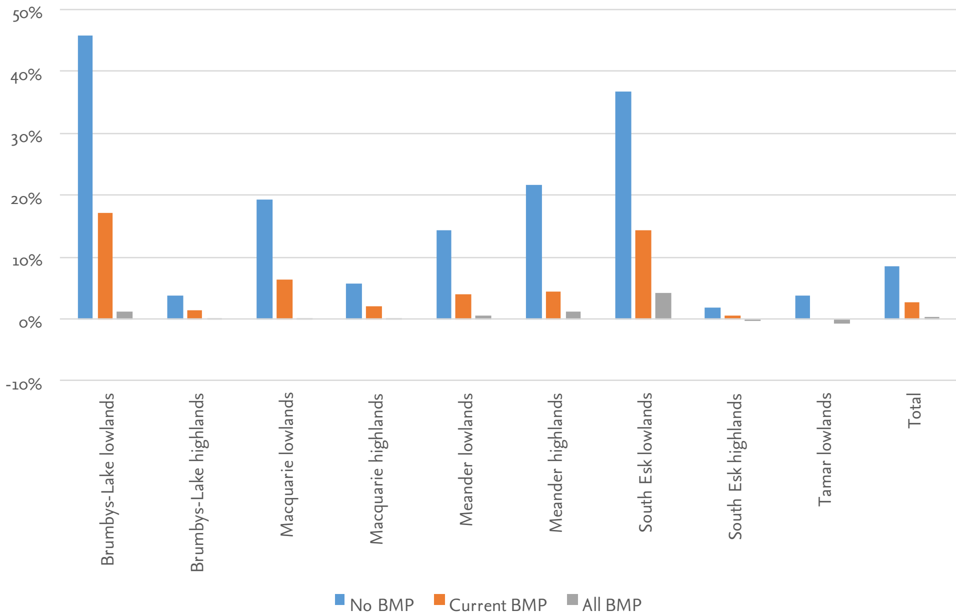
Figure 20 shows that, in general, increases in TN are greatest where intense expansion is undertaken on grazing areas only although this depends on the catchment.

- Relative impacts on individual catchments differ by expansion option. For example, the South Esk-lowlands experience a greater increase in TN loads under the broadscale expansion options than is experienced in the Meander lowlands, while this relationship is reversed where expansion is intense. This is largely because different areas are assumed to be affected in each catchment under each expansion option.
- Applying 'Current BMP' reduces increases in TN substantially for all catchments and expansion options. However, substantial increases in TN loads in some catchments would still be expected to occur.
  - TN loads are reduced to less than a third, and frequently substantially less, of the increase under the 'No BMP' scenario.
- Applying 100% BMP on new areas ('All BMP') can lead to no change in pollutant loads under dairy expansion, or in some catchments, decreases in TN loads.
  - Improvements are seen in some catchments where expansion occurs on grazing land, with decreases in the order of 2% of TN possible in the Brumbys-Lake lowlands.
  - Where expansion occurs on cropping then grazing areas, 'All BMP' is expected to constrain impacts in all catchment areas to effectively 0% change in TN.

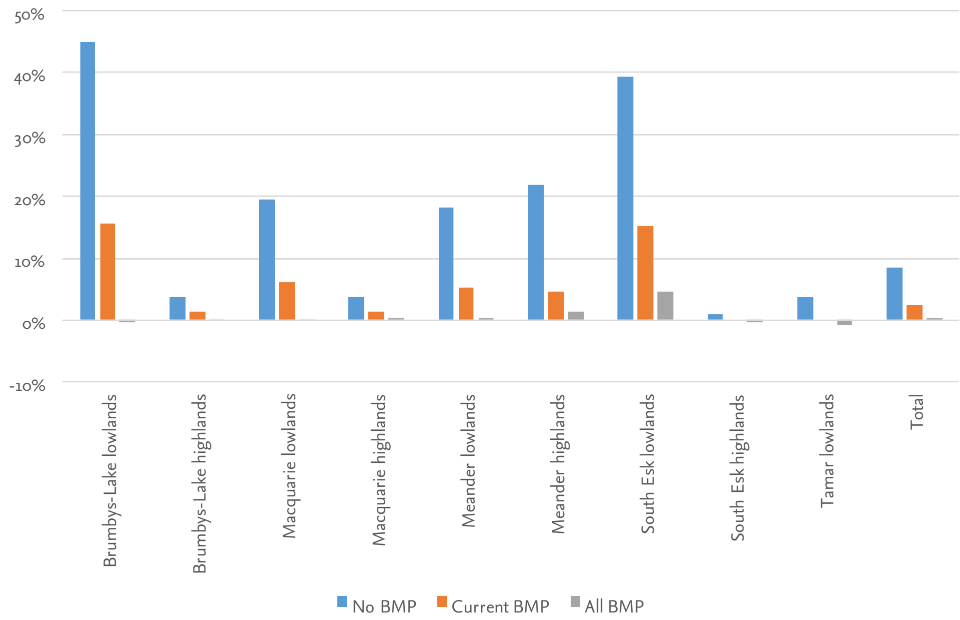
21A Grazing only, broadscale expansion



21B Cropping then grazing, broadscale expansion



21C Grazing only, intense expansion



21D Cropping then grazing, intense expansion

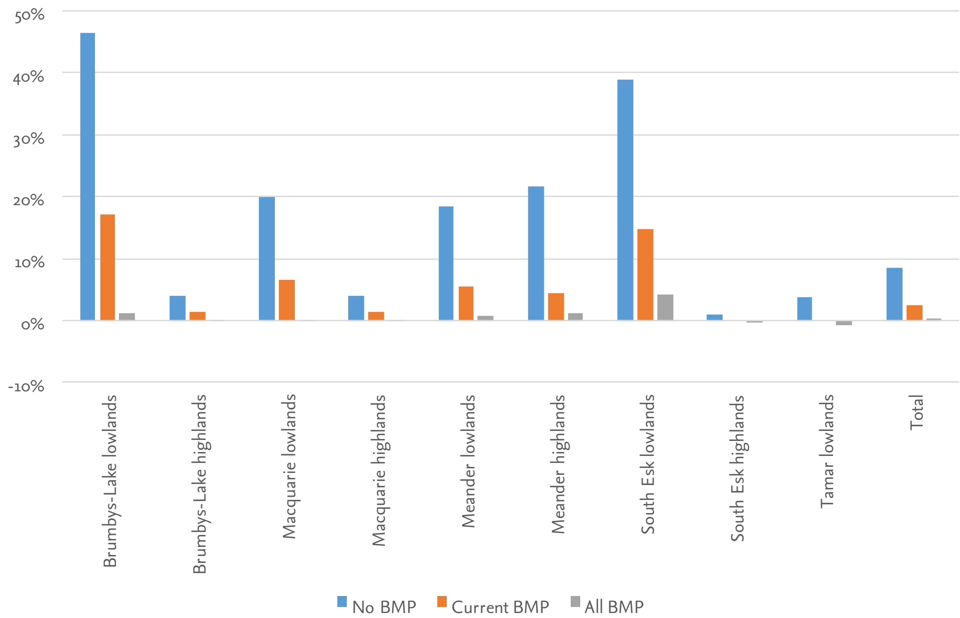
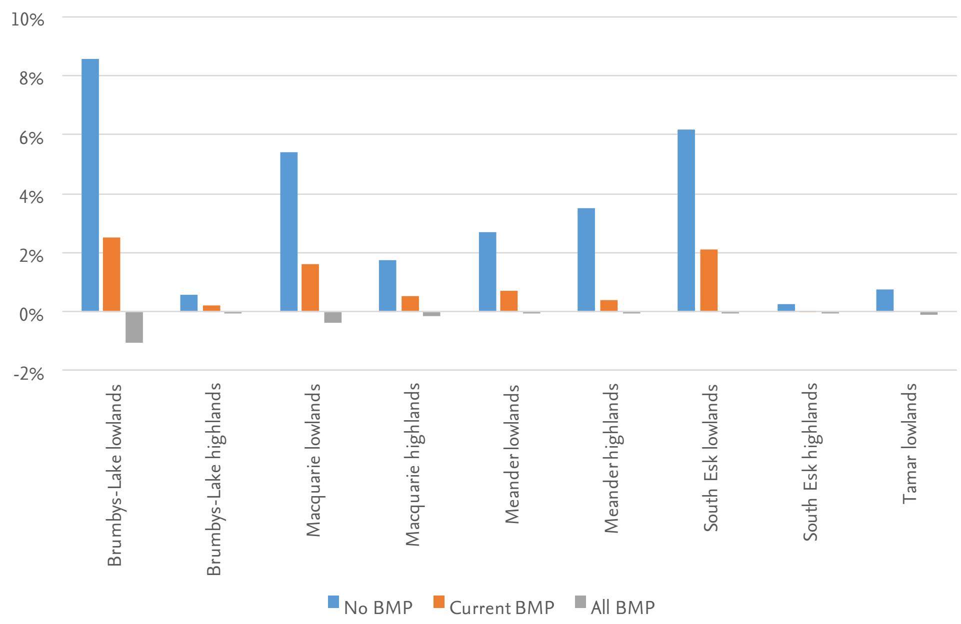


Figure 21. Modelled impacts of various dairy management practice options and expansion scenarios on total phosphorous

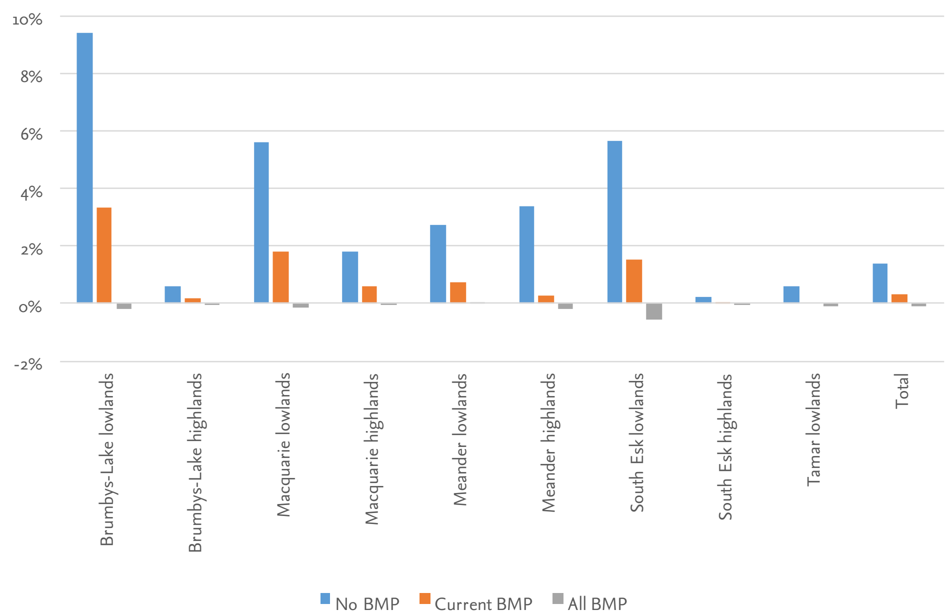
Figure 21 shows that, in general, where no BMP is applied, changes in TP are very similar across all expansion options.

- Applying 'Current BMP' reduces increases in TP substantially for all catchments and expansion options. Large increases in TP would still be expected in some catchments, with a greater than 15% to 20% increase in TP loads from the Brumbys-Lake lowlands and 1% to 20% increase in loads from other impacted catchments.
  - Increases in TP are reduced by 60 to 80% of the change that would be expected under the 'No BMP' option.
- Applying 100% BMP on new areas ('All BMP') could lead to small increases in pollutant loads under dairy expansion, or in the Tamar lowlands a very small decrease in TP.
  - The largest increase in TP is in the South Esk lowlands where loads increase by 4-5%.
  - In other catchments either no increase in TP is seen or else increases or decreases of approximately 1% are expected.

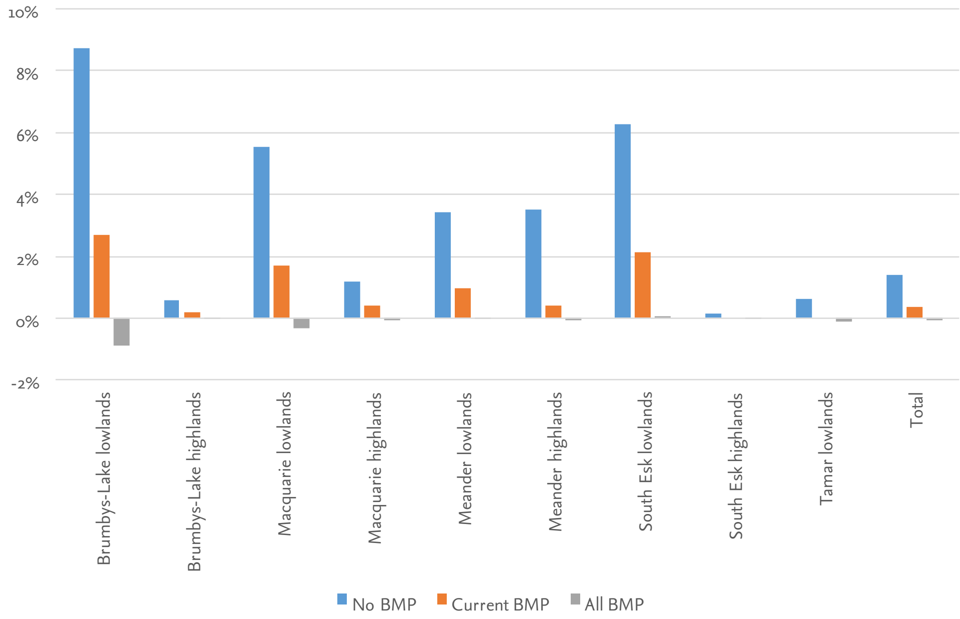
22A Grazing only, broadscale expansion



22B Cropping then grazing, broadscale expansion



22C Grazing only, intense expansion



22D Cropping then grazing, intense expansion

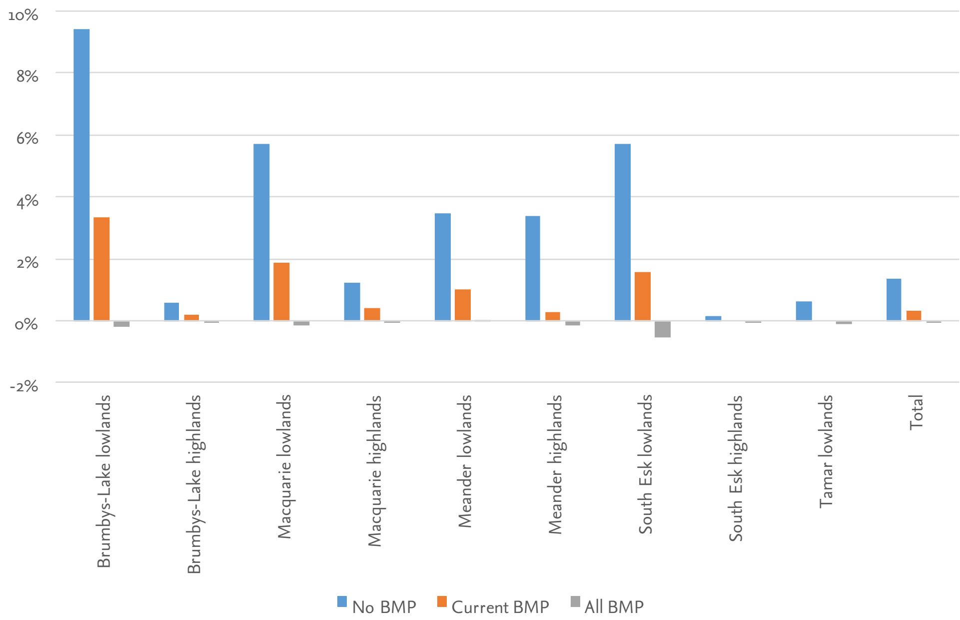
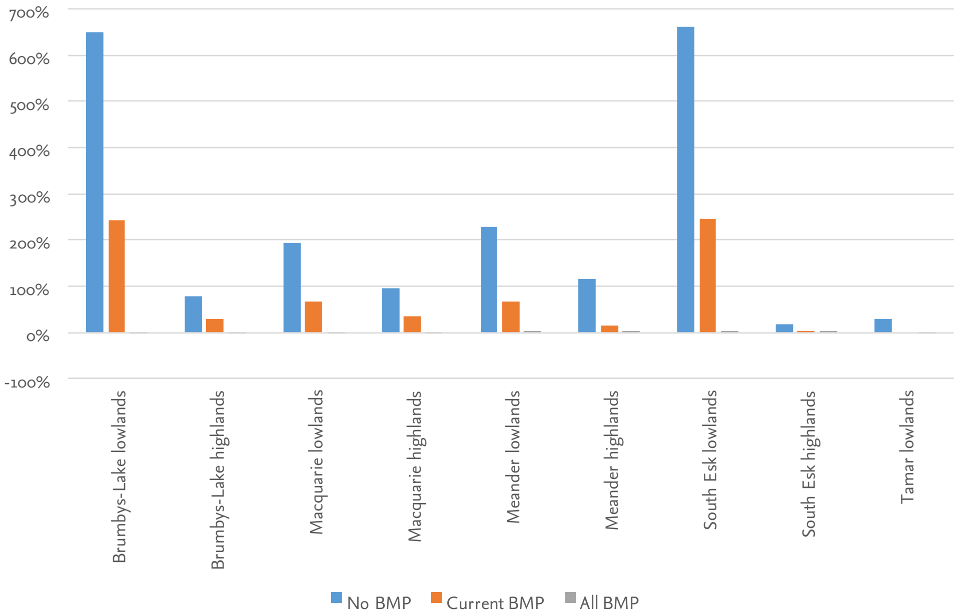


Figure 22. Modelled impacts of various dairy management practice options and expansion scenarios on total suspended solids

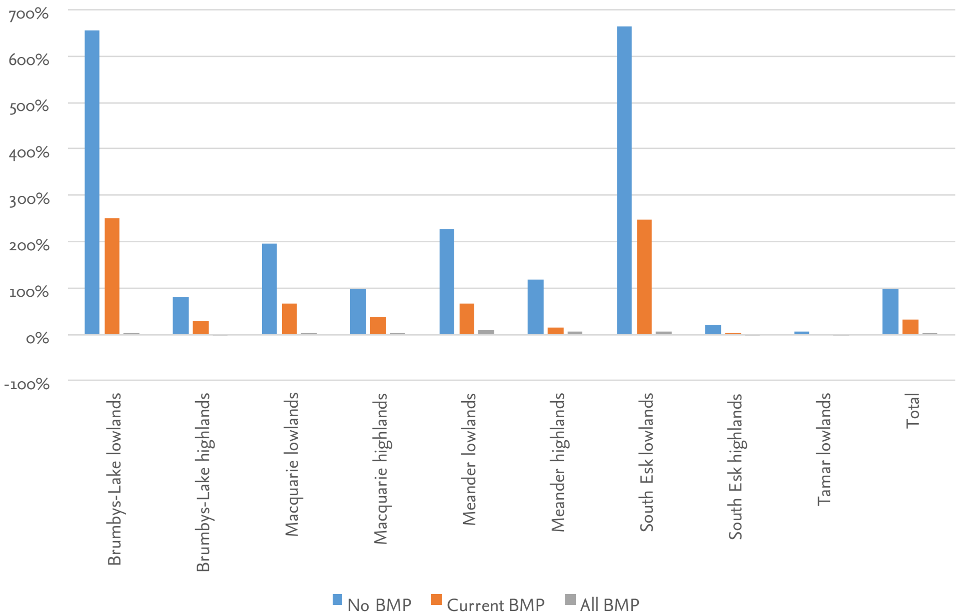
Dairy generally produces relatively low sediment loads compared to other land uses due to generally good levels of groundcover. Figure 22 shows:

- The greatest impacts on TSS loads are seen in the Brumbys-Lake – CFLP lowlands, followed by the Meander and the South Esk lowlands. Impacts in these areas range from 6 to 9% where no BMP are applied. Note that impacts of dairy expansion on TSS under a 'No BMP' option are likely to be underestimated as the effects of increased stock accessing streams on stream bank erosion are not accounted for in this analysis.
- Applying 'Current BMP' reduces increases in TSS substantially for all catchments and expansion options.
    - Increases in the Brumbys-Lake lowlands are reduced to roughly 1/3 of the increase under the 'No BMP' scenario.
    - Increases in all catchments are constrained to less than 3% and in most catchments to less than 1%.
- Applying 100% BMP on new areas ('All BMP') generally leads to small decreases in TSS compared to current loads with decreases of approximately 1% seen in the Brumbys-Lake lowlands when expansion is undertaken on grazing lands.

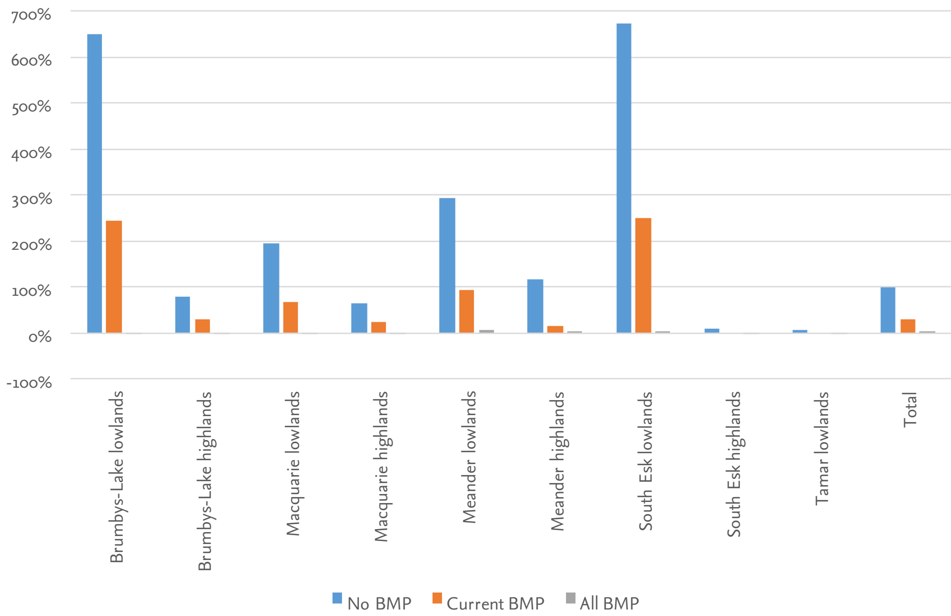
23A Grazing only, broadscale expansion



23B Cropping then grazing, broadscale expansion



23C Grazing only, intense expansion



23D Cropping then grazing, intense expansion

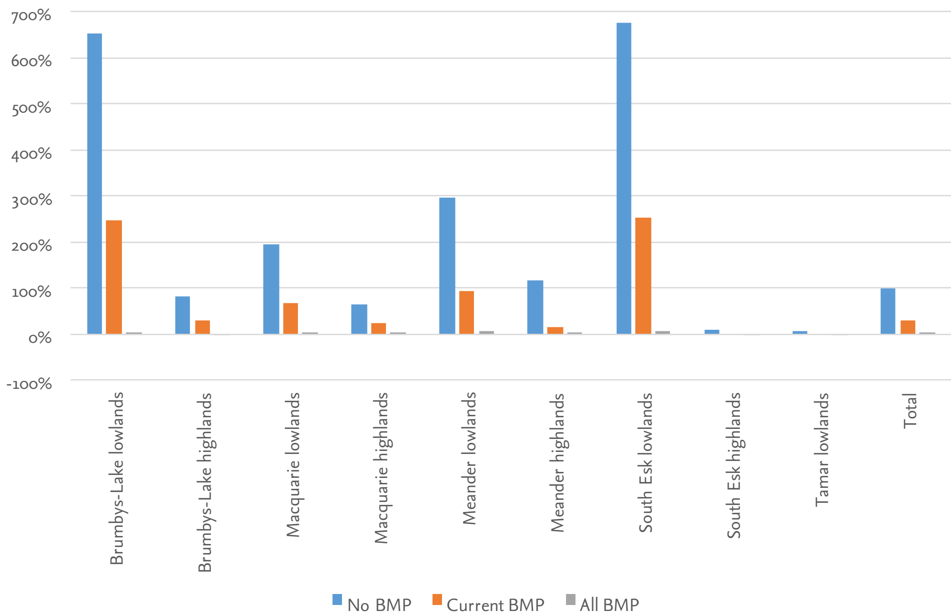


Figure 23. Modelled impacts of various dairy management practice options and expansion scenarios on enterococci

Dairy is a significant source of enterococci loads to the catchment, due to higher stocking rates and greater potential runoff of pathogens from manure compared to other land uses.

- In general, increases in enterococci are very similar across all expansion options (Figure 23). Increases in enterococci are very large for many catchments, with three to more than seven times the total current load of enterococci expected under a 'No BMP' expansion scenario in some catchments.
- As was the case with other pollutants, relative impacts on individual catchments differ by expansion option. The greatest increases are seen in the South Esk then Brumbys-Lake lowlands.
- Applying 'Current BMP' reduces increases in enterococci substantially for all catchments and expansion options.
    - Increases in enterococci resulting from expansion with 'Current BMP' range from roughly 15% to 40% of the increase under the 'No BMP' scenario, with relative reductions within a catchment very similar under the different expansion options.

- Applying 100% BMP on new areas ('All BMP') can lead to no change in pollutant loads under dairy expansion, or in some catchments, small increases or decreases in enterococci load.
    - The largest increases occur where cropping land is converted to dairy with increases of enterococci of up to 8% in the Meander lowlands.

These results show the importance of any expansion in dairy in the TEER being undertaken with high levels of adoption of BMP. They support the importance of sustainable development of dairy areas: **without BMP, dairy expansion could lead to significant declines in water quality. However so long as BMP are adopted, dairy expansion is an opportunity to improve water quality in some of our catchments, and in other cases can be undertaken with no or very limited impacts on water quality.**

2.2.2 Leverage and Cost Effectiveness of Management Actions

Different management actions have very different impacts on the loads of sediments, nutrients and enterococci exported from dairy areas. These impacts can vary by catchment but in general follow a similar pattern in terms of how they rank in their ability to impact on loads. Figure 24 and Figure 25 show the impacts of different management actions on total loads of TN, TP, TSS and enterococci respectively from the greater TEER catchment relative to current diffuse loads. Note that the magnitude of impacts is much greater in affected catchments than is the case for the total TEER loads shown below (in line with the results shown in Figure 20 to Figure 23). For simplicity, the broadscale expansion on grazing areas option is used to illustrate relative impacts of the management actions.

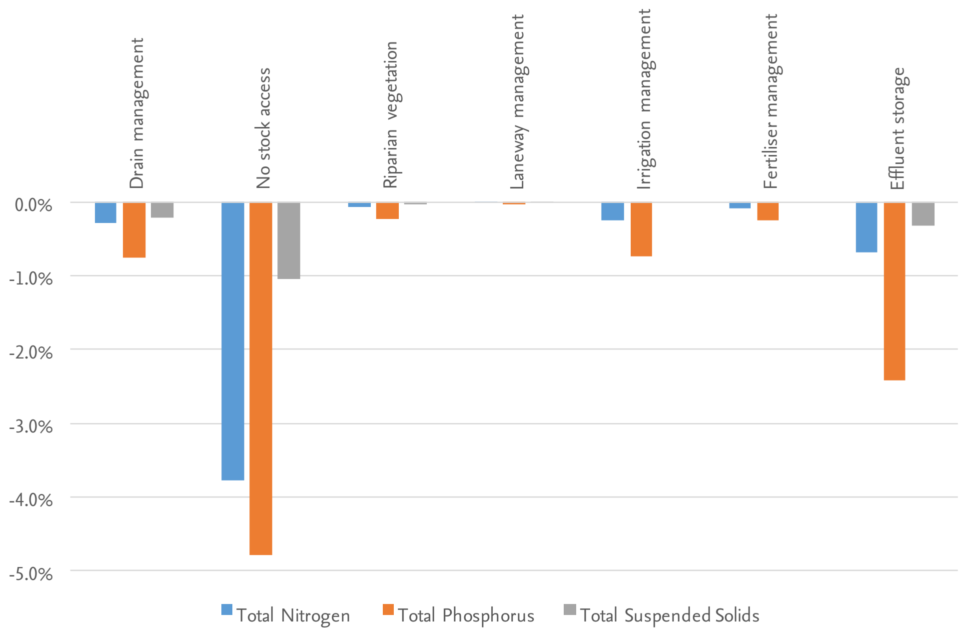


Figure 24. Modelled impacts of dairy management actions on diffuse nutrient and sediment loads from the greater TEER catchment

Reducing stock access to streams is the highest leverage action for removing TN loads, having over five times the impact of the next most effective option, provision of sufficient effluent storage. Drain management and irrigation management are also relatively key actions for reducing TN loads. Riparian management, fertiliser management and laneway management have very small impacts on loads. In the case of riparian management of dairy areas, the limited effectiveness of this action is due to the small proportion of loads that are expected to pass from paddocks to the stream in sheet flows through riparian buffers. The extensive use of drains on dairy farms channelizes flows and provides the main transport pathway for pollutants to the stream. Fertiliser management has a greater, but still small impact, relative to these options.

To remove TP loads, removing stock access, followed by provision of sufficient effluent storage are the most effective management actions. Drain management and irrigation management also have relatively large impacts on loads. As was the case with TN, riparian vegetation, laneway management and fertiliser management have significantly smaller impacts on TP loads. Figure 24 shows that for the management of TP, there are much smaller differences in the leverage of different management actions on loads so that broadscale adoption of a range of actions would be required to address potential increases in loads under an expansion scenario.

To reduce TSS loads, the highest leverage action is removing stock from streams. Note that the benefit of this action is likely to be underestimated as it does not account for changes in stream bank erosion likely to be caused by stock accessing streams. This further supports the importance of this action for reducing TSS load increases likely to result from dairy expansion. Provision of sufficient effluent storage then drain management are two other key actions for reducing TSS loads from dairy areas. Riparian vegetation, laneway management, fertiliser management and irrigation management have no or very small impacts on TSS loads.

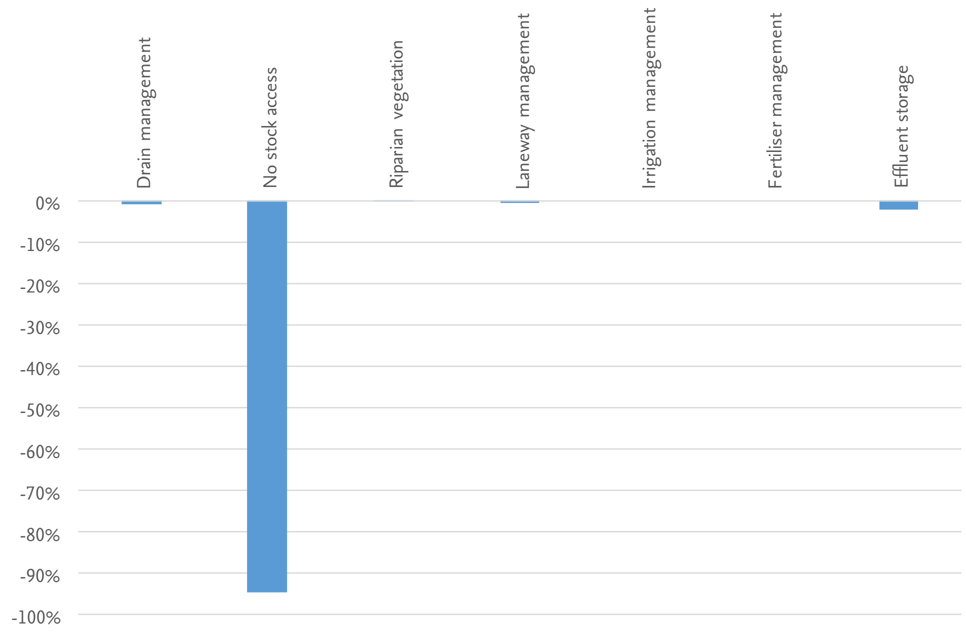


Figure 25. Modelled impacts of dairy management actions on diffuse enterococci loads from the greater TEER catchment

The single most important action for reducing enterococci loads to streams coming from dairy areas is restricting stock access to streams (Figure 25). Effluent storage and drain management have small impacts (1 to 2%) on enterococci loads while other actions can be expected to have no or very small enterococci outputs.

2.2.3 Recommendations

While dairy is currently a small contributor to overall nutrients and sediment loads from the greater TEER catchment, it currently contributes significantly to the total load of pollutants coming from the Meander highlands, particularly in terms of TP and enterococci, and to a lesser extent from the Tamar catchment, Brumbys-Lake lowlands, Meander lowlands and South Esk highlands. Implementation of dairy best management practice in these catchments should be considered a high priority to improve catchment water quality.

This analysis shows that while dairy is currently a small contributor to total sediment and nutrient loads from the greater TEER catchment, if predictions of dairy expansion proposed in the greater TEER catchment occur, then dairy could potentially contribute substantially to future loads at the greater TEER catchment scale. This impact can be expected to be most pronounced in the Brumbys-Lake lowlands, with substantial impacts also experienced in the Macquarie, Meander and South Esk lowlands and Meander highlands.

Importantly the results show that dairy expansion can be viewed as both a threat and an opportunity in terms of water quality. Without broadscale adoption of BMP, dairy expansion can be expected to lead to significant increases in nutrient, sediment and particularly pathogen loads to the system. This is the case regardless of whether expansion is broadscale or intense, or whether it occurs on grazing or cropping areas. However if expansion occurs with broadscale adoption of BMP, these impacts can be reduced substantially, to the point where, in some cases, dairy expansion could lead to improvements in water quality if it replaces other land uses where BMP is not currently being adopted or that are associated with high levels of pollutant export. Note that adoption of BMP on current dairy areas provides a further opportunity to improve water quality and to provide a buffer against potential future increases in loads from land use or other changes over and above the opportunities presented in this analysis.

In terms of the management actions, four actions have been identified as key to reducing loads:

- Provision of sufficient effluent storage;
- Restricting stock access to streams;
- Irrigation management; and
- Drain management.

The relative importance of these actions varies by the pollutant being controlled with restricting stock access to streams the key action for controlling all pollutants. While this action also has a significant impact on TP, a much broader management focus is required to control TP loads from dairy areas than is the case for other pollutants.

Management priorities in dairy areas, both for existing and future expansion areas are:

- Sufficient effluent storage should be provided for on dairy farms. This storage should be well-designed and placed to ensure effluent can be applied to an adequate area of the farm, and storages are unlikely to leach or overflow effluent.
- Stock should be restricted from all streams on dairy farms wherever it is feasible. The inclusion of riparian buffers is likely to have very small benefits for water quality, however could be expected to benefit stream health through shading, and increased bank stability, increased connectivity between vegetation remnants and provision of wildlife corridors. Creation of riparian buffers should be encouraged for these reasons, however the most important outcome for water quality in most cases is that stock are removed from streams. Therefore management should be flexible to allowing for this with either minimal or no buffers where this is likely to achieve greater adoption of this action.
- Irrigation scheduling should be managed to match irrigation to soil infiltration rates and pasture growth rates, and irrigation water reused to reduce drainage losses where possible.
- Drains need to be managed to minimise the transport of pollutants off the farm. This presents some practical challenges for dairy farmers and more consultation is needed to develop practical solutions for best management practice.

2.3 Crop Management in the Tamar Estuary and Esk Rivers Catchment

Cropping is a very minor land use in the greater TEER catchment. Broadacre cropping accounts for approximately 3% of the catchment area, with intense cropping and horticulture making up less than 0.1%. These areas account for roughly 1% of the diffuse sediment and nutrient loads to the estuary with a negligible contribution to diffuse enterococci loads (see Figure 26).

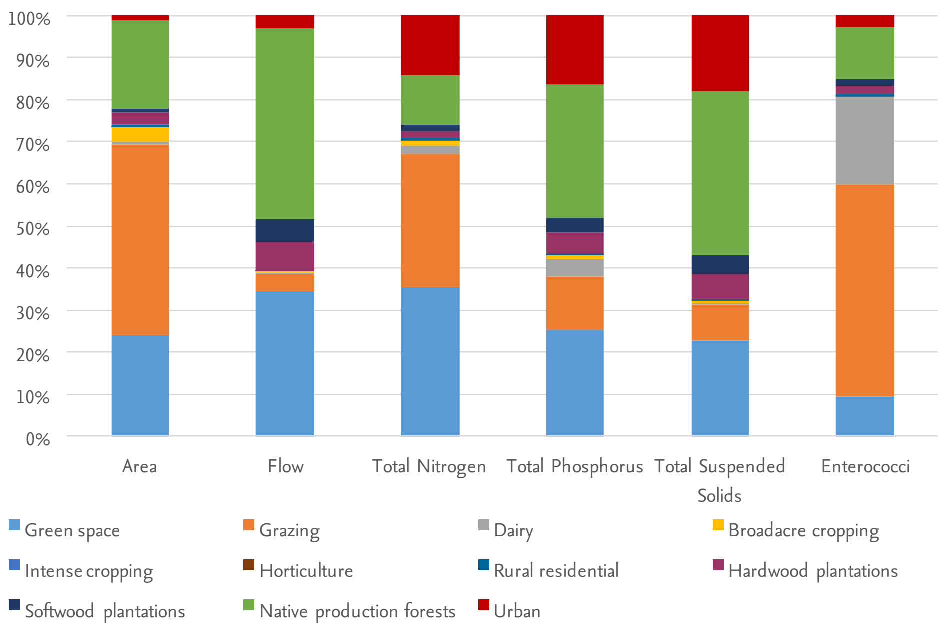


Figure 26. Relative land use contribution to diffuse pollutant loads and total catchment area in the greater TEER catchment

Figure 27 shows the relative contribution of cropping and horticulture to catchment loads and areas. This figure shows that cropping and horticulture are minor contributors to loads in all catchments, in many catchments producing less than their relative contribution to the area of the catchment.

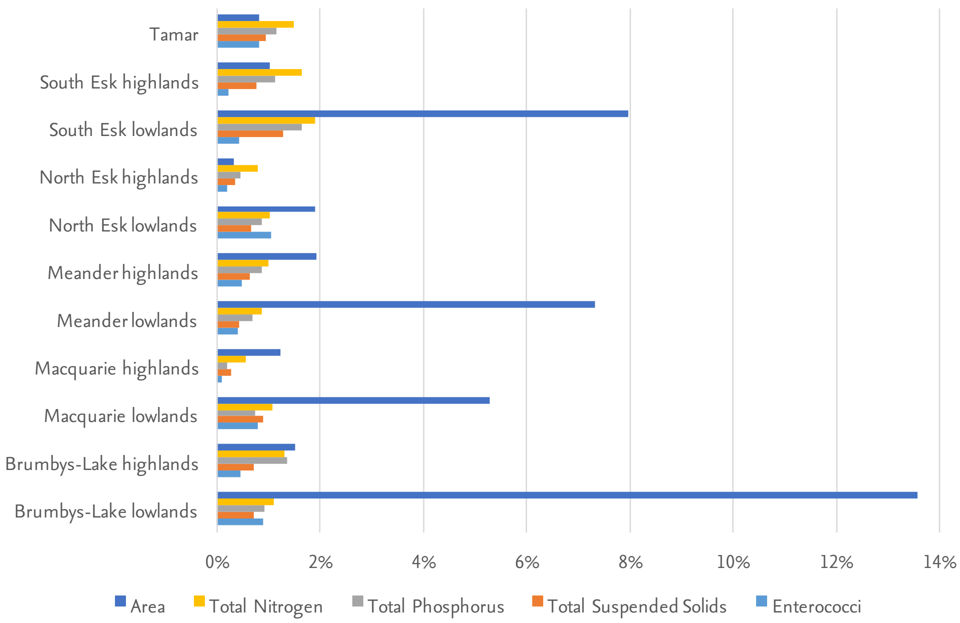


Figure 27. Relative contribution of cropping and horticulture to catchment loads and area

Given this, crop management does not have a major role to play in improving water quality at a greater TEER catchment scale, however in some subcatchments it could potentially have some impact. This section describes the potential for three crop management options to improve water quality in the greater TEER catchment:

- Groundcover management;
- Use of enhanced efficiency fertilisers; and
- Creating vegetated riparian buffers.

2.3.1 Groundcover Management

Bare soils can be a large source of sediments and consequently nutrients from cropping lands due to the potential for erosion. Cropping practices that minimise the period in which soils are bare and maximise groundcover, play an important part in improving the quality of runoff from cropping lands. The percentage of bare soil in cropping lands currently varies little across the catchment, at roughly 22% to 25% in summer and 18% to 20% in winter. Management actions that have the potential to improve groundcover include the use of mulches, direct drilling and minimum tillage techniques and the use of cover crops instead of bare fallows.

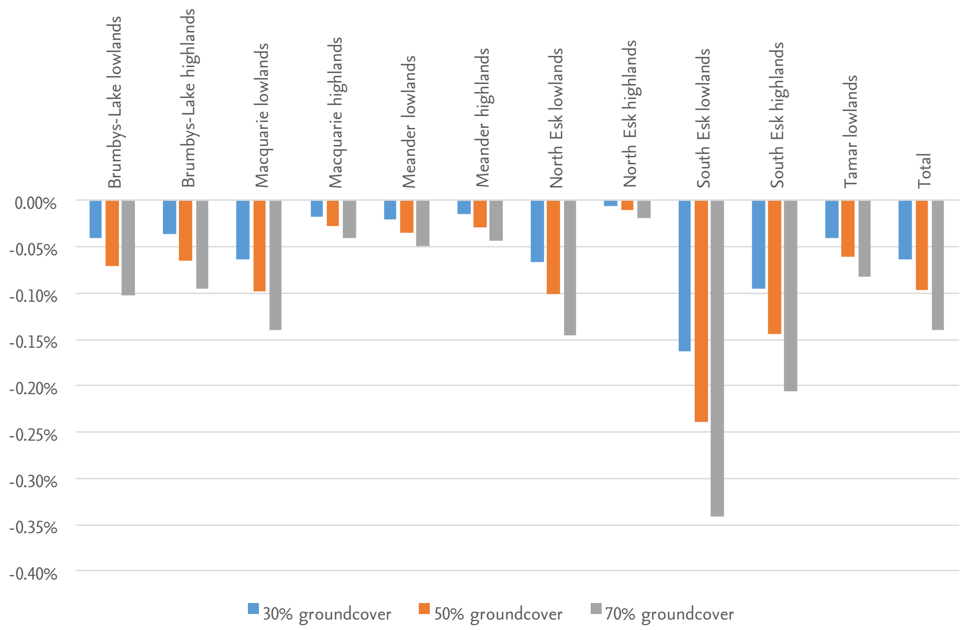
Key stakeholders were asked about the likely levels of adoption of groundcover management techniques. Their feedback indicates that groundcover management is likely to be adopted more slowly in cropping areas than grazing areas due to the greater increase in profitability expected from improvements in grazing areas. They indicated that reasonable levels of groundcover improvement would see summer bare soils at 20% while winter bare soils could be reduced to approximately 10%. Stakeholders suggested considering three levels of adoption of this groundcover management scenario: 30%, 50% and 70%.

Figure 28 shows the impact of these groundcover management scenarios on diffuse sediment and nutrient loads from the freshwater report card zones. No change in enterococci is expected as a result of these changes.

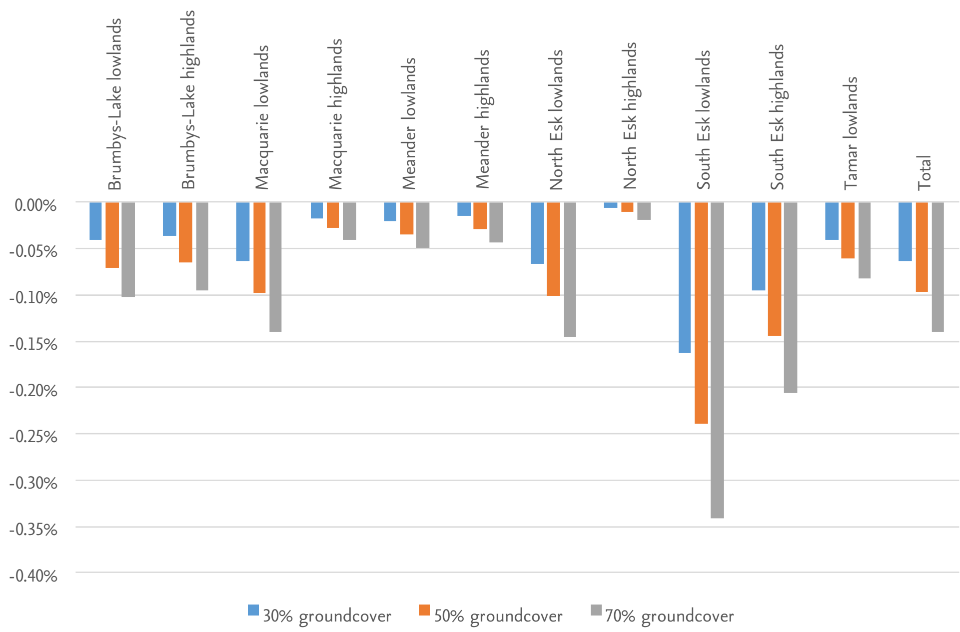
This figure shows that, as expected, estimated impacts on nutrient and sediment loads at a whole of TEER catchment scale (total) are very small, ranging from 0.05% to 0.15% for different levels of adoption. The greatest impacts are expected in the lowlands of the South Esk river catchment, ranging from a reduction of approximately 0.15% to 0.35%. Some impacts are expected in all catchments of the greater TEER catchment.

On smaller individual subcatchments, the greatest impact is seen in the Lower Nile catchment, where sediment exports can be expected to decrease by 1.7% and nutrients by 1.9% to 2%.

28A Total Nitrogen



28B Total Phosphorus



28C Total Suspended Solids

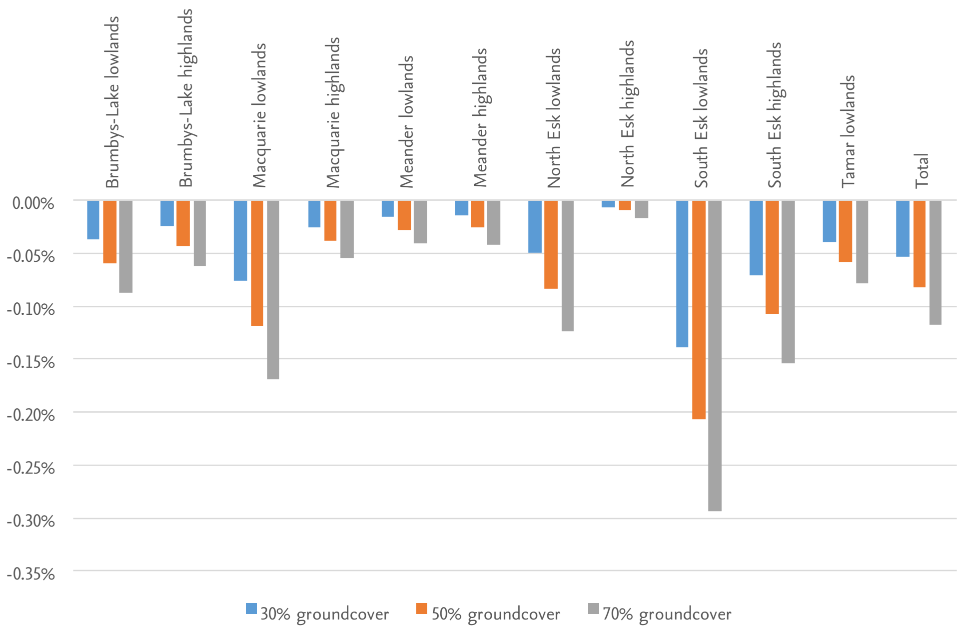


Figure 28. Modelled impacts of groundcover management on diffuse pollutant loads

2.3.2 Fertiliser Management

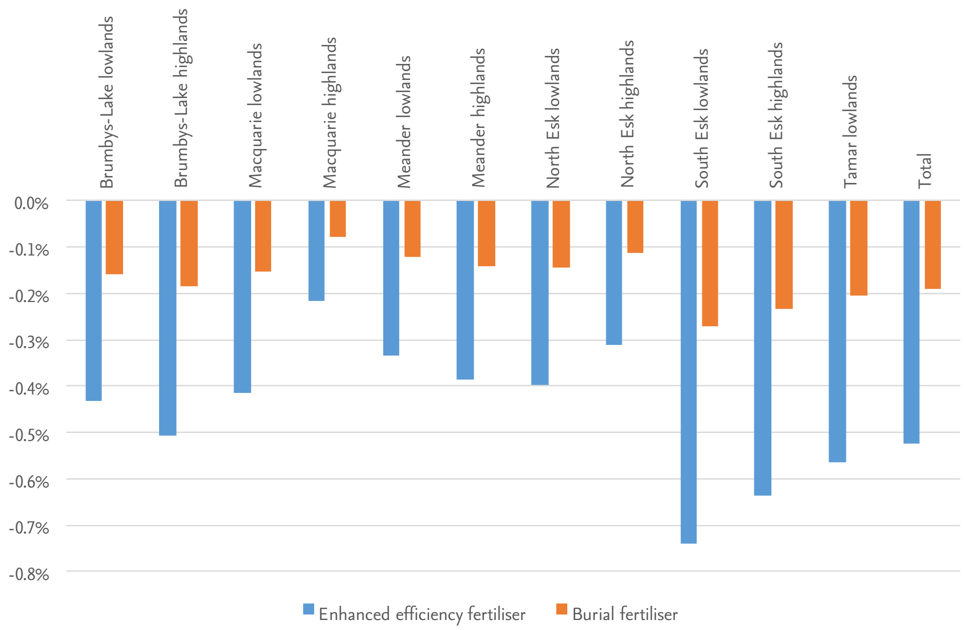
Fertilisers are a potential source of nutrient loads from cropping areas. Nutrient budgeting, where nutrient applications are matched to soil nutrient requirements and crop demands, is an important part of minimising nutrient exports from cropping areas. Specific options that can be used to better match crop nutrient demand to application are the use of enhanced efficiency fertilisers and burial of fertilisers. Feedback from key stakeholders indicated that uptake of enhanced efficiency fertilisers is slow but would be expected to reach 100% over a long term time frame (30 years). Burial of fertilisers is seen to be more immediately adoptable with a current uptake of approximately 95%. Mulching and the use of green manures is another potential management actions that is becoming more popular, however there is a low percentage of farms for which this is appropriate.

Given this feedback the impacts of two scenarios were considered:

- The use of enhanced efficiency fertilisers adopted by 95% of farmers; and
- Burial of fertilisers adopted by 95% of farmers.

Figure 29 shows the modelled impacts of these scenarios on nutrient loads. Note that no impact on sediment or enterococci loads is expected. This figure shows that fertiliser management is more effective than groundcover management for reducing nutrient loads if enhanced efficiency fertilisers are used. Reductions in nutrient loads are roughly twice the greatest reductions for groundcover management (70% adoption). Burial of fertilisers can be expected to have a much smaller impact on pollutant loads than the use of enhanced efficiency fertilisers, but impacts are of a greater magnitude than groundcover management. The magnitude of reductions in TP is slightly greater than for TN in all cases. As was the case for groundcover management, the catchment expected to be impacted the most is the South Esk lowlands. Much greater impacts can be expected in the Brumbys-Lake catchment, both in the lowlands and highlands, than was the case for groundcover management.

29A Total Nitrogen



29B Total Phosphorus

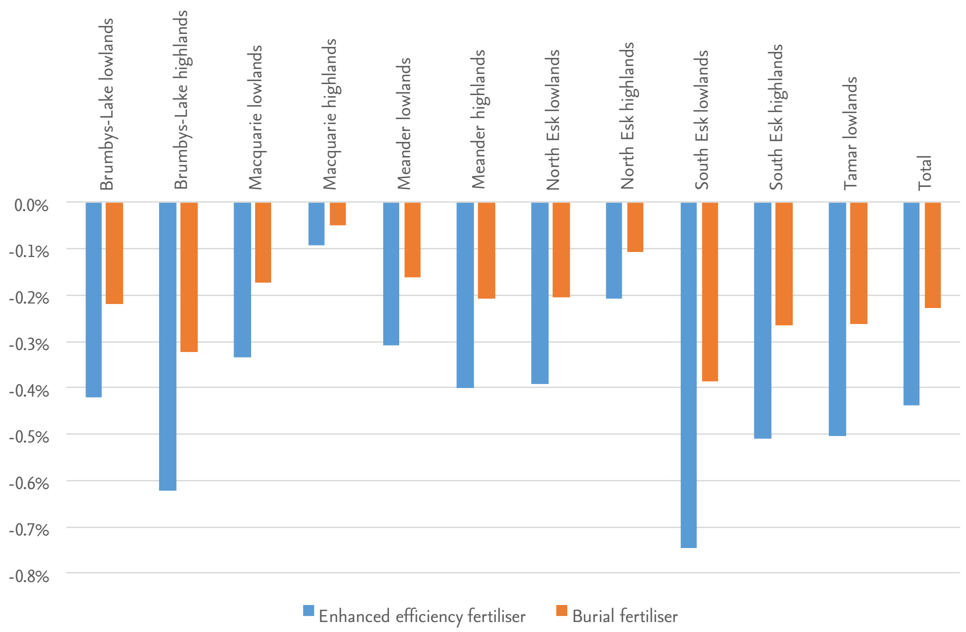


Figure 29. Modelled impacts of fertiliser management on diffuse catchment nutrient loads

In terms of impacts on individual subcatchments, the subcatchment with the greatest improvement in nutrient loads is still the Lower Nile catchment, with decreases of approximately 4%. Several other subcatchments can be expected to see decreases of 1% to 2% of nutrient loads.

2.3.3 Riparian Buffers

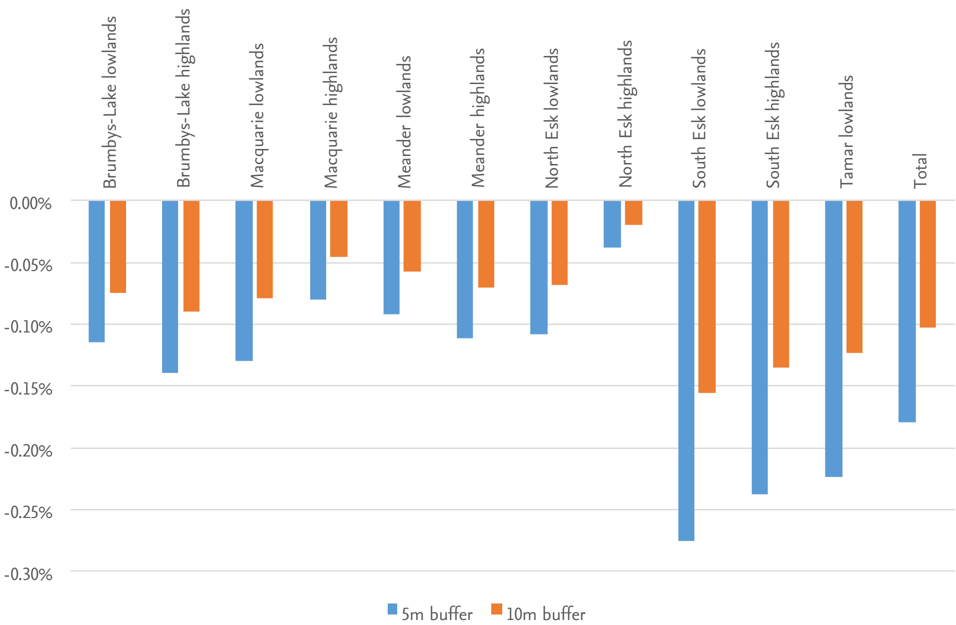
Vegetated riparian buffers can be used to help reduce nutrient and sediment loads by filtering runoff from cropping lands. These buffers are effective where runoff passes as sheet flow through the buffer, rather than being channelized in rills and small gullies. The width, slope and roughness of the buffer are important features which dictate the effectiveness of the buffer in improving water quality. Feedback from key stakeholders indicates that wide buffers are unlikely to be adopted in cropping areas because of the loss of productive lands. Wide buffers mean smaller farms that reduce the profitability of cropping enterprises. It was suggested that upfront incentives would be required to get any adoption of riparian buffers but that additional incentives for maintenance of the buffer would be unlikely to lead to any further increases in adoption. Key stakeholders indicated that with incentives, approximately 20% of farmers could be expected to adopt 5m buffers, 10% would adopt 10m buffers but that no one would adopt 20m buffers.

Given these expectations two riparian buffer scenarios were considered:

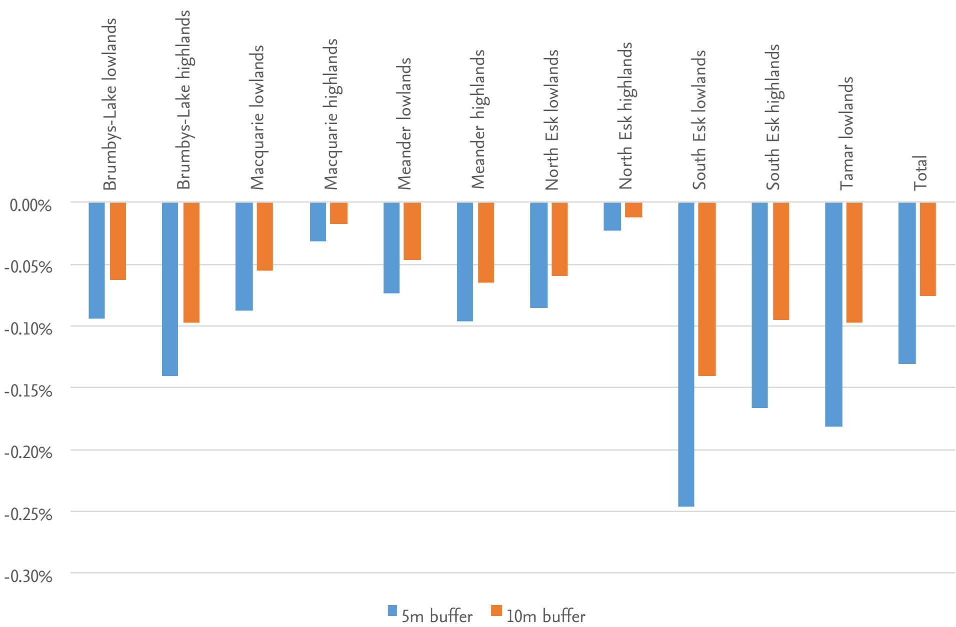
- 20% adoption of 5m buffers; and
- 10% adoption of 10m buffers.

Figure 30 shows the estimated impacts of these two options on sediment and nutrient loads. This figure shows that even though 10m buffers can be expected to remove a greater percentage of the pollutant load per unit length of buffer, the greater levels of adoption associated with narrower 5m buffers mean that, at a catchment scale, these narrower buffers could be expected to reduce pollutant loads by nearly twice as much as 10m buffers. This is because the increased effectiveness of buffers is not linear, decreasing as the width increases. At a whole of catchment scale, 5m buffers can be expected to reduce pollutant loads by slightly more than 70% adoption of groundcover management, although the difference is not substantial. The most impacted catchment is the South Esk lowlands, however in this case the next most impacted catchments are the Tamar, the Macquarie lowlands and the South Esk highlands, indicating that a lack of riparian vegetation is likely to be an issue in these catchments.

30A Total Nitrogen



30B Total Phosphorus



30C Total Suspended Solids

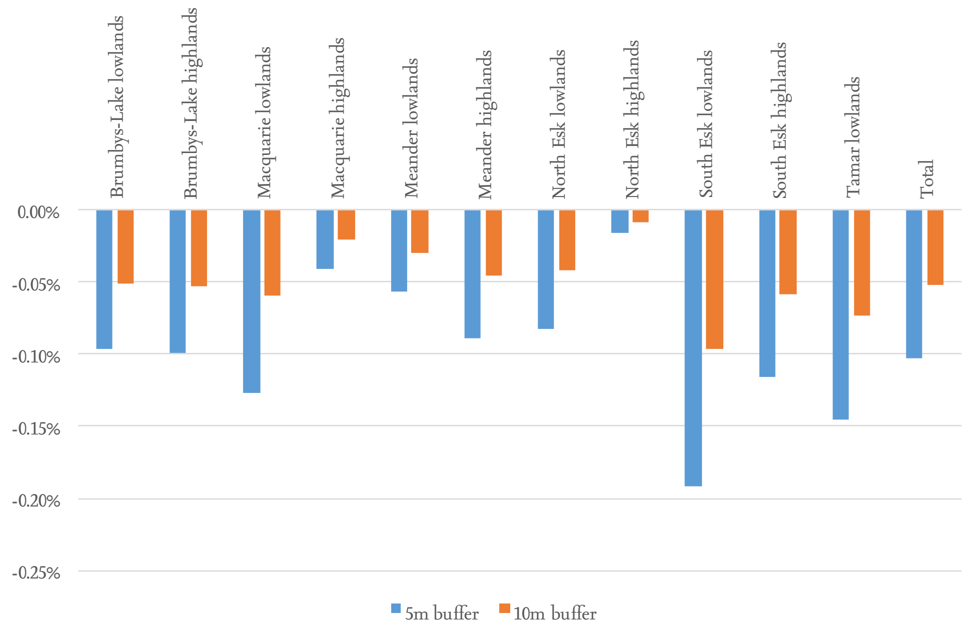


Figure 30. Modelled impact of riparian buffers on diffuse catchment sediment and nutrient loads

The greatest impact in an individual subcatchment is again expected to be in the Lower Nile catchment, with decreases in sediments of roughly 1% and nutrients of 1.5%. All other subcatchments can be expected to experience decreases of less than 1%.

2.3.4 Relative Cost Effectiveness of Management Actions

While the modelled impacts of these actions on pollutant loads are similar, with the use of enhanced efficiency fertilisers the most effective action for nutrients, the costs associated with implementation of the actions are very different. This has implications for the relative cost effectiveness of these scenarios. This relative cost effectiveness can be compared by the cost per unit load reduced. Lifecycle costs, which integrate the upfront and maintenance costs of the action, are shown here to measure the cost effectiveness of actions. The cost per kg of TN removed at a greater TEER catchment scale is shown in Figure 31. Note that a similar pattern of relative costs was found at catchment levels and for the different pollutants (with no cost effectiveness for fertiliser management on TSS).

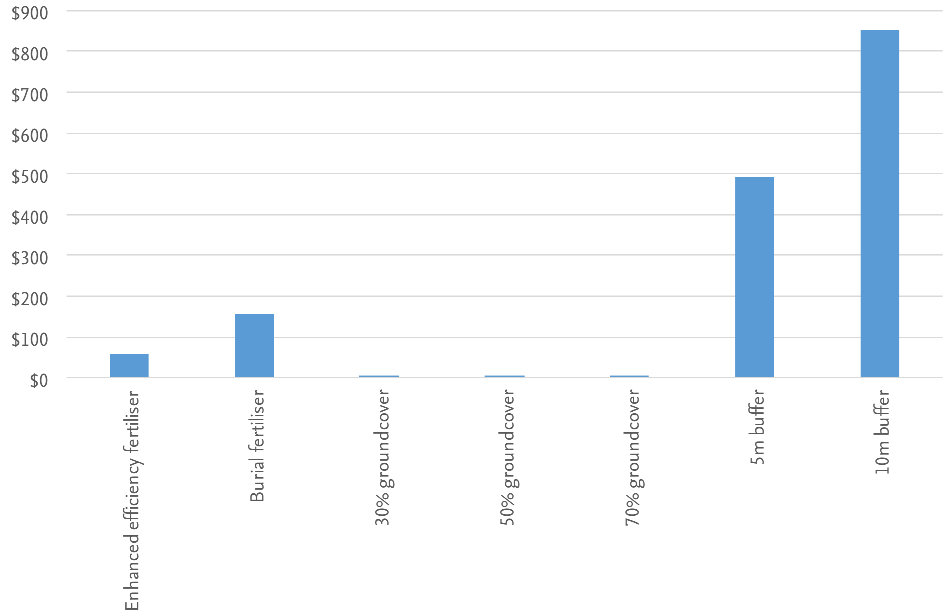


Figure 31. *Relative cost effectiveness of crop management actions - $ per kg of total nitrogen removed*

This figure shows that while groundcover management and riparian buffers have a similar magnitude of impact on total loads, groundcover management achieves these reductions at a much lower cost per unit load reduced. In addition, while enhanced efficiency fertiliser is likely to be more effective at decreasing pollutants at a catchment scale, this is still more expensive per unit TN load reduced than groundcover management. It is significantly more cost effective than implementing riparian buffers. The relative cost effectiveness of riparian buffers is greater for 5m buffers than 10m buffers.

2.3.5 Recommendations

Based on this analysis and feedback from key stakeholders, recommendations for managing cropping areas are:

- Fertiliser management is a key action in reducing nutrient losses from cropping areas. Adoption of enhanced efficiency fertilisers should be strongly encouraged as these are likely to have the greatest impacts on nutrient runoff.
- While fertiliser management is very effective for reducing nutrient runoff, improving water quality off cropping areas will require a more holistic approach to ensure sediment loads are reduced. Both improving groundcover and adoption of riparian buffers can improve water quality in terms of sediment loads, as well as having impacts on nutrient runoff. Adoption of narrow riparian buffers can be expected to have greater impacts than low levels of adoption of groundcover management.
- While the magnitude of impacts of riparian buffers are similar to those of groundcover management, groundcover management is likely to be significantly more cost effective than riparian buffers which achieve load reductions at a much greater cost per kg than the other management options. This emphasises the importance of focusing on these low cost options even where they are not very effective at a catchment scale at reducing pollutant loads as they represent value for money in achieving some improvements in water quality.
- Narrower buffers have the potential to improve water quality at a catchment scale by more than wider buffers where these are seen as more adoptable. A flexible approach should be used in encouraging farmers to adopt riparian buffers with an emphasis on broadscale adoption of narrow buffers likely to be more effective than lower adoption of wider buffers. Greater incentives for farmers willing to adopt wider buffers may need to be provided. An emphasis on adoption of narrow buffers in the short to medium term with long term encouragement to expand these to wider buffers is likely to be more effective in terms of water quality benefits.
- Focusing extension efforts to emphasise the long term benefits of buffers in reducing streambank erosion and subsequent losses of productive land are also expected to be more effective in increasing the adoption of buffers rather than a focus on the environmental benefits, given that the loss of productive land to buffers was identified as a key impediment to their adoption. Upfront incentives are required for any level of adoption of buffers. Maintenance incentives shouldn't be a focus of programs in cropping areas given feedback that these are unlikely to have any impact on the adoption of buffers.

Benefits of improving the management of cropping lands are expected to be seen at local scales rather than at the whole-of-catchment scale given the relatively small contribution these areas make to pollutant loads in the greater TEER catchment.

2.4 Future Land Use Change: Impacts of Tasmanian Irrigation Schemes on Water Quality

Tasmanian Irrigation Pty Ltd was established in July 2011 to oversee development and operation of publicly subsidised irrigation schemes. Several Tasmania Irrigation schemes currently operate in the greater TEER catchment, with an additional scheme on the North Esk currently in the feasibility stage. This dam would supply 2,850 ML of water to the Evandale, White Hills and Relbia area. Table 5 summarises schemes already operating in the greater TEER catchment.

Table 5. Tasmanian Irrigation schemes operating in the greater TEER catchment[2]

Scheme	Commenced	Communities	Volume (GL)	Irrigable area (ha)
Meander Valley	Nov 2011	Deloraine	36	44,200
Lower South Esk	Oct 2013	Conara, Epping Forest, Perth, Longford	6	15,421
Whitemore	2011-12	Whitemore, Oaks, Bracknell, Liffey, Glenore	5.5	12,000
Midlands	2014	Campbell Town, Ross, Tunbridge, Oatlands, My Seymour, Jericho, Kempton	38.5	55,484

Tasmanian Irrigation (TI) requires that all TI water must be applied on the farm according to a Farm Water Access Plan (Farm WAP). These plans contain water, soil and biodiversity modules which dictate that water must be applied in line with modern sustainability principles. These plans contain management prescriptions around factors such as groundcover, stock exclusion, vegetation of drains, vegetated streamside buffers, tillage and irrigation management. Monitoring requirements are spelled out in the plans and farms can be audited on their performance under the plans. Non-compliance can lead to water access being denied.

Figure 32 shows subcatchments in the TEER region affected by Tasmanian Irrigation schemes.

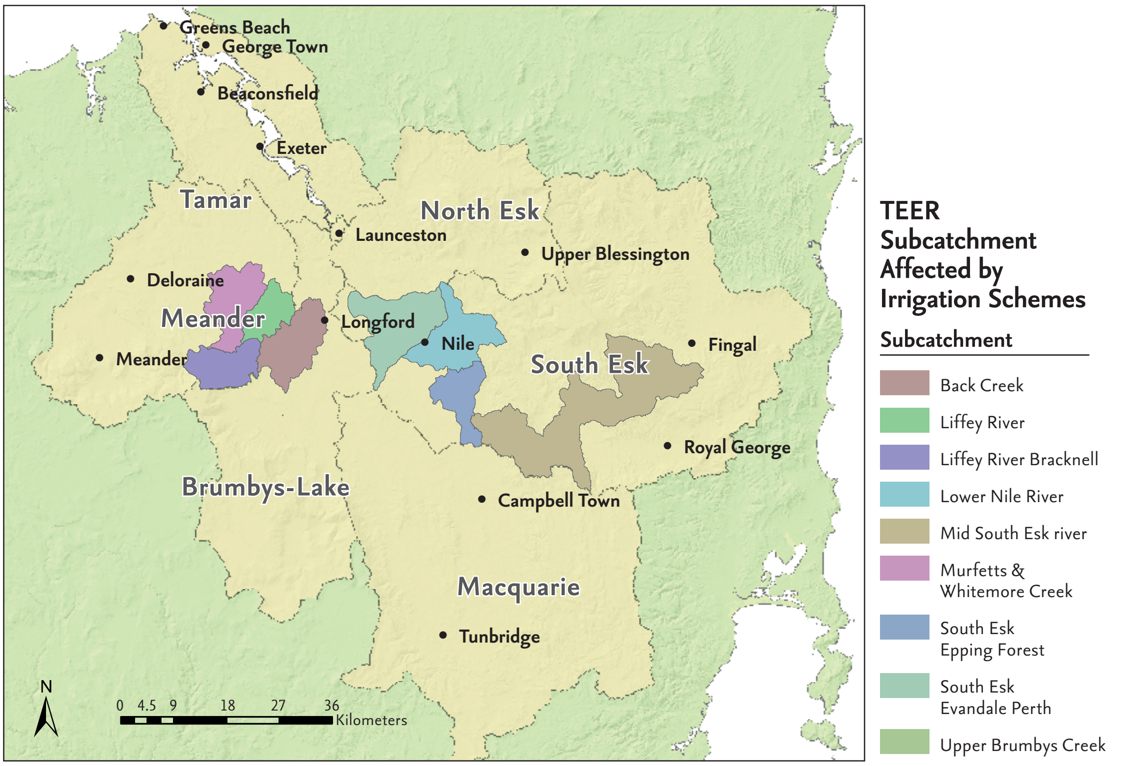


Figure 32. Subcatchments in the greater TEER catchment affected by Tasmanian Irrigation schemes

2 Data provided by Tasmanian Irrigation in March 2014. These data represent operational schemes where Farm WAPs have been developed and Tasmanian Irrigation water is being used on farms.

This section considers the potential impact of Tasmanian Irrigation schemes on water quality in the greater TEER catchment. Tasmanian Irrigation provided data on the areas of irrigable land affected by these schemes, showing the area previously irrigated which is now covered by Farm WAP as well as any expansion to irrigable area under the scheme. This data shows that most of the area covered by Farm WAPs and serviced by the Tasmanian Irrigation schemes will involve intensification of existing irrigable areas, with improved water security (91%). A much smaller proportion (9%) of the land area is subject to irrigation expansion. The areas affected in each of the subcatchments shown in Figure 32 are provided in Table 6.

Table 6. Irrigable area subject to intensification and expansion due to Tasmanian Irrigation water

Subcatchment	Pre TI irrigable area (ha) covered by Farm WAP	Irrigation expansion area (ha) due to TI water
Back Creek	154	0
Liffey River	3026	0
Liffey River Bracknell	918	0
Lower Nile River	182	0
Lower South Esk River	635	0
Mid-South Esk River	1050	365
Murfetts & Whitemore Creeks	3545	0
South Esk Epping Forest	823	0
South Esk Evandale to Perth	1043	874
Upper Brumbys Creek	822	0
Total	12198	1239

Given this, the development of these Tasmanian Irrigation schemes in the TEER imply essentially:

- Improved management on the 91% of irrigable area affected by the schemes which was already irrigated before the TI scheme became operational as farms are now expected to manage their land according to the management prescriptions in the Farm WAP; and
- Expansion of irrigation applying the prescriptions of the Farm WAP to new irrigation areas (9% of the total affected areas).

The impacts of this scenario on sediment and nutrient loads from each of the affected subcatchments are shown in Figure 33.

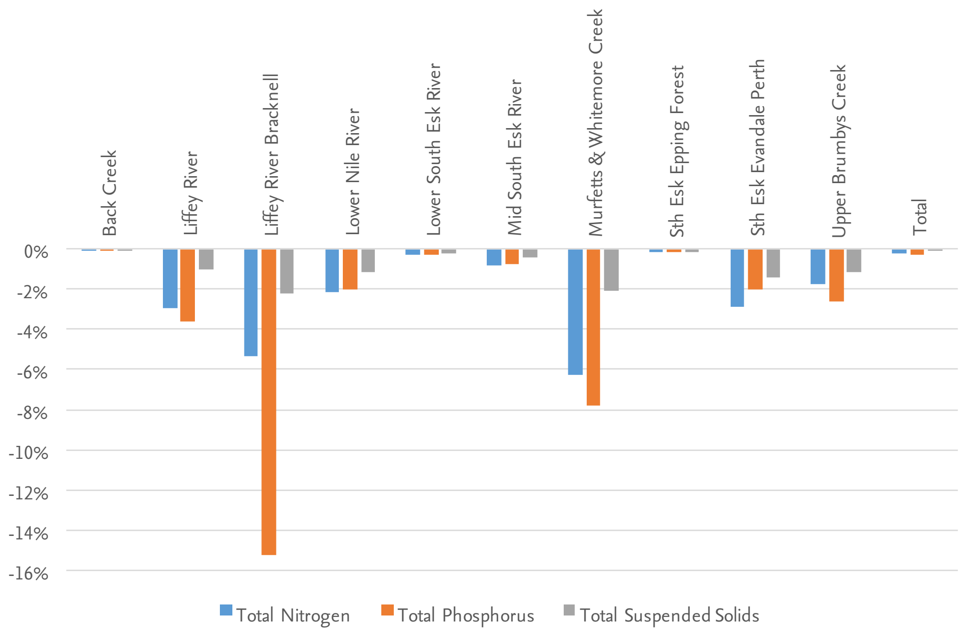


Figure 33. Impacts of Tasmanian Irrigation schemes on diffuse subcatchment sediment and nutrient loads

This figure shows that the modelling indicates that in all cases Tasmanian Irrigation scheme developments can be expected to improve water quality as a result of the improved management practices adopted under the Farm WAPs. The greatest benefits would have been in the Liffey River Bracknell subcatchment where phosphorus loads are estimated to decrease by 15%. Nitrogen and suspended sediments are estimated to have decreased by 5% and 2% respectively in this subcatchment. The Murfetts and Whitemore creeks subcatchment is also estimated to have had substantial load reductions ranging from 6% to 8% of nutrients and approximately 2% of sediments. Smaller impacts are expected to have occurred in other subcatchments. The impacts at the greater TEER catchment scale is estimated to be very small (load decreases of 0.1% to 0.3%) which is as expected given that the area affected by Tasmanian Irrigation schemes is a very small part of the greater TEER catchment.

2.5 Impacts of the Forest Practices Code

Nearly 25% of the greater TEER catchment is subject to forestry activities, with the vast majority (21%) being native production forests and small areas of hardwood and softwood plantations (3% and 1% respectively). Forestry activities occur predominantly in the highland areas of the catchment. The Forest Practices Code was first introduced in 1987 to provide regulatory protection for forest special practices including flora and fauna, water quality and cultural values. The current code was released in 2000 and is administered by the Forest Practices Authority (FPB, 2000). It contains two main provisions to protect water quality:

- The inclusion of streamside reserves to create buffers between forest activities and the stream.
- Limits to the total proportion of a catchment that can be harvested in a single year in water supply catchments.

Streamside reserves are implemented as buffers of varying widths depending on the stream class being protected. Streamside reserve widths used in the code are given in Table 7.

Table 7. Streamside reserve widths used in the Forest Practices Code

Stream class	Minimum horizontal width from watercourse bank to outer edge of reserve
Class 1 – Rivers, lakes, artificial storages (other than farm dams) and tidal waters	40m
Class 2 – Creeks, streams and other watercourses from the point where their catchment exceeds 100ha	30m
Class 3 – Watercourses carrying running water most of the year between the points where their catchment is from 50 to 100 ha	20m
Class 4 – All other watercourses carrying water for part or all of the year for most years	Machinery exclusion zone: no machinery within 10m of streambanks with exceptions

Introduction of the Forest Practices Code was a major management change that had significant benefits for water quality. Figure 34 shows the estimated impacts of introducing these provisions of the code on pollutant loads from the greater TEER catchment. This figure shows that introduction of the code would have led to very large decreases in suspended sediment loads (approximately 8%) even at the whole of TEER catchment scale. Impacts on nutrients would have been much smaller, with approximately a 1% decrease in nitrogen and insignificant changes in TP.

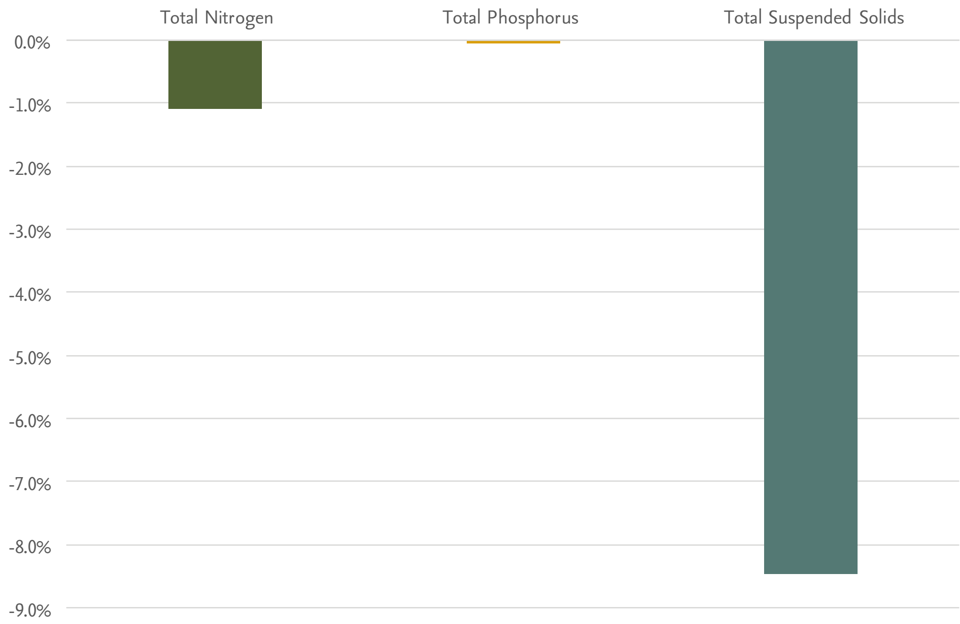


Figure 34. Modelled impacts of the Forest Practices Code on diffuse pollutant loads in the greater TEER catchment

Localised impacts would have been greater in many cases than those shown here for the whole of TEER catchment scale. Figure 35 shows the impact of FPC streamside reserve provisions on TSS loads from each of the catchments of the greater TEER catchment.

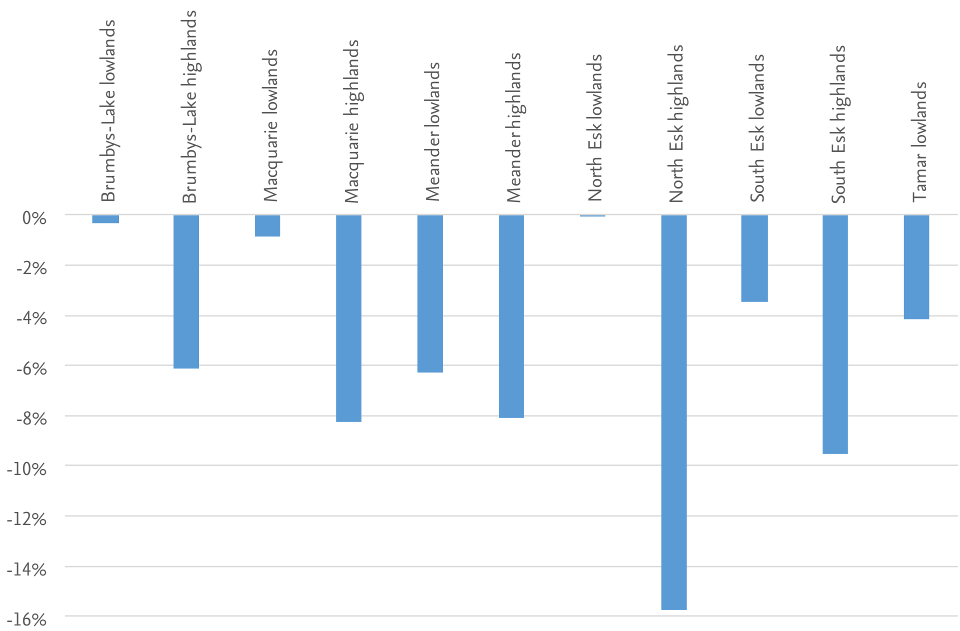


Figure 35. Modelled impacts of the Forest Practices Code on diffuse catchment total suspended solid loads

This figure shows that the greatest impacts of the implementation of the code were experienced in highland areas, in particular of the North Esk, where decreases of nearly 16% have been estimated. Other forested highland areas are estimated to have experienced decreases in the order of 6% to 10% of total suspended sediment loads.

These results show the importance of the FPC in protecting water quality.

2.6 Urban Management

Urban areas account for only 1% of the area of the greater TEER catchment but contribute 3% of total flows, approximately 10% of total (diffuse plus point source) nutrient loads, 18% of TSS and over 20% of total enterococci loads to the estuary. These contributions are made in the form of stormwater runoff as well as combined system overflows (CSO) in Launceston where sewage and stormwater are transported in the same pipe network to the Ti Tree Bend sewage treatment plant (STP).

Figure 36 shows the relative contribution of urban areas to loads and area for each of the catchments of the greater TEER catchment. This figure shows that while urban areas contribute a modest proportion of total loads to the Tamar River estuary, they are the dominant source of sediment and nutrient loads in many catchments. In all cases they contribute loads substantially greater than their relative area:

- Urban areas contribute significantly to nutrient loads. They are the dominant source of TN in the Brumbys-Lake (45%), North Esk (53%) and South Esk (14%) lowlands. They also contribute large proportions of TN in the Macquarie (35%) and Meander (27%) lowlands, although in these cases grazing makes a greater contribution.
- They are the dominant source of TP from the Tamar (47%), the Brumbys-Lake highlands (61%) and lowlands (23%), and lowland areas of the North (71%) and South Esk (19%) catchments. They contribute 15% of TP from the Meander highlands, with dairy areas being the dominant source in this catchment.
- Urban areas the dominant source of controllable sediments in most catchments. Over 50% of TSS from the Tamar catchment (57%), and North Esk (81%), Macquarie (60%) and Brumbys-Lake (73%) lowlands. They also make significant contributions to TSS loads from the South Esk (22%) and Meander (40%) lowlands, and Meander (19%) and Brumbys-Lake (20%) highlands.
- They make a smaller relative contribution to enterococci than for other pollutants as the dominant source of pathogens is generally stock in gazing and dairy areas. Even so 13% of enterococci from the North Esk lowlands comes from urban areas and 5% to 10% from the Tamar catchment and the Brumbys-Lake, Meander and South Esk lowlands.

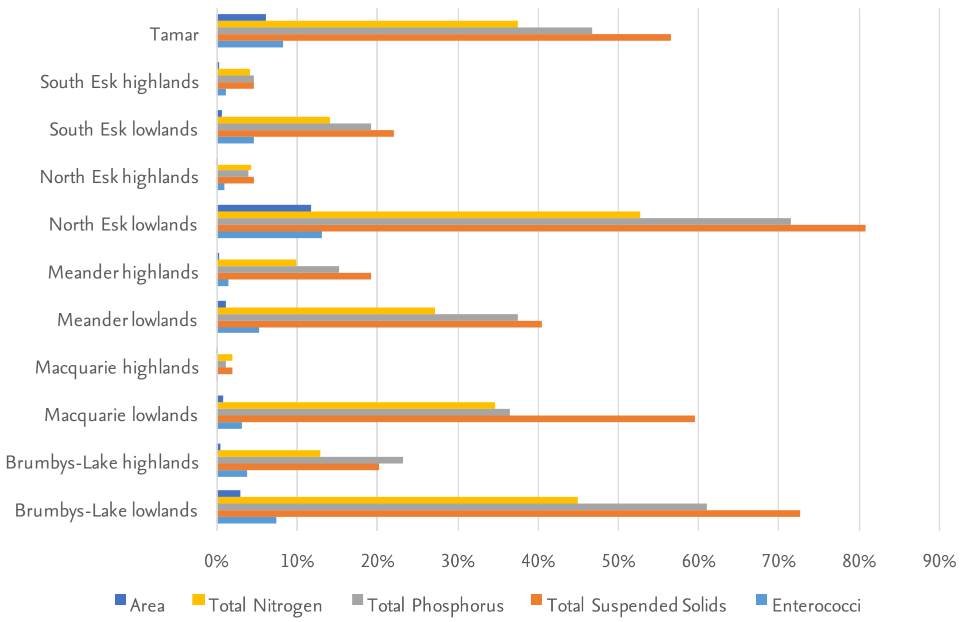


Figure 36. Relative contribution of urban areas to catchment loads and areas

There are two main options for reducing pollutant loads from existing urban areas:

- Encouraging households to install small scale, household based management options such as Water Sensitive Urban Design (WSUD); and
- Incorporating large scale water sensitive urban design devices either through retrofitting existing areas or using infill redevelopment as an opportunity to introduce these measures.

In general, household scale WSUD such as rainwater tanks and rain gardens work by reducing flows. This can improve stormwater as flows are necessary to wash pollutants off surfaces and transport these to waterways. Large scale WSUD are generally designed to improve the quality of water running off the land surface by treating it to remove varying proportions of nutrients, sediments and pathogens. The effectiveness of these actions in the greater TEER catchment differs based on whether the action is being implemented in the combined system in Launceston or to improve the quality of stormwater from urban areas elsewhere in the catchment. Options that reduce peak flows are likely to be more effective in reducing loads from CSOs as they can reduce the frequency of sewer overflow events.

This section first analyses the impacts of incorporating large scale WSUD options (illustrated here using a 60m swale and 200sqm wetland in train as an example) and household scale WSUD (using rainwater tanks as an example) in existing urban areas in the catchment. Feedback from key stakeholder workshops is used to underpin assumptions relating to the adoption of various scenarios. Impacts exclude those from the combined system in Launceston, focusing entirely on stormwater export from other urban areas.

The impacts of WSUD adoption on CSOs are then explored separately.

2.6.1 Impacts of WSUD on Diffuse Catchment Loads

Large scale management options for stormwater involve incorporating WSUD devices such as wetlands, swales, biofiltration systems and ponds in catchments to treat stormwater flows before they reach the waterway. These devices generally need to be developed and maintained by local government or in partnership with business. Feedback from key stakeholders suggest that broad scale retrofitting of these types of devices can be challenging for a number of reasons including the difficulty of identifying appropriate sites that don't conflict with other needs and uses such as recreation, and issues around on-going maintenance of such systems. Key stakeholders suggested that as a result of these difficulties, the rate at which these could be adopted and implemented across the landscape would be fairly low.

Feedback from key stakeholders indicates expected relative adoption levels for these options are as shown in Table 8. Adoption rates are assumed to vary with the type of incentives offered.

Table 8. Assumed rates of adoption of large scale water sensitive urban design devices

	Without incentives	With incentives	With maintenance funding
Large scale WSUD devices	2%	4%	8%

Three household scale management scenarios are also considered, assuming different rates of adoption for households installing rainwater tanks with:

- No incentives or education programs to support adoption;
- Education focused on benefits to the household but no incentive program; and
- Combined education and incentive programs.

Feedback from key stakeholders indicates that adoption levels for household scale options would be at levels shown in Table 9. This table shows that without incentives, fairly low levels of adoption can be expected, however where incentives and education are provided it could be expected that a quarter of households would be willing to install rainwater tanks.

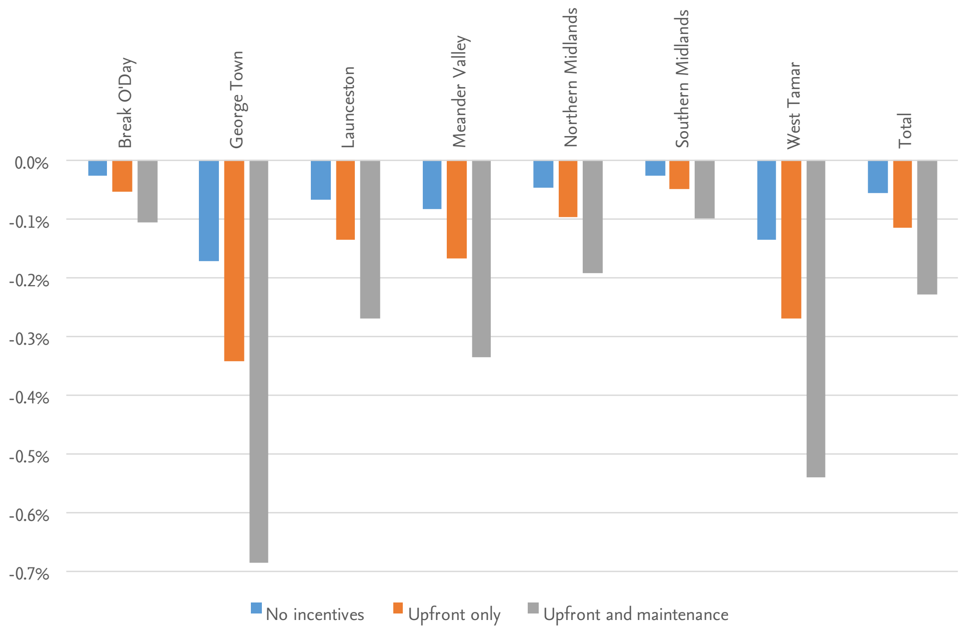
Table 9. Assumed rates of adoption of household scale water sensitive urban design

	Without incentives	With incentives and education	With education, no incentives
Household scale	<5%	20-30% (25%)	5%

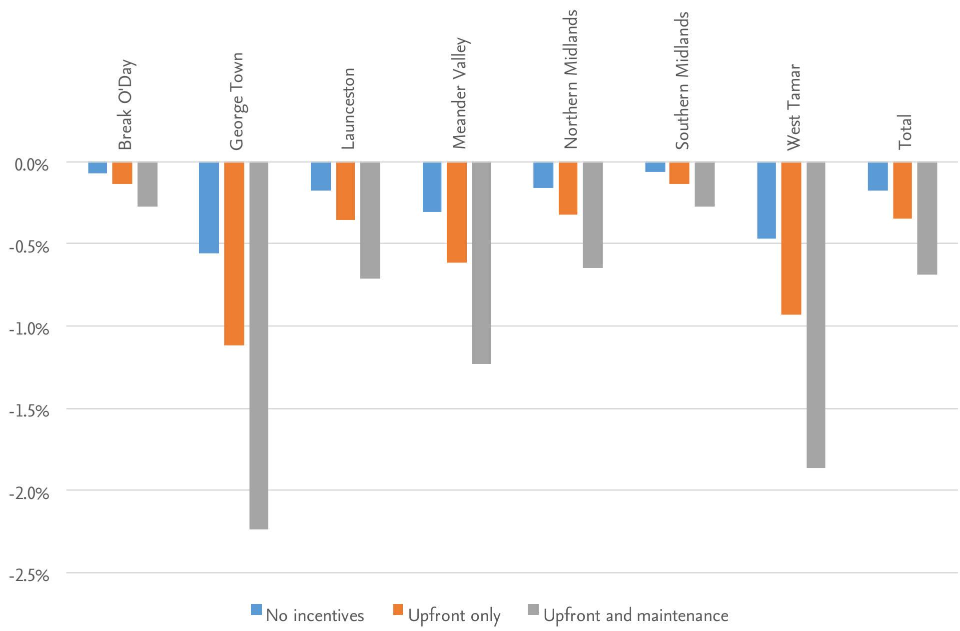
Figure 37 and Figure 38 show a comparison of the estimated effects of large scale WSUD and household scale WSUD adoption scenarios on diffuse plus CSO pollutant exports. Note that this shows the impacts from stormwater management on areas excluding the combined system in Launceston. A very broad selection of potential WSUD treatment trains would be possible to use to treat stormwater. The specific option which best suits a particular site is generally dependent on site specific constraints and objectives. The analysis below assumes adoption of 60m swales with 200sqm wetlands to illustrate the potential impacts of large scale WSUD implementation. Actual impacts would depend on the specific treatment trains adopted, their scale and design, and catchment features such as slope, rainfall and perviousness. Household scale WSUD options are represented by rainwater tanks that are plumbed into the household water supplies[3].

3 Household scale WSUD is represented here using rainwater tanks that are plumbed into households. No modelling was available for the greater TEER catchment to estimate the impacts of any household scale WSUD device. The analysis here uses results from MUSIC modelling undertaken for the Botany Bay catchment where rainwater tanks of 3kL were assumed to be applied to medium density urban areas. It was assumed that 50% of the roof was captured by the tank while the remaining roof runoff entered the stormwater drainage system. Roofs were assumed to occupy 50% of the total lot area (200 m2/dwelling). The rainwater tank was set to be re-used for internal use within toilets and laundry (131 kL/yr/dwelling, assuming three occupants/dwelling) and external use within gardens (112 kL/yr/dwelling). Using these assumptions rainwater tanks applied to all residential dwellings in the catchment are estimated to decrease flows by 14%, with associated pollutant load reductions of 19% TSS, 16% TN, 17% TP and 14% enterococci. Note these decreases are assumed to apply equally to all rainfall events.

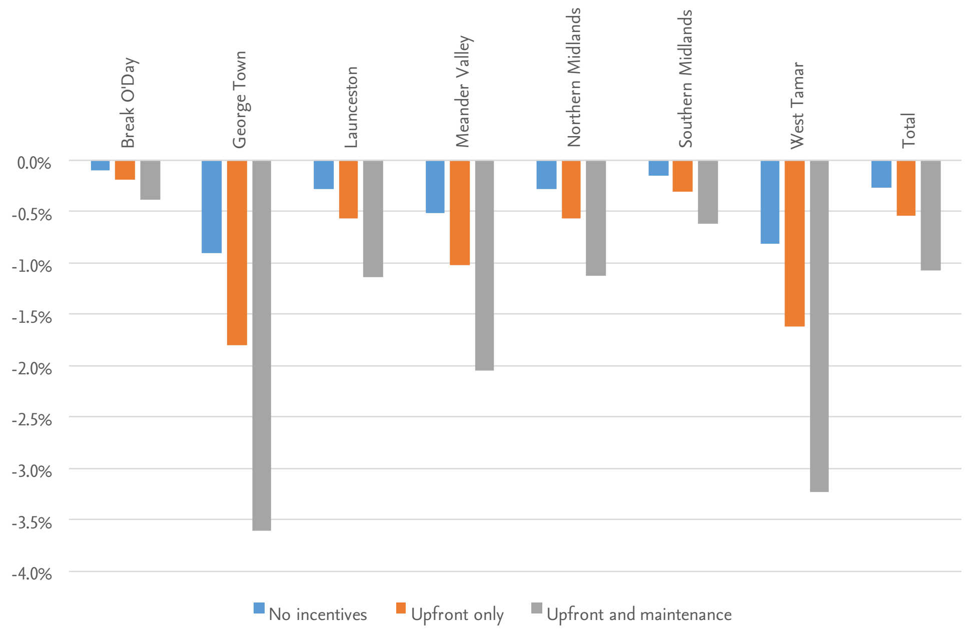
37A Total Nitrogen



37B Total Phosphorus



37C Total Suspended Solids



37D Enterococci

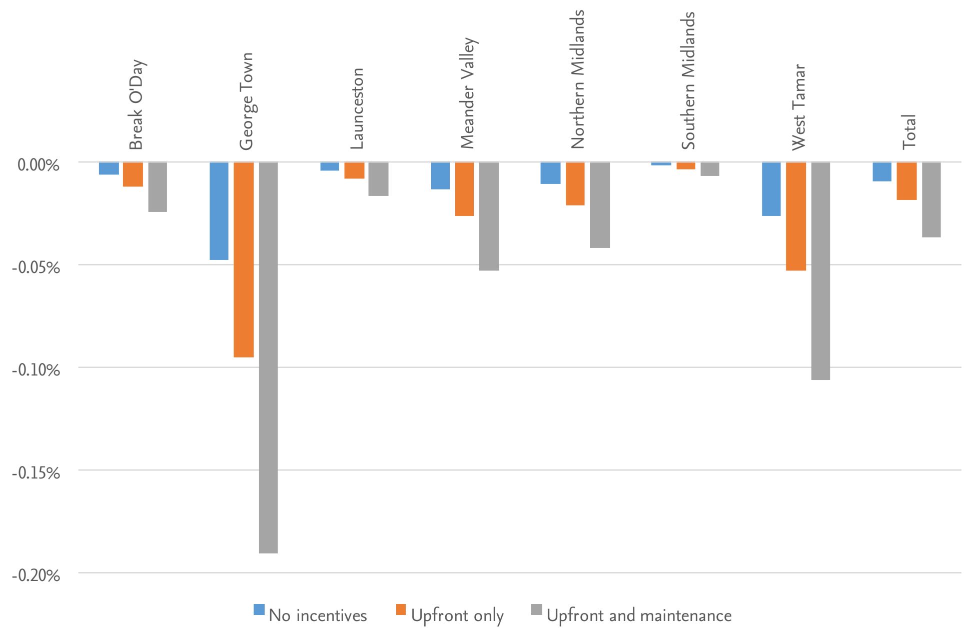
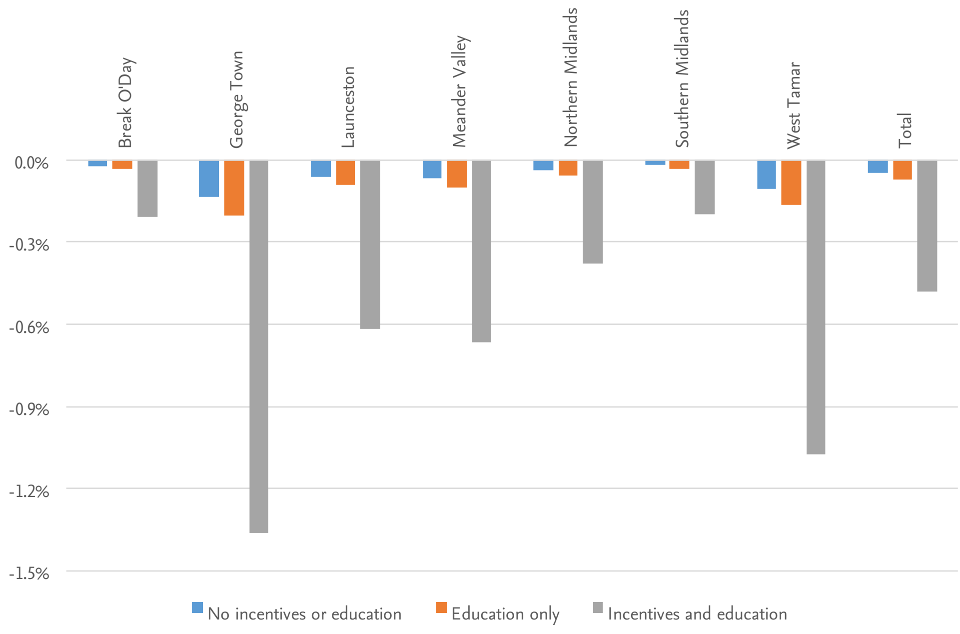
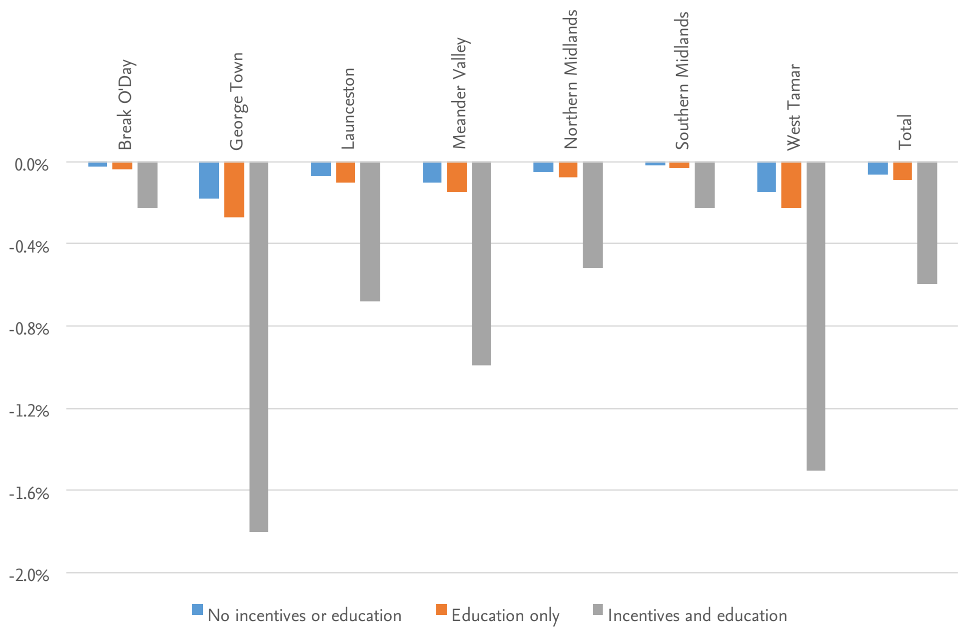


Figure 37. Modelled impact of large scale water sensitive urban design option scenarios on diffuse plus combined sewer overflow pollutant loads

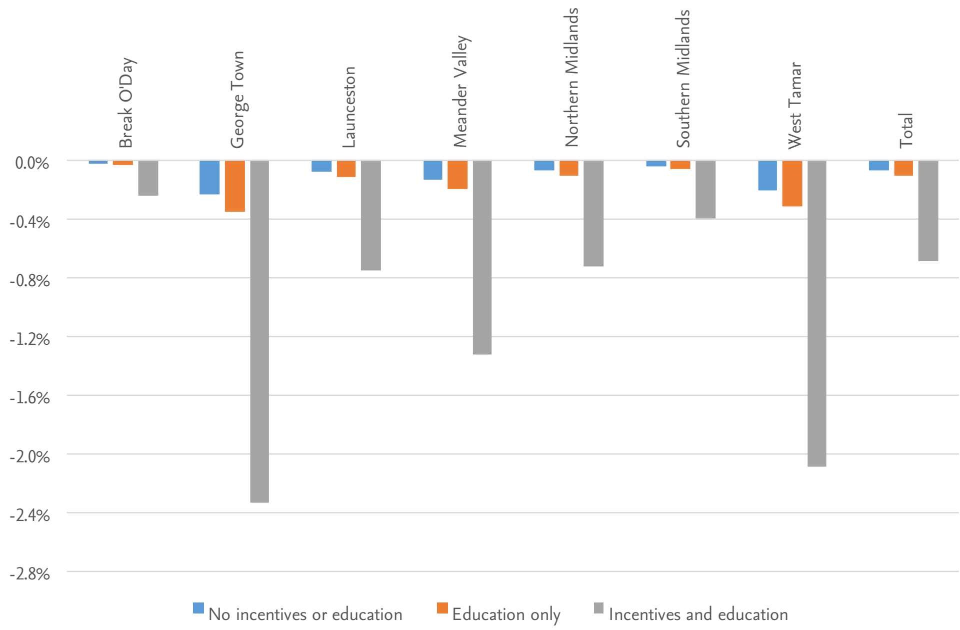
38A Total Nitrogen



38B Total Phosphorus



38C Total Suspended Solids



38D Enterococci

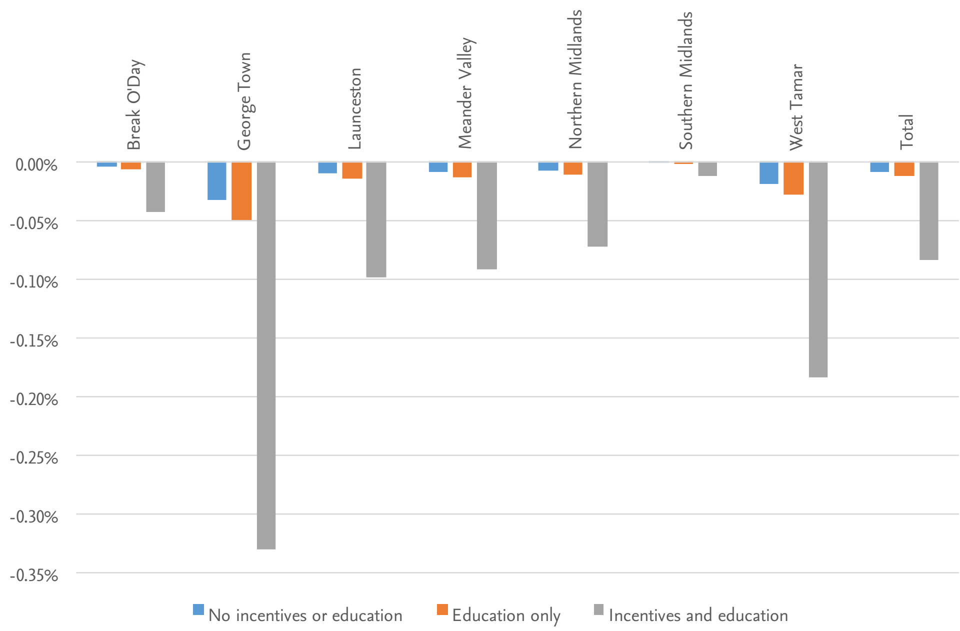


Figure 38. Modelled Impact of household scale water sensitive urban design option scenarios on diffuse plus combined sewer overflow pollutant loads

Figures 37 and 38 show:

- The greatest proportional reduction in diffuse loads of nutrients and sediments is in the George Town and West Tamar LGAs;

Very small changes in the loads from Launceston are seen from either household scale or large scale WSUD. These impacts are on stormwater discharging directly to the estuary. Note that CSOs are not included in this analysis; and

- In general, the impacts of household scale WSUD are greater than those for large scale WSUD on TN and enterococci loads. Large scale WSUD is more effective at removing TP and TSS. This is due to the trade-off between the greater leverage of large scale WSUD for removing pollutants versus the greater adoptability of household scale WSUD options.

2.6.2 Managing Combined System Overflows in Launceston Using WSUD

The combined system in Launceston operates very differently to the traditional stormwater systems operating in other urban areas of the catchment. The combined system refers to the combination of sewer and stormwater systems such that sewage and stormwater are transported in the same pipes and treated at the Ti Tree Bend STP. During low flow periods this combination of sewage and stormwater is fully treated at the STP, however, during high flow periods the designed treatment capacity of the sewage system is exceeded and additional combined flows, a mixture of stormwater and sewage, are bypassed directly to the estuary. TasWater's corporate goal is to avoid dry weather overflows and to reduce wet weather overflows, providing treatment for all events to 1 in 5 year weather events where feasible. Water sensitive urban design can influence these sewer overflows in two ways: by reducing the flow volume during a given rainfall event, making CSO events less likely to occur and by improving the quality of stormwater, reducing the concentrations of pollutants in discharged water.

Due to the very high pollutant load concentrations of sewage compared to stormwater, options that focus on reducing flow volumes are generally more effective at reducing loads from this combined system. While household scale WSUD, such as rainwater tanks that are plumbed in to household use or rain gardens, may be less effective at removing pollutants from flows than larger scale options that filter water to remove pollutants, these options can be effective at reducing overflows by reducing peak flows of stormwater entering the combined system. As shown above, feedback from key stakeholders also indicates that household scale options such as rainwater tanks and rain gardens are likely to be more highly adoptable than large scale options so long as incentives are provided.

Figure 39 shows the impacts of the household and large scale options on pollutant exports from the combined system as well as their potential combined impact as a proportion of total load from diffuse sources and CSOs. This figure shows the relative effectiveness of household scale options backed up by incentives and education particularly on reducing enterococci loads produced by the combined system. In combination with large scale WSUD (assuming upfront and maintenance incentives are provided) this feasible option for WSUD implementation has the potential to produce large improvements in pollutant load reductions from the combined system which discharge directly to Zone 1 in the upper Tamar River estuary. Reductions of approximately 6% of nutrients and enterococci are possible, while TSS could be reduced by over 10%.

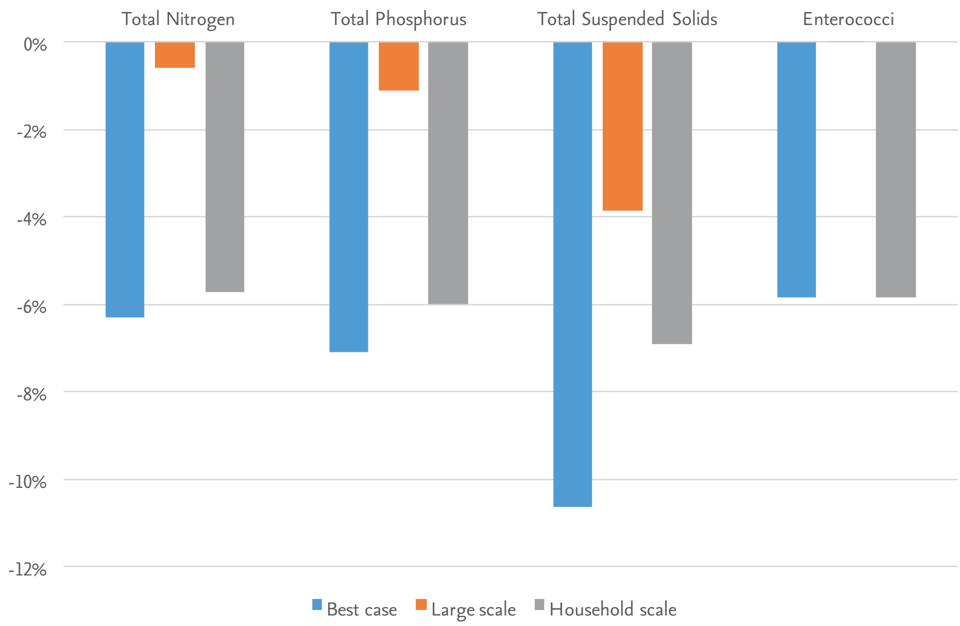


Figure 39. Modelled effect of 'best case' urban management on pollutant loads from the combined system as a proportion of diffuse plus combined system overflow loads

2.6.3 Best Case Impacts

This section estimates the relative benefits of combining the most effective options for both household and large scale WSUD (implementation of rainwater tanks with education and incentives WITH large scale WSUD and maintenance incentives) on urban areas outside the combined system. The total impacts at an LGA scale are explored first before the impact on several focus catchments is demonstrated. These localised impacts are very important both environmentally but also to show the local benefits to communities of actions they take. Note that these impacts are on diffuse loads plus those from CSOs.

LGA scale

Modelled impacts of the 'best case' retrofitting option for urban management on pollutant exports from the various LGAs are given in Figure 40. This figure shows that with the exception of Launceston, the best case option will be most effective at removing TSS, followed by TP. In general the option will have little effect on enterococci, except in the combined system in Launceston where it can be expected to substantially reduce loads through reduced combined system overflows. Total loads from diffuse sources (including combined system overflows) can be expected to decrease by roughly 2% for sediments, 1.5% for phosphorus and enterococci and 0.8% for nitrogen. The greatest relative impacts are generally experienced in George Town and West Tamar LGAs with TSS load reductions of approximately 6.5% and 5.8% respectively.

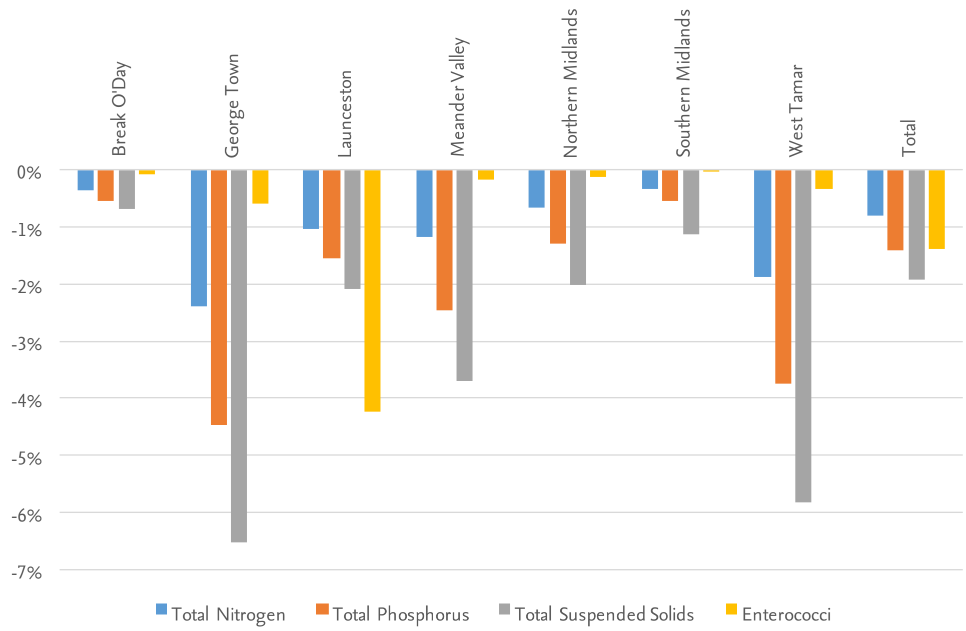


Figure 40. Impacts of 'best case' urban management on areas outside the combined system on total diffuse plus combined system overflow loads from local government areas

Focus subcatchments

Figure 41 shows the impact of this 'best case' option on several heavily impacted subcatchments. As can be seen in this figure, the benefits of improving stormwater quality and reducing loads to individual subcatchments can be very large in comparison to the benefit achieved at a whole of TEER catchment scale. For example, Kings Meadows rivulet can be expected to see reductions in the order of 10% TSS, 8% TP, 5% TN and 2% enterococci if this 'best case' scenario is implemented. The relative effectiveness of the option is different for different pollutants across the catchment depending on the mix of land uses in the catchment and the extent to which urban areas are a dominant source of each pollutant in the subcatchment.

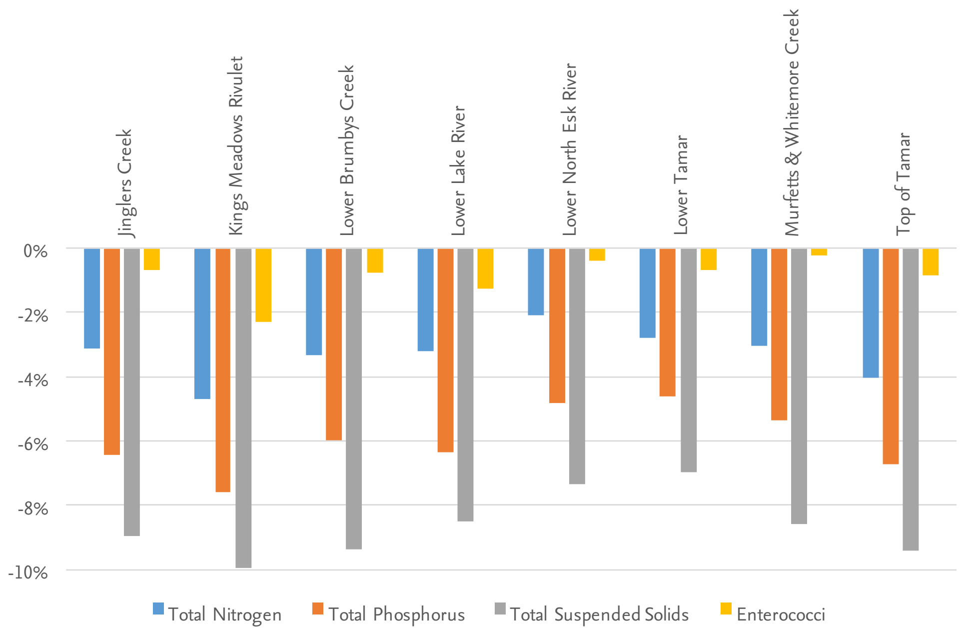


Figure 41. Impacts of 'best case' urban management on diffuse subcatchment loads

2.6.4 Recommendations

Based on this analysis and feedback from key stakeholders, recommendations for stormwater management are:

- Household scale WSUD devices such as plumbed in rainwater tanks and rain-gardens should be encouraged using a combination of incentives and education focused on both environmental benefits and those directly experienced by the householder. In particular, these devices have the potential to be very effective at reducing overflows from the combined system in Launceston if they can reduce peak flows. It is recommended that City of Launceston and TasWater encourage adoption of household scale devices such as these to assist in the management of CSOs;
- Large scale retrofit options are much more difficult to adopt broadly across the catchment. Opportunities should be sought by councils to identify 'win-win' opportunities for retrofitting WSUD – for example as a feature of green space areas, or by including water quality management in existing flow detention systems;
- The Northern Stormwater Working Group should continue to work together to build the capacity of councils to develop and maintain large scale WSUD systems. Opportunities should be sought to fund ongoing maintenance of systems as this is a key impediment to broad scale retrofitting of WSUD identified by stakeholders;
- Councils should work proactively with the community, in particular local businesses, to identify small scale WSUD options that can be incorporated in refits and redevelopments, for example, to treat or reduce pollutant exports from commercial car parks and other hard surfaces; and
- The NRM North Stormwater and Catchment Officer and councils should engage with the community and provide education about the sources of pollutants in urban areas, the role and advantages of WSUD and actions they can take to improve stormwater quality. This may include but not be limited to school education programs, workshops with developers and builders and education of home owners on the potential benefits of household scale WSUD options.

2.7 Future Land Use Change: The Greater Launceston Plan

The Greater Launceston Plan (GLP) is a major planning initiative that has been undertaken by the City of Launceston in conjunction with the Tasmanian Government, the Australian Government (through the Department of Infrastructure, Liveable Cities Program) and with the support of the surrounding municipalities including the West Tamar, George Town, Meander Valley and Northern Midlands councils (see LCC, 2014). This plan is set to guide urban development in the LGAs in the greater TEER catchment over the medium term (until 2036). Areas proposed for urban and rural residential development under the plan have been identified. These areas are shown in Figure 42 along with local government boundaries.

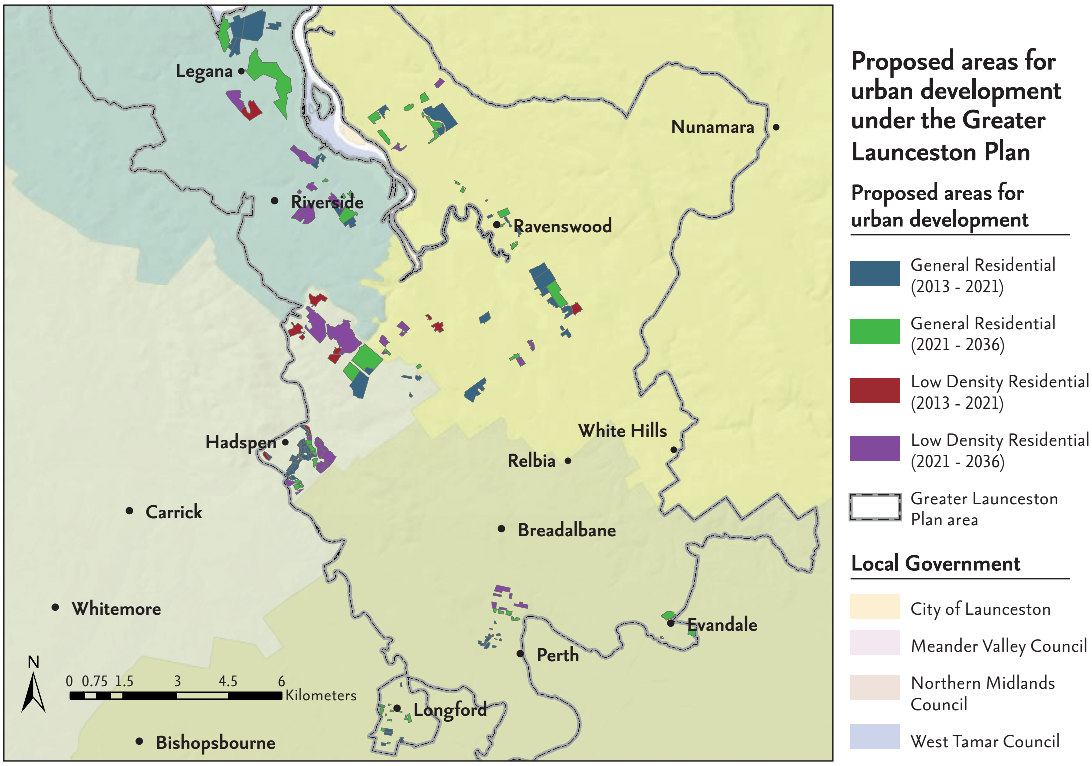


Figure 42. Proposed areas for urban development under the Greater Launceston Plan

This development involves an additional 785ha of urban land, or a 6.3% increase in urban land in the greater TEER catchment. It also involves net increases of 408ha of rural residential land (5.6% increase). This land will be converted from a broad range of existing land uses.

The analysis presented here shows the potential impacts of urban development under the GLP on catchment loads being delivered to the Tamar River estuary and its freshwater tributaries both with and without BMP.

2.7.1 Scenario Options

Urban development has the potential to lead to large increases in pollutant exports. Urban land is generally impervious in comparison with other land uses, that is natural soils and vegetated areas are replaced by hard surfaces such as roads and roofs which do not allow water to penetrate. Flows and pollutants are transported from hard surfaces very quickly into the stormwater system which very efficiently carries them directly to the stream. Another important source of pollutants off urban land is bare soils exposed during the building and development phases of urban developments. Soils can be left bare for up to two years, leaving them vulnerable to erosion. Erosion and Sediment Controls (ESC) which detain this sediment on building sites can be used to limit the runoff of sediments and other pollutants from these sites.

This section analyses the potential impacts of the GLP in light of several potential futures:

- The worst case scenario ("No WSUD") for water quality where development is undertaken without any WSUD or ESC.
- An option where WSUD only (no ESC) is implemented ("WSUD Only").
- An option where only ESC (no WSUD) is implemented ("ESC Only").
- The best case scenario for water quality where development involves both WSUD and ESC ("WSUD and ESC"). To show the total leverage of this option for reducing impacts on water quality this is assumed to occur on 100% of newly developed areas.

No retrofitting of existing urban areas is considered in this analysis.

Many potential WSUD treatment trains (i.e. combinations of WSUD devices) are possible. The best option is generally very site specific and should be determined in consultation with experts for a particular site given available areas of land as well as other site specific constraints. For the purposes of this scenario a single WSUD option, a 60m swale in combination with a biofiltration system, applied to all expansion areas has been assumed. Note that while different treatment trains will have different effects on pollutant loads (e.g. some WSUD devices target nutrients more than others which are more effective for removing sediments) the general lessons from this scenario analysis are applicable regardless of the treatment trains used in specific locations.

2.7.2 Impacts at a Local Government Level

Figure 43 to Figure 46 show the impacts of the four different scenario options on diffuse pollutant loads from affected Local Government Areas (LGA) and from the greater TEER catchment. LGA load impacts refer to loads coming from the portion of the LGA within the greater TEER catchment. Note that in all cases in this section the diffuse load contains overflows from the combined system.

Figure 43 shows the impact of the four scenarios on TN. The greatest increases in TN are expected in Launceston and the West Tamar LGAs. Without any BMP, increases in TN loads from the Launceston LGA can be expected to be in the order of 1%, with load increases from West Tamar LGA closer to 0.8%. Implementing ESC alone has a very small impact on TN loads (less than 0.01%). Where WSUD is applied, increases in TN loads can be expected to be around a third of the increase experienced without WSUD. In the case of TN some increase in loads is to be expected regardless of the WSUD implemented, although this increase is reduced substantially by WSUD. This is because TN is commonly carried dissolved in runoff and is generally more difficult to remove than other types of pollutants.

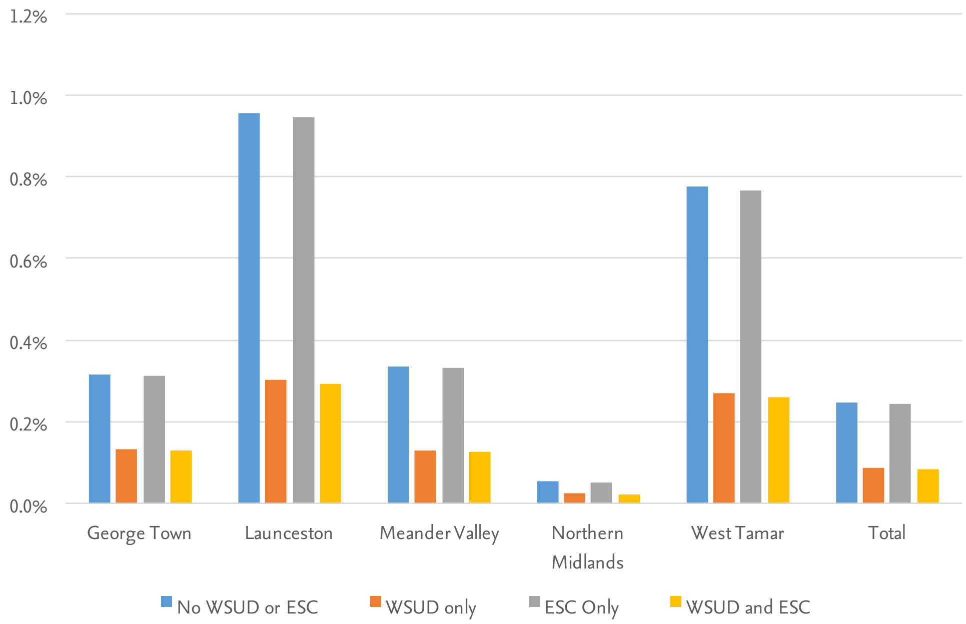


Figure 43. Impacts of the Greater Launceston Plan with and without best management practice on total nitrogen loads from local government areas

Figure 44 shows the impacts of the GLP on TP loads. Again the increases in loads are greatest for the Launceston and West Tamar LGAs. The increase in loads in these LGAs is very similar, at roughly 1%. Total diffuse loads for the greater TEER catchment can be expected to increase by roughly 0.3%.

WSUD is seen here to be more effective for reducing loads of TP than it was for TN, largely because TP is more frequently transported bound to sediments and is easier to remove from runoff than nitrogen. In all cases, incorporating WSUD can reduce increases in TP to very close to zero, or no net increase in TP loads. As was the case with TN, ESC is seen to have a very small impact on increases in phosphorus loads.

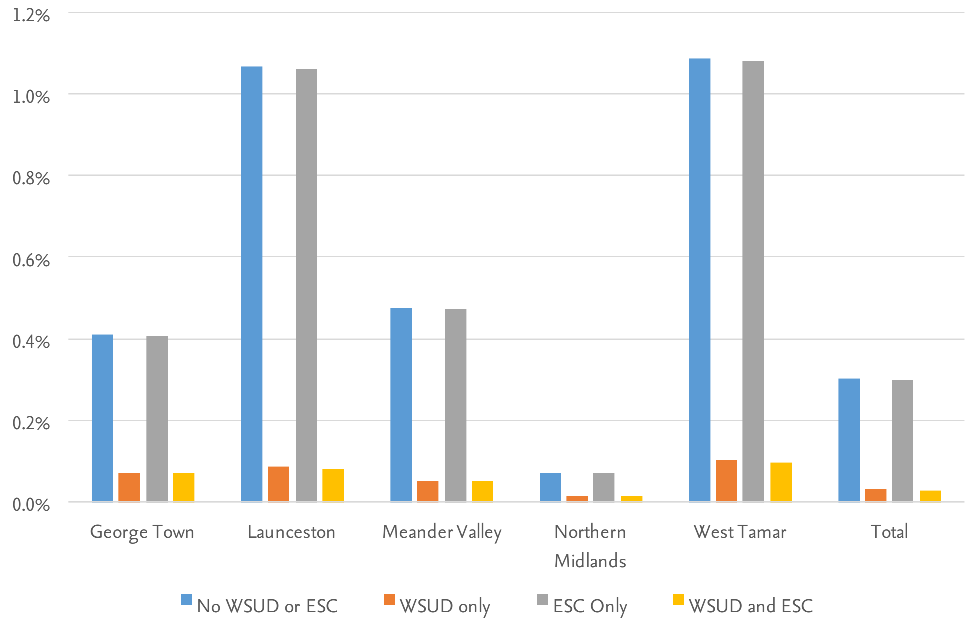


Figure 44. Impacts of the Greater Launceston Plan with and without best management practice on total phosphorous loads from local government areas

Figure 45 shows the impact of the GLP on TSS. As was the case with other pollutants, the greatest increases are in the Launceston and West Tamar LGAs, however in this case increases in loads from the West Tamar are slightly higher than those from the Launceston LGA. Increases in TSS without any BMP implementation are in the order of 1.2%. ESC can be seen to have a relatively small impact on TSS increases, although larger than was the case for TN and TP (up to 0.1%). WSUD is very effective at removing sediments from stormwater runoff and can be expected to lead to small improvements in water quality overall measured by TSS compared to the current loads exported from these areas (approx. 0.05% decrease for greater TEER catchment and 0.2% for the Launceston and West Tamar LGAs).

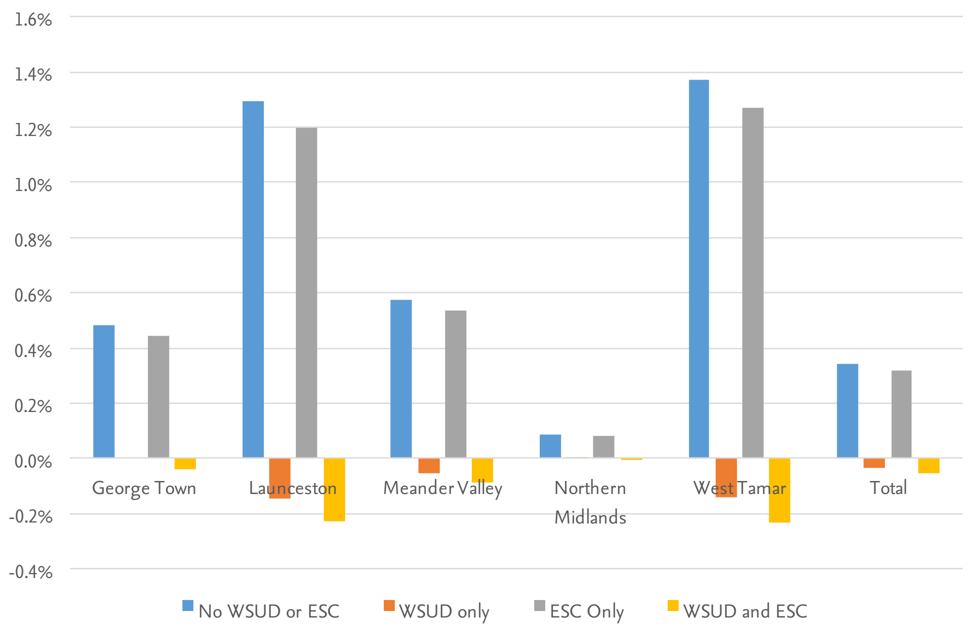


Figure 45. Impacts of the Greater Launceston Plan with and without best management practice on total suspended solid loads from local government areas

Figure 46 shows the impact of the GLP on enterococci. Relative increases in pathogen loads from GLP developments are much smaller than for other pollutants (less than 0.1%). In this case they are highest in the West Tamar LGA while negligible increases can be expected from the Launceston LGA. This small increase is likely to be due in part to the inclusion of sewer overflows from the combined system in total loads from the Launceston LGA. These are a significant source of pathogen loads at a whole of TEER catchment scale and as such are likely to damp down the relative impact of any improvement in general stormwater from other areas in the LGA. Importantly WSUD implemented in GLP development areas has the potential to constrain changes in pathogen loads either to very small increases or in some cases to small net decreases in load. This means that in the case of pathogens, urban development with WSUD can lead to either no net impact on pathogens or even small improvement in water quality.

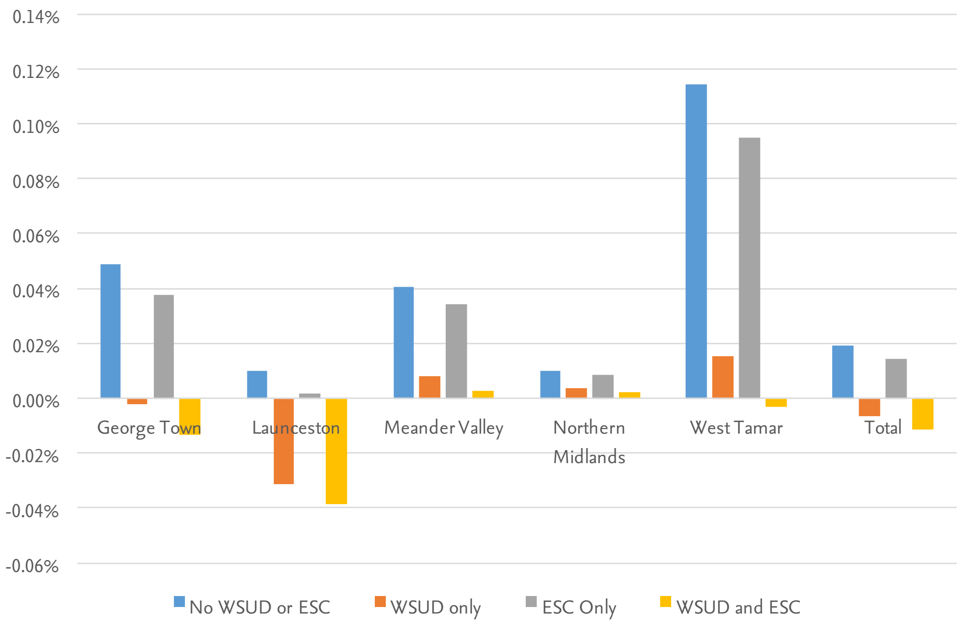


Figure 46. Impacts of the Greater Launceston Plan with and without best management practice on enterococci loads from local government areas

2.7.3 Impacts on Specific Subcatchments

Catchment and LGA wide impacts of urban development under the GLP can seem relatively small (in the order of 1%), largely because the impacts of the relatively small areas of urban development involved are damped by the broad range of land uses and sources of pollutants seen at the whole of TEER catchment scale. However, the GLP has the potential to impact very substantially, both positively and negatively, on water quality at more local scales in some subcatchments (see Appendix 3 for a map of subcatchments used in this analysis). This section describes the impacts on water quality of the GLP with and without WSUD in one of the most heavily impacted subcatchments, Newnham Creek.

Figure 47 shows the impacts of the GLP with and without WSUD on loads from Newnham Creek. This figure shows that the impacts at a subcatchment level can be significant, with 10-15% increases in nutrients and sediments possible without WSUD. Similarly to what was found at the LGA scale, WSUD has the potential to:

- constrain increases in TN to roughly a half of the increase that can be expected without WSUD;
- constrain increases in TP to roughly 20% of the increase that can be expected without WSUD;
- lead to no net increase in TSS; and
- lead to small net improvements in water quality in terms of enterococci.

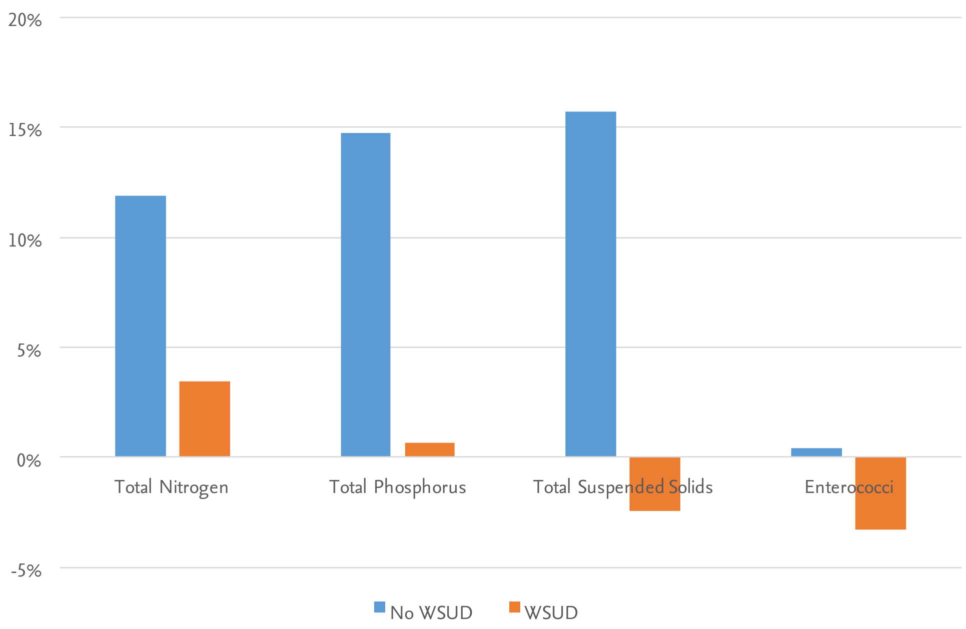


Figure 47. Impact of the Greater Launceston Plan on loads from Newnham Creek with and without water sensitive urban design

2.7.4 Recommendations

This section shows that urban development under the GLP can be viewed as either a threat to water quality, where no BMP is adopted, or an opportunity to slightly improve water quality in some cases. At the very least urban development with WSUD can lead to very small to no net increases in loads. Broad scale adoption of WSUD in development under the GLP is necessary to take advantage of this opportunity. Without this, water quality can be expected to decline, both at the catchment scale, but more dramatically in particular subcatchments that are the focus of development activities. The specific nature and scale of impacts in different areas depends not only on the type of urban land being transitioned to (e.g. the proportion of impervious areas in newly developed urban areas) but also to the land use and management currently in place in these areas. Lands that are currently producing high loads due to poor land management provide a good opportunity to improve water quality through land use change.

Based on this analysis and feedback from key stakeholders, recommendations for managing urban expansion in the Greater Launceston area are:

- Water sensitive urban design should be broadly adopted in all new development areas where on-site constraints allow this to occur. Specific treatment trains will need to be designed subject to site specific constraints using expert assistance to ensure that they provide the greatest benefit at the lowest cost. In order to be effective, WSUD devices need to be properly maintained.
- While erosion and sediment controls can be seen to have a relatively small impact catchment wide they still represent an important action in preserving and improving water quality. These controls should be used and properly managed on all new development sites to minimise soil erosion from new developments.
- The Northern Tasmanian Stormwater Working Group should develop templates for incorporating WSUD into Development Control Plans (DCPs) and Local Environment Plans (LEPs) for new developments to assist councils in their efforts to implement WSUD in future developments.

2.8 Launceston Sewerage Improvement Plan

TasWater currently operates seven sewage treatment plants (STP) in the greater Launceston area to service a population of approximately 75,000 (see Figure 48). These STPs are aging and are reaching their treatment capacity as a result of population growth. On an annual basis, none of these plants consistently comply with contemporary environmental requirements. In order to address these issues and provide a plan for population growth in the greater Launceston area, TasWater has been developing the Launceston Sewerage Improvement Plan (LSIP). The LSIP has identified a number of options for reconfiguring the sewerage system in Launceston.

As was discussed in Section 2.6, older parts of Launceston operate a combined sewerage-stormwater system. This system in operates very differently to the traditional sewerage systems operating in other areas of the catchment. The combined system refers to the combination of sewer and stormwater systems such that sewage and stormwater are transported in the same pipes and treated at the Ti Tree Bend STP. During low flow periods this combination of sewage and stormwater is fully treated at the STP. However during high flow periods, the pipe and STP capacity is not sufficient and a mixture of stormwater and sewage overflows directly to the estuary, bypassing the STP. The Ti Tree Bend STP also currently receives sewage from urban areas in Launceston outside this combined system.

This section considers the potential impacts of the current preferred LSIP option (as at May 2015). TasWater is currently undertaking further investigations to refine constructability and more accurate costings for this option (for details see www.taswater.com.au/Community---Environment/Water---Sewerage-Improvement-Projects/LSIP). In the discussions below, AMT refers to the accepted modern technology (AMT) standards agreed to within the sewage industry. These standards set maximum acceptable concentrations of various pollutants which STPs should not exceed in their discharge to fresh and marine waters (see DPIWE (2001) for details).

The current preferred LSIP option consists of two stages:

- Stage 1:
    - Existing STPs; Hoblers Bridge, Norwood, Newnham, Prospect Vale, Riverside and Legana to be decommissioned.
    - Sewage from existing STPs redirected to a new STP (New Northern STP) to be co-located with the current Ti Tree bend STP.
    - Sewage not part of combined system currently treated at the Ti Tree bend STP, redirected to the New Northern STP.
    - The New Northern STP constructed to comply with AMT or other EPA approved limits.
    - Existing Ti Tree bend STP continues to operate, treating the combined effluent.
- Stage 2:
    - Ti Tree Bend STP upgraded if required.

Modelling of the effectiveness of the current preferred LSIP option in reducing loads of sediments, nutrients and enterococci under the existing population is first considered. The impact of population growth in and around Launceston on trajectories of modelled loads, with and without the reconfiguration proposed in the preferred LSIP option, are then explored.

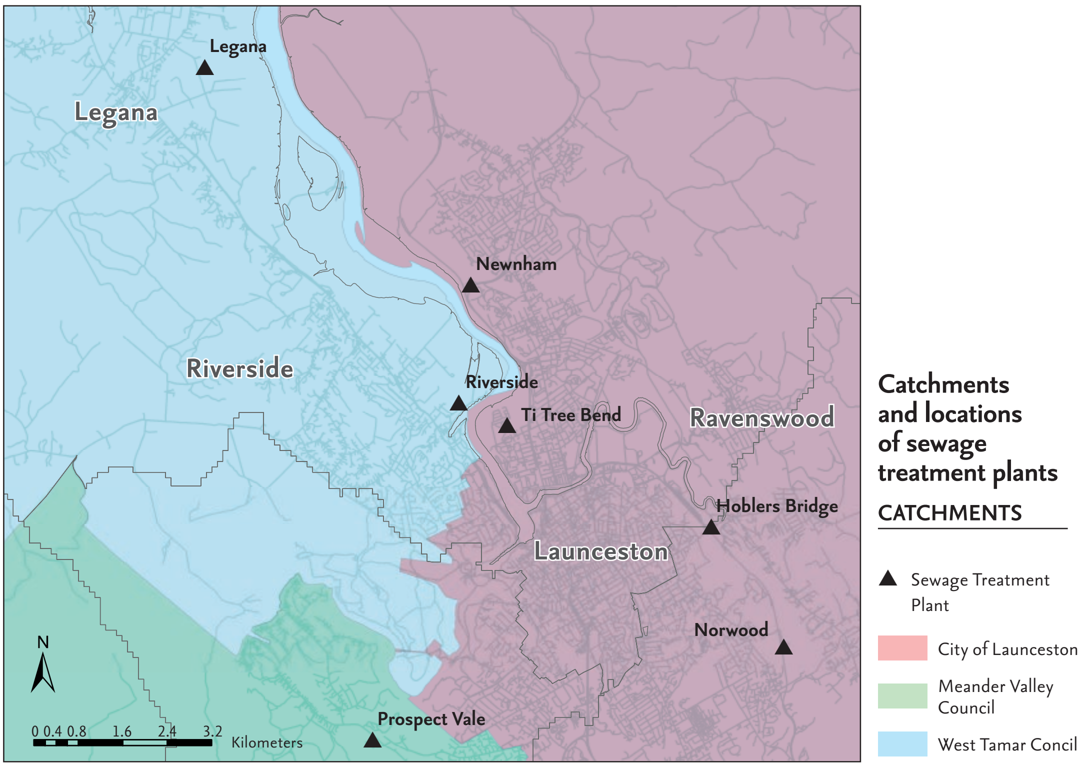


Figure 48. Sewage treatment plants currently servicing the Launceston area

2.8.1 Impacts of the Current Preferred Option Assuming Existing Population

To assess the effectiveness of the proposed reconfiguration in reducing current pollutant loads to the Tamar River estuary, the current preferred option is first considered with existing population levels. Results are presented to demonstrate the impact of load reductions to the estuary expected from Stage 1 and Stage 2 of this option with existing population levels (see Figure 49).

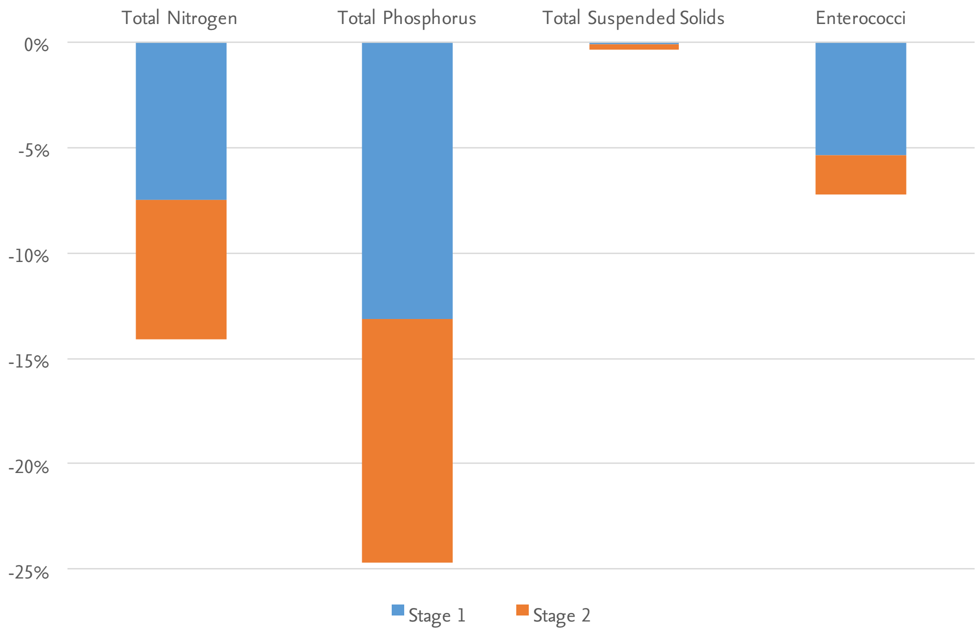


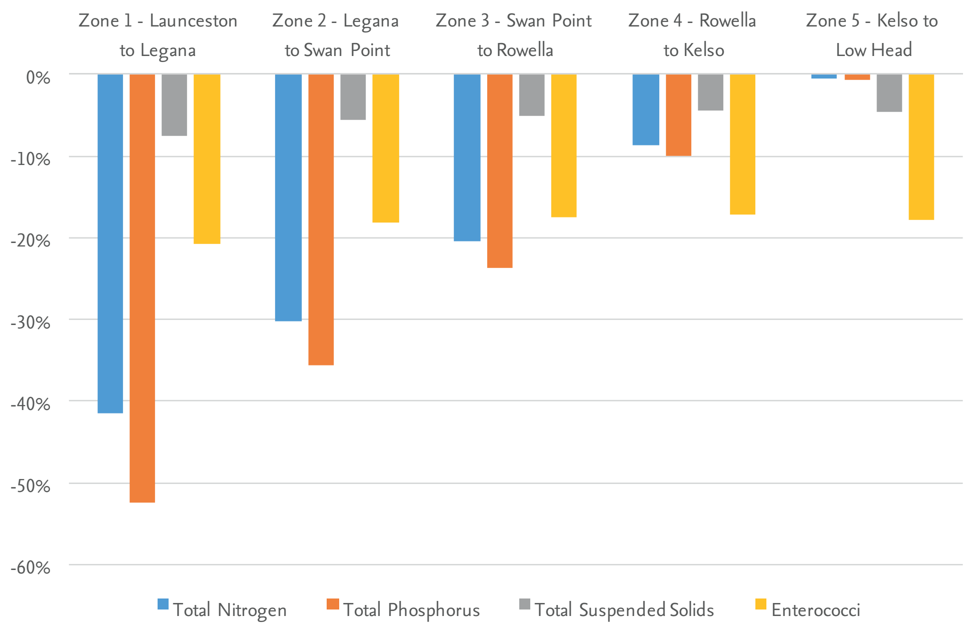
Figure 49. Changes in total loads (diffuse and point source) to the Tamar River estuary for current preferred option for the Launceston Sewerage Improvement Plan with existing population

Figure 49 shows the impacts of the current preferred option on decreasing the total loads to the Tamar River estuary (diffuse and point source loads) from Stage 1 and Stage 2 assuming existing population levels. This scenario is likely to have a large impact on total nutrient loads to the estuary, with decreases in TN of approximately 15% and TP of approximately 25%. Enterococci loads would also decrease substantially, by approximately 7%. Very little impact is expected on TSS as STPs in the Launceston area are not a significant source of suspended solids. While Stage 1 is shown to have the greatest impact on all pollutants compared to Stage 2, the two stages produce very similar impacts on TN and TP. Stage 1 accounts for a substantially greater proportion (5%) of enterococci decreases than Stage 2 (2%).

These changes in loads can be expected to have significant impacts on estuary water quality, particularly since these STPs directly discharge to the estuary. The relative change in average concentration across each zone for each pollutant in summer and winter is shown in Figure 50. This figure shows that the greatest relative impacts on nutrient levels in the estuary would occur in Zone 1, stretching from Launceston to Legana. This focus of impacts is due both to the location of these STPs in Zone 1 as well as the influence of incoming tides which retain pollutants in this zone.

In Zone 1, decreases in nutrient concentrations of 40 to 50% are possible in summer and 50% to 60% in winter. Relative impacts on nutrients decrease moving down the estuary to Zone 5 (Kelso to Low Head), with insignificant benefits expected in Zone 5. Relative changes in TSS and enterococci concentrations vary less down the estuary, although they still show a trend to decrease down the estuary. This is in part because base case nutrient concentrations are relatively high for the full extent of the estuary so that the greater absolute decrease in nutrient concentrations in the upper estuary translate into higher proportional changes in concentration. By comparison base TSS and enterococci concentrations drop off very quickly moving down the estuary from Zone 1 so that the decreasing absolute change in concentration translates to a relatively constant relative change moving down the estuary. A further point of interest is that the change in pollutant concentration is relatively high compared to the change in loads as a proportion of total catchment load. This is because loads from these STPs discharge directly into the estuary and consequently have direct impact on pollutant concentrations relative to the loads derived from diffuse inputs further up in the catchment.

50A Summer



50B Winter

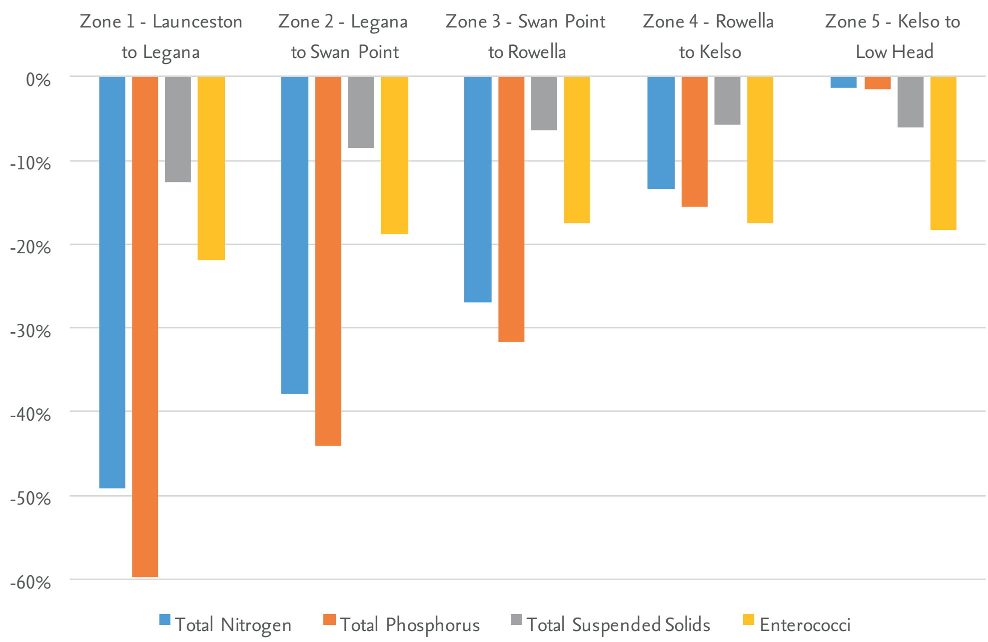


Figure 50. Changes in average of median pollutant concentration across estuary zones from current preferred option with existing population

2.8.2 Trajectories of Loads Under Population Growth

It is important that the current preferred LSIP option is designed to meet both existing population demands as well as future population growth. It is currently projected that Launceston's population will increase by approximately 50% by 2060.

This section considers the impacts of two scenarios that incorporate assumptions around future growth in population serviced. The current preferred option under population growth is compared with the worst case option, where population growth occurs but the current configuration and levels of treatment of STPs are maintained. All impacts are described relative to current loads. Note that the modelled worst case is expected to underestimate the true worst case, as a failure to invest now in future treatment would no doubt lead to poorer levels of treatment and greater system failure than is currently experienced.

Figure 51 shows the trajectory of modelled total pollutant loads under these two scenarios. In each case, the dashed line represents the effects of the new treatment option (best case) whereas the continuous line shows the worst case increase in loads as population growth occurs without any improvement in treatment. The greatest changes, both increases and decreases, are expected in nutrients, with TP increases under the worst case of nearly 10% versus improvements in TP loads of over 20% if the system is reconfigured. Very small changes in TSS loads are expected in either case. Small relative increases in enterococci loads (~1%) can be expected if the worst case option if no investment in improved treatment is made, while significant improvements of roughly 7% are expected under the best case investment option.

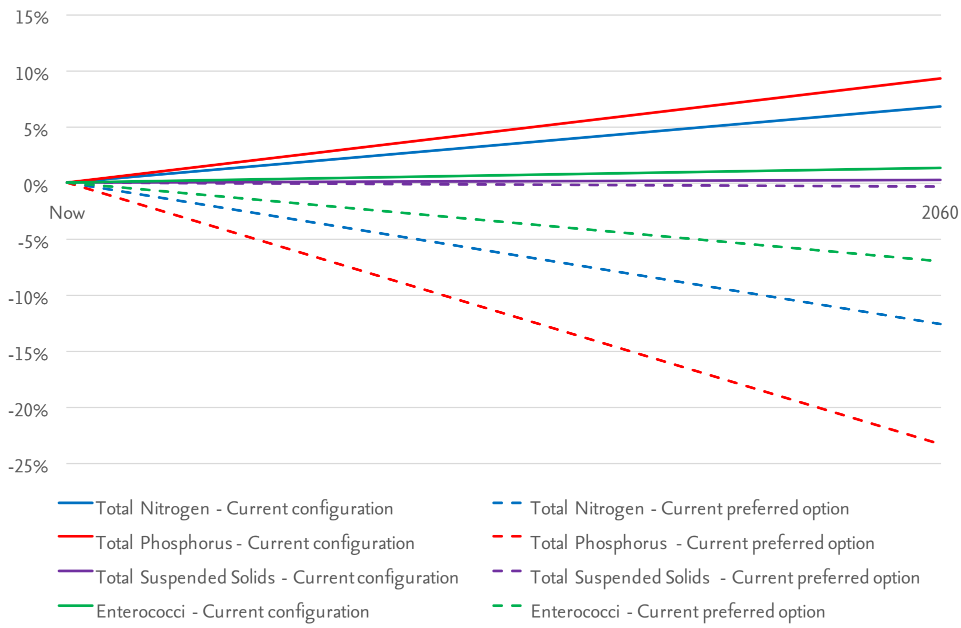


Figure 51. Trajectories of total future loads to the Tamar River estuary given population growth with the current preferred option (best case) and the current sewage treatment plant configuration (worst case)

These results indicate that the LSIP current preferred option (as at May 2015) can not only avoid significant future declines in water quality but can lead to large improvements in water quality for the Tamar River estuary in the medium to long term.

2.9 Aquaculture in the Tamar River Estuary

Whilst the Tamar River estuary and its tributaries have received inputs of land based pollutants for over a century, direct input of nutrients from aquaculture are a relative newcomer contributing to the nutrient load in catchment and estuary.

Currently there are a number of aquaculture operations utilising water sources that form part of the catchment, including salmonid hatcheries at Upper Esk, Targa and Cressy, a salmonid sea farm at Rowella, seahorse farm at Beauty Point and an abalone farm at Clarence Point.

Van Diemen Aquaculture run the northern-most Atlantic salmon sea farm in Tasmania in the lower reaches of the Tamar River estuary, close to Rowella (see Figure 52), and has contributed production data to this plan. This salmon farm currently grows up to 750,000 salmon per annum. There is limited scope for expansion in the Tamar within the terms of the current marine farm development plan for the estuary. The current site allows Van Diemen Aquaculture to utilise the Tamar River estuary's very high tidal flows, with a tidal range of 3.5m and peak flows due to tidal exchange of 80cm/second. Salmon grown in water currents equivalent to their swimming speed have improved physiological performance, faster, and more uniform growth rates and make more efficient use of their feed.

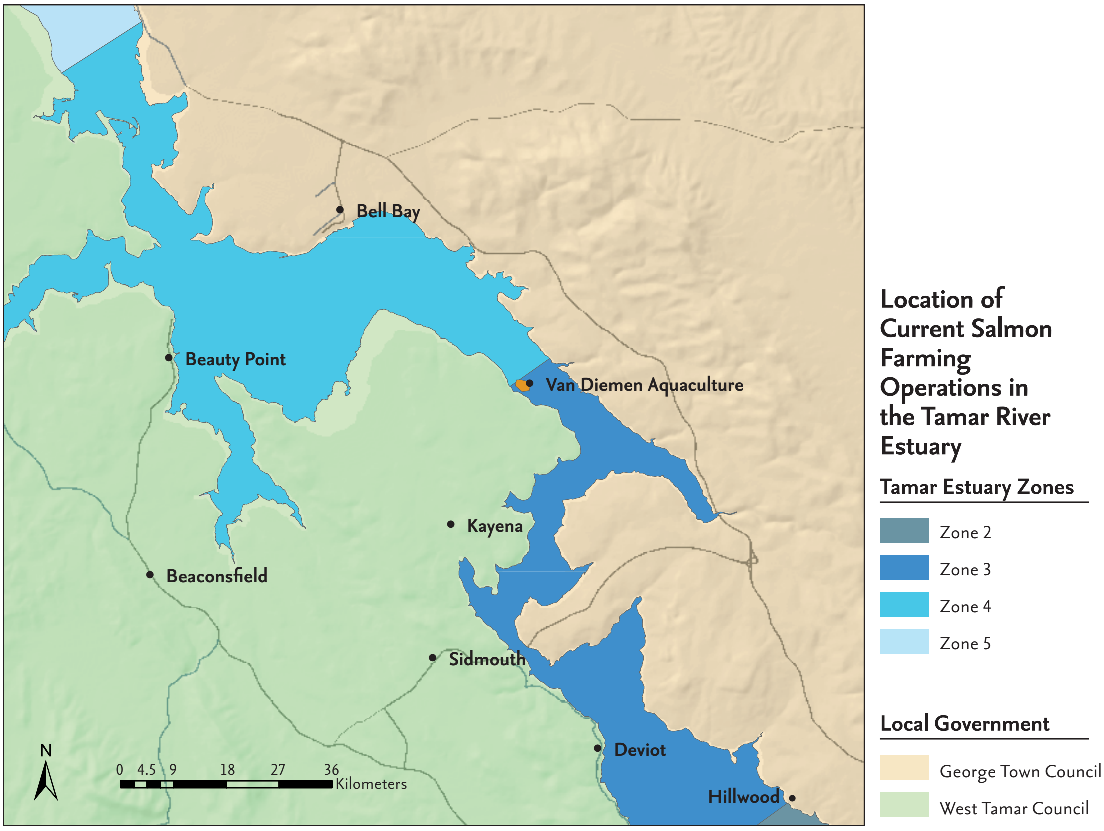


Figure 52. Location of current salmon farming operations in the Tamar River estuary

Salmon farming accounts for approximately 6% to 7% of the modelled nutrient loads input to the estuary. Figure 53 shows the contribution of salmon farming to nutrient concentrations in the estuary in summer and winter.

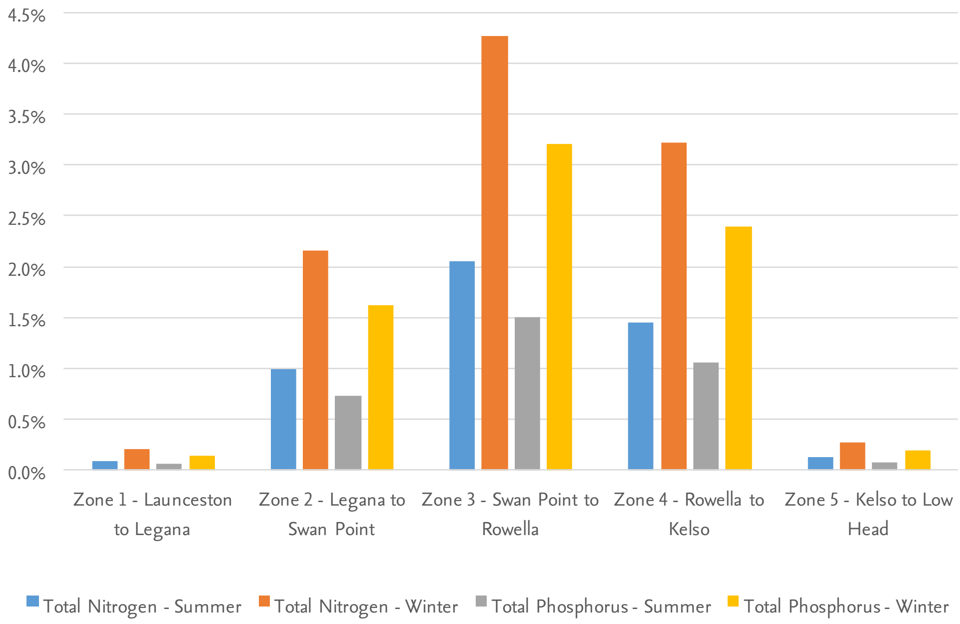


Figure 53. Relative contribution of nutrients from aquaculture to nutrient concentrations in the Tamar River estuary

This figure shows that, as expected, the greatest impacts are in the zones adjacent to the salmon farm (located at Rowella). The greatest contribution of salmon farming is to nitrogen loads in winter in Zone 3, which extends from Swan Point to Rowella. In this zone, roughly 4% of the winter nitrogen concentration can be attributed to salmon farming. Approximately 3% of phosphorus concentrations in winter in this zone can be attributed to salmon farming. Relative contributions of aquaculture to summer concentrations are approximately half that of winter contributions due to the seasonality of salmon farming. The relative contribution of aquaculture to nutrient concentrations in the estuary is less than its relative contribution to load due to the high level of tidal flushing and strong flows at the salmon farm. This flow buffers the estuary from greater impacts on pollutant concentrations.

Nutrient outputs from salmon farming result from indigestible material from the diet being excreted as faecal waste as well as from uneaten food. The conversion of feed to fish is a key productivity measure in salmon farming, with producers aiming to improve feed conversion ratios to improve their own productivity and subsequent profitability. Presently, food conversion ratios (FCR), which measure the kilograms of feed input for each kg of fish output, at Van Diemen Aquaculture typically sit at or around 1.39:1. A continual focus is being put on feed formulations and feeding technology to improve this ratio, and therefore reduce the environmental impact of the farm. Reducing FCR equates directly to a reduction in nutrient input to the estuary from salmon farming. This means that nutrient management is a win-win for the salmon farmer and the estuary and that over time, so long as current levels of farming are undertaken, the contribution of salmon farming to nutrient loads in the estuary is likely to fall as a result of production and profitability pressures.

section 3
LOAD AND CONDITION TARGETS

This section presents load targets for the freshwater system in the greater TEER catchment as well as water quality and condition targets for the Tamar River estuary. These targets are based on a feasible improvement scenario defined using assumptions derived from discussions with key stakeholders which implement the recommendations presented in this plan. These targets have been provided based on current land use as well as considering potential future land use change.

3.1 Assumptions Behind Load Target Scenarios

3.1.1 Current Land Use Scenario

The first target scenario, using current land use, applies levels of adoption of various management practices as follows:

- Urban management –
  - 8% of urban areas treated with large scale WSUD devices, assuming both upfront and maintenance incentives are provided.
  - 25% of urban areas of the combined sewer stormwater system in Launceston is treated with household scale WSUD devices such as rainwater tanks, assuming both incentives and education are provided.
  - 95% of building sites adopt and maintain effective erosion and sediment control.
- Grazing management –
  - 25% of streams have limited stock access to streams, assuming maintenance and upfront incentives are provided.
  - 75% of remaining unvegetated stream sections have a 5m vegetated riparian, assuming upfront and maintenance incentives are provided.
  - Groundcover levels are raised to the 90th percentile for any areas currently below this level, corresponding to 84% in summer and 89% in winter.
- Crop management –
  - 50% of areas with bare soil greater than 20% in summer and 10% in winter reduce bare soil to these levels.
  - 10m riparian buffers are implemented on 10% of steam length that is currently unvegetated.
  - 95% of farmers adopt controlled release fertilisers.
- Dairy management –
  - Stock are excluded from 90% of streams.
  - 100% of dairy farms have sufficient effluent storage.
- Sewage treatment assuming the current preferred option (as at May 2015) –
  - Stage 1 – existing plants at Hoblers Bridge, Norwood, Newnham, Prospect, Riverside and Legana are decommissioned. Effluent currently treated at these plants is redirected to a new STP collocated with the current plant at Ti Tree Bend. In addition to this, 4ML/day of effluent that currently gets treated at the existing Ti Tree Bend STP is also directed to the new plant. Treatment at this plant is assumed to comply with accepted modern technology (AMT) standards agreed to within the sewage industry.
  - Stage 2 – the existing STP at Ti Tree Bend is upgraded and continues to operate, treating a smaller volume (as outlined above) of effluent than currently. Treatment standards at this plant are also increased to AMT standards.

Note that with the exception of the dairy management option, these assumed levels of adoption are in line with those tested in Section 2 of this plan based on stakeholder feedback. In the case of dairy management, feedback from key stakeholders is that regulation to ensure adequate effluent storage will mean 100% adoption of this action in the future. Excluding stock from streams was suggested as being highly adoptable, with rates of adoption higher than was the case from grazing land. This is because of the lower cost and production benefits of excluding stock in dairy areas, where a single wire fence is generally appropriate. Incentives would boost adoption rates. The dairy industry has set a target of 90% of streams fenced to exclude stock. Adoption of other actions in dairy areas is not included but could be expected to lead to greater decreases in pollutant loads compared to the load target scenario presented below.

3.1.2 Future Land Use Scenario

The future land use target scenario assumes the same levels of treatment for remaining areas of current land. Land use changes and assumed adoption of management actions on these areas are as follows:

- Urban growth – urban expansion in line with the Greater Launceston Plan with:
  - 50% large scale WSUD applied on new urban areas.
  - 95% of building sites on expansion areas apply erosion and sediment controls.
- Dairy expansion – broadacre dairy expansion on grazing areas with:
  - Stock excluded from 100% of streams in expansion areas and on areas using Tasmanian Irrigation water.
  - 90% adoption on expansion areas of BMP drain management and 100% on areas using Tasmanian Irrigation water.
  - 90% adoption of BMP fertiliser and irrigation management on expansion areas and 100% on areas using Tasmanian Irrigation water.
  - 100% adoption of sufficient effluent storage on all expansion areas.
- Irrigation expansion – intensification and expansion under proposed future Tasmanian Irrigation schemes with:
  - Farm WAP implemented for 100% of areas using Tasmanian Irrigation water.
- Sewage treatment under population increase – future population growth of 50% by 2060 with current preferred option implemented.

It is important to note that these assumptions have been used to derive a feasible scenario for setting load targets. Factors such as improvements in technology or changes in the cost of actions might mean that a different mix of management actions are best to adopt to reach these targets.

3.2 Impacts on Total Loads from the Greater TEER Catchment

Table 10 shows total current loads as well as targeted reductions for current and future land uses and population. These loads and targets are for total loads, including diffuse and point source loads.

Table 10. Current loads and load targets

Subcatchment	Current load	Load target Current land use	Load target Future land use
TN (kg/yr.)	1,967,209	-18%	-17%
TP (kg/yr.)	313,031	-29%	-27%
TSS (t/yr.)	82,798	-6%	-6%
Enterococci (cfu/yr.)	3.16E+15	-25%	-24%

Figure 54 and Figure 55 show the impacts on total pollutant loads from the catchment under the current and future land use and population scenarios respectively. Cumulative impacts are shown separated into contributions from diffuse and point sources.

Figure 54. Modelled decreases in total pollutant loads from diffuse and point sources from the greater TEER catchment under the current land use scenario

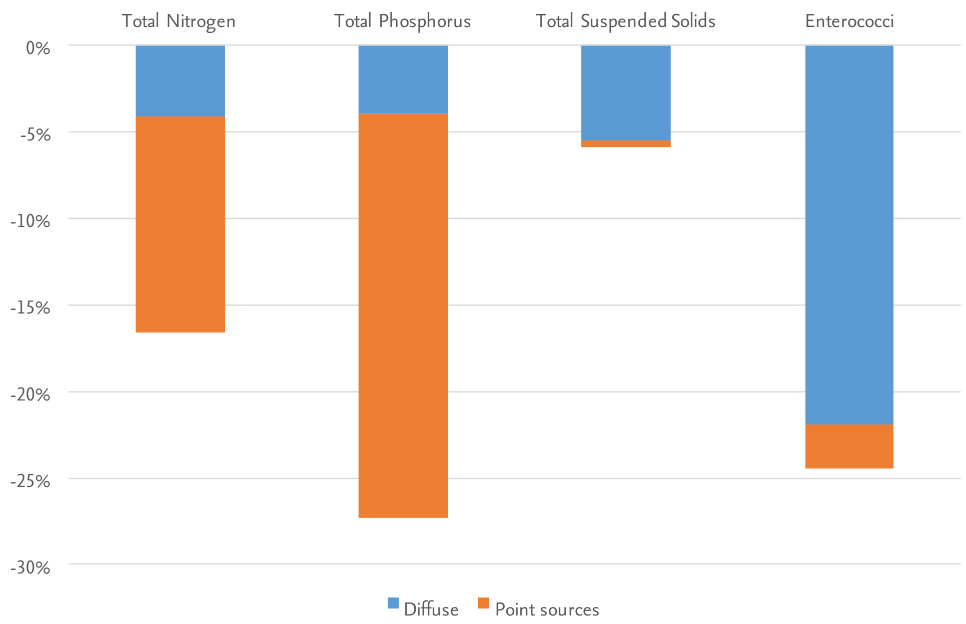


Figure 55. Modelled decreases in total pollutant loads from diffuse and point sources from the greater TEER catchment under the future land use scenario

Figure 54 and Figure 55 show that total decreases in loads under the current and future land use scenarios are very similar, with decreases in loads slightly smaller under future land use when compared to current land use. These figures show that substantial decreases in loads are feasible both under current and future land use options. If targeted load reductions for these pollutants are set at the smaller levels that are estimated to be achieved under the future land use scenario, then targeted decreases in pollutant would be set at:

- 17% for TN
- 27% for TP
- 6% for TSS
- 25% for enterococci

These figures also show that decreases in nutrients are largely due to decreases in point source loads while decreases in TSS and enterococci occur largely as a result of decreases in diffuse source loads. Modelled decreases in enterococci depend very strongly on the exclusion of stock from streams. To achieve planned decreases in enterococci, a large management focus needs to be placed on broadscale stock exclusion, particularly in areas of dairy expansion.

3.3 Catchment Contributions to Load Reductions

The contribution of these load decreases from various catchments and direct loads to the estuary is shown in Figure 57 and Figure 58 for the current land use and future land use scenarios respectively. The location of these Freshwater Report Card catchments is shown in Figure 56. Current catchment loads and load targets are given in Appendix 1.

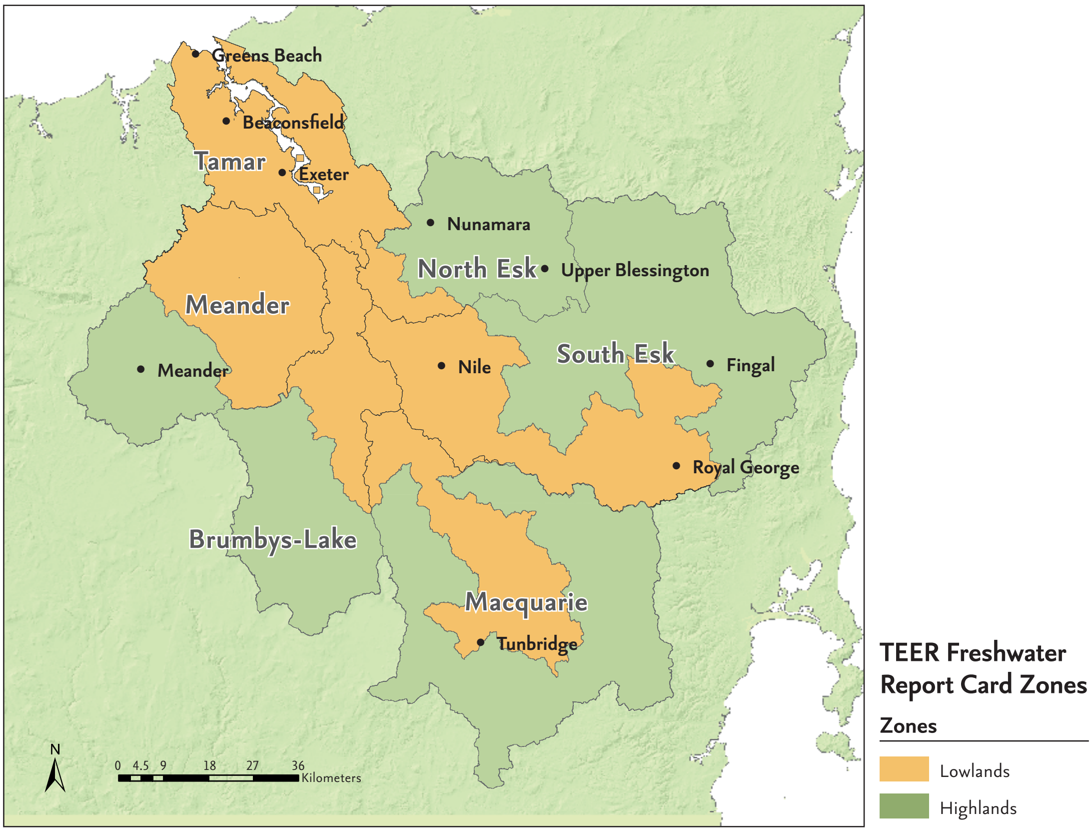


Figure 56. Freshwater Report Card catchments used in analysis

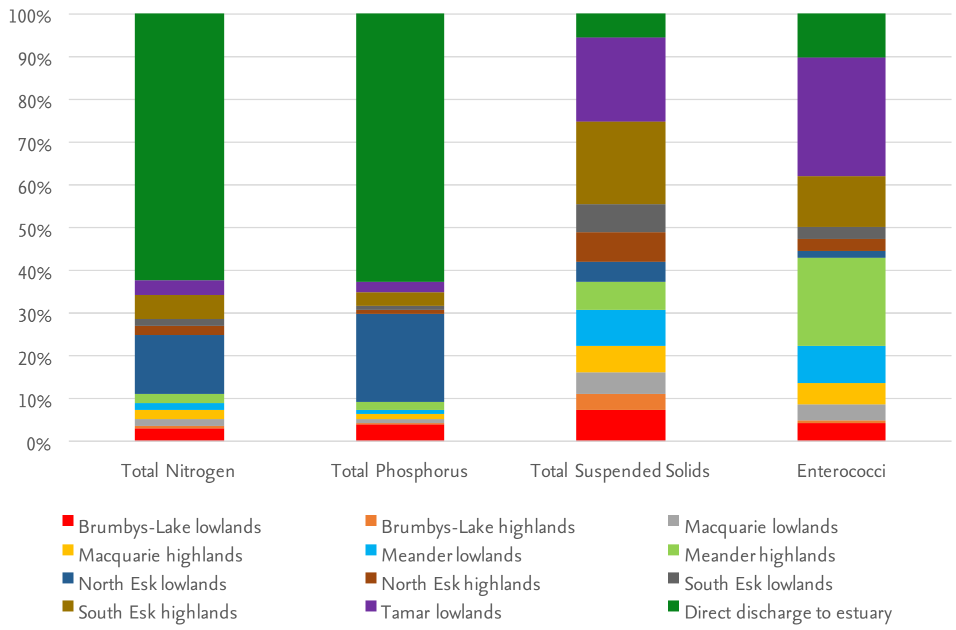


Figure 57. Relative contribution of modelled changes in load from individual catchments to total decreases in loads from the greater TEER catchment under the current land use and population scenario

Figure 57 shows that under the current land use and population scenario, the majority of nutrient load reductions would be as a result of decreases in nutrients directly discharging into the estuary, all from point sources (~60%). Decreases in loads from the lowlands of the North Esk would also make a substantial contribution to overall catchment load reductions (14% TN and 21% TP). Decreases in TSS and enterococci loads are more evenly contributed to by load reductions across a range of catchments. The greatest contribution of TSS load reductions comes from decreases in loads from the Tamar (20%) and South Esk highlands (19%). For enterococci, decreases in the Tamar catchment (28%) and Meander highlands (21%) have the greatest impact on loads to the Tamar River estuary.

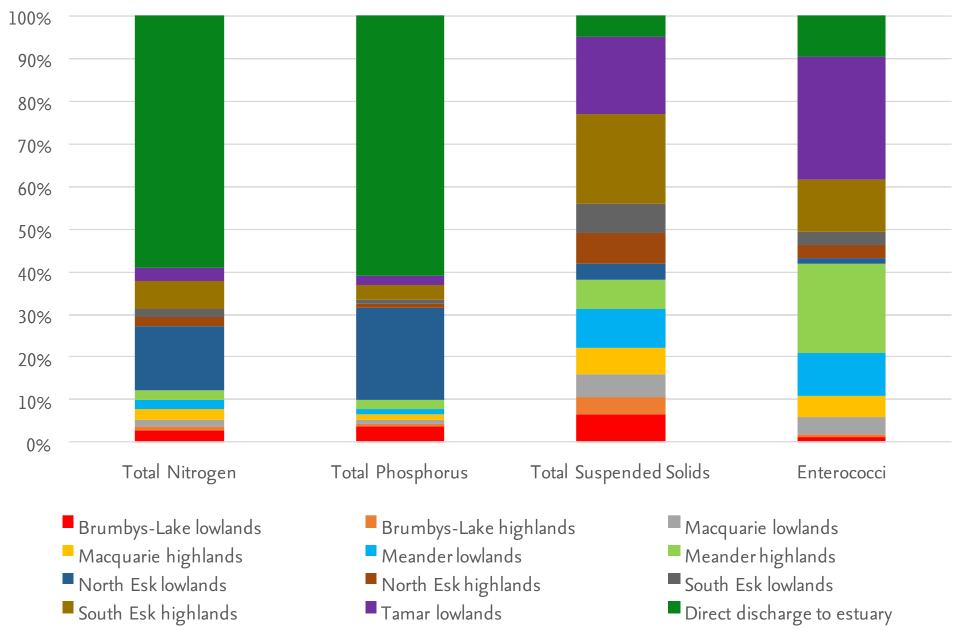


Figure 58. Relative contribution of modelled changes in load from catchments to total decreases in loads from the greater TEER catchment under the future land use and population scenario

Figure 58 shows that under the future land use and population scenario, the majority of nutrient load reductions would occur as result of changes in direct discharges to the estuary (60%) and then from the lower North Esk catchment (15%). A relatively large proportion of TN reductions also occur as a result of changes in the highland areas of the South Esk catchment (6%). The relative contributions of catchments to decreases in TSS and enterococci loads look very different to nutrients. For

TSS, the highland areas of the South Esk catchment (21%) and the Tamar catchment (18%) are responsible for the greatest proportion of the decrease in loads. For enterococci, the Tamar (29%) and Meander highlands (21%) make the greatest impact on load reductions.

3.4 Impacts on Catchment Loads and Freshwater Condition

The target scenarios have significant impacts on total pollutant loads in many of the catchments of the greater TEER catchment. This can be expected to have impacts on the condition of these freshwater systems. Note that results in this section refer to the percentage change in loads within the catchment only. In some cases, the absolute decrease in loads may be relatively small compared to other catchments but because of the smaller contribution of that catchment to total loads to the estuary, the relative impact on total greater TEER catchment loads may be greater. Figure 59 to Figure 62 show the change in total loads of TN, TP, TSS and enterococci respectively as a result of the target scenarios in each of the TEER catchments. Current catchment loads and load targets are given in detail in Appendix 1.

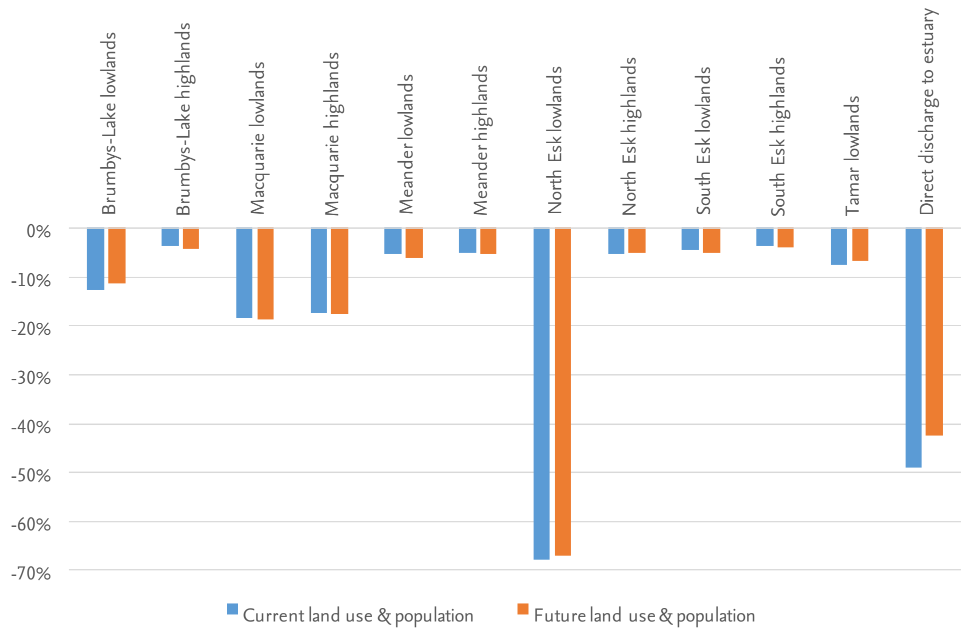


Figure 59. Modelled changes in total catchment total nitrogen load under the current and future land use and population scenarios

At a catchment scale, the greatest relative modelled impact on nutrient loads is in those generated from the lowlands of the North Esk River (over 60% decrease). The second greatest change in loads is for loads discharging directly to the estuary (40% to 50%) from point sources. The changes in total loads both discharging directly to the estuary and to a lesser extent, the North Esk lowlands, are as a result of reconfiguring the sewage treatment system and reducing CSOs using WSUD. Substantial changes in TN loads are also expected for both the lowlands and highlands of the Macquarie catchment, with decreases of nearly 20% (Figure 59). The lowlands of the Brumbys-Lake catchment can also expect to see decreases in TN loads of over 10%. Other areas are estimated to experience decreases in TN load of between 4% and 8%.

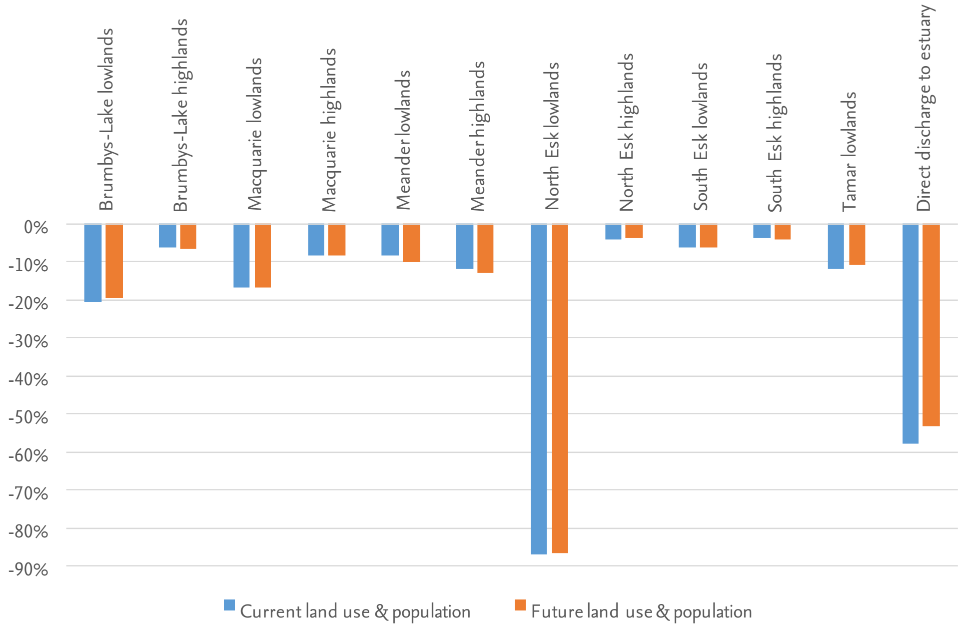


Figure 60. Modelled changes in total catchment total phosphorous loads under the current and future land use and population scenarios

As was the case with TN, the greatest relative modelled changes in TP are seen in the North Esk lowlands (over 80%) and discharges direct to the estuary (over 50%). The lower part of the Brumbys-Lake and Macquarie catchments also see decreases in TP loads of nearly 20% (Figure 60). Decreases in TP loads of greater than 10% can be expected in the Tamar catchment and Meander highlands. Other catchment areas experience decreases in TP loads ranging from 4% to 8%.

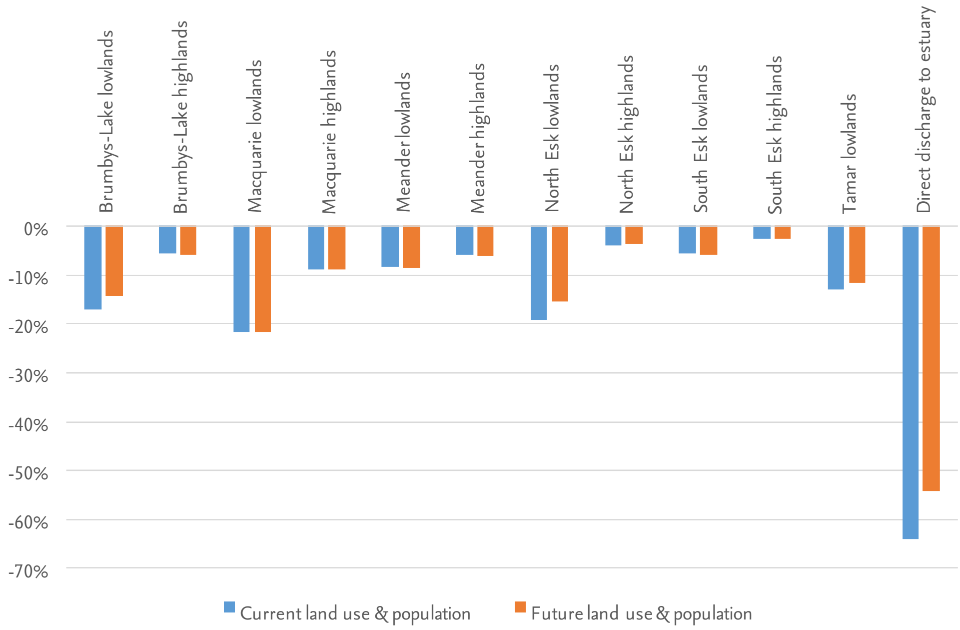


Figure 61. Modelled changes in total catchment total suspended solid loads under the current and future land use and population scenarios

The greatest relative change in modelled TSS loads (64% and 54% for current and future scenarios respectively) is experienced in discharges direct to the estuary (see Figure 61). It should be noted that absolute loads in this case are very low (approx. 0.5% of TSS loads for the total catchment) so this large relative impact has very little impact on total loads to the estuary. Substantial decreases in TSS load can be expected for the lowlands of the Macquarie, North Esk and Brumbys-Lake catchments with decreases of 15% to 22%. Impacts in the Tamar catchment are expected to be over 10%. The lowest relative decrease in loads is seen in the highlands of the South Esk where decreases of 4% can be expected. Other catchments can expect decreases of 4% to 9%.

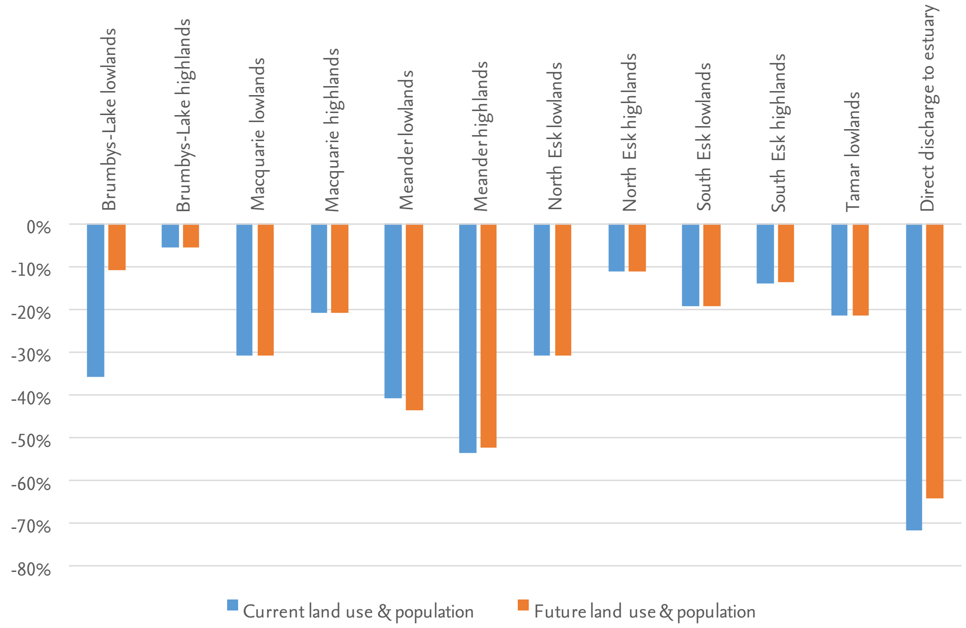


Figure 62. Modelled changes in total catchment enterococci loads under the current and future land use and population scenarios

Relative impacts on enterococci loads are generally higher for all areas than was the case for nutrients or sediments (Figure 62). As was the case for other pollutants, large relative decreases in discharges direct to the estuary can be expected. Decreases of 40% to 50% of loads from both the lowlands and highlands of the Meander subcatchment are likely. Decreases of 30% can be expected in the lowlands of North Esk and Macquarie catchment. Similarly decreases of roughly 30% can be expected in the lower Brumbys-Lake catchment. Substantial changes of 10% to 20% are expected in all areas except the Brumbys-Lake highlands, where decreases of only 5% of enterococci loads are expected.

These changes in loads can be expected to lead to substantial improvements in stream condition in affected freshwater waterways in the greater TEER catchment. Changes in loads in many subcatchments are substantial and can be expected to lead to decreased turbidity and algal growth. Changes in enterococci inputs can also be expected to make streams safer for recreational activities such as swimming and fishing, as well as for stock and domestic uses. In particular, water quality in lowland areas can be expected to improve substantially.

3.5 Impacts on Estuary Water Quality and Condition

The load target scenarios can be expected to lead to substantial improvements in water quality in the Tamar River estuary. Figure 63 shows the functional zones in the estuary. Figure 64 and Figure 65 show the change in the modelled median summer and winter pollutant concentrations in each of these zones, averaged across the zone, as a result of the current and future land use and population scenarios respectively.

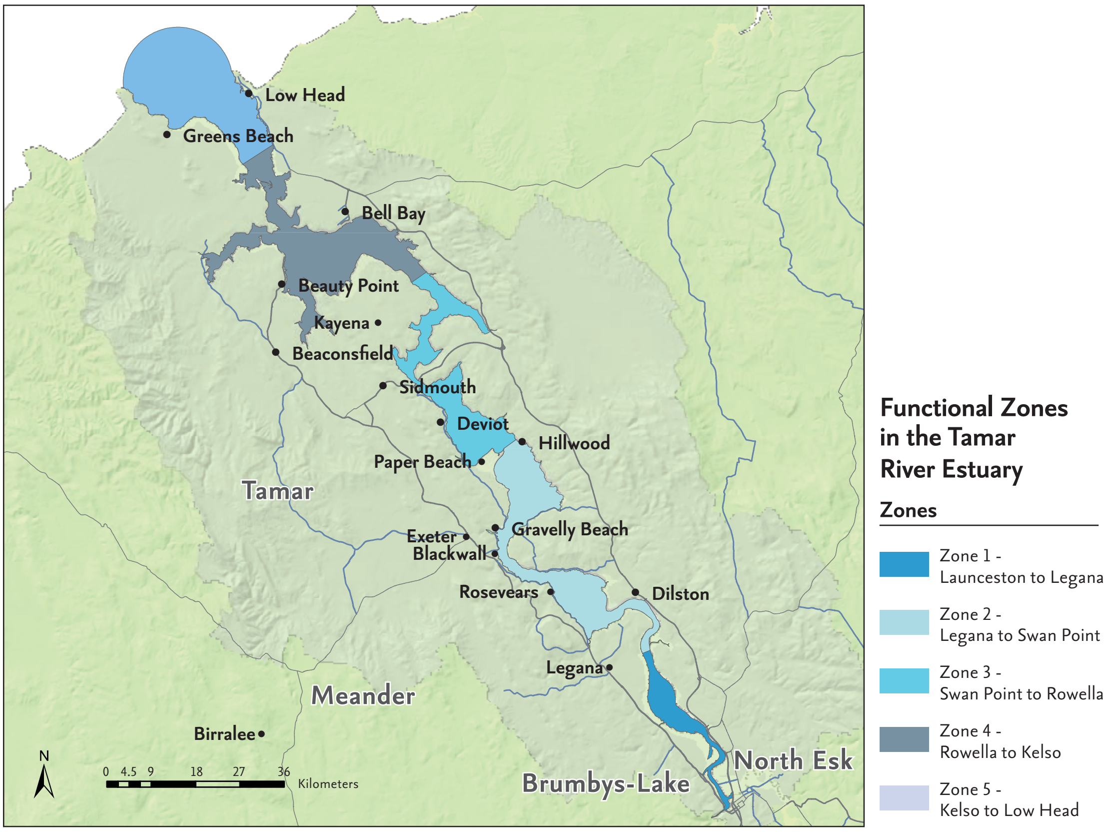
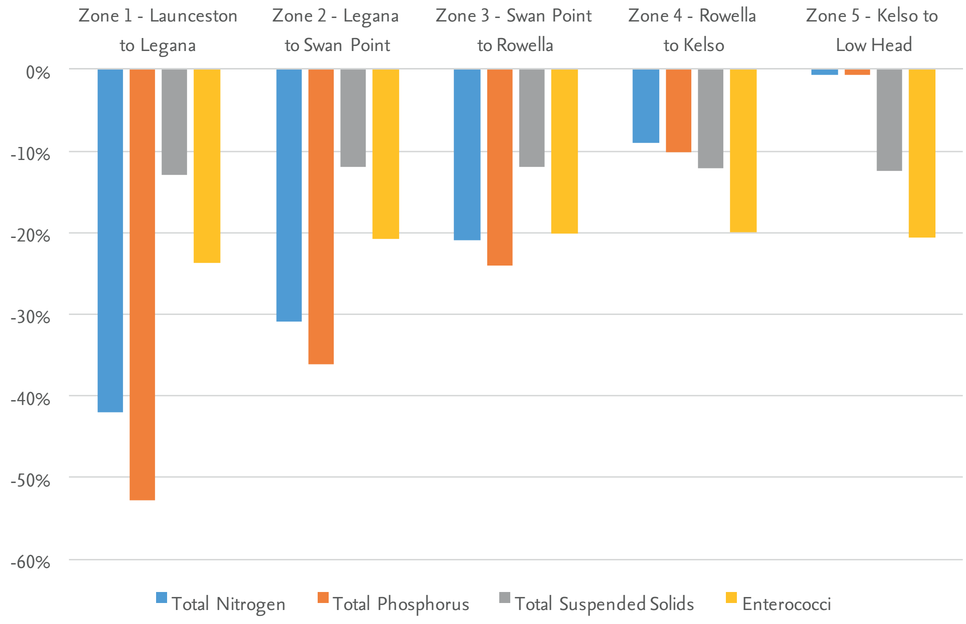


Figure 63. Functional zones in the Tamar River estuary

64A Summer



64B Winter

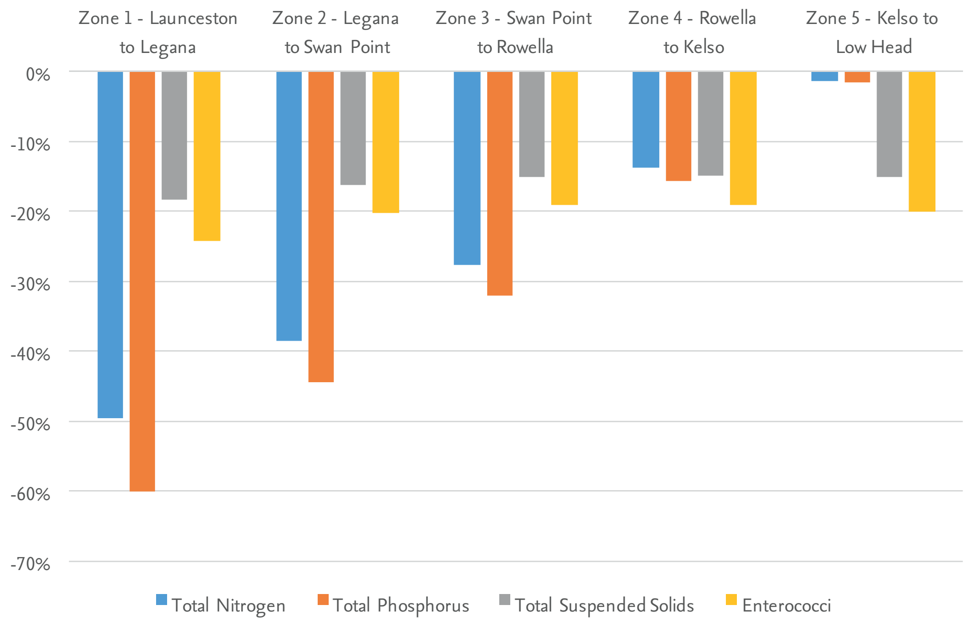
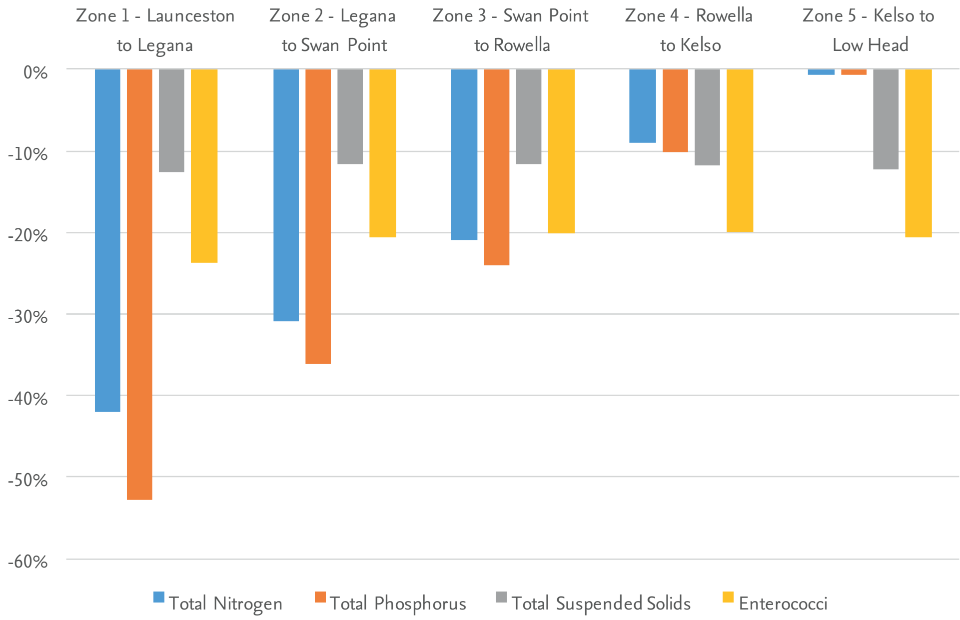


Figure 64. Modelled impacts on average estuary pollutant concentrations in the Tamar River estuary report card zones using current land use and population scenarios

65A Summer



65B Winter

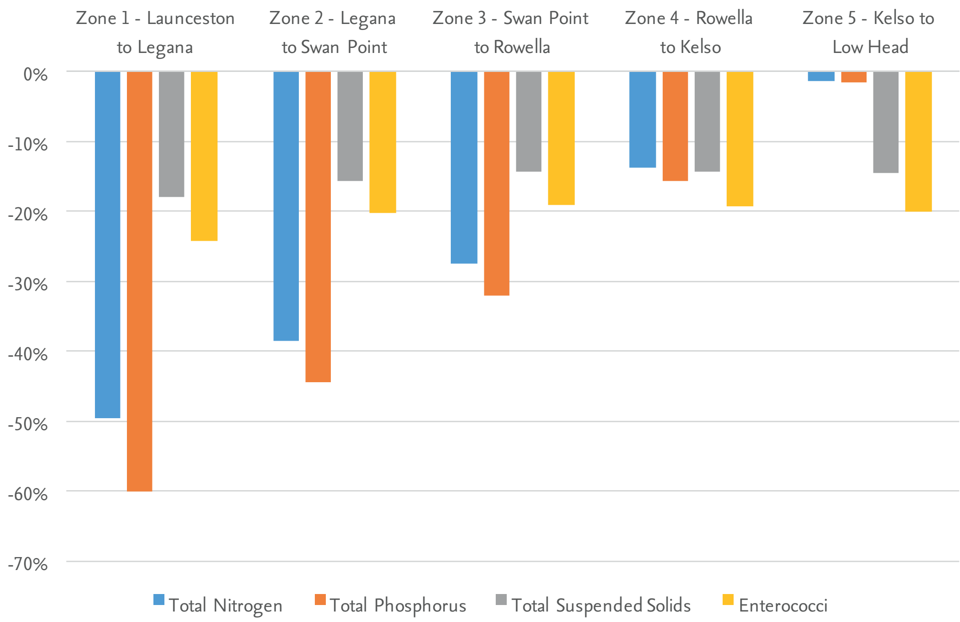


Figure 65. Modelled Impacts on estuary pollutant concentrations in the Tamar River estuary report card zones using future land use and population scenario

Figure 64 and Figure 65 show that modelling estimates that these scenarios can be expected to lead to very substantial decreases in nutrient concentrations in the upper estuary, with changes in Zone 1 (Launceston to Legana) of 40% to 50% and 50% to 60% for TN and TP respectively. Relative changes in nutrient concentration decrease down the estuary until decreases in Zone 5 (Kelso to Low Head) are effectively zero. Changes in TSS are smaller but more even down the estuary, with decreases of 12% to 13% in summer and 15% to 18% in winter. Decreases in enterococci concentrations are slightly greater in Zone 1 but stay relatively constant down the estuary at approximately 20%.

There is very little difference between the impacts of the current and future land use and population scenarios.

Changes in nutrients and sediments will have the greatest impact on condition in the upper estuary. The TEER Program's report cards for the Tamar River estuary are expected to shift Zone 1, from Launceston to Legana, one report card grade (e.g. from a D grade for poor to a C grade for fair condition). Zone 2, from Legana to Swan Point, is also expected to improve one report card grade. Other better flushed zones are unlikely to see changes great enough to substantially improve their condition, however it can be expected these small improvements will provide some buffer to future stresses and pressures on the estuary.

In terms of recreation, modelling shows that changes in enterococci can be expected to produce the greatest benefits in the upper estuary, particularly in Zone 1 around Launceston. This means that recreational guidelines would be met most of the time. This zone of the estuary is currently the most impacted and restricted for recreation. Other zones will see reduced pathogen levels and improved water quality for recreation.

section 4 RECOMMENDATIONS

The greater TEER catchment covers a substantial proportion of the state and contains a very broad ranges of land uses and other point sources. Managing such a complex system to improve water quality means it will require action by a very broad section of the community. Recommended management actions to reduce pollutant loads in the catchment are summarised below, based on the analysis and stakeholder feedback detailed in Section 2. Appendix 2 provides a list of actions and groups and stakeholders needed to undertake these for the WQIP to be implemented.

4.1 Dryland Grazing

Grazing areas are a major source of pathogens in all catchments of the greater TEER catchment and are the dominant source of nutrients and/or sediments in many catchments. Priority areas for grazing management are:

- Nutrient management – Brumbys-Lake, Macquarie, North Esk and Meander catchments.
- Sediments – Macquarie catchment and North Esk highlands.
- Enterococci - all catchments.

Management recommendations are:

- A major focus of management should be on improving groundcover management in the identified high and medium priority catchments emphasising productivity benefits to landholders.
    - In the short term, emphasis should be placed on getting those landholders not yet meeting median groundcover levels to improve to this level before trying to improve the groundcover on other farms.

- Actions to reduce stock access to streams should focus on lower cost solutions that are flexible to physical constraints on specific farms as well as the needs and preferences of individual farmers:
    - In subcatchments where riparian revegetation is not a priority action or where there are significant physical constraints, simply excluding stock from the stream with narrow fenced buffers should be considered.
    - Options where the stock are restricted from entering most of the stream while still having limited hardened access for stock watering should be considered where this is the preference of the landholder to increase the adoption and lower the overall cost of this action.
    - The specific design of fencing (e.g. single wire fencing versus six wires fences) should be determined on a case by case basis with landholders depending on their preferences so long as the fencing adequately restricts stock access to the stream.
    - Incentives should focus on compensating for the initial costs of fencing out streams.

- The primary focus of efforts to revegetate the riparian zone in order to improve water quality (not including biodiversity outcomes) should be on establishing broadscale adoption of narrower buffers (5m). For example: it would be substantially more effective for a landholder to create a 200m long, 5m wide buffer than a 100m long 10m wide buffer. Where landholders are happy to establish wider buffers on the same length of stream this should be encouraged.
    - Limited stock access to riparian zones (e.g. crash grazing to keep weeds out) should not be actively discouraged except in sensitive areas where excluding stock has been identified as a priority.
    - Incentives for revegetating riparian zones should be developed to address both upfront and ongoing maintenance costs for at least the first five years of establishment.

4.2 Dairy Management

While dairy is currently a small contributor to overall nutrients and sediment loads from the greater TEER catchment, it currently contributes significantly to the total load of pollutants coming from the Meander highlands, particularly in terms of TP and enterococci, and to a lesser extent from the Tamar catchment, Brumbys-Lake lowlands, Meander lowlands and South Esk highlands. Implementation of dairy best management practice in these catchments should be considered a high priority to improve catchment water quality.

- Sufficient effluent storage should be provided for on dairy farms. This storage should be well-designed and placed to ensure effluent can be applied to an adequate area of the farm, and that storages are unlikely to leach or overflow effluent.
- Stock should be restricted from all streams on dairy farms wherever it is feasible. The inclusion of riparian buffers is likely to have very small benefits for water quality, however could be expected to benefit stream health through shading, increased bank stability, and increased connectivity between vegetation remnants and provision of wildlife corridors. Creation of riparian buffers should be encouraged for these reasons, however the most important outcome for water quality in most cases is that stock are removed from streams. Therefore management should be flexible to allowing for this with either minimal or no buffers where this is likely to achieve greater adoption of this action.
- Irrigation scheduling should be managed to match irrigation to soil infiltration rates and pasture growth rates, and irrigation water reused to reduce drainage losses where possible.
- Drains need to be managed to minimise the transport of pollutants off the farm. This presents some practical challenges for dairy farmers and more consultation is needed to develop practical solutions for best management practice.

4.3 Crop Management

Cropping areas contribute small proportions of total loads in all catchments of the greater TEER. Impacts of cropping on water quality are likely to be localised with the Lower Nile the main area of focus.

- Fertiliser management is a key action in reducing nutrient losses from cropping areas. Adoption of enhanced efficiency fertilisers should be strongly encouraged as these are likely to have the greatest impacts on nutrient runoff.
- While fertiliser management is very effective for reducing nutrient runoff, improving water quality off cropping areas will require a more holistic approach to ensure sediment loads are reduced. Both improving groundcover and adoption of riparian buffers can improve water quality in terms of sediment loads, as well as having impacts on nutrient runoff. Narrow riparian buffers can be expected to have greater impacts than low levels of adoption of groundcover management.
- Groundcover management to reduce pollutant exports. While the magnitude of impacts of riparian buffers are similar to those of groundcover management, groundcover management is likely to be significantly more cost effective than riparian buffers which achieve load reductions at a much greater cost per kg than the other management options. This emphasises the importance of sometimes focusing efforts on lower cost - lower leverage options as they can still be economically efficient for achieving some improvements in water quality.
- Narrower buffers are more readily adoptable because of less loss of productive land and fewer issues with pests and weeds. For this reason, a focus on adoption of narrower buffers may lead larger improvements in water quality at a catchment scale. A flexible approach should be used in encouraging farmers to adopt riparian buffers with an emphasis on broadscale adoption of narrow buffers likely to be more effective than lower adoption of wider buffers. Greater incentives for farmers willing to adopt wider buffers may need to be provided. An emphasis on adoption of narrow buffers in the short to medium term with long term encouragement to expand these to wider buffers is likely to be more effective in terms of producing water quality benefits.
- Focusing extension efforts to emphasise the long term benefits of buffers in reducing streambank erosion and subsequent losses of productive land are also expected to be more effective in increasing the adoption of buffers rather than a focus on the environmental benefits, given that the loss of productive land to buffers was identified as a key impediment to their adoption. Upfront incentives are required for broadscale adoption of buffers in cropping areas. Maintenance incentives shouldn't be a focus of programs given feedback that these are unlikely to have any impact on the adoption of buffers.

4.4 Forest Management

- The Forest Practices Code has been essential in improving water quality from production forest areas. It is important that this continues to be implemented in the future.
- Any areas that are pre-code in the catchment should be identified and, where possible, streamside reserves should be created in these areas prior to harvesting activities.

4.5 Stormwater Management

Urban areas are the dominant source of controllable sediments in eight of the 11 catchment areas of the TEER, contributing more than 50% of TSS from the Tamar catchment and from the Brumbys-Lake, Macquarie and North Esk lowlands, as well as 40% of TSS from the Meander lowlands. They also contribute a large proportion of nutrients in these catchments.

- Household scale WSUD devices such as plumbed in rainwater tanks and rain gardens should be encouraged using a combination of incentives and education focused on both environmental benefits and those directly experienced by the householder. In particular, these devices have the potential to be very effective at reducing overflows from the combined system in Launceston. It is recommended that City of Launceston and TasWater look to household scale devices such as these to assist in the management of combined system overflows.
- Large scale retrofit options are much more difficult to adopt broadly across the catchment. Opportunities should be sought by councils to identify 'win-win' opportunities for retrofitting WSUD – for example as a feature of green space areas, or by including quality management in existing flow detention systems.
- The Northern Stormwater Working Group should continue to work together to build the capacity of councils to develop and maintain large scale WSUD systems. Opportunities should be sought to fund ongoing maintenance of systems as this is a key impediment to broad scale retrofitting of WSUD identified by stakeholders.
- Councils should work proactively with the community, in particular local businesses, to identify small scale WSUD options that can be incorporated in refits and redevelopments, for example, to treat or reduce pollutant exports from commercial car parks and other hard surfaces.
- The Stormwater and Catchment Officer and councils should engage with the community and provide education about the sources of pollutants in urban areas, the role and advantages of WSUD and actions they can take to improve stormwater quality. This may include but not be limited to school education programs, workshops with developers and builders and education of home owners on the potential benefits of household scale WSUD options.

4.6 Urban Expansion in the Greater Launceston Area

- Water sensitive urban design should be broadly adopted in all new development areas where on-site constraints allow this to occur. Specific treatment trains will need to be designed subject to site specific constraints using expert assistance to ensure that they provide the greatest benefit at the lowest cost. In order to be effective, WSUD devices need to be properly maintained.
- While erosion and sediment controls can be seen to have a relatively small impact catchment wide, they still represent an important action in preserving and improving water quality. These controls should be used and properly managed on all new development sites to minimise soil erosion from new developments.
- The Northern Tasmanian Stormwater Program should facilitate the development of templates for incorporating WSUD into Development Control Plans (DCPs) and Local Environment Plans (LEPs) for new developments to assist councils in their efforts to implement WSUD in future developments.

4.7 TasWater

- TasWater should continue to investigate and refine options for improving sewage discharges in the Launceston area through the Launceston Sewerage Improvement Plan.

4.8 Heavy Metals

Heavy metals were raised by the community as a serious water quality concern. These were not modelled in the CAPER DSS because: diffuse loads are unlikely to be a major source of metals – these are likely to be sourced primarily from historic mine sites and urban areas; and insufficient information was available to model these at the catchment scale. Management options outlined in this plan for improving stormwater quality in terms of nutrients, sediments and pathogens are likely to also produce benefits in terms of reducing heavy metal exports from these areas. Resuspension of contaminated sediments in the estuary is also an issue that needs to be considered in managing pollution from metals.

- Historic mine sites leaching metals should be identified and where possible remediated to manage potential future discharges of heavy metals.
- The impacts of resuspension of contaminated sediments particularly in Zone 1 of the estuary should be investigated.

4.9 Scientific Investigations, Modelling and Monitoring

This plan relies on the best available science to evaluate the potential benefits of proposed management actions. In collating and integrating this information, several weaknesses in current data and information were identified. Priorities for scientific investigations, modelling and monitoring to fill these gaps are:

- The TEER Tamar Estuary Ecosystem Health Assessment Program (EHAP) should continue to collect monitoring data for the Tamar River estuary. This data is essential to understanding the current condition of the estuary and identifying changes into the future.
- Further agricultural trials should be conducted to collect more locally sourced data on the impacts of management actions such as improvements to groundcover, impacts of fertiliser management and the impacts of drain management on dairy farms. Costing actions and identifying barriers to their adoption as part of these trials would also be useful.
- Collection of disaggregated data on the adoption of management actions. In most cases current rates of adoption of various management actions have been obtained either through state-wide surveys of land holders, or else in discussion with key stakeholders. Very little data is collected to help quantify the current rates of adoption of specific management actions within regions of the state or catchments.
- Continued monitoring of pollutant concentrations and flows in stream systems in Tasmania is vital to understanding current condition and pressures on water quality in these systems. Monitoring of instream water quality, collocated with flow measurements should be continued and where possible expanded in areas where land use and management is likely to be having impacts. Ideally other ecological monitoring such as AUSRIVAS data collection should be conducted where stream monitoring is available to allow linkages between water quality, flow and ecological health to be investigated.
- Monitoring of overflows from the combined system should be undertaken, including locations, flows and concentrations of overflows. These should be collected to allow comparison with rainfall and antecedent conditions.
- The Source Catchments model used to underpin the CAPER DSS has been calibrated to flow, nutrient and sediment data. Literature values are used to model enterococci loads. Ideally the Source Catchments model will be refined and calibrated to include pathogens in future revisions.
- The CAPER DSS should be updated as new information and modelling becomes available. This includes: revised versions of the Source Catchments and receiving water quality modelling, improved land use data, improved information on adoption rates of current practices, improved information on the effectiveness and costs of proposed management actions, and additional MUSIC modelling of WSUD options which are based on local data, including for household scale options such as raingardens and rainwater tanks.

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DETAILED LOAD TARGETS

Section 3 provided load targets for the Tamar Estuary and Esk Rivers catchment. This appendix breaks these targets (Table 11 and Table 12) down into targets for total loads (diffuse plus point source) from freshwater report card regions and for diffuse pollutant loads from Local Government areas (LGAs).

Table 11. Total load targets by freshwater report card regions

Subcatchment	TN (kg/yr)	TP (kg/yr)	TSS (T/yr)	Enterococci (cfu/yr)
Current loads				
Brumbys-Lake lowlands	82,116	17,178	2,217	9.68E+13
Brumbys-Lake highlands	67,614	5,558	3,236	7.47E+13
Macquarie lowlands	28,641	4,587	1,188	1.02E+14
Macquarie highlands	47,205	12,280	3,460	1.87E+14
Meander lowlands	109,787	12,968	5,128	1.76E+14
Meander highlands	143,041	13,646	5,482	3.11E+14
North Esk lowlands	73,574	21,320	1,228	3.74E+13
North Esk highlands	134,079	21,417	9,242	2.11E+14
South Esk lowlands	124,543	13,588	5,899	1.24E+14
South Esk highlands	544,055	74,002	37,643	6.85E+14
Tamar lowlands	158,371	18,946	7,636	1.04E+15
Direct discharge to estuary	454,182	97,540	440	1.17E+14
Total	**1,967,209**	**313,031**	**82,798**	**3.16E+15**
Load target - current land use				
Brumbys-Lake lowlands	-13%	-20%	-17%	-36%
Brumbys-Lake highlands	-4%	-6%	-6%	-5%
Macquarie lowlands	-19%	-17%	-22%	-31%
Macquarie highlands	-17%	-8%	-9%	-21%
Meander lowlands	-5%	-8%	-8%	-41%
Meander highlands	-5%	-12%	-6%	-53%
North Esk lowlands	-68%	-87%	-19%	-31%
North Esk highlands	-5%	-4%	-4%	-11%
South Esk lowlands	-4%	-6%	-5%	-19%
South Esk highlands	-4%	-4%	-3%	-14%
Tamar lowlands	-8%	-12%	-13%	-21%
Direct discharge to estuary	-49%	-58%	-64%	-71%
Total	**-18%**	**-29%**	**-6%**	**-25%**

Load target - future land use				
Brumbys-Lake lowlands	-11%	-19%	-15%	-32%
Brumbys-Lake highlands	-4%	-7%	-6%	-5%
Macquarie lowlands	-19%	-17%	-22%	-29%
Macquarie highlands	-18%	-8%	-9%	-20%
Meander lowlands	-6%	-10%	-9%	-44%
Meander highlands	-5%	-10%	-6%	-52%
North Esk lowlands	-67%	-87%	-17%	-31%
North Esk highlands	-5%	-4%	-4%	-11%
South Esk lowlands	-4%	-4%	-6%	-14%
South Esk highlands	-4%	-4%	-3%	-14%
Tamar lowlands	-6%	-11%	-12%	-21%
Direct discharge to estuary	-43%	-53%	-54%	-64%
Total	**-17%**	**-27%**	**-6%**	**-25%**

Table 12. Diffuse pollutant load targets by local government areas

LGA	TN (kg/yr)	TP (kg/yr)	TSS (T/yr)	Enterococci (cfu/yr)
Current loads				
Break O'Day	386628	58103.5	30357.5	5.5E+14
Central Highlands	32207.4	3307.8	1965.2	2.9E+13
Dorset	22257.2	4373.3	2185.6	2E+13
George Town	30805	3641.2	1594.5	3.6E+13
Launceston	169830	24575.3	10466.9	1.1E+15
Meander Valley	222660	23423	9951.9	4.6E+14
Northern Midlands	438489	50413	20570.4	6.5E+14
Southern Midlands	11046.6	1555.5	488.52	5.1E+13
West Tamar	101774	11384	4652.1	1.7E+14
Load target - current land use				
Break O'Day	-4%	-4%	-3%	-15%
Central Highlands	-1%	-2%	-1%	-7%
Dorset	0%	0%	0%	0%
George Town	-5%	-7%	-11%	-15%
Launceston	-6%	-5%	-6%	-19%
Meander Valley	-5%	-10%	-6%	-51%
Northern Midlands	-6%	-7%	-6%	-21%
Southern Midlands	-26%	-22%	-24%	-25%
West Tamar	-6%	-12%	-11%	-25%

Load target - future land use				
Break O'Day	-5%	-4%	-3%	-15%
Central Highlands	-1%	-2%	-1%	-7%
Dorset	0%	0%	0%	0%
George Town	-7%	-9%	-13%	-15%
Launceston	-6%	-5%	-6%	-19%
Meander Valley	-5%	-10%	-8%	-51%
Northern Midlands	-7%	-7%	-7%	-19%
Southern Midlands	-27%	-23%	-25%	-24%
West Tamar	-6%	-12%	-12%	-25%

RECOMMENDED ACTIONS AND RESPONSIBILITIES

Section 4 presented the recommendations arising from the WQIP. Table 13 breaks these recommendations into actions and lists the groups and stakeholders needed to implement these actions.

Table 13. Recommended actions and responsibilities in implementing the WQIP

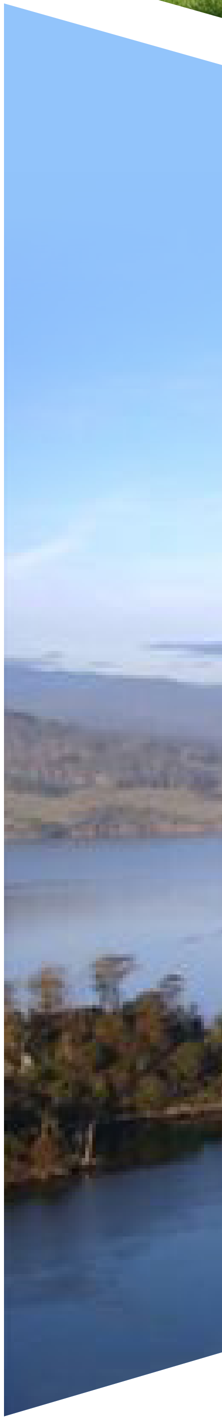
Land use	Action	Lead Groups and Stakeholders
Grazing	Improve groundcover	Landholders
Grazing	Reduce stock access to streams	Landholders
Grazing	Revegetate riparian zone	Landholders
Grazing	Provide incentives for creation of riparian buffers	NRM North/TEER & other funding bodies
Grazing	Provide education and extension programs emphasising the production benefits of improved groundcover	NRM North/TEER & other funding bodies
Grazing	Provide incentives and advice for limiting stock access to streams, including off-stream water and fencing options	NRM North/TEER & other funding bodies
Dairy	Sufficient effluent storage should be provided for on dairy farms. This storage should be well-designed and placed to ensure effluent can be applied to an adequate area of the farm, and such that storages are unlikely to leach or overflow effluent	Dairy landholders/ farmers
Dairy	Stock should be restricted from all streams on dairy farms wherever it is feasible	Dairy landholders/ farmers
Dairy	Irrigation scheduling should be managed to match irrigation to soil infiltration rates and pasture growth rates, and irrigation water reused to reduce drainage losses where possible	Dairy landholders/ farmers
Dairy	Work with dairy farmers to develop better management options for reducing pollutant transport through drains	Dairy Tasmania, NRM North/TEER, TIA DPIPWE
Dairy	Work with dairy farmers to ensure best practice effluent management on dairy farmers	Dairy Tasmania, NRM North/TEER, TIA, DPIPWE
Dairy	Work with dairy farmers to ensure best practice irrigation management on farms	Dairy Tasmania, NRM North/TEER, TIA, DPIPWE
Dairy	Provide incentives for farmers to restrict stock access to streams and where possible for riparian buffers to be established	Dairy Tasmania, NRM North/ TEER, other funding bodies
Cropping and horticulture	Adopt enhanced efficiency fertilisers and best practice fertiliser management	Landholders, Agricultural Advisors, NRM North
Cropping and horticulture	Maximise groundcover on cropping areas	Landholders, Agricultural Advisors, NRM North
Cropping and horticulture	Create vegetated riparian buffers between cropping areas and streams	Landholders, Agricultural Advisors, NRM North
Cropping and horticulture	Provide extension programs emphasising the benefits of riparian buffers for reducing loss of productive land. Provide upfront incentives for the creation of vegetated buffers with greater incentives provided for wider buffers	NRM North/TEER, DPIPWE, other funding bodies
Cropping and horticulture	Provide extension programs emphasising the production benefits of improved groundcover and providing knowledge on techniques for best practice groundcover management	NRM North/TEER, DPIPWE, other funding bodies

Forestry	Continue to implement the Forest Practices Code	Forest Practices Authority
Forestry	Identify pre-code areas in the catchment and where possible create streamside reserves before harvesting these areas	Forestry Tasmania, Private Forests Tasmania, Private Timber Companies, Landholders
Urban	Investigate the potential for household scale WSUD devices (such as rainwater tanks and raingardens) to manage combined system overflows	TasWater, City of Launceston, NRM North/TEER
Urban	Install plumbed-in rainwater tanks, raingardens and other small scale WSUD devices to detain and treat stormwater	Households, Businesses, NRM North/TEER
Urban	Identify win-win opportunities for retrofitting WSUD in existing urban areas	Local government, NRM North/TEER
Urban	Investigate options and seek funding for on-going maintenance of WSUD treatment trains	Local government, NRM North/TEER
Urban	Provide funding for investment in WSUD and maintenance of WSUD devices	Australian Government, State Government, Local Government, NRM North/TEER
Urban	Continue funding for the NRM North Stormwater and Catchment Officer position	Local Government, NRM North/TEER
Urban	Provide education to developers, businesses and households about the sources of pollutants in urban areas, the role and advantages of WSUD	Local government, NRM North/TEER
Urban	The Northern Tasmanian Stormwater Working Group should continue to work together to build the capacity of councils to develop and maintain large scale WSUD system	Local government, NRM North/TEER
Sewage	TasWater should continue to investigate and refine options for improving sewage discharges in the Launceston area through the Launceston Sewerage Improvement Plan	TasWater
Heavy metals	Historic mine sites leaching metals should be identified and where possible remediated to manage potential future discharges of heavy metals	EPA, Mineral Resources Tasmania, NRM North/TEER
Heavy metals	The impacts of resuspension of contaminated sediments particularly in Zone 1 of the estuary should be investigated	NRM North/TEER, Launceston Flood Authority
Scientific investigations, monitoring and modelling	The TEER Tamar Estuary Ecosystem Health Assessment Program (EHAP) should continue to collect monitoring data for the Tamar River estuary. This data is essential to understanding the current condition of the estuary and identifying changes into the future	NRM North/TEER
Scientific investigations, monitoring and modelling	The TEER program should continue to be funded	Local government, NRM North, State Government, Hydro Tasmania, TasWater
Scientific investigations, monitoring and modelling	Further agricultural trials should be conducted to collect more locally sourced data on the impacts of management actions such as improvements to groundcover, impacts of fertiliser management and the impacts of drain management on dairy farms. Costing actions and identifying barriers to their adoption as part of these trials would also be useful	NRM North, Utas, TIA
Scientific investigations, monitoring and modelling	Collection of disaggregated data on the adoption of management actions	NRM North, Utas, TIA, TFGA, Dairy Tasmania, Dairy Australia, Other Peak Bodies in the Agricultural Sector

Scientific investigations, monitoring and modelling	Continued monitoring of pollutant concentrations and flows in stream systems in Tasmania is vital to understanding current condition and pressures on water quality in these systems. Monitoring of instream water quality, collocated with flow measurements should be continued and where possible expanded in areas where land use and management is likely to be having impacts. Ideally other ecological monitoring such as AUSRIVAS data collection should be conducted where stream monitoring is available to allow linkages between water quality, flow and ecological health to be investigated	DPIPWE, NRM North/TEER, Hydro Tasmania, Tasmanian Irrigation, TasWater
Scientific investigations, monitoring and modelling	Monitoring of overflows from the combined system should be undertaken, including locations, flows and concentrations of overflows. These should be collected to allow comparison with rainfall and antecedent conditions	TasWater, City of Launceston
Scientific investigations, monitoring and modelling	The Source Catchments model used to underpin the CAPER DSS has been calibrated to flow, nutrient and sediment data. Literature values are used to model enterococci loads. Ideally the Source Catchments model will be refined and calibrated to include pathogens in future revisions.	NRM North/TEER
Scientific investigations, monitoring and modelling	The CAPER DSS should be updated as new information and modelling becomes available. This includes: revised versions of the Source Catchments and receiving water quality modelling, improved land use data, improved information on adoption rates of current practices, improved information on the effectiveness and costs of proposed management actions, and additional MUSIC modelling of WSUD options which are based on local data, including for household scale options such as raingardens and rainwater tanks.	NRM North/TEER







NRM North
Tamar Estuary and Esk Rivers
Natural Resource Management in Northern Tasmania

FURTHER INFORMATION

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