



# Byron Shire Recycled Water Management Strategy 2017 – 2027



# EXECUTIVE SUMMARY

The Byron Shire Recycled Water Management Strategy 2017 – 2027 establishes the path for recycled water management in the Byron Shire over the next ten years. This document formalises our vision that:

***Effluent will be managed in an ecologically sustainable way that ensures public health and protects and enhances the natural environment.***

This community vision for effluent management has shaped the development of recycled water management strategies in the Shire over the last 20 years. Community aspirations for high levels of effluent reuse has seen the development of the multi-award winning Byron Bay Integrated Water Management Reserve, the Byron Bay Urban Recycled Water Scheme and the rural Main Arm Recycled Water Scheme.



*The endangered Black-necked Stork at the Byron Bay Integrated Water Management Reserve*

Councils experience in operating recycled water management schemes has provided valuable insight into the future directions of recycled water management in the Byron Shire. In the absence of high water using industries, and in an area that receives sufficient rainfall, Council has been challenged to find ways to significantly increase levels of recycled water use. One of the main changes in Councils approach to recycled water management over the next decade, will be the focus on projects which Council can apply controls and maximise recycled water application.

Environmental Schemes form the key direction in recycled water management for the Byron Shire Recycled Water Management Strategy 2017 - 2027. These applications provide Council with the ability to proactively manage recycled water to provide long term demand security. This strategy has been developed based on the determination that, not only do environmental projects have the lowest level of risks and offer the highest levels of security for long term use, but this application is also capable of using the volumes of recycled water required to achieve the community objectives. The successful implementation of the Byron Bay Integrated Water Management Reserve in achieving, not only high levels of effluent reuse through evapotranspiration and seepage but also in the environmental remediation of localised acid sulphate soil and habitat loss, has resonated in Council's key direction.

Council have commenced investigations into other viable Council controlled land applications that have the potential to achieve high levels of recycled water use. The Brunswick Valley Sustainability Centre project has provided Council with a unique opportunity. Biomass cropping at some sewage treatments plants is considered a viable option for maximising the evapotranspiration of recycled water. The prospect of recycling water to irrigate crops to be harvested for bioenergy production, to be then used to power the Byron Shire Sewage Treatment Plants, is emerging as one of the preferred recycled water management strategies. This project provides Council with an opportunity to utilise high volumes of recycled water through land application as well as significantly contributing to the communities zero emissions target and sustainability ethos.

The Byron Bay Urban Recycled Water Scheme will continue to develop until full capacity. All sporting fields and nurseries along the Urban Corridor currently use recycled water for irrigation purposes, and recently the scheme has extended to include flushing of public toilets with the local Hotels and caravan parks connecting imminently. An upgrade to the system will be considered based on a secure demand, although it is considered growth will be small and incremental. Urban schemes are not considered viable for the smaller villages in the Byron Shire and therefore urban schemes for Brunswick Valley, Bangalow or Ocean Shores Sewage Treatment Plants, will not be pursued at this time.

The Council operated rural scheme, Main Arm Recycled Water Scheme, has been the least successful recycled water application with the scheme failing to meet community aspirations. The uncertainty with the operation of rural schemes due to external limitations such as high rainfall, along with the practical business considerations of private landowners, increase the risks associated with the development of rural schemes. Reliance on small businesses and farming enterprises to achieve the community objectives for recycled water management has not provided the long term security that the Byron community desire. However, rural schemes have the potential to utilise high volumes of recycled water and Council are committed to supporting farming enterprises who are committed to utilising the resource.

The community aspirations of the 2005 Effluent Management Strategy have not yet been realised, and consequently Council have resolved to actively pursue projects which Council can apply operational control to maximise recycled water use. Each scheme is driven by a number of external forces which dictate the current and future demands for the recycled water as a resource. Predicting how these drivers will evolve over the next decade, and how they will ultimately affect recycled water demand, has a level of risk and uncertainty. A key to the long term success of the strategy will be to ensure that demand for the resource keeps up with supply.







## **EXECUTIVE SUMMARY**

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# INTRODUCTION

The Byron Shire Recycled Water Management Strategy 2017—2027 provides the strategic direction in recycled water management for Byron Shire. The Strategy has been developed based on the vision and objectives adopted by Byron Shire Council and emphasises Councils commitment to managing its recycled water systems to ensure community objectives, regulatory requirements and improved environmental outcomes are achieved.

The Sewage Management Strategy (1999) set the path for effluent management, developing the vision and guiding principles that would shape the development of recycled water strategies across the shire. The Byron Bay Effluent Management Strategy (2005) subsequently developed a set of objectives to align community expectations with the management of effluent in Byron Bay. These Strategies were developed through extensive consultative committee processes represented by Councillors, community members, Council staff, and State Government. The Byron Shire Recycled Water Management Strategy 2017—2027 builds on the intent of both these documents.

The Byron Shire Recycled Water Management Strategy 2017—2027 sets out an updated set of objectives and discusses how the objectives for recycled water management will be achieved in terms of Councils key strategic directions, specific projects, recycled water potential and timeframes. The Strategy is focussed on the beneficial use of recycled water in urban, rural and environmental applications. In the context of recycled water management, the strategy does not attempt to address issues such as sewage minimisation, sewage source control, in-stream sewage quality, sewage treatment process management, or biosolids management.

Improvements in the operation and management of Byron Shire sewage and recycled water systems since the early 2000's have seen financial, social and environmental outcomes across the Shire. Council has implemented recycled water applications for all sewage treatment plants (STP) with varying treatment processes and recycled water quality dictating the recycled water applications that are applied to each scheme. The schemes for each of the four sewage treatment plants operated by Byron Shire Council are outlined in the table below.

## Strategic Direction for Recycled Water Management in the Byron Shire

STP	Key Direction 2006 - 2016	Key Direction 2017- 2027
<b>Byron Bay</b>	<ul style="list-style-type: none"> <li>Byron Bay Urban Recycled Water Scheme</li> <li>Byron Bay Integrated Wetland Management Reserve</li> </ul>	<ul style="list-style-type: none"> <li>Urban scheme - expansion to full capacity</li> <li>Environmental scheme - wetland expansion in Belongil Catchment</li> <li>Rural scheme - development of the Western Corridor</li> </ul>
<b>Brunswick Valley</b>	<ul style="list-style-type: none"> <li>Main Arm Recycled Water Scheme</li> </ul>	<ul style="list-style-type: none"> <li>Rural scheme - expansion of MARWS</li> <li>Environmental scheme - Biomass cropping and constructed wetlands</li> </ul>
<b>Bangalow</b>	<ul style="list-style-type: none"> <li>Bangalow STP Bamboo Plantation</li> </ul>	<ul style="list-style-type: none"> <li>Environmental scheme - Biomass cropping</li> </ul>
<b>Ocean Shores</b>	<ul style="list-style-type: none"> <li>Ocean Shores Wetlands</li> </ul>	<ul style="list-style-type: none"> <li>STP decommissioned - Ocean Shores sewage loads and wetlands integrated into Brunswick Valley Recycled Water Management Strategy</li> </ul>



# VISION AND OBJECTIVES

## Vision

**Recycled water will be managed in an ecologically sustainable way that ensures public health and protects and enhances the natural environment**

## Objectives

- ◆ **Reduce wastewater generation**
- ◆ **Eliminate discharge to waterways, unless environmental benefit is proven**
- ◆ **Maximise effluent reuse from the sewer system**
- ◆ **Use recycled water as close to source as practicable**
- ◆ **Increase the benefit from recycled water as a resource to achieve broader environmental and economic objectives**
- ◆ **Link the development of increased effluent loads with recycled water use**
- ◆ **Integrate with other strategies**



The vision and objectives of the Recycled Water Management Strategy were developed and adopted through the Byron Shire Council Water, Waste and Sewer Advisory Committee with community representatives including Byron Shire Councillors, community leaders and Council staff. Workshops were held in February and March 2018 to confirm the vision, objectives and future direction.

# STRATEGIC DIRECTION

## Current Recycled Water Use (average 2010 - 2016)

	Byron Bay	Brunswick Valley	Bangalow	Ocean Shores
<b>Environmental</b>	<b>23 %</b>	<b>-</b>	<b>13 %</b>	<b>Unknown</b>
<b>Urban</b>	<b>15 %</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>Rural</b>	<b>-</b>	<b>8 %</b>	<b>-</b>	<b>-</b>
<b>Total Reuse</b>	<b>38 %</b>	<b>8 %</b>	<b>13 %</b>	<b>-</b>

**Constraints** limiting recycled water use in urban, rural and environmental applications have influenced the key directions in the 2017-2027 strategy:

- An absence of high water using industries limiting options for rural and urban applications
- Climatic conditions such as a pronounced wet season which limits the need for irrigation at certain times of the year
- Environmental considerations limiting irrigation opportunities e.g. the presence of shallow water tables or site and soil suitability
- Lack of commercial demand for long term security of supply
- Commercial considerations of private users provide a elevated risk for long term demand and supply security
- Reliance on private users to achieve Councils recycled water management objectives inhibits Councils ability to manage, adapt and maximise recycled water use

**Opportunities** for recycled water use in urban, rural and environmental applications provide the key directions for the 2017-2027 strategy:

- Environmental schemes provide Council with a high degree of confidence and long term security
- Environmental projects can be controlled and adapted by Council to maximise recycled water application
- Sustainably sourced biomass for bioenergy projects is evolving as a preferred option for recycled water management
- Development of the proposed Brunswick Valley Sustainability Centre will support a biomass cropping industry for renewable energy generation.
- Brunswick Valley, Ocean Shores and Bangalow STP's have available Council owned land for wetlands or biomass cropping projects
- Future urban opportunities include dual reticulation for new housing developments in Byron Bay to offset increased sewage loads
- Construction of the Byron Bay Rural Scheme (Western Corridor Stage 1) to deliver recycled water for farming purposes

## Projected Recycled Water Reuse (2027)

	Byron Bay	Brunswick Valley	Bangalow	Ocean Shores
<b>Environmental</b>	<b>55 %</b>	<b>29 %</b>	<b>100 %</b>	Ocean Shores Integrated into Brunswick Valley Recycled Water Management Strategy
<b>Urban</b>	<b>15 %</b>	<b>-</b>	<b>-</b>	
<b>Rural</b>	<b>5 %</b>	<b>19 %</b>	<b>-</b>	
<b>Total Reuse</b>	<b>73 %</b>	<b>48 %</b>	<b>100 %</b>	





## ENVIRONMENTAL

schemes form the primary direction for recycled water management in the Byron Shire Recycled Water Management Strategy 2017 - 2027. The combination of recycled water use potential with other valuable environmental outcomes makes environmental projects highly desirable. These applications not only have the ability to maximise recycled water reuse, they also strongly support Council goals towards ecological sustainable development.



Byron Shire Council operates three environmental recycled water schemes:

1. Byron Bay Integrated Water Management Reserve (BBIWMR)
2. Ocean Shores Wetlands
3. Bangalow STP onsite bamboo plantation

**Wetland** utilise a significant volume of recycled water through evapotranspiration and seepage. It has been estimated that the BBIWMR 40ha site uses approximately 400 ML/

year, providing a significant flow path for Byron Bay STP. Wetlands take time to establish to optimise evapotranspiration rates, but given suitable land and efficient operational management, this option has the potential to maximise recycled water reuse in suitable areas and significantly contribute to achieving the Recycled Water Management Objectives. Furthermore the ability of wetlands to sequester carbon will contribute to Councils executive direction to reduce greenhouse gas emission targets.

**Biomass cropping** for bioenergy production is evolving as a viable option for long term recycled water management. With the emergence of a bioenergy industry in Australia, Council are proceeding with investigations for the development of a Brunswick Valley Sustainability Centre in the Byron Shire. The prospect that Council can use recycled water for the irrigation of a viable biomass stream to feed bioenergy facilities, is being considered as a strategic direction in the Byron Shire. Bioenergy as a means of energy generation can significantly reduce the high energy and environmental costs associated with sewage treatment. Council have available land area around the Brunswick Valley, Bangalow and Ocean Shores STP's to facilitate the development of this application. This project has multiple benefits, not the least being the development of a small scale industry with the potential to use high volumes of recycled water while leaping Council towards zero emissions targets.



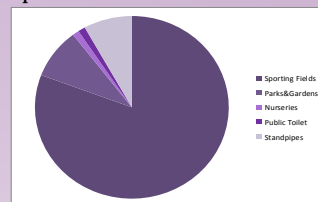
## URBAN

schemes will continue to contribute to recycled water management over the next ten years in the Byron Shire. Byron Shire Council operates one urban recycled water scheme: Byron Bay Urban Recycled Water Scheme (BBURWS). Recycled water is suitable for the following unrestricted purposes:

- Dual reticulation – toilet flushing
- Municipal use – sporting fields, nurseries, parks and gardens, and standpipe access

The BBURWS was implemented in accordance with the Byron Bay EMS 2005 and has the potential to reuse 1 ML/day. Currently the scheme is at 70 % capacity with the Byron Bay Golf Course the major user of the recycled water. Council will continue to expand the BBURWS, although it is anticipated that growth over the next ten years will be slow and incremental. The opportunities are limited as the majority of suitable businesses and sporting fields are already connected to the recycled water main, or will be imminently. Unless there is a significant development (industry or housing), the BBURWS has minimal capacity for growth, and will not achieve the high levels of reuse that the community desires. Any future upgrade of the BBURWS will be determined based on security of demand e.g. dual reticulation for future housing developments.

Urban schemes are not considered viable for the smaller villages of Brunswick Valley, Bangalow and Ocean Shores. The volumes of recycled water used for urban purposes are relatively low per application and will only be a minor contributor to recycled water reuse. While urban reuse represents only a small percentage of the STP flow, the schemes are highly resource dependent. Urban schemes are high risk due to public health considerations and require high levels of treatment, monitoring and reporting as per the regulatory requirements, and as such requires a high level of Council resourcing.



## RURAL

schemes will be a minor contributor to recycled water management over the next ten years in the Byron Shire. Byron Shire Council operates one rural recycled water scheme: Main Arm Recycled Water Scheme (MARWS). Recycled water was used for irrigation purposes on two adjacent cattle grazing enterprises, although currently only one farm is connected to the scheme.

The MARWS has a total capacity of 3.6 ML/day of which currently approx. 4 % is utilised. The MARWS has the capacity to recycled 100% of the Brunswick Valley wastewater flow given the users. No new rural water users along the MARWS corridor have connected to the scheme since it was installed or have been identified as potentially suitable.

Although rural schemes have potential to reuse significant volumes of recycled water, the MARWS has not achieved the community aspirations, with recycled water use well below minimum expectations. Rural recycled water requirements are highly variable with irrigation influenced by a number of external (environmental and commercial) factors. Farmers must address a complex set of issues when selecting farming operations and determining optimal strategies. The communities recycled water management objectives for maximising recycled water reuse will not always be consistent with farm goals.

The Brunswick Valley Sustainability Centre project may provide an incentive for the rural scheme expansion and Council will explore biomass cropping opportunities with landowners along the MARWS corridor as the Brunswick Valley Sustainability Centre project develops.

Council has commenced investigations to develop the Byron Bay rural scheme (Western Corridor) with the purpose to supply recycled water to The Farm, Byron Hospital and surrounding landowners. An extension of the Western Corridor main to Tyagarah will be implemented based on supply security. Currently no significant users have been identified.



# Byron Bay

**BACKGROUND** The Byron Bay recycled water management system, comprising of the Byron Bay Integrated Water Management Reserve (BBIWMR) and the Byron Bay Urban Recycled Water Scheme (BBURWS), recycles 38% of effluent from Byron Bay STP.

The recycled water management system was developed in 2005 as part of the Byron Bay STP (previously West Byron STP) upgrade which included the decommissioning of the South Byron STP. A ten year moratorium had been placed on development in Byron Bay due to the aging sewage treatment infrastructure and highly degraded waterways. A condition of approval for the augmented Byron Bay STP included no increase in nutrient loads discharged to the Belongil Catchment. With the increased sewage loads diverted from South Byron STP, a community consultative committee formed to develop a strategy that would ensure a high level of environmental protection. Subsequently, the Byron Bay EMS 2005 was developed and the BBIWMR and BBURWS established.

The BBIWMR was developed as a major integrated environmental project that used effluent for the environmental remediation of acid sulphate soils, wetland and catchment degradation, loss of critical habitat and fish kills. The 40 ha site consists of multiple management areas including constructed treatment cells; a habitat cell (Cell H), and the 24 Ha Melaleuca regeneration site. The BBIWMR has evolved to be an intrinsic part of the Belongil landscape, providing important habitat for many species including endangered and vulnerable birds and frogs. The multi-award winning project has exceeded Council's expectations and has reached projected reuse potential. The BBIWMR provides a significant flow path for Byron Bay STP wastewater, with 400 ML of treated effluent used annually.

Melaleuca regeneration in the low lying agricultural land of the Belongil Catchment was identified in the EMS 2005 as a future option for reuse and will be actively pursued as part of this strategy.

The BBURWS corridor runs from the Byron Bay STP to the Byron Bay Golf Course (South Byron) supplying a very high quality recycled water for the purpose of dual reticulation (toilet flushing) and unrestricted urban municipal use (irrigation). Historically, Council commenced the recycled water supply Byron Bay Golf Club from South Byron STP in the early 1980's.

A Rural Scheme was investigated for the Byron Bay EMS 2005, with land in Ewingsdale, Myocum and Tyagarah assessed as suitable for recycled water irrigation. The Tyagarah Turf farm had expressed interest in using high volumes of recycled water with an EIS undertaken in 2005. However, due to commercial considerations of the landowner the project did not eventuate with Council resolving to defer construction of the pipeline until sufficient customers were secured.

Growth in the Byron Shire has been relatively controlled over the last ten years and current planning indicates the sewage system will reach full capacity in 2025.

The BBURWS is currently at 70% capacity.

**Byron Shire Recycled Water Management Strategy 2017— 2027**



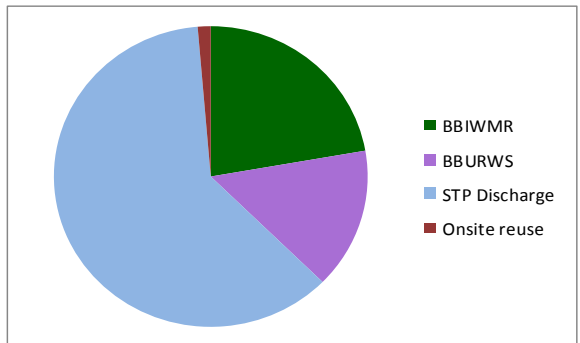
**Wetland Reuse**  
400 ML/year  
23% of STP inflow



**Urban Reuse**  
272 ML/year  
15% of STP inflow



## EFFLUENT FLOWS 2011—2016



## KEY STRATEGIC DIRECTION

### Constructed Wetland Regeneration

#### Environmental

Opportunities are being investigated in the low lying agricultural land in the Belongil Catchment for wetland regeneration. Based on the current reuse achieved at the BBIWMR, 80 ha of constructed wetlands is required to assimilate approx. 800 ML of effluent annually. Council owned land adjoining the BBIWMR in the SE corner will be investigated for wetland expansion (20ha). Council has not yet acquired the remaining 60ha.

The wetland project has been staged. **Stage 1** will see 20 ha wetland regeneration project on Council land. Council must commence negotiations with Landowners to secure the remaining land. **Stage 2** will be pursued incrementally to offset increased sewage loads and allow Council the time to consult with Landowners.

#### Urban

The BBURWS will continue to develop until full capacity: 1 ML/day. There is sufficient capacity remaining to supply another 0.3 ML/day. Unless there is a major development in Byron Bay, it is not anticipated that the capacity of the scheme will be reached within the timeline of this EMP. Demand for the recycled water is low as the majority of potential businesses and sporting fields are already connected, or will be imminently. Dual reticulation for new housing developments in the Byron Bay scheme will be pursued where appropriate to offset increased sewage loads. A Recycled Water Facility upgrade will be considered based on demand.

#### Rural

The development of the rural project has been staged.

**Stage 1** includes the construction of the Western Corridor main. Design investigations have commenced. The Western Corridor will provide recycled water to the neighbouring properties around "The Farm", Byron Hospital and surrounding enterprises.

**Stage 2** will involve the extension of the Western Corridor. Council maintain to defer Stage 2 until demand can be secured. Given the current interest, it is not envisioned that Stage 2 will occur within the 10 year span of this strategy.





# Brunswick Valley

## BACKGROUND

The Main Arm Recycled Water Scheme (MARWS) was developed in 2003 with the installation of a recycled water main from the Mullumbimby STP to the farm dams on two rural properties on Main Arm Road, Mullumbimby. The sewage system was augmented in 2010 with the closure of Mullumbimby and Brunswick Heads STPs and the commissioning of the new Brunswick Valley STP. This saw an increased volume of effluent available for reuse. However, demand for recycled water has not increased with supply.

The MARWS infrastructure has the capacity to recycle 100% of the effluent produced at the Brunswick Valley STP. Currently the MARWS recycles 8% of inflow.

There has been no new connections to the MARWS pipeline since the scheme commenced. Further to this, demand from the two users has significantly decreased with recipients failing to meet the projected minimum volumes of use. When the scheme commenced, high volumes of recycled water was applied for irrigation purposes. This use did not continue in subsequent years with the application rate decreasing by more than 60%.

The MARWS was developed based on potential demand projections. The demand estimates, which may have been influenced by environmental conditions (e.g. drought) and/or business considerations, proved to be optimistic and has not yielded the volume of reuse anticipated. Rural application is reliant on private landholders to ensure their farming enterprise utilises the recycled water resource and thereby achieves the recycled water management objectives of the community. Under this application commercial decisions made by landowners can significantly impact the volumes of recycled water used.

Experience in the MARWS has influenced Council to shift the focus in recycled water management to applications that Council can operate to maximise recycled water application and ensure long term supply security.

The development of an urban scheme was considered for Mullumbimby, but due to the low volumes of water used in this application, especially for the smaller villages in the Shire, Council have directed resources towards more beneficial higher water demand uses.

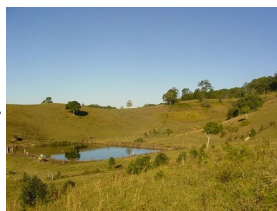
Environmental options such as biomass cropping to feed renewable energy generation is evolving as a viable option for recycled water irrigation opportunities. Council are in the preliminary stages of a land use investigation for the Brunswick Valley STP site. The Brunswick Valley Sustainability Centre project will involve constructed wetlands, biomass cropping and renewable energy production including solar farming and co-generation.

The proposed Brunswick Valley Sustainability Centre project has instigated a potential industry for biomass cropping. Given industry growth, the MARWS recycled water corridor may provide a financial incentive for landowners to consider biomass cropping.

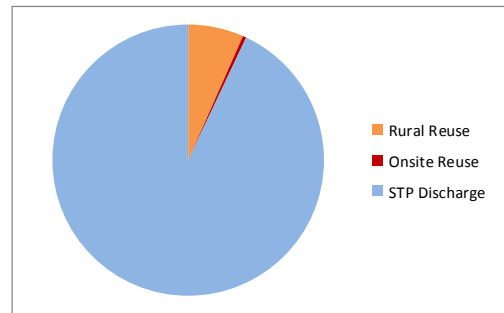
Current planning for the Brunswick Valley STP indicates that STP capacity will be reached with the closure of the Oceans Shores STP and the transfer of Ocean Shores sewage loads. With this impending increase of effluent loads, Council is actively diverting the appropriate resources to support the development of a project that will see high levels of recycled water used for beneficial purposes.



**Rural Reuse**  
**51 ML/year**  
**8 % of STP Inflow**



## EFFLUENT FLOWS 2011—2016



## KEY STRATEGIC DIRECTION

### Brunswick Valley Sustainability Centre: Biomass Cropping

#### Environmental

Development of the Brunswick Valley Sustainability Centre for:

- Biomass cropping
- Constructed wetlands

Other types of cropping will also be considered based on water consumption.

Ocean Shores Wetland will be upgraded as part of the Brunswick Valley Recycled Water Management Strategy. Given the construction of the proposed sewage transfer pipeline, Council will install a recycled water main from the Brunswick Valley STP to be used for environmental applications at the established Ocean Shores Wetlands and decommissioned STP site.

With appropriate management, this integrated approach could see the majority of dry weather flow diverted for beneficial reuse



#### Rural

Council will continue to explore opportunities along the MARWS recycled water corridor. No interested users have been identified.

The MARWS pipeline has a total capacity to supply 3.6 ML/day. There is sufficient capacity remaining to supply 3.5 ML/day of recycled water. Council could pursue this area for biomass cropping if a successful industry is created through the Brunswick Valley Sustainability Centre Project.



# Bangalow

## BACKGROUND

Bangalow STP commenced using recycled water for onsite land applications in 2003.

In collaboration with the SCU, innovative trials for Bamboo, Hemp and Kenaf were conducted. The trials set out to identify crops that have a high water uptake as well as a high end product value (e.g. fibre).

In 2006, Council expanded the bamboo plantation across 5.23ha as part of the Bangalow effluent strategy. The scheme recycles 13% of the effluent from Bangalow STP.

After ten years of recycled water irrigation the bamboo plantation project is close to completion, with harvesting of the bamboo scheduled for 2019.

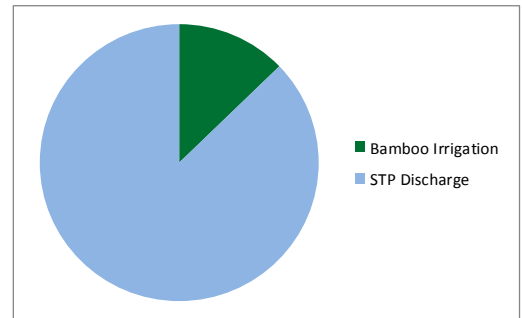
The development of the proposed Brunswick Valley Sustainability Centre project has opened prospects for biomass cropping. Council see this as an opportunity for expanding recycled water application at the Bangalow STP.



**Environmental Reuse (bamboo)**  
18 ML/year  
13 % of STP Inflow



## EFFLUENT FLOWS 2011—2016



## KEY STRATEGIC DIRECTION

### Biomass Cropping

### Environmental

Biomass cropping investigations undertaken as part of the Brunswick Valley Sustainability Centre project will steer the development of a biomass plantation at the Bangalow STP.

Bangalow STP has available land onsite for biomass cropping. The currently irrigated 5.23ha can be expanded to approx. 20ha. Council will consider expanding the cropping area as a way to increase effluent reuse.

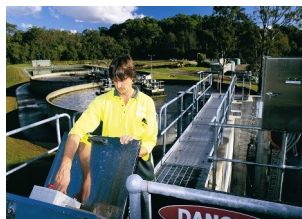
# Ocean Shores

**BACKGROUND** The Ocean Shores Wetland was integrated into the Ocean Shores STP effluent management system in 1997.

The Ocean Shores STP has reached full capacity, and Council are assessing options, of which the outcome will impact on the future direction of effluent management in Ocean Shores.

Council's current planning identifies that the Ocean Shores STP will be decommissioned within the next 5 years, and it is proposed that all sewage loads will be transferred to the Brunswick Valley STP.

Given the construction of the proposed sewage transfer pipeline, Council will install a recycled water main from the Brunswick Valley STP back to the Ocean Shores STP. The recycled water will be used for environmental applications at the established Ocean Shores Wetlands and decommissioned STP site.



### Wetland Reuse



## KEY STRATEGIC DIRECTION

### Integrate into Brunswick Valley EMS:

- Decommission Ocean Shore STP
- Ocean Shores Wetlands upgrade

### Environmental

The Ocean Shores Wetland will be upgraded as part of the development of the Brunswick Valley Recycled Water Management System.

The use of this site for environmental remediation will support Council achieve the objectives for Brunswick Valley STP.

Future options for the development of the Ocean Shores STP decommissioned site could include wetlands expansion and or biomass cropping.





# STRATEGIC PROGRAM

The strategic program outlined in the following pages provides a pathway for maximising recycled water use in the Byron Shire. Councils experience over the last fifteen years provides valuable insight and has steered the direction of this strategy. Although the program provides for maximising reuse, inherent risks and uncertainties exist which have the potential to impact on the successful implementation of the strategy.

Year	Byron Bay			Brunswick Valley			Bangalow		
	STP Inflow (ML/yr)	Total Reuse (ML/yr)	Annual Reuse (%)	STP Inflow (ML/yr)	Total Reuse (ML/yr)	Annual Reuse (%)	STP Inflow (ML/yr)	Total Reuse (ML/yr)	Annual Reuse (%)
2006 - 2016	1825	701	38	757	63	8	139	18	13
2017 - 2019	1,840	999	54	548	63	11	139	50	36
2020 - 2022	2,000	1,454	73	1,327	463	35	150	100	67
2023 - 2027	<b>2,200</b>	<b>1,664</b>	<b>76</b>	<b>1,387</b>	<b>663</b>	<b>48</b>	<b>150</b>	<b>150</b>	<b>100</b>

## Byron Bay

Full development of the Byron Bay recycled water management program is based on environmental projects. These applications have the ability to assimilate high volumes of recycled water into the environment thereby achieving the high levels of reuse desired by the community. The demand for recycled water in the urban and rural context will not balance the supply. The success of this strategy is reliant on Council acquiring the available land for wetlands regeneration. Council must commence community consultation to determine if this option has community support and proceed with Stage 1 of the land acquisition.

Full development of the Byron Bay recycled water management program will see Council achieve the community objectives. The Byron Bay EMS 2005 calculated that at the Byron Bay STPs ultimate capacity of 2,200 ML/year, a minimal reuse volume of 1,200 ML/year would be required to achieve the nutrient discharge loads. The proposed recycled water program goes well beyond this requirement with a potential volume of 1,664 ML /year projected.

Given the current growth pattern, the Byron Bay STP will reach full capacity in 2025. This includes the initial stages of the proposed West Byron Development, with dual reticulation for the development included in the program. Should the West Byron Development proceed, there is an opportunity to offset the increased sewage loads with wetland regeneration and dual reticulation for toilet flushing and out door garden use.



## Brunswick Valley

Full development of the Brunswick Valley recycled water management program is dependent on the construction of the proposed Brunswick Valley Sustainability Centre. The success of this strategy is reliant on Councils planning including optimising land use at the Brunswick Valley STP site, specifically to achieve high evapotranspiration as well as the development of the proposed Brunswick Valley Sustainability Centre project.

The proposed Brunswick Valley Sustainability Centre project has the potential to support the development of a small scale biomass cropping industry that if managed efficiently is capable of achieving high levels of reuse. Although in the initial stages, this project is growing momentum and has full Council support. The development of a biomass industry could reinitiate interest in the MARWS Corridor. The prospect of a secure water supply and a market demand for the end product may provide an incentive for farmers along the MARWS corridor. Council will pursue interest in this area given the success of the initial stages of the Biomass cropping investigations.



## Bangalow

Full development of the Bangalow recycled water management program will involve an environmental cropping regime similar to the current Bamboo project. Council will develop the northern Paddocks at the Bangalow STP to increase the irrigation area and volume of recycled water applied. Biomass cropping will be considered given the proposed Brunswick Valley Sustainability Centre project is successfully implemented. Alternative cropping will be undertaken as required.



# STRATEGIC PROGRAM

Year	Recycled Water Management Program	Reuse Volume (ML / year )				Cumulative Total Reuse	
		STP Onsite	Urban	Wetlands	Rural		
<b>Byron Bay</b>							
2006 - 2016	Current (average 2010—2016)	29	272	400	-	701	
2017	<b>Urban Expansion BBURWS</b> Toilet connection Private Business					714	
	<ul style="list-style-type: none"> <li>The Northern Hotel</li> <li>The Railway Hotel</li> <li>The Beach Hotel</li> <li>First Sun Caravan Park</li> <li>Byron Holiday Park</li> <li>Habitat development</li> </ul>		13	-	-		
	Toilet connections Sporting Fields		1	-	-		715
	<ul style="list-style-type: none"> <li>Rec Grounds Rugby Toilets</li> <li>Red Devils Park</li> </ul>						
2018	<b>Urban Expansion BBURWS</b> Irrigation Sporting Field					743	
	<ul style="list-style-type: none"> <li>Byron Golf Course—expansion of irrigation to a further 4 ha</li> </ul>		28	-	-		
	Irrigation Nursery		0.5	-	-		743.5
	<ul style="list-style-type: none"> <li>Eden at Byron</li> </ul>						
2019	<b>Urban Expansion BBURWS</b> Elements of Byron		0.5	-	-	744	
	<ul style="list-style-type: none"> <li>Sunrise Hotel</li> </ul>						
2019	<b>Rural Expansion Western Corridor Stage 1</b> The Farm		-	-	50	794	
	<ul style="list-style-type: none"> <li>Flicks Property Irrigation</li> <li>Surrounding farmland</li> </ul>						
2019	<b>Urban Expansion BBURWS</b> Private Businesses along Urban Corridor		5	-	-	799	
	<ul style="list-style-type: none"> <li>Anticipated - not identified</li> </ul>						
2020 - 2022	<b>Wetlands Expansion Stage 1</b> 20 ha Low lying land in Belongil Catchment		-	200	-	999	
	<b>Rural Expansion Western Corridor 2</b> Anticipated - not identified		-	-	50	1,049	
	<b>Wetlands Expansion Stage 2</b> 40 ha Low lying land in Belongil Catchment		-	400	-	1,449	
2023 - 2027	<b>Expansion BBURWS</b> Dual Reticulation for new housing developments (development aligned)		5	-	-	1,454	
	<b>Expansion BBURWS continued</b> Dual Reticulation (development aligned)		10	-	-	1,464	
2023 - 2027	<b>Wetlands Expansion Stage 2 continued</b> 20 ha Low lying land in Belongil Catchment (development aligned)		-	200	-	1,664	
	<b>Total Volume per Application by 2027</b>	29	335	1200	100	1,664	



# STRATEGIC PROGRAM

Year	Effluent Management Program	Reuse Volume (ML / year )				Cumulative Total Reuse
		STP Onsite	Urban	Wetlands / Enviro	Rural	
<b>Brunswick Valley</b>						
2006 - 2016	Current (average 2010 - 2016) <ul style="list-style-type: none"> <li>Brunswick Valley STP</li> <li>Ocean Shores STP</li> </ul>	3	-	-	60	63
2017 - ongoing	<b>Rural expansion of MARWS</b> <ul style="list-style-type: none"> <li>As suitable user/s applies</li> </ul>	-	-	-	u/k	63
2019 - 2020	<b>Environmental</b> <ul style="list-style-type: none"> <li>Brunswick Valley Wetlands</li> <li>Biomass Plantation</li> </ul>	-		100 200		363
2021 - 2023	<b>Environmental</b> <ul style="list-style-type: none"> <li>Ocean Shores Wetland</li> </ul>	-	-	100	-	463
2024 - 2027	<b>Rural expansion of MARWS</b> <ul style="list-style-type: none"> <li>Biomass cropping along MARWS corridor</li> </ul>	-	-	-	200	663
	<b>Total per Application</b>	<b>3</b>	<b>NIL</b>	<b>400</b>	<b>260</b>	<b>663</b>

Year	Effluent Management Program	Reuse Volume (ML / year )				Cumulative Total Reuse
		STP Onsite	Urban	Wetlands / Enviro	Rural	
<b>Bangalow</b>						
2006 - 2016	Current (average 2008 - 2016)	u/k	-	18	-	18
2017 - 2019	Bamboo Harvesting	-	-	0	Nil	0
2020 - 2027	<b>Environmental</b> <ul style="list-style-type: none"> <li>Biomass Plantation</li> </ul>	-	-	150	Nil	150
	<b>Total per Application</b>	<b>u/k</b>	<b>Nil</b>	<b>150</b>	<b>Nil</b>	<b>150</b>

# RISK BASED IMPLEMENTATION

**Risks & Uncertainty** There is a significant level of risk and uncertainty with the development and use of recycled water schemes. The greatest risk with the use of recycled water is to public health due to the potential for exposure to harmful pathogens. These risks have been assessed and are managed to ensure the required controls and barriers are in place for a safe supply. As such, urban schemes require the highest levels of treatment, monitoring and controls.

Recycled water applications are driven by a number of external forces which in turn dictate their current and future demands for recycled water. Unfortunately, predicting how these forces will evolve over the next decade, and how they will ultimately affect recycled water demand, is fraught with a multiplicity of uncertainties. The inherent uncertainty in the Byron Shire Recycled Water Management Strategy is the unpredictability of the future outcome, primarily due to the external risks that Councils cannot control.

This strategy has been developed based on the determination that, not only do environmental projects have the lowest level of risks and offer the highest levels of security for long term supply management, but they are also capable of using the volumes of recycled water required to achieve the strategic objectives.

	RISKS		UNCERTAINTY	
Urban	<p>Urban Schemes are assessed as high risk due to the potential human health consequences. Factors such as uncontrolled public access and the potential for cross connections with the potable water supply, influence the risk rating.</p> <p>These risks are assessed and managed to ensure public health and safety.</p>	HIGH	<p>Councils treatment processes, management and monitoring of the urban scheme reflects the level of risk, with controls in place to reduce risks.</p> <p>The BBURWS has provided Council with a secure reliable flow path for Byron Bay STP recycled water. Reuse volumes show a consistent use pattern, although seasonal and annual variability exists.</p> <p>The most significant advancement in the urban scheme will be the connection of dual reticulation in new developments. Projected recycled water volumes are often difficult to predict for new urban developments. Although household demand can be estimated with accuracy; the rate of development and the number of households joining the scheme over time is significantly more difficult to predict.</p>	MEDIUM
Rural	<p>Rural schemes have significantly lower risks than urban schemes due to Controlled Public Access. Nevertheless, significant controls are required to ensure no environmental degradation or decline in crop health.</p> <p>Commercial uncertainty is highlighted as one of the major risk facing recycled water schemes. Should a user reduce production, cease operations or relocate, the viability of the scheme is reduced.</p>	MEDIUM	<p>The development of new rural schemes have the highest levels of uncertainty and risk. Although significant potential exists, the long term outcome of rural schemes to maximise recycled water application is limited by external factors including environmental and commercial constraints. Council lacks the confidence to rely on rural schemes to provide for secure long term demand.</p> <p>The MARWS was developed based on potential demand projections which did not eventuate. The demand projection for the recycled water use was optimistic for an area with high rainfall, and commercial externalities were not factored into the projected use. Farmers must address a complex set of issues pertaining to risk, uncertainty, prices, and opportunity costs, when selecting farming activities and determining optimal strategies. The Byron Shire objectives for maximising recycled water application are not always consistent with farm goals.</p> <p>Council must assess these risks when developing a new rural scheme and ensure there are sufficient controls in place (through a robust Recycled Water Agreement) to reduce the uncertainties in developing a rural scheme .</p>	HIGH
Environmental	<p>The health risks associated with environmental schemes are greatly reduced by Controlled Public Access. Nevertheless, significant controls are required to ensure no environmental degradation or decline in plant health.</p> <p>Wetlands associated with STP's, in fact, reduce the risks for environmental pollution by providing a risk management buffer zone, that can be operated should a hazardous event occur.</p>	LOW	<p>Recycled Water applications for environmental purposes afford Council with a high level of supply security. Experience with the BBIWMR and Bangalow Bamboo crop has proven with confidence that this application can achieve high volumes of reuse. The long term demand for the resource can be maximised by a Council owned, managed and operated application.</p> <p>The proposed Brunswick Valley Sustainability Centre project provides the key direction for Brunswick Valley, Ocean Shores and Bangalow STP. The project has yet to be approved by Council, although early investigations indicates that this integrated project will proceed. The fact that Council already own available land at Brunswick Valley, Bangalow and Ocean Shores STP's, provides Council with a higher degree of security that environmental projects will proceed.</p> <p>The regeneration of wetlands forms the key direction for Byron Bay Strategy. This application involves the acquisition of land through either a voluntary lease arrangement or land sale. Council have not yet acquired the land necessary, nor has community consultation commenced, within the Belongil Catchment which highlights the uncertainty for Byron Bay Strategy.</p>	MEDIUM



# RISK BASED IMPLEMENTATION

**Risk Management Framework** Council takes a risk management approach to the operation of the recycled water systems in accordance with the *Australian Guidelines for Water Recycling – Managing Health and Environmental Risks 2006* (AGWR). The AGWR sets out the framework for the management of recycled water quality, providing a structured risk-based approach. These guidelines form the primary guidance for recycled water quality and management in Australia.

**Wastewater Management System** Council's Waste Water Management System is based on the AGWR Risk Management Framework, describing the nature of the recycled water systems and how it is operated and managed. The Wastewater Management System is one of the key requirements for Section 60 approval. All information pertinent to the recycled water schemes is detailed in the Wastewater Management System.

**Recycled Water Agreements** The recycled water agreement is the product of negotiations between the Byron Shire Council and the end users. Under the recycled water agreement, the parties agree to a set of obligations and responsibilities which the water recycling scheme will operate. To reduce the uncertainty and ensure the viability of new schemes, Council must ensure strong commitment from the users with an agreed minimum volume of recycled water applied.

The recycled water agreement establishes:

- the rights and obligations of the parties and supports these with legal sanctions;
- who should perform certain tasks and when and who bears the costs;
- who bears the risks associated with supply and use of the product; and
- the commercial terms under which recycled water is supplied.

**Monitoring and Controls** Council have monitoring and controls in place in accordance with the level of risk for each recycled water scheme. Of utmost importance is to ensure the quality of the recycled water is suitable for the intended use. Critical control points, developed as part of the risk management system, provide the triggers to ensure water of unsafe quality is not supplied to the user. Human health and environmental monitoring are continually and routinely undertaken by Council.

**Funding and Costing's** Recycled water management schemes in Byron Shire were originally developed with government funding. Infrastructure such as recycled water storage tanks and irrigation equipment were purchased with no direct costs to the end user. Although not available at this time, Council will continue to explore funding opportunities for the continual development recycled water schemes. Currently the cost for recycled water schemes are recovered through developer contributions under Section 64 of the Local Government Act.

The recycled water user agreement sets out conditions for who is responsible for the cost of the infrastructure for the recycled water scheme. In general Council will cover the costs of supplying recycled water to the premises. That is, Council will provide recycled water to the user's boundary and then it is the responsibility of the user to pay for any additional infrastructure required on their premises, for example storage tanks, irrigation equipment and/or internal plumbing.

The cost of supplying recycled water is not recovered in the current pricing structure. The present value of the recycled water use is in meeting the Councils discharge requirements and community aspirations. The pricing reflects the role of recycled water as part of Councils integrated water resource planning system.

Council charge a minimum cost for the recycled water based on consumption, providing a financial incentive to connect to the recycled water scheme. The recycled water is charged at 1 cent per kilolitre, which is considerable lower than potable water charges (< \$2.50 per kilolitre).

Council have developed a policy to ensure equitable access to the recycled water schemes offering a two-tiered approach to connect commercial businesses to the recycled water schemes. The business can either pay upfront for the recycled water infrastructure or enter in to a cost recovery agreement with Council. Replacing potable water with recycled water will provide major cost savings for commercial users and therefore the payback period for these schemes is expected to be short.

Whilst generally Council will only cover costs to the user's boundary, Council holds the right to determine the validity of providing any extra funds to projects where it is considered necessary.

# APPENDICES

## APPENDIX 1 Key Milestones in Recycled Water Management

## APPENDIX 2 Annual STP Flows

## APPENDIX 3 Byron Bay EMS 2005 Implementation Review

## APPENDIX 4 Supporting Documents



## APPENDIX 1 Key Milestones in Recycled Water Management

Year	Milestone
<b>Byron Shire</b>	
1999 August	Byron Shire Council adopted a <i>Sewage Management Strategy</i> setting out the vision, guiding principles and objectives for sewage management within Byron Shire.
2017	Water, Waste and Sewer Committee / Coastal Estuary Catchments Panel established
<b>Byron Bay</b>	
1980's	Byron Golf Club commenced recycled water irrigation from South Byron STP effluent
1997	Byron Bay Wastewater Steering Committee established, identifying the need to develop a comprehensive <i>Effluent Management Strategy</i> for Byron Bay.
1997 - 2006	Ten year moratorium placed on development in Byron Bay due to the lack of sewage treatment capacity
2000 May	Belongil Rehabilitation Working Group established to develop Byron Bay STP effluent management
2000 - 2001	Environmental Assessments undertaken for Byron Bay Sewerage System augmentation
2001	24 Ha Melaleuca Regeneration project commenced
2002 December	Byron Bay Sewerage System augmentation approved by Council
2004 July	Byron Bay Sewerage Augmentation System commenced construction
2002 - 2003	Environmental Reporting undertaken for Byron Bay Urban Recycled Water Scheme
2005	Byron Bay Effluent Management Strategy adopted.
2005 November	South Byron STP closed, with transfer of sewage load to the Byron Bay STP
2006	Byron Bay Urban Recycled Water Scheme commenced (sporting fields, nurseries)
2016	Byron Bay Urban Recycled Water Scheme extension completed (public toilets)
2016	Capacity Assessment of the Belongil Creek Drainage System – Development of a preferred STP Effluent flow path (AWC and BMT WBM)
<b>Brunswick Valley</b>	
2002 - 2004	Environmental Reporting undertaken for Main Arm Recycled Water Scheme
2004	Main Arm Recycled Water Scheme commenced (rural applications)
2010	Brunswick Valley STP commissioned
2017	Investigations commence for Biomass production for bioenergy
<b>Ocean Shores</b>	
1996	Ocean Shores STP upgraded
~1997	Ocean Shores Wetland constructed
<b>Bangalow</b>	
2002	BSC conducts trials, in partnership with Southern Cross University, investigating the potential for 'Mop Crops' to assimilate effluent
2003 October	Bangalow Recycled Water Scheme Onsite Bamboo Irrigation commenced



## APPENDIX 2 Annual STP Flows

Year	STP Location	STP Inflow (ML)	Recycled Water (ML)	Wetlands (ML)	Total Reuse (ML)
2016	Byron Bay	1939	211	400	611
	Brunswick Valley	705	45	-	45
	Bangalow	122	0	-	0
	Ocean Shores	539	-		
2015	Byron Bay	1800	274	400	674
	Brunswick Valley	871	17	-	17
	Bangalow	134	6	-	6
	Ocean Shores	572	-		
2014	Byron Bay	1797	297	400	697
	Brunswick Valley	564	84	-	84
	Bangalow	122	12	-	12
	Ocean Shores	524	-		
2013	Byron Bay	1950	287	400	687
	Brunswick Valley	856	64	-	64
	Bangalow	161	16	-	16
	Ocean Shores	598	-		
2012	Byron Bay	1805	294	400	694
	Brunswick Valley	821	53	-	53
	Bangalow	135	30	-	30
	Ocean Shores	605	-		
2011	Byron Bay	1727	287	400	687
	Brunswick Valley	726	42	-	42
	Bangalow	135	24	-	24
	Ocean Shores	565	-		
2010	Byron Bay	1754	257	400	657
	Bangalow	141	24		24
2009	Byron Bay	1717	175	400	575
	Bangalow	159	28		28
2008	Byron Bay	1716	204	400	604
	Bangalow	144	20		20
2007	Byron Bay	1483	199	400	599



# APPENDIX 3 Byron Bay EMS 2005 Implementation Review

Byron Bay EMS Program (2005)								Review	
Year	BBURWS	ML/ year	Wetland Regen	ML/ year	Rural Land	ML/ year	Total ML	10 Year Review	
<b>Short Term 2006 - 2007</b>									
2006	BBIWMR Berms (4ha)	20	BBIWMR 24 ha	236			411	All short term urban reuse corridor and regeneration projects were operational in 2007, with the exception of the standpipe at the Council depot which was installed in 2010.	
	Byron Bay Bowls Club	5	BBIWMR Cell "H"	41					
	Byron Golf Course	96							
	Rugby League Club	5							
	Byron High School	5							
	B.B.H.N. Nursery	1.3							
EnVite Nursery	1.4								
2007	BBIWMR Berms (4ha)	20	BBIWMR 24 ha	15			478		
	Urban Reuse Standpipe Commercial (non-potable)	10							
	Byron Bay Recreation Ground	22							
<b>Medium Term 2008 - 2010</b>									
2008	Main to Clarke's Beach Reserve	15	BBIWMR NW site STP	59	Tyagarah Farms	32	915		<ul style="list-style-type: none"> <li>Main to Clarke's Beach reserve installed 2016.</li> <li>Sunnybrand Chickens closed.</li> <li>Becton – (now Elements) already use rainwater and bore water onsite.</li> <li>Habitat—infrastructure installed 2015</li> <li>West Byron has not developed as yet. Dual reticulation to occur with new developments</li> <li>4 x Standpipes throughout BB township installed 2016</li> <li>West Byron playing fields (Cavanbah Centre) reuse commenced 2010</li> <li>Tyagarah Farms – deferred until sufficient demand</li> </ul>
	Sunny brand Chickens	55	BBIWMR 24 ha	40					
	Becton (now Elements)	22	Cavanbah Centre	98					
	Belongil Fields ( West Byron)	42							
	Brandon Saul Development (Habitat)	4							
	Urban Reuse Standpipe – Commercial (non-potable)	10							
	West Byron 249 Ewingsdale Rd Playing Field (Cavanbah Centre)	60							
2009	Sunrise Park, Belongil Crt,	1	BBIWMR 24 ha	28	Tyagarah Farms	150	1099	Sunrise Park and Julian Rocks—not considered viable	
	Julian Rocks Dr (drainage reserves)							Butler Street upgrade	
	Butler St (oval & netball)	5							
2010	Byron Recreational Ground	9	BBIWMR 24 ha	3	Tyagarah Farms	100	1211	<ul style="list-style-type: none"> <li>Irrigation expanded at Recreation Grounds in 2016</li> </ul>	
<b>Long Term</b>									
2011	Council Parks & Gardens + Railway Park + Byron St	2	BBIWMR 24 ha	8	Expans- ion of Reuse	100	1331	<ul style="list-style-type: none"> <li>BBURWS extension main installed 2016 for irrigation of parks and gardens</li> <li>Rural lands expansion (western corridor) will commence in 2018</li> </ul>	
	Private Controlled Urban Reuse	10							
2015	Private Controlled Urban Reuse	10			Expans- ion of Reuse	100	1441	<ul style="list-style-type: none"> <li>Negotiations with Hotels for toilet flushing commenced in 2016 with the installation of the extension</li> </ul>	

## **APPENDIX 4 Supporting Documents**

- 1. Sewage Management Strategy for Byron Shire (BSC 1999)**
- 2. WBM Ecological Assessment of Tallow and Belongil Creeks (WBM 2000)**
- 3. Byron Shire Effluent Reuse Study (OWRU March 2000)**
- 4. Belongil Estuary Management Plan (2000)**
- 5. Main Arm Environmental Impact Statement and Environmental Management Plan (2002)**
- 6. Byron Bay Sewerage Augmentation Design Development and Concept Design (GHD 2001)**
- 7. Byron Bay Sewerage Augmentation Scheme Environmental Impact Statement (2002)**
- 8. Use of Reclaimed Water in Tyagarah District (AWM 2003)**
- 9. Plan of Management for 249 Ewingsdale Rd (Land Arc 2004)**
- 10. Tyagarah Effluent Reuse Pipeline Review of Environmental Factors (BSC 2005)**
- 11. Byron Bay Effluent Management Strategy (BSC 2005)**
- 12. Byron Bay Urban Recycle Water Scheme Environmental Management Plan (2007)**
- 13. Byron Shire Council Wastewater Management System (2016)**
- 14. BBURWS Section 60 Application (2017)**
- 15. Valances Road Plan of Management: Conceptual Land Use Investigations (2017)**
- 16. Biomass Prospectus (2017)**





