Department of **Water and Environmental Regulation**
Department of **Primary Industries and Regional Development**

GOVERNMENT OF WESTERN AUSTRALIA

Geographe catchment drainage management plan

Revitalising Geographe Waterways

VASSE taskFORCE

Geographe catchment drainage management plan

Department of Water and Environmental Regulation

February 2020

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1 Scope and purpose of the plan

This *Geographe catchment drainage management plan* identifies opportunities to improve drainage infrastructure within the Geographe catchment to achieve better water quality in Geographe waterways. The plan is a component of the Revitalising Geographe Waterways program, which aims to improve water quality, waterway health and management of Geographe waterways.

The plan provides guidance to organisations responsible for managing drainage infrastructure in the Geographe catchment in relation to water quality. The Department of Water and Environmental Regulation (the department) has developed the plan in consultation with the Water Corporation and the City of Busselton. It is intended to complement current flood management protocols and guidelines and does not replace them.

2 Background

2.1 Background to the drainage management plan

The hydrology of waterways in the Geographe catchment has been substantially modified. From the late 1880s extensive drainage works were undertaken in the catchment, including installation of 400 km of rural drains, river diversions, floodgates, culverts and flood detention basins. The drainage works enabled farming on the coastal plain and protected the growing town of Busselton from flooding. Yet the catchment clearing and drainage works substantially reduced the capacity of the catchment to retain sediment and nutrients.

The nutrient inputs and changed hydrology associated with rural and urban land development has greatly increased the amount of nutrients and organic matter entering catchment waterways and Geographe Bay.

Many catchment waterways now contain nutrient-enriched water from fertilised agricultural and urban lands conveyed to receiving water bodies through natural, modified and artificial drainage structures. Several waterways, including the Lower Vasse River in the centre of Busselton, suffer persistent algal blooms during spring, summer and autumn. The Vasse-Wonnerup wetlands have been identified as the most nutrient-enriched wetlands in south-west Western Australia, characterised by annual major macroalgal blooms. The exit channel of the Vasse Estuary also experiences water quality problems with annual phytoplankton blooms and de-oxygenated water contributing to occasional major fish kills. The Lower Vasse River is highly valued by the local community and the Ramsar-listed Vasse-Wonnerup wetland system has international importance as waterbird habitat.

In 2014 Professor Barry Hart led an independent review of waterways management in the Geographe catchment. The review made several recommendations to government, including that a further review of the Geographe catchment drainage network be conducted to assess:

a) its current and future relevance
b) what might be done to make the drainage network more effective at reducing nutrients, in addition to its flood protection and land drainage functions
c) the potential for re-engineering the drainage system to reconnect natural waterways adversely affected by drains and to provide more freshwater inflow into the Vasse-Wonnerup wetlands and the Lower Vasse River
d) the potential to modify the Station Gully drain so that additional water enters Toby Inlet

2.2 Rethink drainage projects

The Revitalising Geographe Waterways program considered several of the Hart review’s recommendations, as well as community requests to look at ways to use the drainage network to contribute to water quality improvements. The projects below were conducted under the key action area ‘Rethink Drainage’ and have informed the recommendations and management actions outlined in this plan.

1. Reconnecting Rivers

This project responded to community requests to look at whether increased flushing of the Lower Vasse River and Vasse Estuary would improve water quality. The department developed a hydrological model to investigate partial and full reconnection of the Vasse Diversion Drain to the Lower Vasse and Sabina rivers. The study considered flood risk and potential water quality improvements using a variety of reconnection scenarios. The study also looked at options to increase flows into the Lower Vasse River to improve water quality in the river and Vasse Estuary. As a result of this study, the Water Corporation will install a second 900 mm culvert in the Vasse Diversion Drain to increase flows entering the Lower Vasse River during the winter months. A summary report is available online: rgw.dwer.wa.gov.au/rgw-publications/.

2. Reconnecting Toby Inlet

This project responded to community requests to investigate whether increased flushing of the Toby Inlet would improve water quality. The department created a hydrodynamic model for the Toby Inlet to assess different scenarios for sandbar and culvert management to support water quality improvement. The study found that the most effective way to maximise seawater flushing of the Toby Inlet was to keep the sandbar open during the summer months. This management action was implemented by the City of Busselton since the 2017–18 summer, which has resulted in visual improvements to the inlet’s water quality. A summary report is available online: rgw.dwer.wa.gov.au/rgw-publications/.

3. Review Surge Barrier operations

This project, led by the department, investigated the impacts of seawater inflows on water quality in the Vasse Estuary channel under different surge barrier operations. Scientific investigations over four years were used to update the 1990 management guidelines for the Vasse surge barrier. The study showed that sea water could be used to reduce phytoplankton blooms and reduce the risk of fish kills in the Vasse Estuary channel if it were rapidly let into the upper estuary through gates on the surge barriers in early December. The Water Corporation began this management action in summer 2017–18 and significant water quality improvements in the Vasse Estuary channel have been the result. A summary report for this study will be available in 2020.

4. Waterways transition framework pilot

This project, led by Busselton Water, considered options for transforming the existing open rural drainage system in the Buayanyup subcatchment to a managed waterways system. It considered water conveyance, flood protection, biodiversity, water quality, flow regimes, water reuse and improving the ecological health of the system. A summary report is available for this study online: rgw.dwer.wa.gov.au/rgw-publications/.

5. Rural drainage review

For this project, the department and the Water Corporation reviewed current rural drainage management and operating practices in the Geographe catchment and Swan coastal plain more broadly. The project identified opportunities and constraints to using the rural drainage system to contribute to water quality improvements. It included a literature review of local, national and international studies into the impacts of riparian management on water quality. That review has been used to inform this plan.

6. Revitalising the Vasse Diversion Drain

This project was coordinated by GeoCatch during 2018–19 and involved restoration of and improvements to the drain's lower section below Bussell Highway, including rock facing, weed and erosion control, removal of wooden baffles, installation of a viewing platform and installation of a Bay OK waterwise garden. A community survey of local residents and the broader community informed the concept design for the upgrade. A trial opening of the Vasse Diversion Drain sandbar in summer was undertaken as part of this project. Concept designs for later stages of the upgrade will inform future works on the drain. More information is available online: rgw.dwer.wa.gov.au/rethinking-drainage/.

7. Stormwater upgrades

The City of Busselton has installed rain gardens at the new city administration building and a residential area to treat stormwater before it enters the Lower Vasse River. This project extends historical work undertaken by GeoCatch and the City of Busselton to improve the quality of stormwater entering the river.

2.3 The plan area

The plan area sits within the Geographe catchment, which extends from Capel in the north to Eagle Bay in the west and east to Kirup. It is bounded by the Darling Range, the Whicher Range and the Leeuwin-Naturaliste Ridge. Below these ridges is an extensive coastal plain characterised by sandy soils and drained flats, wetlands and river systems that flow to Geographe Bay.

Agriculture dominates the catchment's land area, with dairy and beef grazing the most widespread land uses. Viticulture has expanded in the catchment's west, alongside production horticulture such as potato growing. Busselton's urban area has grown to acquire 'city' status and supports a busy commercial and industrial sector.

The combination of low-phosphorus-holding sandy soils, agricultural practices and urban expansion has led to water quality problems in the catchment's waterways and drains from nutrient runoff. Reducing the nutrients leaving rural and urban areas is a key priority.

The Busselton drainage district sits within the Geographe catchment and is managed by the Water Corporation. It includes all major drainage infrastructure and the rural drainage network (Figure 1).

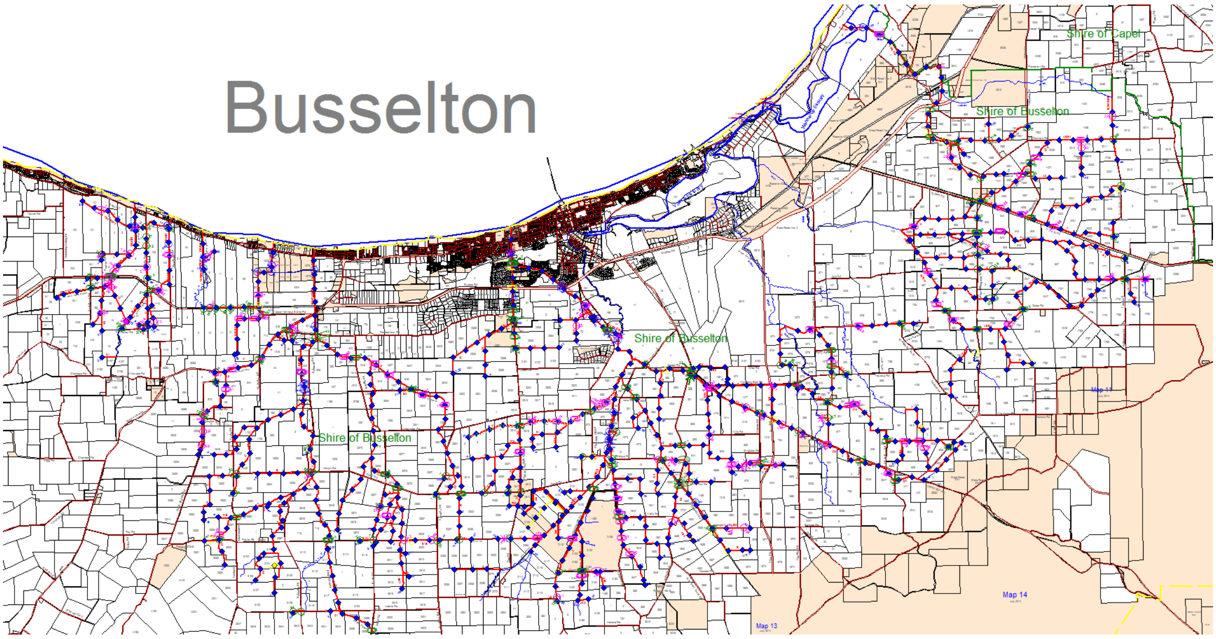

Figure 1 Busselton drainage district

2.4 Busselton drainage district historical perspective

It its natural state, the Swan coastal plain consisted of linked wetlands that supported a rich and diverse ecosystem. Meandering streams and swamps conveyed water to estuaries and the ocean with many areas inundated during winter. After European settlement in the Busselton area in the 1830s, the catchment was cleared of native vegetation and developed for agricultural and urban land uses. The Busselton drainage network was developed to overcome seasonal inundation and enable the development of farms, settlements, transport and infrastructure.

The new settlers could not do the broadscale drainage works they considered necessary on their own, so in 1894 they asked the government for help. In 1900 the first Land Drainage Act was enacted by Parliament and extensive works began. New drains were built and the banks of natural waterways were mounded and straightened.

In 1908 floodgates were installed on the Vasse and Wonnerup surge barriers to stop saltwater flooding the low-lying areas around the estuaries and to protect Busselton from storm surges. During the 1920s extensive drainage networks were constructed in the Ludlow, Abba, Sabina, Vasse, Iron Stone Gully, Buayanyup and Carbanup river catchments. These works increased the rate and volume of river flows. Additional works were then needed to prevent more frequent flooding of farms and other developments, including the town site of Busselton.

In 1927 the Vasse Diversion Drain was constructed to divert river flow to the ocean to reduce flooding of the Busselton township. About 60% of flow from the Sabina River and 90% of flow from the Vasse was diverted to the ocean. In addition, many catchment rivers which once flowed into the wetlands were diverted to Geographe Bay during the early to mid-1900s. See Appendix A for a summary of major drainage works in the Geographe catchment.

2.5 Flooding in the catchment

Flood damage in the catchment has often been the result of heavy rainfall events and subsequent overtopping or failure of levee banks. Storm-surge events and associated sea level rises have also damaged coastal properties. Since the 1960s, many flood events have resulted in overtopping of the Vasse Diversion Drain. A recent example was in 1997, when about 100 mm of rainfall over a 19-hour period saw the failure and subsequent overtopping of the drain. This caused widespread damage to the surrounding Busselton township.

This flood event triggered a response from the Water Authority at the time (WAWA 1997). A regional flood study (JDA 1998) completed the following year made several recommendations about the capacity of the Vasse Diversion Drain. One of these was to construct compensation basins in the catchment to restrict peak flow in the drain.

In 2013 GHD was commissioned to assess the impact of the compensation basins on flows in the Vasse Diversion Drain. The study found that for the peak flow in a 1% annual exceedance probability (AEP) flood event, the drain was at capacity but still presented a flood risk – prompting the Water Corporation to consider further upgrades to the drain. See Appendix B for an outline of major flood and storm events in the catchment.

2.6 Major asset descriptions

Most rural drains in the Busselton drainage district are on private land. Some of the larger drains, road drainage and urban drains are owned and managed by local and state government agencies.

Historically, service providers have taken a ‘conveyance approach’ to drainage. Drains were constructed and maintained to remove excess water from the landscape to mitigate inundation and flooding. Traditionally the drainage network has been managed without consideration of water quality within the drains. At present there is no legal requirement for these drains to maintain a certain level of water quality.

Drainage infrastructure within this catchment includes drains in road reserves, drains on farms, drains running through urban areas, compensation basins, levee banks, penstocks, bridge timber structures, access tracks and fire breaks.

Major infrastructure within the Busselton drainage network includes the following:

The Vasse Diversion Drain

The Vasse Diversion Drain is a 6 km major arterial drain that was built to reduce the risk of flooding to the townsite of Busselton. The drain diverts about 90% of the upper Vasse River and 60% of the upper Sabina River into Geographe Bay. A 900 mm culvert between the drain and the Lower Vasse River allows manual diversion of water from the drain into the river during the winter months. The drain runs through the township of Busselton and flows year-round, including inflows of treated waste water from the Busselton waste treatment plant. The mouth of the drain is mostly open but can close during the summer months, contributing to poor water quality.

The drain's catchment is one of the largest of the Geographe subcatchments. The subcatchment supports a thriving agricultural industry dominated by beef and dairy grazing. The urban residential and lifestyle lots of west Busselton are also located in this catchment. Water quality in the drain is generally poor, and median winter concentrations are consistently above the guidelines in the *Water quality improvement plan for the Vasse Wonnerup Wetlands and Geographe Bay* (2010) for both total nitrogen and total phosphorus.

The Buayanyup Diversion Drain

The Buayanyup River originates in the Whicher Scarp before it extends across the Swan coastal plain as several main branches. These come together near Vasse as a modified channel – the Buayanyup Diversion Drain – which discharges directly to Geographe Bay.

The Buayanyup River catchment supports a diversity of land uses – beef and dairy grazing being the most dominant. The suburb of Vasse Newtown is located near the drain's northern end and is growing rapidly. Stormwater and groundwater drainage from Vasse Newtown is not connected to the Buayanyup drain. Nitrogen concentrations in the drain are consistently above guideline values, whereas phosphorus concentrations are relatively low due to heavier soils in this catchment. River health assessments within the drain's lower sections have shown that the drain provides habitat for a range of native aquatic species.

Compensation basins

The three compensation basins in the catchment were built between 2001 and 2009. The first two were constructed on the Vasse River and Diversion Drain in 2001 and 2003, and a third on the Sabina Diversion Drain in 2009. These basins are a crucial part of the drainage network to protect Busselton by storing flood waters and slowly releasing them downstream. The basin storage capacity and subsequent release rate provides protection from the 1% AEP flood event if the basins are empty before a flood event. The basins cannot be used to store water without compromising their flood protection function.

Vasse and Wonnerup surge barriers and Wonnerup Inlet sandbar

Surge barriers were first installed at the exit channels of the Vasse and Wonnerup estuaries in 1908 to minimise flooding from storm surges and inundation of adjacent, low-lying agricultural land with salty sea water. They help protect Busselton by preventing large storm surges from flooding the town and surrounding agricultural land. The barriers were replaced in 2004 and are now automatic one-way flow structures (water flows out when water levels are lower in the Wonnerup Inlet). The new surge barriers include a fish gate to allow fish to move between the estuaries and Wonnerup Inlet, and allow water to move between the two systems.

During the summer months, smaller fish gates on the surge barriers are opened to improve water quality in the upper estuaries and allow fish to move through the barriers. The surge barriers have been operated under guidelines that the Water Corporation developed in 1990. Those guidelines have been reviewed and updated through the Review Surge Barrier Project.

The Vasse and Wonnerup estuaries empty to the sea via the Wonnerup Inlet. At the mouth of the inlet is a shallow bar formed by the easterly drift of coastal sand. The bar is kept open for varying periods (days, weeks or months) each year by manually opening the bar with an excavator. In winter the sand bar is artificially opened to drop water levels in the inlet – allowing the floodgates to open. In summer the bar is opened to improve water quality in the inlet. It is believed the mouth of the Wonnerup Inlet has been opened manually since about the late 1890s, with the earliest reference to the openings in 1905 after a major fish kill in the inlet.

The Vasse-Wonnerup wetlands have been identified as the most nutrient-enriched wetlands in south-west Western Australia, characterised by annual major macroalgal blooms. The exit channel of the Vasse Estuary also experiences water quality problems with annual phytoplankton blooms and de-oxygenated water contributing to occasional major fish kills.

Lower Vasse River – Butter Factory weir

The Lower Vasse River is a highly valued waterway that flows through the centre of Busselton. The river is about 5.5 km in length from the Vasse Diversion Drain to the weir boards at the old Butter Factory. About 90% of the upper Vasse River is diverted through the Vasse Diversion Drain directly to Geographe Bay. A 900 mm culvert between the drain and the river reduces this diversion to about 60% when the culvert is open.

The Butter Factory weir boards (also referred to as check boards or butter boards) were installed in the Lower Vasse River opposite the factory in around 1933 to hold back water in the river during summer.

The Lower Vasse River catchment supports urban residential, industrial and commercial land uses. The primary land use in the upper catchment is beef grazing, with pockets of horticulture. Water quality in the Lower Vasse River is poor during the summer months, characterised by annual toxic algal blooms that negatively affect the river’s social and recreational values.

Drainage network ocean outlets

The drainage network has a number of ocean outlets that the Water Corporation opens manually on a case-by-case and needs basis (e.g. as flood mitigation or on request from other agencies and/or the community). The main ocean outlets include the Vasse Diversion Drain, Wonnerup Inlet, Station Gully and the Capel River.

The Station Gully Drain (also known locally as the Annie Brook Drain) redirects water flow from the upper reaches of Station Gully, Annie Brook and Mary Brook streams, as well as downstream runoff from wetlands east of Quindalup Siding Road, into a single straightened drain that intersects with Toby Inlet near the ocean entrance. The Station Gully culvert allows exchange of water between the drain and Toby Inlet (with the inlet to the west and the ‘deadwater’ to the east).

The Capel River was the first of the Geographe catchment waterways to be diverted to the ocean via the Higgins Cut in the late 1880s. In 1904 the first major work began on the Stirling Estate west of Capel near the Capel River. Main tributary channels were excavated and a floodgate was erected. The Water Corporation manages various floodgates, culverts, penstocks and a weir within the Capel River and Stirling wetland systems. Two penstocks on the freshwater side of Capel weir that control water for irrigation purposes are controlled by local landowners.

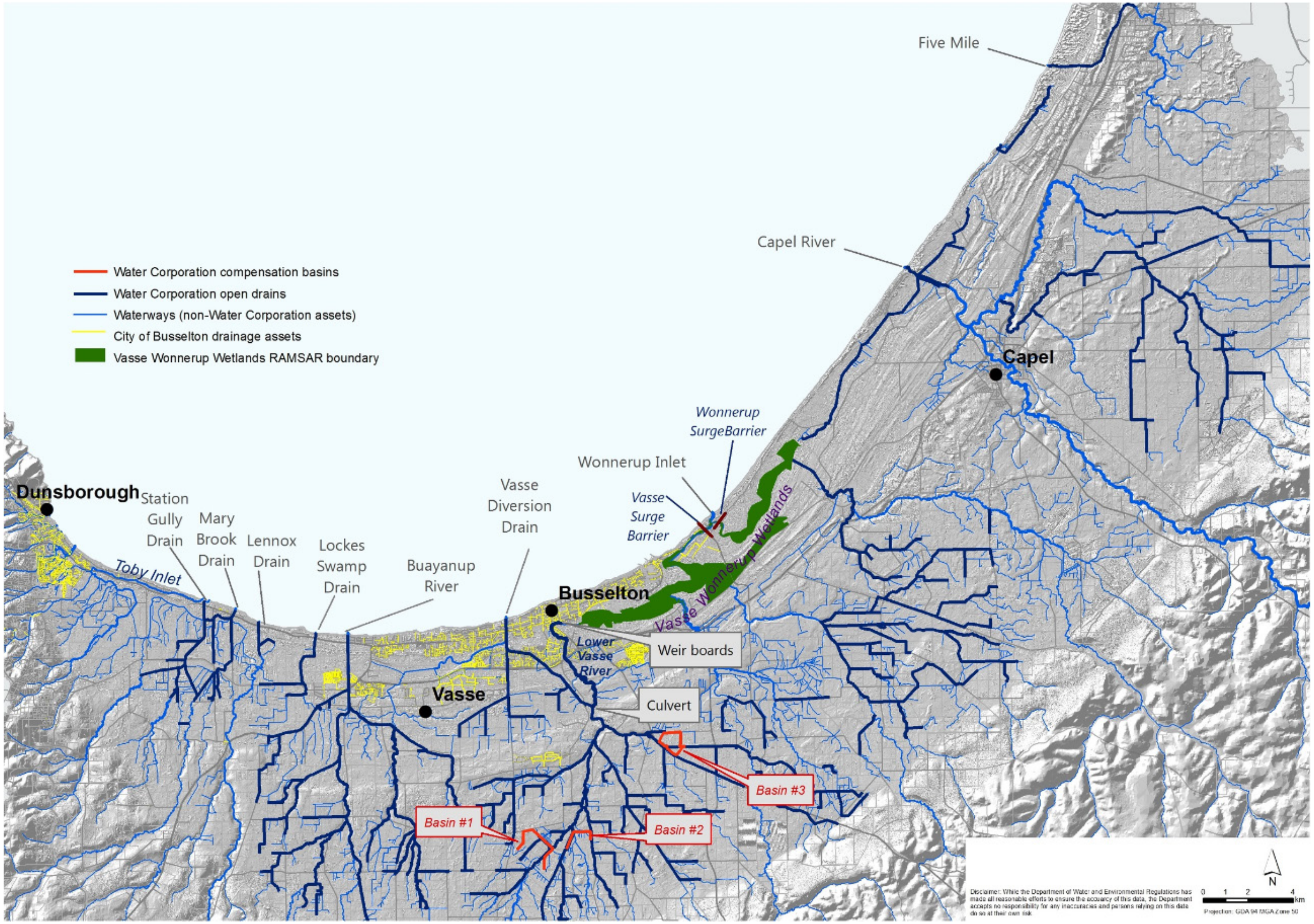

Figure 2 Busselton drainage network map of infrastructure assets

they may compromise the functioning of the drainage network and result in flooding on roads or neighbouring properties.

Some reaches of rural drainage located on freehold land are given additional protection by way of an easement. These contain restrictive covenants on the property title, which state what cannot be done on the land (e.g. cattle crossing, filling in the drain).

Waterways

Not all rural drainage comprises constructed drains: some reaches were formerly waterways. These reaches can still maintain their natural form or be highly modified, by channel reshaping or removal of meanders to straighten the channel. Waterways may be located on land owned or vested by a variety of parties.

The department is the lead agency for the management of state's waterways, which it does through a variety of different mechanisms. The *Water Agencies (Powers) Act 1984* provides the Minister for Water and the department with the power to perform the general functions of conserving, protecting, assessing and managing water resources, which includes waterways. In addition, for waterways proclaimed under the *Rights in Water and Irrigation Act 1914*, the department has the power to allocate surface water resources and require proponents to obtain a permit if they intend to interfere with beds or banks. The environmental water requirements of waterways are also considered when surface water and groundwater allocation plans are developed.

The department also monitors water quality and does ecological assessments in high-priority waterways. It has developed water quality improvement plans for catchments where the receiving waterbodies have poor water quality. The department also prepares flood management plans for major rivers in high-risk environments.

In the Geographe catchment the department has led the Revitalising Geographe Waterways program that aims to improve water quality, waterway health and management of Geographe Waterways by coordinating cross-government efforts to protect and manage key water resources. This program supports a collaborative approach to managing waterways through cooperative partnerships between landowners, land managers, catchment groups, state government agencies, and local governments.

Regional transport network drainage

Drainage is also used to protect specific infrastructure. This includes rail reserves managed by the Public Transport Authority, regional roads managed by Main Roads WA, and local roads and urban areas managed by the City of Busselton and Shire of Capel.

Railways and regional roads are administered in accordance with the *Public Transport Authority Act 2003* and *Main Roads Act 1930*, neither of which make any reference to drainage. However, the drainage is located within the reserve and as such is protected from interference from third parties.

Railways require protection against the 1% AEP flood, while the level of protection for road infrastructure varies depending on the type of road, and is detailed in Main Roads WA's supplement to Austroads *Guide to road design* (2015). Importantly, flood protection is not only provided by drainage channels but also by raising the infrastructure above the surrounding land using imported fill.

Main Roads WA also promotes water quality management and applies water sensitive urban design measures. These are embedded in its drainage and waterway procedures and manuals to improve water quality before it is discharged to the receiving environment.

Local roads and urban drainage

The City of Busselton and Shire of Capel are guided by the *Local Government Act 1995*, which provides them with powers to 'carry out works for the drainage of land'. This includes land that is not the local government's property. They are responsible for local roads, which are located within road reserves and as such are protected from interference from third parties. Similar to regional roads, the level of protection from flooding varies and at times is also provided by raising the infrastructure higher than the surrounding land using imported fill. These systems will generally connect to and discharge into regional road drainage, rural drainage and/or waterways.

Urban drainage may be located either in road/drainage reserves or easements. In more recent years these systems have been designed in accordance with the *Decision process for stormwater management in WA* (DWER 2017) and the Water Corporation and department's Drainage for Liveability Program. These are considered and addressed through water management documents that are required to support planning applications in accordance with *Better Urban Water Management* (*BUWM* – WAPC 2008). *BUWM* provides a strong focus on water sensitive urban design principles to take account of both flood management and water quality.

Drainage services for urban development are required to provide 1% AEP flood protection for habitable dwellings, and generally a 20% AEP flood protection to maintain road serviceability. Evacuation routes may require a higher level of flood protection.

Water quality is addressed by managing water as close to source as possible using vegetated and disconnected drainage systems. This provides a treatment train approach that enables appropriate management of a range of flow events, while providing water quality outcomes. No water quality targets have been set but nutrient loads are expected to be modelled during urban development planning using the department's Urban Nutrient Decision Outcomes (UNDO) tool.

Urban drainage systems will generally be connected to and discharge into rural drainage, waterways or the ocean. Importantly, on the flat coastal plain urban development results in large areas of land being filled, which reduces the flood storage. To prevent the flood regime of the general area being detrimentally affected in these situations, the lost flood storage must be mitigated during the planning and design of the urban development.

Private drainage

A significant amount of private drainage services predominantly rural and agricultural land. The primary aim of this drainage is to ensure the land is useable (by removing excess water) and preventing it from becoming inundated during winter. Private drainage will generally be connected to and discharge into rural drainage or waterways

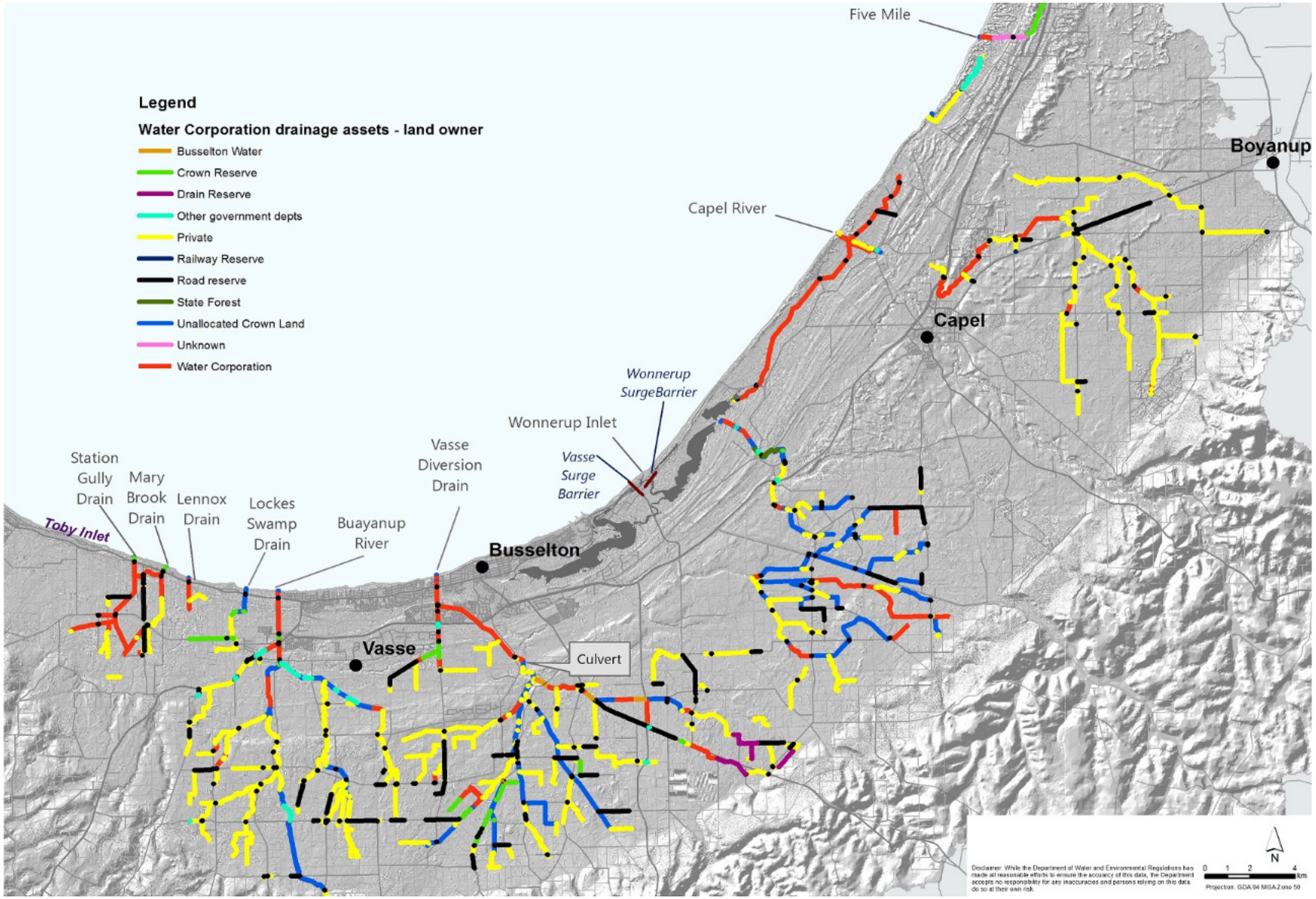

Figure 3 Drainage ownership in the Geographe catchment

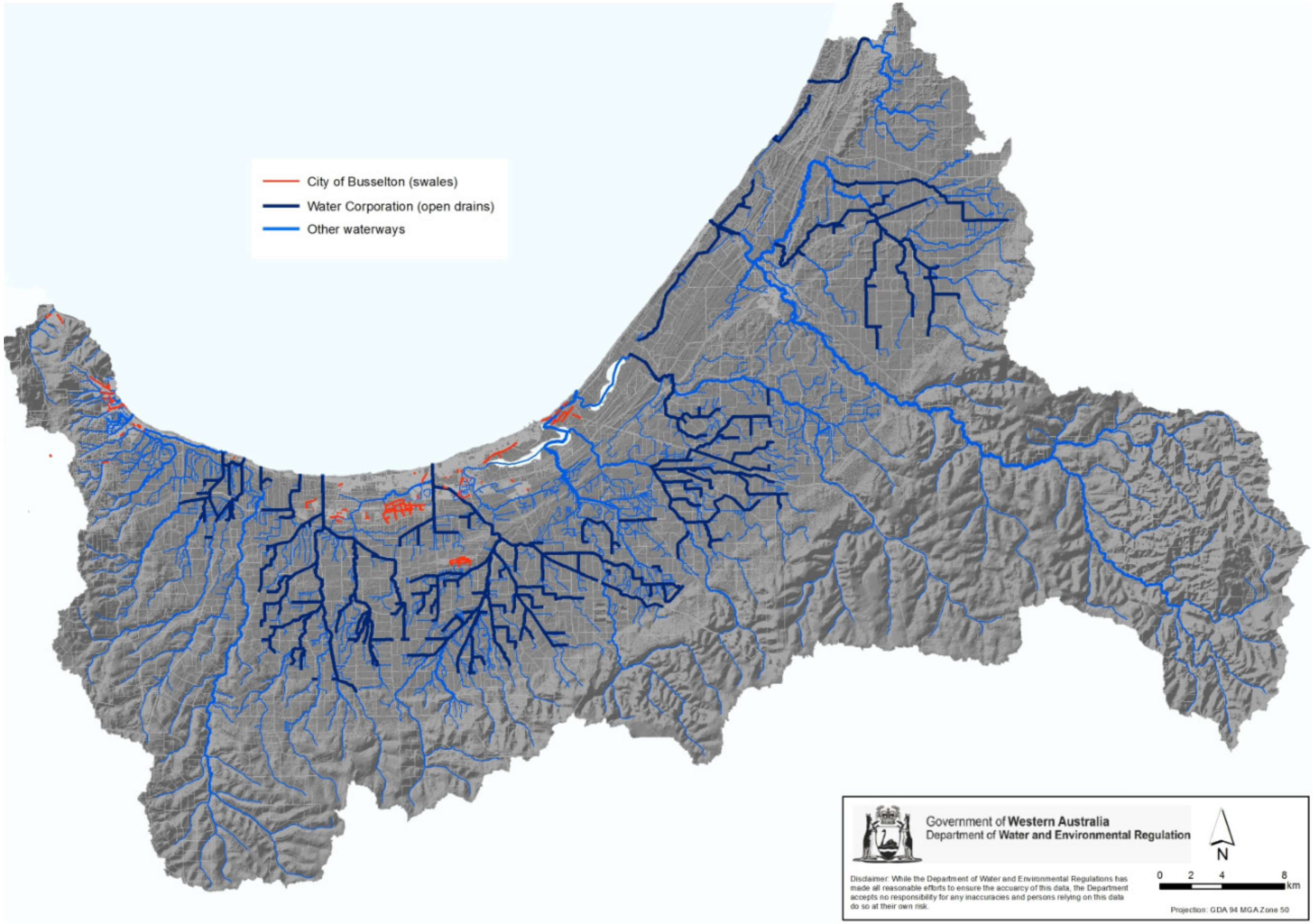

Figure 4 Drainage asset managers in the Geographe catchment

3 Drainage management, recommendations and responsibilities

A major objective of this plan is to use the science, modelling and stakeholder consultation from the Revitalising Geographe Waterways program to identify opportunities to optimise the drainage network. This will contribute to water quality improvements by assigning clear management responsibility and actions. This section of the plan outlines the key drainage infrastructure, historical management, recommendations for future management and the lead organisations responsible for implementing recommendations. The recommendations have been made in consultation with lead organisations.

3.1 Vasse Diversion Drain

The Vasse Diversion Drain is an important component of Busselton's flood mitigation network. The drain diverts flows from the upper Sabina and Vasse rivers into Geographe Bay. A 900 mm culvert between the drain and the Lower Vasse River allows flows from the drain to be diverted down the river.

Current management and operations

The Water Corporation owns and operates the Vasse Diversion Drain. It does regular site inspections and maintains the drain's levee banks and drainage infrastructure. It is licensed to discharge treated water from the Busselton waste treatment plant into the drain. At present the City of Busselton opens and closes the culvert between the drain and the Lower Vasse River (the City opens the culvert during the winter months after the first substantial rains). Historically there has been a lack of clarity on who has responsibility for operating the culvert.

Management recommendations

The Reconnecting Rivers study found that winter flows to the Lower Vasse River from the drain could be increased by installing a second 900 mm culvert, without impacting on the flood risk to Busselton. As an outcome of this study, the Water Corporation will be installing a second culvert as part of its 2020 major upgrade to the drain. The study also recommended developing an operating strategy for the culvert, which is an action in this plan. Interim culvert operating guidelines have been included in this plan and will be reviewed in 2020. The guidelines state that the culvert will be opened fully at the start of July and closed at the end of December. These guidelines take into account that 90% of flows occur between July and October and flows outside of these times are likely to be higher in nutrients. The culverts will remain open during flood risk as modelling has demonstrated that two culverts fully opened meet the 1% AEP flood event. The following table is a list of management recommendations for the Vasse Diversion Drain to improve water quality within the drain itself and the Lower Vasse River through increased diversions of flow.

Table 1 Vasse Diversion Drain management recommendations

Management recommendation	Responsibility	Time
Continue to manage the Vasse Diversion Drain as a major component of the flood mitigation network	Water Corporation	Ongoing
Install second 900 mm culvert in the drain	Water Corporation	2020
Operate Vasse Diversion Drain culvert by opening culvert penstock at 100% on, or close to, 1 July each year and closing culvert on, or close to, 31 October, at the end of winter flows (as per the interim operating guidelines – Appendix C)	Water Corporation	Ongoing
Undertake intensive flow and nutrient monitoring of the Vasse Diversion Drain to inform operating guidelines	DWER	2019
Update interim operating guidelines for the Vasse Diversion Drain culvert and review on a five-yearly basis	Water Corporation, City of Busselton, DWER	2020
Open the Vasse Diversion Drain sandbar in early December to increase seawater exchange and improve water quality	Water Corporation	Annually
Maintain revegetation and restoration works undertaken in the Revitalising the Vasse Diversion Drain project following MOU with the CoB and GeoCatch	Water Corporation	Ongoing
Seek funding and partnerships to undertaken Stage 2 of the Revitalising the Vasse Diversion Drain project	GeoCatch Water Corporation	Ongoing

3.2 Butter Factory weir boards

The Butter Factory weir boards (also referred to as check boards or butter boards) were installed in the Lower Vasse River opposite the factory in about 1933 to hold back water in the river during summer.

Current management and operations

The City of Busselton normally installs the weir boards during October each year to retain water upstream after winter flows and then removes them in May/June.

Management recommendations

Modelling undertaken for the Reconnecting Rivers project indicated that removal of the Butter Factory weir boards would not create a flooding risk or result in drying out of the river during the summer months. Lidar information used for the model suggested the land elevation downstream of the weir boards above Ford Road was the control point that maintained water in the river during summer, more so than the actual boards that were old and leaky. In the 2018–19 summer, the City of Busselton trialled not installing the weir boards to assess the impacts on water levels in the river and community perceptions.

Table 2 Butter Factory weir boards management recommendations

Management recommendation	Responsibility	Time
Review 2018–19 trial of not installing Butter Factory weir boards	City of Busselton	2019
Review function of the Butter Factory weir boards to inform their future use and need for replacement	City of Busselton	2019

3.3 Vasse and Wonnerup surge barriers and Wonnerup Inlet ocean entrance

Surge barriers were installed at the exit channels of the Vasse and Wonnerup estuaries in 1908 to minimise flooding from storm surges and inundation of adjacent, low-lying agricultural land with salty sea water. The current surge barriers were installed in 2004 and include a fish gate to allow fish to move between the estuaries and Wonnerup Inlet and water to move between the two systems. The Vasse and Wonnerup estuaries empty to the sea via the Wonnerup Inlet. At the mouth of the inlet is a shallow bar formed by the easterly drift of coastal sand.

Current management and operations

The Water Corporation owns and operates the surge barriers and opens the Wonnerup Inlet sandbar following operating guidelines developed in 1990.

In winter the sand bar is artificially opened to drop water levels in the inlet. This allows the floodgates to open to reduce the risk of flooding. In summer the bar is opened to improve water quality in the Wonnerup Inlet. During summer, smaller fish gates on the surge barriers are opened to allow fish to move through the barriers or when the risk of a fish kill is high. The Water Corporation also monitors water levels upstream and downstream of the surge barriers.

Since a major fish kill in 2013, the Vasse-Wonnerup Wetlands Partnership (Departments of Water and Environmental Regulation; Biodiversity, Conservation and Attractions; Primary Industries and Regional Development; Water Corporation; and City of Busselton) has worked with the Water Corporation to trial management of the Vasse surge barrier during summer to reduce the risk of fish kills and improve water quality. This has included removal of algal build-up at the barriers, opening fish and prop gates within the surge barriers, removal of sediment and the trial of an oxygenation plant in the Vasse Estuary channel. During this time the Vasse surge barriers were operated outside the 1990 guidelines for the summer months.

Management recommendations

The Review Surge Barriers Project identified that seawater inflows could be used to reduce harmful phytoplankton blooms in the Vasse Estuary, as well as the risk of fish kills. This information has been used to review and update the 1990 operating guidelines including opening of the Inlet sandbar and gates on the Vasse surge barrier early in December to allow sea water into the Vasse estuary. The impact of seawater inflows on water quality in the Vasse Estuary have been well-studied through the Revitalising Geographe Waterways program, but what is not as well-understood is how seawater inflows may impact on the ecology of the wetlands in the longer-term.

To assess this risk an ecological monitoring program was initiated in March 2017 to assess the relationship between water regime (salinity and water levels) and ecology (aquatic plants, benthic invertebrate, fish and waterbirds). This study will continue at least until March 2020. While we wait to gain a better understanding of the impact of sea water on the wetlands' ecology, draft operating guidelines have been developed that will be reviewed annually in conjunction with ecological and water quality monitoring to assess impacts of the altered operation of the surge barriers.

Table 3 Vasse and Wonnerup surge barrier, ocean inlet management recommendations

Management recommendation	Responsibility	Time
Operate the surge barriers and Wonnerup Inlet sandbar opening following 2018 draft operating guidelines (Attachment D)	Water Corporation	Ongoing
Review draft operating guidelines on an annual basis in conjunction with ecological and water quality monitoring	Vasse Wonnerup Wetlands Partnership	Annually – May
Undertake five-year review of draft guidelines and update	Vasse Wonnerup Wetlands Partnership	2024
Remove algal build-up in front of surge barriers over summer months to improve water quality	Water Corporation	As required
Remove sediment build-up in front of the Vasse surge barrier	Water Corporation	As required
Investigate opportunities to automate check board installation on surge barriers	Water Corporation	2019–21

3.4 Toby Inlet, Station Gully Drain and culvert

The Toby Inlet is a small estuary to the east of Dunsborough, with a catchment that has been highly modified with artificial drainage. The inlet itself provides important habitat for fish and waterbirds and is highly valued by the local community.

The artificial drainage, including the Station Gully Drain, was installed to reduce flooding and support agricultural development. These drainage modifications have substantially reduced freshwater flows into Toby Inlet, which is often cut off from the ocean by the formation of a sandbar. The resulting warm, shallow, nutrient-rich waters can suffer from poor water quality during the summer months, and algal blooms can occur.

Current management and operations

The Water Corporation manages the Station Gully Drain, culvert and sandbar opening. The culvert is kept open to maximise water exchange with the Toby Inlet. Historically the Water Corporation has opened the Station Gully sandbar when complaints occur, as part of its normal complaints management process.

The City of Busselton manages the Toby Inlet and sandbar opening at the end of the Inlet. In the past much debate has occurred as to whether the sandbar should be opened in summer to improve water quality. The City has usually opened the Toby Inlet sandbar in response to flooding or community concerns about water quality in the inlet.

Management recommendations

The Reconnecting Toby Inlet model found that the greatest flushing of the Toby Inlet would be achieved by opening the inlet sandbar. Modelling found that opening the Station Gully sandbar had limited additional benefits, although water quality in the deadwater or Station Gully Drain might improve as a result. The culvert between Station Gully and Toby Inlet only has a minor influence on water exchange, which is naturally limited by a narrow channel between the two waterbodies.

The following recommendations are based on key findings of the Reconnecting Toby Inlet study and are also outlined in the Toby Inlet water management plan.

Table 4 Toby Inlet, Station Gully Drain and culvert management recommendations

Management recommendation	Responsibility	Time
Ensure the Toby Inlet ocean outlet is kept open through the period from 1 November to 31 April to improve water quality, with a minimum sill height of 0.15 m AHD	City of Busselton	Ongoing
Open the Toby Inlet sandbar during the period 1 May to 31 October to alleviate localised flooding as required	City of Busselton	As required
Monitor the status of the Toby Inlet outlet through a telemetered system to determine when opening of the sandbar is necessary	City of Busselton	Ongoing
Maintain opening of the culvert between Station Gully and the Toby Inlet	Water Corporation	Ongoing
Open Station Gully sandbar in response to community requests or poor water quality in the Station Gully drain or deadwater	Water Corporation	As required

3.5 Rural drainage network

The rural drainage network lies within the Busselton drainage district and consists of a network of over 400 km of artificial drains, river diversions, floodgates and culverts. Most rural drains are on private land. Some of the larger drains, road drainage and urban drains are owned and managed by local and state government agencies.

Drainage infrastructure within the catchment includes drains in road reserves, drains on farms, drains running through urban areas, compensation basins, levee banks, penstocks, bridge timber structures, access tracks and fire breaks.

Current management and operations

The Water Corporation manages the rural drainage network in the Busselton drainage district. Management of drainage infrastructure is prioritised according to flood risk with major flood infrastructure including the Vasse and Buayanyup diversion drains, the three compensation basins and the Vasse and Wonnerup surge barriers. These are regularly inspected and maintained (see Appendix E). The highest-priority flood infrastructure assets are inspected daily during significant weather events.

To manage operation of the rural drainage network, the Water Corporation has an automated maintenance system that generates work orders or generic work instructions at varying frequencies, depending on the asset's potential flood risk.

The Water Corporation's primary maintenance activities for rural drains include:

- weed spraying to ensure channels are free flowing and to reduce fire hazard
- weed removal via slashing (usually in high conservation areas)
- sediment removal
- management of erosion and silting
- maintaining firebreaks
- cleaning drains – including removal of nuisance species (e.g. bamboo) and debris, and reshaping entire drain reaches
- maintaining drainage structures (e.g. penstock, flood gate) to ensure proper functioning
- civil inspections on drop structures and bridges
- feral animal control

The Water Corporation uses contractors for most of the maintenance activities above. Contractors usually work in specific areas of the network, which allows the contractors to build rapport with the landholders and to better understand the system they are managing. Some maintenance contractors have developed a database of landholders to build up local knowledge, but these are not centrally held by the Water Corporation. Procedures for maintenance works are often undocumented and reliant on the knowledge and experience of the contractors.

Management recommendations

Under the Revitalising Geographe Waterways program, the department, in consultation with Vasse Taskforce partners, the Water Corporation and the City of Busselton, undertook a review of rural drainage management and operations in the

Geographe catchment to assess opportunities to use the rural drainage network to contribute to water quality improvements.

Since the mid-1990s, rural drainage on the Swan coastal plain has been the subject of numerous reviews and studies to identify opportunities for nutrient reductions. These reviews have highlighted potential management actions to improve water quality, but many of the proposed actions have not been supported by science. While using the rural drainage network to achieve water quality outcomes has attracted considerable interest, there is still little evidence of the effectiveness of many actions.

The current review used a number of different approaches to assess the potential effectiveness of a range of previously identified management actions to improve water quality in the rural drainage network. A literature review of riparian management based on local, interstate and international literature, with a particular focus on the drains of the sandy coastal plain, was undertaken. In addition, a number of workshops and site visits were conducted with the Water Corporation Busselton District drainage team to assess constraints/challenges and opportunities to implement actions. Appendix F is an assessment of the potential management actions that have been outlined in previous reviews against potential constraints and likely effectiveness. This work has informed the recommendations below:

Table 5 Rural drainage network management recommendations

Management recommendation	Responsibility	Time
Document procedures for drainage team and contractors on drainage maintenance and inspections and include in generic work instructions (e.g. weed control and spoil management)	Water Corporation	2021
Characterise rural drainage reaches using draft flood risk matrix and link to maintenance schedule (Appendix E)	Water Corporation	2021
Continue to support landholders to do fencing and provide off-stream watering points to protect and restore riparian vegetation along waterways and low-order rural drains	GeoCatch Water Corporation	Ongoing
Continue to undertake feral animal control to reduce bank erosion of rural drains	Water Corporation	Ongoing
Continue to trial different bed designs using soil amendments and additives (e.g. Iron Man Gypsum) to determine potential long-term rates of P removal in rural drains	DWER and DPIRD	2019
Investigate the effectiveness of different management actions within drains (e.g. weed control and spoil removal) designed to help in the exposure of P adsorptive soils in the drains and reduce P export	DWER, DPIRD Water Corporation	2019

3.6 Urban drainage

Urban drainage is installed on land developed for residential, commercial, industrial and rural residential uses. The drainage is constructed as urban development expands, ultimately entering existing catchment drainage systems, such as wetlands, waterways, diversion drains and/or the ocean. Urban drainage provides a range of service functions to both the urban area and the receiving environment. Urban areas are protected against major flooding and from shallow groundwater; transport corridors are kept open during minor events; and water quality is improved by managing small-event runoff as close to source as possible before pollutants are mobilised into the drainage system.

Current management and operations

Urban drainage is owned and managed by local government. For new urban expansion areas it is designed and constructed by developers in accordance with *Better Urban Water Management* (WAPC 2008), which promotes the use of water sensitive urban design. One year after these systems have been constructed the local government takes ownership and responsibility for ongoing maintenance of the drainage assets. Maintenance is undertaken in accordance with the local government's asset management system and procedures. Due to drainage assets comprising both engineered and vegetated systems, this includes inspections, desilting, litter collection, vegetation management, and where required system replacement. In view of the range of maintenance activities, it is critical that staff from different disciplines understand the drainage functions to avoid unintended impacts. Aging infrastructure and changing land use (e.g. increased residential densities) results in the need for local government to undertake capital drainage replacement programs, in-house works and retrofitting projects. This provides an opportunity for historic and traditional drainage systems to be incrementally replaced with systems that apply the principles of water sensitive urban design (WSUD).

Since 2007, GeoCatch, the City of Busselton, Capel Shire and the department have been working together to retrofit stormwater infrastructure to improve water quality entering Busselton and Capel waterways, wetlands and Geographe Bay. The projects have included principles of WSUD including constructed wetlands, living streams, gross pollutant traps and rain gardens in high-profile strategic locations around Busselton and Capel. These projects have been complemented by a community behaviour change program – Bay OK Gardens. This program aims to improve awareness of waterwise low-nutrient gardens and improve policy for new and infill developments in the City of Busselton.

The department has also developed the Urban Nutrient Decision Outcomes (UNDO) tool. UNDO is a conceptual-decision-support tool that evaluates nutrient reduction decisions for urban developments on the sandy Swan coastal plain in south-west Western Australia. It is designed for urban development proponents as well as local and state government authorities. The department has also recently updated the *Decision process for stormwater management in Western Australia* (DWER 2017), which gives practical advice to developers and local government on WSUD principles and application.

Management recommendations

Since the introduction of *Better Urban Water Management* (WAPC 2008), the adoption of WSUD has significantly increased. We can see this in the drainage proposals provided by developers and the capital works and retrofit projects undertaken by local government. Local governments are embedding WSUD principles in their policies to further influence both developer and internally initiated drainage works. Therefore, the management recommendations in Table 6 focus on the continuation of these practices.

Table 6 Urban drainage management recommendations

Management recommendation	Responsibility	Time
Continue to promote the uptake of water sensitive urban design in new developments though implementing *Better Urban Water Management* (BUWM)	Local government, DWER	Ongoing
Encourage the use of living streams for major urban drainage systems	Local government, Water Corporation, DWER	Ongoing
Include capital upgrade projects, using water sensitive urban design in local government forward budgets	Local government	Ongoing
Continue to seek opportunities to retrofit priority urban stormwater systems with water sensitive urban design	Local government, GeoCatch	Ongoing
Continue to ensure staff from various disciplines are appropriately trained (engineering, works, parks and gardens) to implement and maintain water sensitive urban design infrastructure	Local government	Ongoing
Seek opportunities to implement recommendations from the *RGW optimising planning tools – final review report – August 2018*	Department of Planning, Lands and Heritage in consultation with local government	Ongoing

Appendices

Appendix A — Summary of major drainage works in the Geographe catchment

- 1880s – The Capel River was diverted to the ocean via the Higgins Cut.
- 1904 – The first major work began on the Stirling Estate west of Capel near the Capel River. Main tributary channels were excavated and a floodgate was erected.
- 1904 – The extension of the south drain to discharge into the Wonnerup Estuary.
- 1907–08 – A scheme began to alleviate flooding in Busselton and Wonnerup. Surge barriers (flood gates) were constructed at the mouths of the Vasse-Wonnerup estuaries to prevent saltwater ingress.
- 1915 – A cut was made to drain water from New River to the ocean.
- 1925 – The Busselton drainage district was proclaimed under the Land Drainage Act, giving government more control over future drainage works.
- 1927 – The Vasse Diversion drain was constructed (following a large flood in 1926). This drain diverts much of the upper catchment which previously drained into the Vasse Estuary. This has reduced the risk of flooding in the estuary, however spoil bank failures in the late 1990s illustrate that the drain still poses a potential hazard for Busselton. Recent construction of the compensation basins and upgrades to the levee bank has reduced the risk of levee failure.
- 1928–29 – New tidal gates were constructed at the mouth of the Vasse-Wonnerup estuaries.
- 1930s onwards – Continual agricultural growth and clearing resulted in increased runoff volume, higher flood levels and quicker time to flow peak.
- 1942 – Removable stop-gates were added to the surge barriers at the Vasse-Wonnerup estuaries.
- 1954–86 – Major capital works in the Busselton district including enlargement of main drains.
- 1964–65 – The Vasse Diversion Drain is redesigned to reduce flood flows.
- 1983–93 – Vasse Diversion Drain is upgraded to increase peak flow capacity.
- 2001–03 – Two compensation basins built on the Vasse Diversion Drain.
- 2004 – New surge barriers at the Vasse-Wonnerup (20 m upstream from original gates).
- 2008 – Sabina Diversion weir upgraded.
- 2009 – Third compensation basin built on Sabina Diversion Drain.

- 2016–present – Upgrade to the Vasse Diversion Drain to increase the flood protection capacity.

Appendix B — Historical flooding events in the Geographe catchment

Year	Details	Source
1843	Cyclone affects Perth Colony. At Bunbury the tide increased by 4 feet.	BoM website
1872	Cyclone – Bunbury was affected.	BoM website
1909	Flood – Rainfall estimated at 107 mm in 12 hours, with a further 23 mm the following day.	West Australian (1909) in GHD (2013)
1937	Cyclonic storm passes Busselton resulting in storm surge into the estuary and damage to the floodgates.	The Mercury, Hobart TAS (1937) in GHD (2013)
1963	Flood – Heavy rainfall in July causes extensive flooding. The banks of the Vasse Diversion Drain were breached.	WAWA (1987) in GHD (2013)
1963	Flood – Riverine flooding in August on the Capel and Ludlow rivers	WAWA (1987) in GHD (2013)
1964	Flood – Vasse Diversion Drain embankment overtopped, The catchment was already saturated from winter rain	WAWA (1987) in GHD (2013)
1965	Flood – 97 mm of rainfall falls on the 20 July, but the Vasse Diversion Drain does not fail.	WAWA (1987) in GHD (2013)
1967	Flood – 19 and 20 June, high rainfall resulted in flooding, and the Vasse Diversion Drain was overtopped briefly.	WAWA (1987) in GHD (2013)
1978	Cyclone Alby	Public Works Department (1978)
1986	Flood – highest levels seen in the Vasse Diversion Drain since 1965 upgrade	GHD (2013)
1988	Flood – June	GHD (2013)
1990	Flood – Peak flows estimated at 130-140 m3/s after rainfall of 81-103 mm across the catchment	GHD (2013)
1997	Flood – Between 69 and 107 mm of rain fell in 19 hours. Peak flows of 128 m3/s in the Vasse Diversion Drain, which overtopped/failed in a number of locations. After this event a commitment was made to improve the drainage infrastructure.	GHD (2013)
1999	Flood – Similar to 1997	GHD (2013)

Appendix C — Interim operating guidelines for the Vasse Diversion Drain culvert (2019)

The Vasse Diversion Drain penstock regulates flow from Vasse Diversion Drain to the Lower Vasse River via a 900 mm diameter culvert fitted with a gate. The Water Corporation will be installing a second 900 mm culvert as part of the broader Vasse Diversion Drain upgrade in 2020.

The interim operating guidelines below are based on water quality and flow monitoring and flood risk modelling undertaken in the Reconnecting Rivers study.

During 2019–20 the Department of Water and Environmental Regulation will be undertaking intensive flow and water quality monitoring to inform the update of the interim guidelines.

The Water Corporation is responsible for operating the penstock following the interim guidelines below.

- Open culvert penstock at 100% on, or close to, 1 July each year.
- Close culvert on, or close to, 31 October, at the end of winter flows.

Appendix D — Draft operating guidelines for the Vasse and Wonnerup surge barriers and Wonnerup Inlet sandbar (2018)

General

The Vasse and Wonnerup surge barriers were originally installed in 1908 to protect the township of Busselton from storm surges, as well as low-lying land from seawater inundation. The current barriers were installed in 2004 and are automatic one-way structures (water flows out when water levels are lower in the Wonnerup Inlet). In winter the sand bar is artificially opened to drop water levels in the inlet, allowing floodgates to open. In spring check boards are installed, which raise the effective sill height to 0.4 m AHD, to maintain water in the estuary during spring and summer. In summer the bar is opened to improve water quality in the Wonnerup Inlet and to allow seawater into the estuaries via fish and propped gates within the barrier structure. Seawater is introduced into the estuaries in summer to prevent the estuaries from almost completely drying out and to allow fish movement into the Wonnerup Inlet.

> These draft guidelines replace the 1990 guidelines for operating the floodgates and managing the sand bar.

Maintenance

The floodgates must be lifted each year and scraped clear of marine growth and any corrosion on the steel work protected.

Operation

Winter

Immediately after the first rains produce runoff, remove the check boards in both the Vasse and Wonnerup surge barriers.

When water levels in the Vasse Estuary are at least 0.7 m AHD, manually open the Wonnerup Inlet sandbar to lower water levels in the inlet – allowing floodgates to open. If levels are less than 0.7 m AHD, the sandbar will close over too quickly.

This operation will need to be repeated over winter/spring if the sandbar closes over and water levels rise in the estuary to 0.7 m AHD or above.

Spring

Install the check boards in the Vasse and Wonnerup surge barriers during spring before the runoff has finished to a height of 0.4 m AHD. This usually occurs in early September but will vary depending on the season and rainfall. If a major rainfall event is predicted, the check boards may need to be removed to reduce flood risk.

Summer

Open the Wonnerup Inlet sandbar before opening the gates in the Vasse or Wonnerup surge barriers (late November to early December on a rising spring tide) and keep the bar open until at least the end of April.

Remove algae and seagrass that accumulates immediately upstream of the surge barriers to improve water quality and reduce sediment build-up.

Vasse Estuary

Open the propped gate and fish gate and associated penstock on the Vasse surge barrier at 100% in early December for two weeks or until the Vasse Estuary channel has reached marine salinities of 35 ppt at least 1.0 km from the surge barrier.

The date in early December should be selected so the gates are first opened on a spring tide or one to two days before, so that the tidal range is large for as many days as possible.

After two weeks, or when the Vasse Estuary channel is at marine salinity of 35 ppt, close the propped gate and maintain the fish gate and penstock open at 100% over summer/autumn. Close the fish gate temporarily if water levels in the Vasse estuary reach 0.2 m AHD and/or when storm surges or unusually high tides are predicted.

> This opening schedule is intended to decrease the likelihood of low oxygen concentrations in the waters of the channel that occur if seawater is introduced slowly or irregularly. Rapidly raising the salinity by opening both the propped and fish gates on a spring tide reduces the likelihood of vertical stratification (freshwater sitting on top of heavier salty water) that leads to low dissolved oxygen conditions. Allowing seawater into the channel in early December also minimises the establishment of harmful algal blooms.
>
> (N.B. Water levels in the estuary may be over the desired level of 0.2 m AHD in the first two weeks of opening both gates. This is fine as the salinity levels in the broader estuary will not be at marine levels and therefore the risks from salinity on surrounding lands will be low.)

Wonnerup Estuary

Open the fish gate and associated penstock when water levels in the Wonnerup Estuary reach -0.4 m AHD and maintain at this water level during the summer months by manipulating penstock opening.

> The Wonnerup Estuary surge barrier operations are the same as historical management. In this way the Wonnerup estuary provides a ‘control’ for the updated surge barrier management in the Vasse Estuary.

For Vasse and Wonnerup estuaries

Open the fish gate and penstock 100% if there is a concern of an imminent fish kill or there are large numbers of fish schooling in front of the surge barriers (estuary side). Close the gates once the fish behaviour has returned to normal or after a maximum of four hours.

Appendix E — Draft Water Corporation risk rating and maintenance and inspection frequency for the Busselton drainage district network

Risk rating	Drain type	Maintenance and inspection frequency
Catastrophic	Rural drains that have the highest level of flood risk to rural and urban properties, people and infrastructure	Given the highest priority maintenance. These drains have floodgate inspections every six months, levee inspections every month and daily inspections during significant weather events. They also have proactive chemical maintenance and vermin control annually. The Vasse Diversion Drain currently receives the highest priority maintenance as it is the main flood mitigation infrastructure in the catchment. Other high-priority drains include the Buayanyup main drain and the three compensation basins.
Major	Rural drains with a higher flood risk such as those that if flooded will impact multiple rural properties, people or infrastructure	Given a higher level of maintenance and inspection priority. Proactive chemical maintenance and vermin control will be undertaken annually, as well as levee inspection and catchment inspection. Any erosion in the drain will be repaired as a high priority and further inspections will take place during and after storm events. A drain with a levee bank is an example.
Moderate	Rural drains located in more significant road reserves (e.g. near a highway or within 100 m of a private dwelling)	Given higher priority maintenance. Proactive chemical maintenance and vermin control will be undertaken annually and any obstructions to the drain will be removed as a priority over minor and insignificant drains. An example of this type of drain is the Vasse A drain.
Minor	Rural drains in road reserves on ‘back roads’	Maintained on an automated five-yearly inspection frequency. Maintenance of these drains is carried out as required and is often customer driven (e.g. desilting and spot spray). Some form of machine maintenance on these drains is expected every 10 to 15 years. An example of this type of drain is the Abba A2A.
Insignificant	Small rural drains (such as natural waterways and paddock drains)	These drains receive the lowest priority maintenance and are considered to have ‘minimal flood risk to public or private property’. At a minimum these drains receive automated five-yearly inspections however there is rarely any maintenance required. Maintenance work on these drains, within the five-year period, is often generated in response to customer issues such as tree removal or major erosion issues. Examples of these types of drains include the Elgin Main Drain and the Abba F and Abba F1.

Appendix F — Geographe rural drainage management – water quality improvement opportunities and constraints

No.	Potential management action	Description	Potential benefits to water quality and waterway health	Potential challenges/constraints	Potential effectiveness	Recommendations
1.	**Riparian zone vegetation management**	Maintaining or restoring vegetative cover along waterways	• Riparian vegetation can hold soils in place and reduce erosion • Can reduce sediment-bound P entering waterways • Enhanced denitrification • Some uptake of nutrients (both N and P) in plants • Improves biodiversity – increasing food and habitat • Shades and cools streams	• Maintaining the vegetative cover requires effective grazing management in paddocks or a targeted weed control program • Can create a potential fire hazard and difficult to control nuisance weeds • Streamlining can increase maintenance costs (tree dropping branches etc.) • Riparian restoration is expensive • Can reduce productive land by allowing for vegetation buffers	Riparian management in Geographe coastal catchments is likely to be relatively effective at reducing TN through denitrification (reducing nitrate) but less effective at reducing TP due to: 1 Most P is in soluble form so little opportunity for riparian vegetation to reduce sediment-bound P 2 P binding capacity of surface soils is generally low so adsorption of P onto soil particles is limited Assimilation of both N and P by plants in the riparian zone can be effective, particularly if buffer widths are greater than 10 m Uptake in native species is usually lower than exotic species (e.g. pasture and weed species), however annual species will re-release nutrients back into the environment Unfertilised pasture grasses can be an effective riparian buffer if the pasture is harvested and removed offsite Restoration with native tree species is effective in assimilating N and will release fewer nutrients back to the environment. Native trees also provide additional ecological services Effectiveness of riparian vegetation at reducing nutrients is likely to be greater in low order streams and rural drains Riparian vegetation providing shade and habitat complexity has been shown to be effective at improving biodiversity of Geographe waterways	Continue to support landholders protect and restore riparian vegetation along waterways and low order rural drains to enhance nutrient uptake and improve waterway health Develop guidelines and support landholders to appropriately fence and manage vegetation along drains and waterways Investigate opportunities to trial and model for water quality enhancements in first order rural drains including benefits of unfertilised pasture

No.	Potential management action	Description	Potential benefits to water quality and waterway health	Potential challenges/constraints	Potential effectiveness	Recommendations

2.	**Controlling stock access to the drain through fencing**	Stock exclusion fencing and off-stream watering points installed to prevent stock access to the drain	• Erosion protection of banks and vegetation
			• Reduced animal defecation in drain and riparian vegetation improving waterway health and reducing nutrient inputs
			• Reduced fertiliser application in fenced area
				• Fencing and installation of off-stream watering points is expensive
				• Access for drainage maintenance and management is compromised
				• Constraints to landholders
				  ○ Loss of productive land
				  ○ Loss of access to stock for watering or feed
				  ○ Restricted crossing points for stock or machinery
				  ○ May split paddocks
					Highly effective at reducing direct deposition of faeces and urine by stock which can be a major contributor to nutrient loads
					
					Effective at reducing nutrients loads from unfertilised areas within fencing
					
					Highly effective at reducing erosion through stock access
					
					Effective at maintaining healthy riparian vegetation communities by preventing trampling and grazing, which will promote plant uptake of nutrients and denitrification processes
						Continue to support landholders to do fencing and provide off-stream watering points along waterways and low order rural drains to control stock access

3.	**In-stream soil amendments**	Placing soil amendment product (such as Iron Man Gypsum) within rural drains to bind with phosphorus and retain in the soil	• Improved nutrient (TP) retention in the soil • Able to be reused on properties	• Water contact times may not be long enough for decent outcomes • Amendment staying in the drain and not being washed away • Still unsure of effectiveness and application amounts • Unsure how long it will be effective • Interaction of nutrient-enriched water with amendment may not be maximised due to limited infiltration	Pilot scale laboratory and field experiments of IMG and other soil amendments show high effectiveness at retaining and reducing P in runoff when there is good water-soil contact In-situ soil amendment trial in a drain in the Geographe catchment had a very small but consistent effect at reducing P but was limited by sedimentation. IMG amended sand beds trialled in drains in the Peel-Harvey catchment had most benefit when treating groundwater seeping into drains and were very limited when treating water flowing through sections	Continue to trial different bed designs using soil amendments and additives (e.g. Iron Man Gypsum) to determine potential long-term rates of P removal in rural drains
4	**Silt traps**	A basin device that is set upstream of a drain or waterway to prevent any kind of silt, soil or sediment from entering the drain by containing water in the trap and allowing particulate materials to settle	• Silt and pollutants are retained at source • Slows flow of water and downstream velocity to reduce erosion and transportation of nutrients • Can be positioned at various hot spots to reduce nutrients moved in sediment	• Cost of establishment • Require regular maintenance to remove and dispose of sediments effectively so as not to recycle through the system • Need appropriate design for different sites	Rates of sedimentation on the Swan coastal plain are low, due to the flat and sandy nature of the plain, so the effectiveness of silt traps in rural catchments is likely to be minimal under normal situations Effectiveness will increase during disturbance e.g. during urban construction or land clearing activities where silt traps are likely to be effective at reducing sediment loads to drains and waterways Limited effectiveness in reducing soluble P	Consider the installation of silt traps during major land disturbance where sedimentation is potentially problematic e.g. urban development or major land clearing to reduce sediment loads entering drains and waterways

No.	Potential management action	Description	Potential benefits to water quality and waterway health	Potential challenges/constraints	Potential effectiveness	Recommendations
8.	**Biological filters and constructed wetlands**	Artificially constructed wetlands or enhanced existing low swamps to act as biological filters	• Reduce nutrients through plant uptake, denitrification or binding with the silt deposits • Constructed wetlands have the ability to assimilate N through denitrification, P though sorption and sedimentation and to assimilate both N and P through the long-term accretion of organic matter • Pollutants will settle out to allow fixing and uptake by natural or planted species • Habitat for bird, aquatic and animal life • Can be used in conjunction with silt traps	• Need large land area to be effective • Most land in rural areas is not readily available or suitable • Potential to become a nutrient source and release nutrients to the environment • Need ongoing management as vegetation may die if not maintained properly	Biological filters work well but effectiveness depends on the size of the filter vs the size of the drained area. Approximately 2% of the drainage area is required to be developed as a constructed wetland or biofilter area if significant treatment rates are to be achieved Constructed wetlands have the ability to assimilate N through denitrification and to assimilate both N and P through the long-term accretion of organic matter where conditions are suitable. They can also reduce the 'first-flush' runoff which commonly contains high rates of inorganic nutrients, and will reduce the duration of flows	Continue to monitor the effectiveness of previously established constructed wetlands Trial the use of constructed wetlands as methods to reduce nutrient loss from high-risk rural land use developments (e.g. avocado plantations, dairies, feedlots) when opportunities arise
9.	**Weed management within rural drains**	Weed control (herbicides or slashing) or no weed control undertaken within drains. Controlling weeds is a regular maintenance function in rural drains to maintain their flood protection function and reduce the risk of fire	• Slashing and removing of weeds removes nutrients from the drainage system • Allowing appropriate weed growth will slow water flow, trap nutrients and enhance uptake nutrients	• Increase in cost and time for drain maintenance if weeds need to be slashed and removed off site • Access issues for slashing machine • Not controlling weeds may increase flood and fire risks	Weeds are effective at taking up nutrients, however this effectiveness is severely limited if weeds are left on site to decompose either through herbicide application or natural senescence. Slashing and removal of weeds is the most effective way of removing nutrients.	Investigate the effectiveness of different weed management actions within drains to optimise nutrient uptake and removal
10.	**Spoil management**	Removal of silt from drains to maintain their flood protection function.	• Silt, nutrients and pollutants reduced if the spoil is removed off site • Exposure of phosphorus adsorptive soils in the drains may reduce phosphorus export • Opportunity to re-use spoil offsite	• Drains not cleared frequently (e.g. once in 10 years) • Cost to take spoil away is high (current practice is to leave spoil on the banks of the drain)	Trials undertaken by DPIRD in Peel Harvey indicate that the disturbance and removal of silt from drains is highly effective at exposing phosphorus adsorptive soils, reducing phosphorus export by removing drain topsoils that are saturated with phosphorus and exposing soils with some P adsorptive capacity	Investigate the effectiveness of spoil management and removal to enhance exposure of phosphorus adsorptive soils and reduce phosphorus export
11.	**Review drain designs and**	Modify trapezoidal drains	• Current design of narrow, relatively deep, trapezoidal	• If flood protection is to be maintained, the hydraulic	This action is not likely to be possible unless significant land-take is undertaken, and a	Undertake a desktop study to investigate

No.	Potential management action	Description	Potential benefits to water quality and waterway health	Potential challenges/constraints	Potential effectiveness	Recommendations
	reengineer (living stream approach)	to make them wider and shallower, and include engineered 'natural' features such as meanders, pools and riffles. Generally includes vegetated high-flow banks and low-flow channel	drains inhibit nutrient uptake due to minimal water contact with drain sediments and vegetation, and limited opportunities for sediment to settle and accumulate • Design modifications offer great potential for improving water quality through soil adsorption, sediment settling and vegetation uptake • Includes a wider array of vegetation complexes within the drainage system, which has associated ecological benefits (improves biodiversity, shades and cools streams, provides habitat for fauna) • Offsetting drainage entry points may have the effect of increasing residence times	capacity of the drain must be maintained. Therefore if drains are to be shallower and vegetated (more resistant to flow), they are required to be wider, hence more land required in most cases to achieve the modification. This is restricted by access and size of easements, or the modification to established farm layouts (use of private land for drainage works) • Earthworks are expensive, and flood studies would be required before modification, which are also expensive • As there is likely to be vegetation in the drainage system there are the same management issues as for riparian vegetation	living-stream approach is considered. In these cases, significant reductions in N load could be realised, but P loads are still unlikely to be significantly altered.	potential areas where re-engineering is plausible and likely to be effective. Consider a range of options for rural drainage management for water quality improvement in sub catchment planning
12.	**Feral animal control**	Baiting and fumigation to control rabbits and foxes to reduce impacts from burrows in drain banks	• Erosion protection of banks and vegetation • Control currently being done for rabbits in priority areas (baiting by contractors) • Protection of native species	• Opportunities for control limited in semi-urban areas • Unlikely to impact water quality in a significant way.	Action will have minor impacts in water quality through reduced erosion	Continue to undertake feral animal control to reduce bank erosion
13.	**Review of the 72 hour rule**	Retain water on land longer than 72 hours by not maintaining flood protection associated with drainage network. Current drainage infrastructure and management is designed to shed water off the catchment within 72 hours to	• Increased assimilation and uptake of nutrients through plants • Reduce erosion	• Current Operating Licence requires Water Corporation to "endeavour to operate and maintain its rural drainage infrastructure so that the period of inundation to land abutting a drain that forms part of the system shall be a maximum of 72 hours" • Different land uses and landholders have different acceptable levels of inundation • Excessive inundation could potentially damage horticultural	Unlikely to be effective at increasing nutrient uptake by plants as plant growth is limited under waterlogged and most likely cold conditions Likely to be an effective at reducing TN through denitrification, and potentially up to an extra 10-30% of TN could be reduced in areas with drains/paddocks that hold back water if appropriate conditions for denitrification are incorporated into drainage design	May need to be considered when assessing the possibility of other management options – for example wetlands or biological filters.

No.	Potential management action	Description	Potential benefits to water quality and waterway health	Potential challenges/constraints	Potential effectiveness	Recommendations
		reduce inundation and flooding		crops and have negative impacts on pasture growth		
14.	**Minimise drain outlets**	Reduce the number of drainage outlets and combine into a single or limited number of controlled access points	• May provide greater opportunity for management of the runoff before entering the drainage network e.g. through soil amendment and/or silt traps	• Likely to be a major cost associated with changes to infrastructure • May cause increased scouring and velocity in drains • Could make the drain problem worse by creating central water access point	Unlikely to be effective in improving water quality unless combined with another management action e.g. constructed wetlands or soil amendment	Should only be considered when assessing the possibility of other management options – for example wetlands or biological filters
15.	**Subsoil drainage**	Provide subsoil drainage to take water through the soil profile before entering the drainage system	• The water is filtered through the soil, giving maximum uptake and binding opportunity • Little solid pollutant will reach the drains through this system • Opportunity to incorporate into new development and agriculture intensification (rural/urban opportunity)	• Subsoil drainage is expensive • There are limited sites where it can be successfully applied • Only likely to be effective for P when the soil has some ability to bind phosphorus • Likely to export high levels of nitrate, as they do not support the process of denitrification	Likely to be an effective action to reduce TP where soils have a moderate to high PBI	Where subsoil drainage is likely to occur, combine with moderate to high PBI soils to reduce phosphorus export Ensure that measures are in place downstream to reduce nitrate runoff
17.	**Groundwater bioremediation trench (sawdust trench)**	Comprises a trench, excavated to below the watertable, oriented perpendicular to the direction of GW flow, and backfilled with a reactive agent (e.g. sawdust)	• Effective in reducing nitrate concentrations in groundwater plumes • Requires minimal land-take	• Expensive due to earthworks • Not all sites are suitable • Does not remove surface flow of nitrate, which can be the most significant source • Needs anoxic conditions for sawdust trench to be effective	Extremely effective in removing high levels of nitrate from the groundwater Possibly effective in reducing TP in GW in very low PRI soils	Should only be considered in areas with very high nitrate groundwater concentrations, adjacent to waterways (e.g. feedlots, dairies, horticulture)

References

Busselton Water (2015), *Rethink Drainage Buayanyup subcatchment pilot project – drainage management plan*, Western Australia.

City of Busselton (2019), *Draft Lower Vasse River waterway management plan*, City of Busselton, Western Australia.

City of Busselton (2019), *Draft Toby Inlet water management plan*, City of Busselton, Western Australia.

Clay, B (2005), *Management plan for the Toby Inlet foreshore and waters*, Western Australia, Shire of Busselton.

Del Marco, A (2007), *Drainage reform plan – Peel-Harvey coastal catchment*, Report by Ironbark Environmental for Peel-Harvey Catchment Council Inc, Western Australia.

Department of Biodiversity, Conservation and Attractions (2019), *Draft Vasse Wonnerup operational plan: guidance for managers 2019*, Department of Biodiversity, Conservation and Attractions, Perth, Western Australia.

Department of Water (2009), *Draft management response framework for rural drainage on the coastal plains of SW Western Australia: statement of response*, Western Australia.

Department of Water (2010), *Vasse Wonnerup Wetlands and Geographe Bay water quality improvement plan*, Department of Water, Government of Western Australia.

English, LB (1994), *Country drainage – Busselton drainage district*, Water Authority of Western Australia.

Frazer, J & Hall, J (2017), *Reconnecting Toby Inlet: options for increasing water circulation in Toby Inlet to improve water quality – a Revitalising Geographe Waterways project*, Water Science Technical Series report no. 80, Department of Water and Environmental Regulation, Western Australia.

Hall, J (in prep), *Literature review of drainage management science*, Department of Water and Environmental Regulation, Western Australia.

Hart, BT (2014), *Independent review of the current and future management of water assets in the Geographe catchment WA*, Water Science Pty Ltd report to Government.

Marillier, B (2018), *Reconnecting rivers flowing to the Vasse Estuary*, Water Science Technical Series, report no. 81, Water Science Branch, Department of Water and Environmental Regulation, Perth, Western Australia.

Peel-Harvey Catchment Council (2008), *Management of diffuse water quality pollution in the Peel-Harvey coastal drainage system – a strategic approach to implementation of best management practices*, Peel-Harvey Catchment Council, Western Australia.

Western Australian Planning Commission (2008), *Better Urban Water Management*, Western Australian Planning Commission and Department for Planning and Infrastructure, State of Western Australia.

WML Consultants (2005), *Drainage reform options for Geographe catchment council,* Consulting report prepared for the Geographe Catchment Council, Bunbury, Western Australia.

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