University of Southern Queensland

Faculty of Health, Engineering & Sciences

Launceston's Combined Sewerage System – Investigation and Strategy Development

A dissertation submitted by

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in fulfilment of the requirements of

Courses ENG4111 and ENG4112 Research Project

towards the degree of

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Abstract

TasWater operates a combined sewerage system that services the greater Launceston area in northern Tasmania. The operation of the combined sewerage system is of interest to the local community and a number of key stakeholders who are concerned that the design principles, age and performance of the combined sewerage system is causing degradation of the receiving waters into which treated effluent and combined sewer overflows (CSO) are discharged.

The Launceston Combined Sewerage System is the last combined system of note within Australia. Due to ongoing stakeholder concern and limited data for CSO events and system performance TasWater is seeking to understand how the combined system performs. To understand system performance a number of samples were collected and analysed for CSO, treated effluent and stormwater. Data was also extracted from TasWater's SCADA to develop pump station and treatment plant flow profiles. This allowed for the calculation of annual pollutant loads from each discharge method.

The performance was compared to recognised service levels and performance standards developed by regulatory authorities in the US and UK. The intention of this assessment was to help educate the community about the combined system and to develop capital and operational programs of work to address deficiencies in the system.

The performance was also compared to a theoretical separated system for the area that is currently serviced by the combined system. This assessment was completed as a recurring theme amongst the community is that separation will resolve the pollutant issues in the receiving environment.

The performance analysis of the system indicated that the existing combined system contributes significant pollutant loading to the receiving environment. The existing combined system operation has a number of areas that could be improved through change in operational methods or capital works investment.

The performance analysis also indicated that separation will not resolve the issues that the receiving environment faces. Although separation would significantly reduce the

nutrient load that the system contributes to the receiving environment, it would cause only minor improvement in pathogen loading and would actually result in elevated solids loading and metal contamination.

Comparison of the existing system operation and performance against international standards for operation of combined systems, through a high level gap analysis, has highlighted a number of areas where the combined system could be improved. These findings will be used to inform future capital and operational budgets for TasWater.

The results of the performance and gap analysis will be used to provide targeted education for the key stakeholder groups and the community as a whole.

Completion of the research project has identified a requirement for additional sampling and investigation works to confirm the results contained within this document.

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Certification of Dissertation

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

C. Jessup

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Finally I would like to thank my family for their support and understanding during the years of my study and particularly this final year.

Glossary of Terms and Acronyms

Definitions and acronyms listed below are used within this document:

Average Dry Weather Flow	ADWF
Average Daily Inflow	AF
Asset and Product Management Division	AM
Australian and New Zealand Environment and Conservation Council	ANZECC
Combined Drainage System	CDS
Combined Sewer Overflow	CSO
Combined Sewer System	CSS
Dry Antecedent Time	DAT
Environment Protection Authority	EPA
Launceston City Council	LCC
Launceston Flood Authority	LFA
Launceston Combined Sewerage System	LCSS
Natural Resource Management – North	NRM North
Operations and Maintenance Division	O&M
Product Quality Department	PQ
Peak Wet Weather Flows	PWWF
Sewage Pump Stations	SPS
Sewage Treatment Plant	STP
Stormwater Pump Station	SWPS
Tamar River Recovery Plan	TRRP
TasWater	TW
Urban Pollution Management	UPM

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1. Project Background

1.1 Introduction

The development of drainage infrastructure for the transport and disposal of human and industrial waste-streams has helped greatly improve human health by reducing the incidence of illnesses such as cholera and gastroenteritis. During the 1850's it was demonstrated that a relationship existed between disease outbreak and water supplies contaminated from sewage flows. Dr John Snow identified the link between sewage disposal and cholera infection during the 1854 cholera outbreak in London (Johnson 2006). This discovery preceded the Great Stink of 1858 that led to the construction of six major interceptor sewers to extend the London Combined Sewerage System.

There is limited history of combined sewerage systems across Australia with only three significant combined sewerage systems constructed and only one in operation today. Combined sewerage systems were constructed in Sydney, Hobart and Launceston, a significant body of work was completed in both Sydney and Hobart to separate the systems during the early 1900's. This means that Launceston is the only city in Australia that still operates a combined sewerage system of meaningful size.

The operation of drainage systems, both stormwater and sewerage, and their impact on the receiving environment is of greater interest to the community today than ever before. This is due to an increased individual and collective understanding of the impact that environmental issues can have on people's health and wellbeing as part of the built environment (Australian Institute of Health and Welfare 2011). This, coupled with increased regulatory and reporting requirements for Australian utilities and service providers, means that most Australians are more aware of the environment in which they live.

1.2 Problem Statement

TasWater operates a combined sewerage system that services the greater Launceston area in northern Tasmania. The operation of the combined sewerage system is of concern to the local community and a number of key stakeholders. These groups are concerned that the design principles, age and performance of the combined sewerage system is causing significant degradation of the receiving waters into which treated effluent and combined sewer overflows (CSO) are discharged.

The overall aim of this project is to better understand the operation of the combined drainage system and the impact that it is having on the receiving environment. This will inform the development of a performance driven strategy that considers capital and operational based initiatives.

The implementation of the strategy will help ensure that the operation of the combined drainage system is not adversely impacting the health of the receiving environment into the future. Finally the project results will be used to engage with the community and key stakeholders about the impact that the combined drainage system currently has on river/estuarine health and the initiatives that TasWater will undertake.

1.3 Project Method

The method used for completing the project is outlined below:

- Complete a literature and industry review of combined sewerage systems to understand the typical asset base (size and age of infrastructure), flows handled and management of CSO events. The literature review will also include review of existing published information on the Launceston Combined Sewerage System (LCSS) and environmental management reports for the receiving environment.
- Collect and analyse SCADA information to calculate hydraulic loading on the LCSS during different flow periods such as during dry weather, average and wet weather

flow periods. Flows calculated to be correlated against rainfall data from the Bureau of Meteorology (BOM) and TasWater owned rain gauges.

- Collect organic and nutrient loading information for influent and effluent, including CSO discharges, during different flows periods as detailed above
- Critically analyse the hydraulic and loading data obtained to determine the trigger rainfall event/amount that will cause CSO events and calculate the frequency, volume and loading associated with CSO events.
- Compare the performance of the LCSS to separate drainage networks that have dedicated stormwater and sewage systems with similar catchment characteristics to the LCSS.
- Compare the performance of the LCSS with regulated performance standards (US EPA and UK UPM) and complete a gap analysis for current performance against target performance.
- Complete stakeholder engagement with key river users to better understand concerns about LCSS performance and perceived impact on the receiving environment.
- Develop a system wide strategy to close the gap between existing performance and regulated and/or desired performance standards.
- Submit an academic dissertation on the research.

1.4 Overview of Dissertation

The dissertation chapters following the proceeding layout:

Chapter 2 – Launceston Combined Sewerage System and Receiving Environment

This chapter introduces the LCSS and receiving environment. The chapter includes a history of the LCSS and provides some context about the issues that TasWater are currently facing in regards to community and stakeholder perception of the system, its performance and potential impact it has on both the receiving environment and risks to public health.

Chapter 3 – Literature Review

This chapter provides an overview on the literature available on combined sewerage systems. It includes information regarding regulated performance requirements for combined sewerage systems in the US and UK, discussion of performance of a number of combined sewerage systems internationally and commentary on factors influencing CSO frequency, volume and loading.

This chapter also provides an overview of the available literature in the local context on the LCSS and the prevailing health of the discharge environment specifically the Tamar and North Esk Rivers.

Chapter 4 – Methodology

This chapter covers the methodology implemented for the calculation and analysis of hydraulic and pollutant loading components of the dissertation. The chapter will also outline how the gap analysis will be completed for the system performance against regulated performance indicators in the US and UK. Finally the chapter will include an overview of the how the stakeholder engagement process was completed and how stakeholder issues are assessed against system performance.

Chapter 5 – LCSS Performance 2013 and 2014

This chapter presents and analyses the results determined in terms of calculation of frequency, volume and loading of CSO events. This chapter will also include a high level mass balance assessment of total volumes, both stormwater and sewage, generated in the LCSS and try to determine where these flows ultimately discharge and the relative composition of the flows (percentage stormwater against percentage sewage).

Chapter 6 – Performance Analysis of LCSS

The chapter will provide similar calculations to those completed in chapter 5 for dedicated stormwater systems that discharge to the same receiving environment and that have similar catchment characteristics to the LCSS. The performance analysis will look to determine the relative difference in pollutant loading between CSO events and general stormwater discharge.

Chapter 7 – Stakeholder Engagement

This chapter will present the results of a series of one on one stakeholder engagements sessions with a number of key stakeholder groups who are actively involved in the current Tamar River Recovery Plan (TRRP). The intention of the stakeholder engagement process is to determine the key drivers for the stakeholder group and to gauge their understanding of the performance and impact of the LCSS and separated stormwater drainage systems on the relative health of the Tamar and North Esk Rivers.

Chapter 8 – Gap Analysis of LCSS Performance

This chapter will contain a high level gap analysis of the performance of the LCSS against regulated combined sewerage system guidelines from the US EPA and the UK UPM. This will include a discussion of performance against nominated overflow frequencies, volumes and loads and against nominated asset management and performance requirements for combined sewerage systems.

A secondary gap analysis is also included that measures system performance against key stakeholder expectations and aspirations.

Chapter 9 – Strategy Development

This chapter contains details of the long term strategy for the LCSS and includes a number of recommendations to improve performance and understanding of the LCSS. The chapter also discusses how the strategy aligns with regulated and stakeholder expectations regarding performance of the LCSS.

Chapter 10 – Conclusions and Further Research Opportunities

This chapter contains conclusions on the research undertaken and outlines additional research and investigation opportunities for the future.

2. Launceston Combined Sewerage System and Receiving Environment

2.1 Combined Sewerage System Inception and Early Days (1860-1900)

Launceston was founded in 1806 and is one of Australia's oldest cities; it was also the second city in the country to have underground drainage (sewers) with the first pipes installed in the 1860's (Hose 1993).

It is worth noting that at the time the Launceston Council considered two options for the construction of the sewerage system; the first being the installation of separate pipes (separated system) for the purpose of conveying runoff and sewage and the second the installation of a single pipeline with an intrinsic low flow section that would be suitable for the carriage of both runoff and sewage (combined system).

The decision was made to proceed with a single pipe (combined) system. It is thought that this was due to the cost savings compared to a separated system and that many European cities were in the process of constructing combined sewerage systems at the time (Hose 1993). The design of the pipeline was such that low flows would be accommodated by a semi-circular section at the bottom of the brick barrel arch pipe or by a low flow pipe (Figure 2-1).

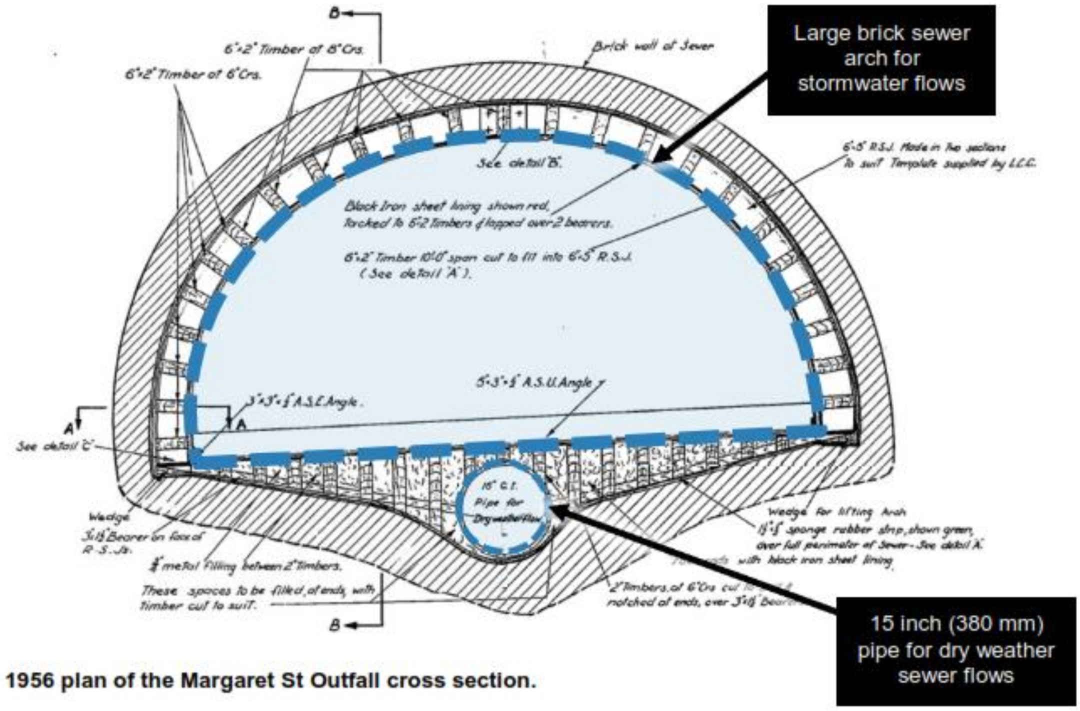


Figure 2-1: Cross Section of the Margaret Street Brick Barrel Outfall

The system was originally constructed to discharge straight into the Tamar Estuary and North Esk River with some forty discharge locations into the watercourses. The installation of the combined sewerage system allowed for continued development in the city and there are significant portions of the original brick barrel mains constructed in the 1880's still in use today. Figure 2-2 is an image that shows the current extent of the combined sewerage area (in pale-green) and some key infrastructure, Appendix B is a schematic showing the infrastructure contained within the Ti Tree Bend Sewerage System.

Figure 2-2: Launceston Combined Drainage System Overview

The original construction of the system had approximately 40 discharge locations along the banks and shores of the North Esk River and Tamar Estuary it was noted that this caused objectionable odours and impacted the visual amenity during tidal changes. To address this issue a proposal was put to council in 1895 to construct intercepting sewers that would collect the sewage and pump it further downriver. This proposed change would have made the LCSS similar to the London system of the 1860’s where intercepting sewers and pump stations were installed to discharge sewage downriver on an ebb tide. The scheme was not adopted at the time due to the prohibitive costs associated with its completion (Hose 1993).

2.2 System Expansion and Community Concerns (1900-1970)

At the turn of last century it was decided that all new areas developed in the city would be served by separate sewers and drainage pipes. The installation of intercepting sewers and pump stations did not commence until the 1930’s and was completed in the 1960’s approximately seventy years after rationalisation of the discharge points was suggested. The completion of these works eliminated sewage discharges at approximately forty locations through consolidation to a single major discharge point however this did not address the quality of discharge only the locality in which discharge occurred. This was of concern to the community and with changes to environmental legislation and regulation; Council investigated options for the installation of a STP that would service the system.

2.3 Ti Tree Bend STP and Improving System Performance (1970-2009)

The next major step in the development of the LCSS was the construction of treatment infrastructure, Figure 2-3 shows an artist’s impression of the proposed STP. Works commenced on the Ti Tree Bend STP in 1972 with the first stage of construction completed in 1978. Initially the STP provided only primary treatment; secondary level treatment infrastructure commenced construction in 1986 and was completed in 1992.

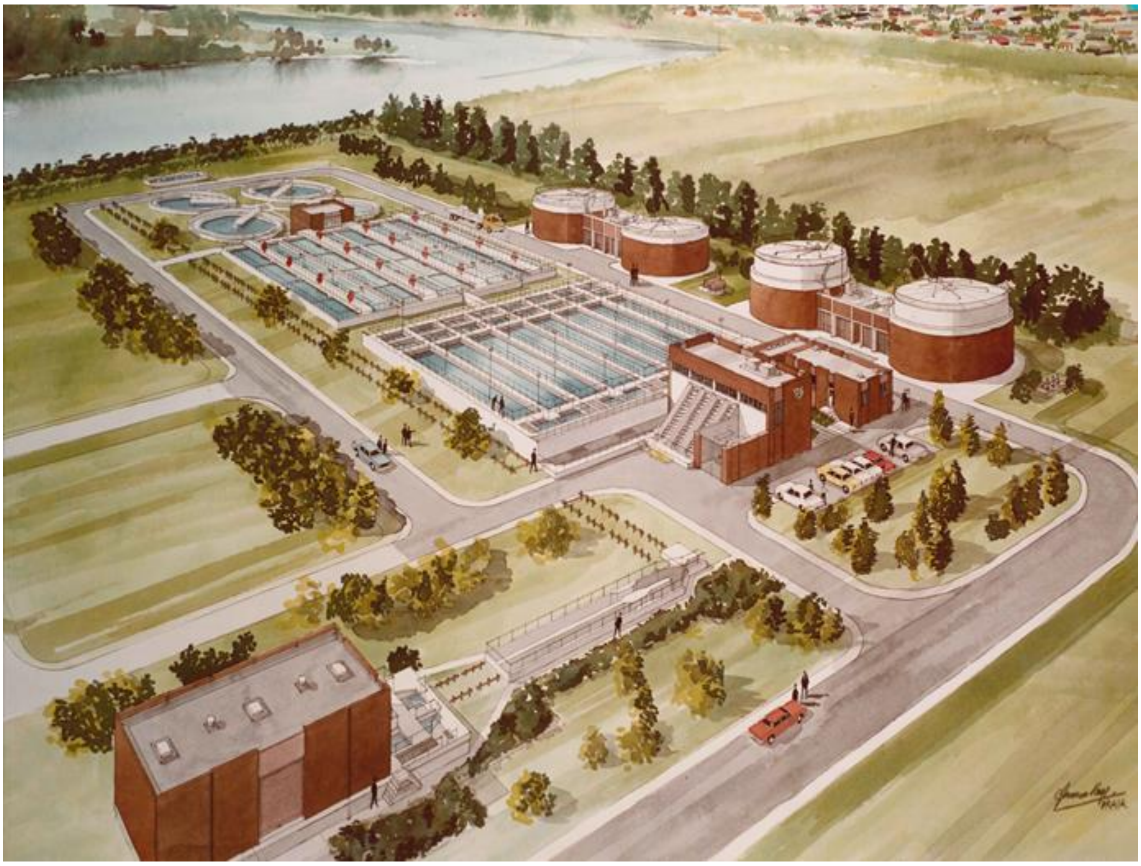


Figure 2-3: Artist's impression of proposed Ti Tree Bend STP

The Ti Tree Bend STP is the largest STP in Tasmania with an average dry weather flow (ADWF) capacity of 25 ML/day. The STP is an activated sludge type plant that has significant wet weather capability due to the combined nature of the system for which it provides treatment.

The construction of the Ti Tree Bend STP meant that during dry weather flows all sewage was treated prior to discharge however even with the increased wet weather capacity of the STP it is not able to provide full treatment during excessive rain events. The STP is constructed with a series of bypasses to prevent flooding or treatment failure. The intention is all flows that make it to the STP will be screened and have some form of disinfection treatment.

The location of the STP is remote to the catchment it serves with all flows requiring pumping to get to the plant. This means that during high rainfall events the SPS that pump to the plant are not able to match inflows and discharge to the environment. This is generally how combined sewerage systems are designed to function with low storm flows and the ‘first flush’ receiving treatment and larger more dilute flows being discharged direct to the receiving environment.

To address these issues Council looked at ways to further improve the operation of the combined drainage system particularly its ability to capture the ‘first flush’ stormwater flows that tend to have the highest contaminant loading. This resulted in the construction of the Margaret Street Detention Basin in 2005; this structure has a capacity of 30 ML and is intended to act as a capture and storage point to limit the environmental impact of discharges from the Margaret Street SPS during overflow periods to the Tamar Estuary. Figure 2-4 and Figure 2-5 show the Margaret Street Detention Basin during dry weather periods and wet weather periods.

Figure 2-4: Margaret Street Detention Basin Dry Weather Flow

Figure 2-5: Margaret Street Detention Basin Wet Weather Flow

2.4 Water Reform and the Tamar River Recovery Plan (2009 onwards)

The creation of a regional water authority, Ben Lomond Water, in 2009 meant that the operation of the Launceston Combined Drainage System was passed from Launceston City Council to the water authority. Further amalgamation of the regional water authorities occurred in 2013 with the formation of TasWater a single state-wide authority. The formation of the regional authorities and subsequently TasWater has coincided with an increased level of social, regulatory and political pressure for the performance of the state's water and sewerage systems to be improved.

TasWater is in the process of completing preliminary design and investigation works for the rationalisation of seven STP's in the greater Launceston area into a single new STP located adjacent to the existing Ti Tree Bend STP. A concurrent project will be the removal of a number of separated sub-catchments that currently discharge into the LCSS. One of the key requirements of the project is to understand community and stakeholder concerns about the performance of the existing STP and sewerage network assets, and the impact that they are having on the receiving environment.

2.5 The Receiving Environment - Tamar and North Esk Rivers

The receiving environment for CSO and treated effluent from the LCSS is the North Esk River and the Tamar River. The Tamar River is actually an estuary rather than a river and is a narrow, highly tidal watercourse, with large freshwater inputs at its head (Pirzl & Coughanowr 1997).

The local community have substantial concerns about the health of the estuary, the impact that it has on the visual amenity of the city and surrounds and the inability to safely use parts of the estuary for primary contact recreation purposes (swimming, fishing, etc.).

The extent of the community concern has made the operation of the LCSS a major political issue in the local region. To that end there is current federal funding allocated for TasWater to implement immediate short term improvements to the system to reduce the impact of CSO events and to complete an investigation into the long term operation of the system and to consider the possibility of separation.

It is considered that a comprehensive review and understanding of the drivers for CSO events and the contaminant loading associated with CSO events in comparison to regular treated effluent discharge loadings and stormwater discharge loadings will be of major benefit in completion of the federally funded project and will allow for informed dialogue and engagement between all stakeholders.

3. Literature Review

3.1 Introduction

The literature review comprises of a review of existing studies and reports completed on the LCSS and investigation into the existence and performance of other combined sewerage systems. The literature review also focuses on the hydraulic, biological and treatment performance of combined sewerage, separated and stormwater systems to understand likely environmental impacts of the varying methods of effluent carriage, treatment and disposal. The review pays particular regard to completed studies and reports about stormwater and sewerage systems in the area surrounding the LCSS as they will have a similar catchment profile in terms of infrastructure age and type, land use and receiving environment.

3.2 Combined Sewerage Systems

A combined sewerage system sometimes referred to as a combined drainage system (CDS), collects stormwater runoff, domestic sewage and industrial wastewater in the same pipe (Montserrat et al. 2015). Combined sewerage systems combine the functions of stormwater and sewage capture and transfer in a single pipe.

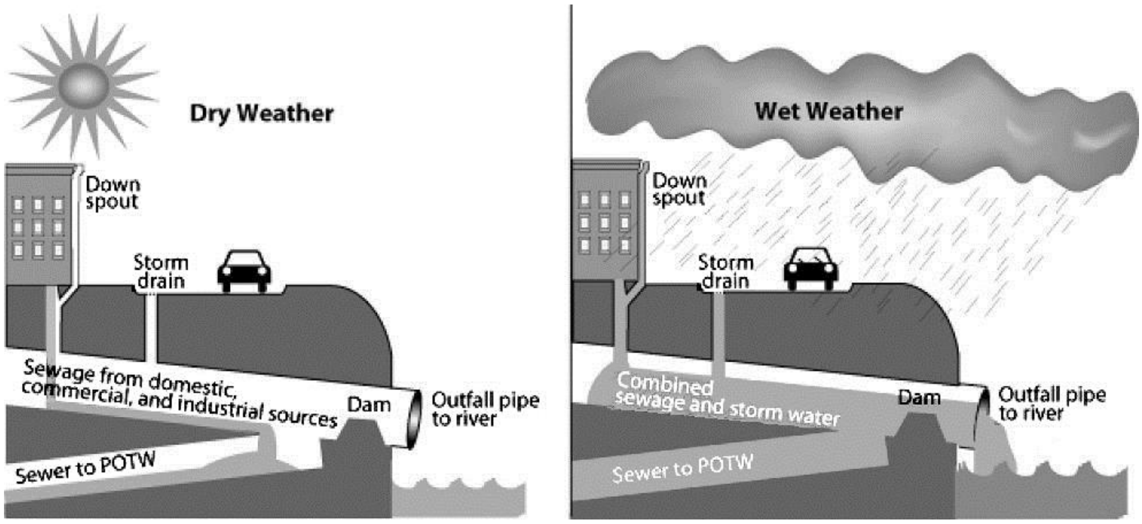


Figure 3-1: Combined Sewerage System (US EPA, 2004)

Combined sewerage systems were commonly installed when drainage systems started to appear in cities across the world. The creation of drainage systems was generally as a response to flooding issues, befoulment of local watercourses or municipal disease.

Combined drainage systems were often selected as the cost of installation was cheaper than that for separated systems (US EPA 2004). Existing natural drainage was frequently intermingled with pipes and channels carrying sewage, and difficult to separate. There was generally a lesser understanding of the impact that untreated sewage could have on both public and environmental health.

London's Victorian Sewer System was constructed at a similar time to the Launceston Combined Sewerage System, with the key design requirement at the time being to remove oppressive odours from the city rather than purification of the discharge environment (Thames Water 2014).

Modern systems are almost universally created as separated systems and many utilities that operate combined sewerage systems have made significant investment and effort to either separate or better control CSO events to improve system performance and public and environmental health outcomes.

3.2.1 London Combined Sewerage System

Possibly the best known combined drainage system in the world is the London Combined Drainage System which was designed by Sir Joseph Bazalgette in the 1860's following the 'Great Stink' of 1858 (Thames Water 2014). The intention of the system was to prevent foul sewage entering the tidal areas of the Thames around the city and stagnating leading to major odour issues, to that end five major trunk mains were constructed either side of the river and embankments were formed to house the pipes and retard surface drainage from entering the river. A side effect of the project was the improved health outcomes for London residents through a major reduction in cholera and other waterborne diseases and viruses.

The London Combined Drainage System was constructed as a combined system by necessity due to the major intermingling and polluted state of existing watercourses in and around the city. Bazalgette decided that in some cases piping of existing watercourses was the most effective method of transporting effluent. The same principle was applied to the Margaret Street Creek in the Launceston Combined Drainage System.

The London Combined Drainage System has undergone significant upgrade since it was first installed as understanding of the impact of both untreated stormwater flows and sewage flows on a receiving environment has increased. The difficulties of managing a combined drainage system mean that this system still experiences one CSO on average per week (Thames Water 2014).

3.3 Stormwater Systems (Local and International)

The primary function of stormwater systems is the capture and conveyance of surface runoff to a discharge environment to prevent flooding of low lying areas (Davis and Cornwell 2002). Typically there has been little thought put to treatment of stormwater as there was limited information available about the pollutant load associated with stormwater discharge.

In recent times there has been an increasing awareness of the pollutant load associated with stormwater 'first flush' discharges after an extended period of dry weather. Kayhanian & Stenstrom (2005) suggest that the first flush can contain ten times the concentration of chemical constituent than the concentration at the end of the storm event. Figure 3-2 below shows a visual observation of stormwater first flush discharges.

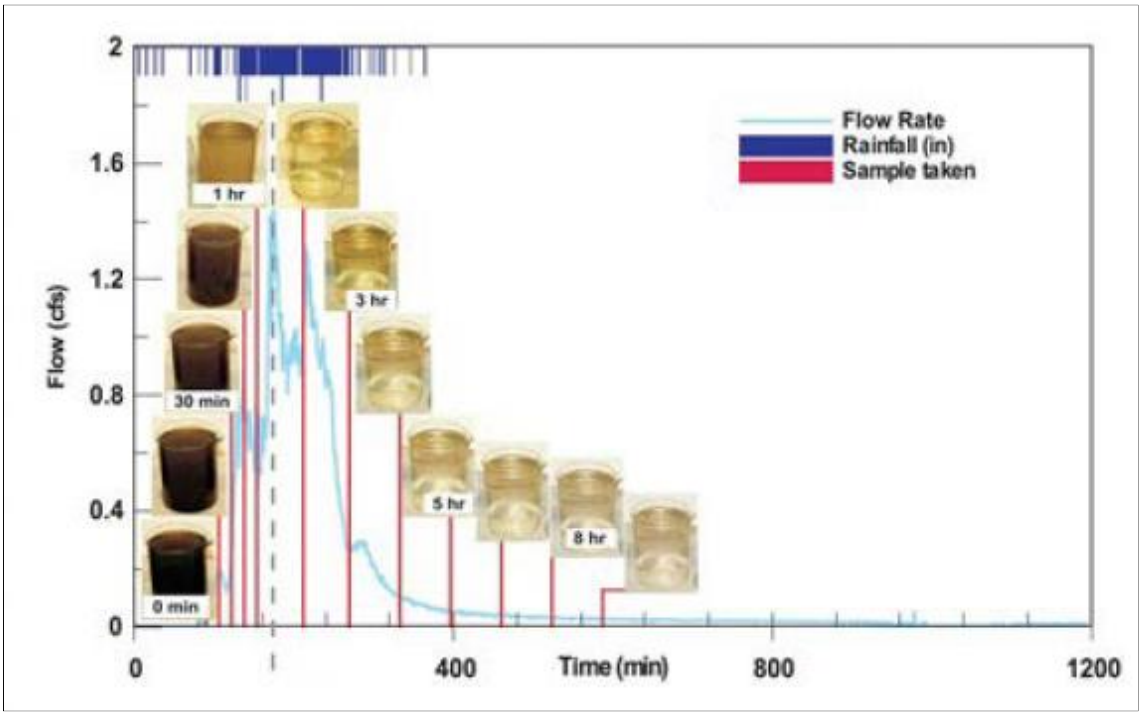


Figure 3-2: Visual observation of Stormwater First Flush (Stenstrom & Kayhanian, 2005)

The operation of stormwater systems in Tasmania resides with local government (councils). There is currently little legislative or regulatory requirement for council's to treat stormwater prior to discharge to the environment, however, stormwater runoff is increasingly being recognised as a major source of pollutants entering waterways and estuaries (Green 1995).

Green (1995) suggested that stormwater flows were responsible for more than 80% of faecal input to the Derwent River in Hobart. This assessment considered that dog faeces were potentially the most significant contributor to faecal contamination and that the stormwater system was not capable of treating this load.

Work completed by Webster (2015) for Launceston City Council shows significant stormwater pollutant loads for a number of rainfall events. The results indicate that the median Enterococci value, an indicator of faecal contamination, was greater than 16 times the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines for secondary contact. Pollutant loadings for a range of metal contaminants such as copper, chromium, lead and zinc were between 1.4 and 7.6 times ANZECC guideline levels. Nutrient loadings from phosphorous and nitrogen also significantly exceeded ANZECC limits.

The results found by Webster strongly align with findings in Boucherville, Canada (Goore et al. 2015) where in some cases stormwater discharges were comparable in strength to CSO in the neighbouring combined system of Longueuil.

3.4 Impact of Untreated/Partially Treated Discharge to the Environment

Urban rainfall runoff is a topic of growing importance due to the increase in impervious land associated with urban growth and the effects of climate change on urban drainage (Goore et al. 2015).

Hemain (1987) suggests urban wet weather discharges (UWWD) refers to all rainfall in an urban catchment that flows directly into a receiving environment without passing through some form of treatment. UWWD are made up of the following:

- Rainwater
- Runoff water
- Stormwater outfalls
- CSO

Increasing urbanisation has resulted in an increase of the speed at which runoff flows into the receiving environment, resulting in accelerated changes in hydrological features of the receiving environment (Goore et al. 2015).

UWWD events result in discharge of gross solids, elevated total suspended solids (TSS), nutrient enrichment through nitrogen (N) and phosphorous (P) compounds and oxygen depletion through increases in chemical oxygen demand (COD) and biological oxygen demand (BOD) in the receiving environment. This reduction in water quality impacts on the environment, public health, visual amenity and aesthetics of the receiving environment.

Combined drainage systems differ from conventional stormwater systems in that during low rainfall periods (low intensity or low total rainfall events) all flows are captured and diverted to a STP for treatment prior to discharge. Thus, during rainfall events that do not trigger a CSO, combined drainage systems offer improved treatment outcomes over conventional stormwater systems that typically have little or no treatment prior to discharge to the receiving environment.

The counterpoint to this is that during significant rainfall periods, either high intensity or high total rainfall events, the combined drainage system is unable to keep up with system inflows and CSO events occur. Typically CSO have a higher contaminant loading than discharges from stormwater outfalls.

To determine the extent of the problem with CSO events it is therefore necessary to understand the frequency and volume of events, and the contaminant loading associated with the discharge.

Saul (1997) suggests that data from 1970 in England and Wales showed in excess of 12,000 overflow events and that 37% of those overflows were considered unsatisfactory from an environmental perspective. The privatisation of the water sector in the UK has resulted in substantial improvements in the operation of combined drainage systems however it is estimated that in 1993 there were still some 25,000 CSO structures, of which approximately 30% were in unsatisfactory condition. Saul (1997) indicates that the number and performance of these UK combined drainage systems is consistent with mainland European countries such as Belgium, France and Germany where nearly 70% of systems are combined and approximately 30% of all CSO structures are considered unsatisfactory in their performance.

Research completed in both France and Canada suggest that a major contributor to contaminant load during CSO events is re-suspension of sewer deposits that settle out during dry weather flows. Data collected in the French combined drainage systems of Clichy and Ecully indicate that on average sewer deposits account for 50% of TSS for a CSO event (Hannouche et al. 2014). The contribution due to runoff and actual wastewater flows during the CSO event varies depending on the catchment profile of the combined drainage system. Similar work by Goore et al (2015) indicate that the major factors in determining the severity of a CSO event are the intensity of the rainfall that precedes the CSO and the dry antecedent time (DAT) since the last rain event.

3.5 UK UPM

The Urban Pollution Management (UPM) Manual was developed following a major programme of research completed in the UK in the late 1980's and early 1990's to address the impact that wet weather discharges from urban catchments have on receiving water quality (FWR 2012). The UPM Manual provides a holistic approach to understanding and managing discharges from urban wastewater systems. The manual addresses all components of the drainage system including CSO, surface water outfalls and treated effluent from STPs (FWR 2012).

The UPM procedure is completed by undertaking the steps shown in Figure 3-3 below.

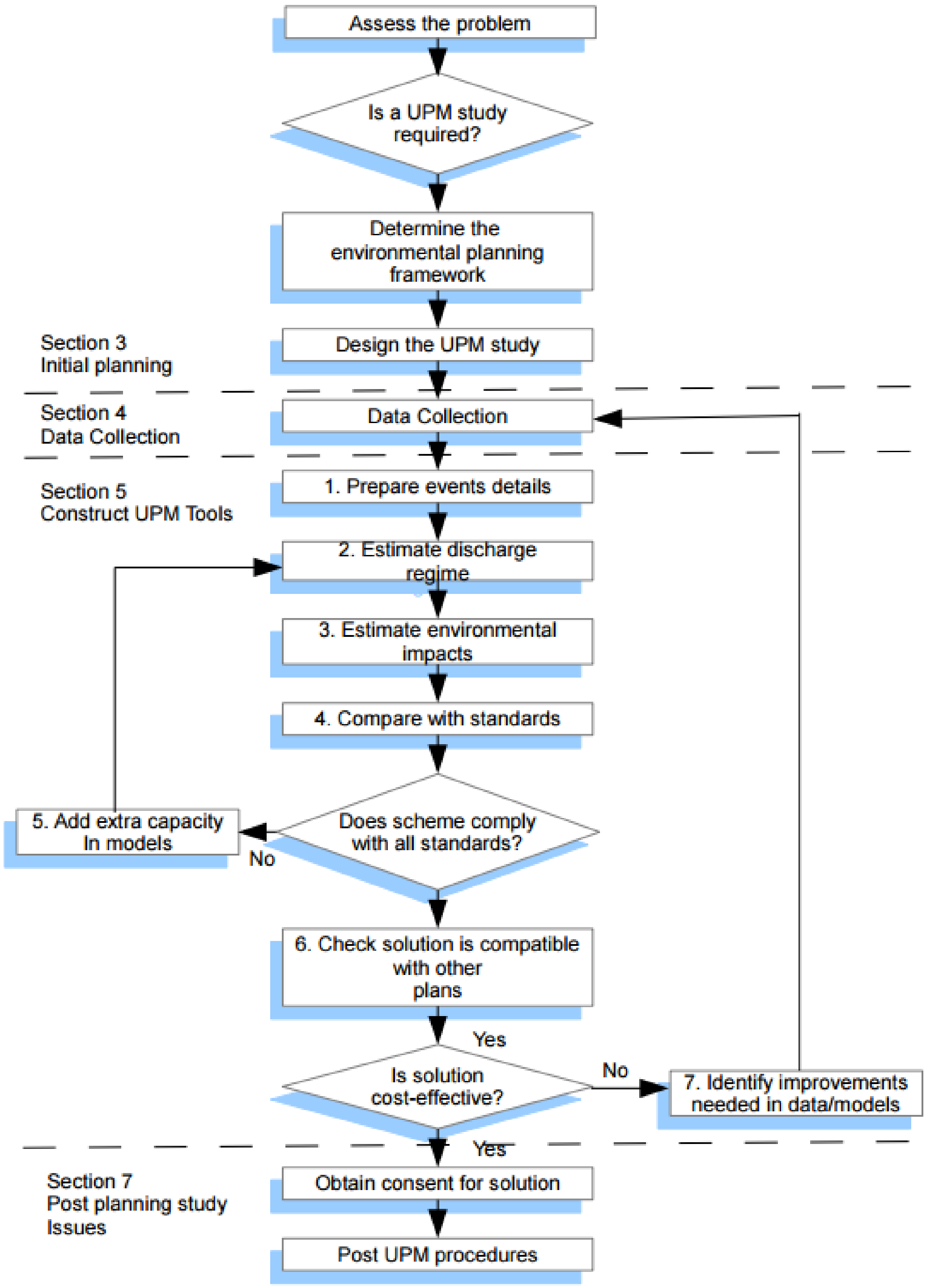


Figure 3-3: Urban Pollution Management Planning Procedure (FWR, 2012)

The gap analysis completed in Chapter 8 assessed the performance of the combined system at a high level using the UPM planning procedures and standards for discharge frequency and environmental impact.

3.6 US EPA

The impact of CSO events in America has led to the development of regulatory guidelines by the Environmental Protection Authority (US EPA) that seek to limit the frequency and impact of CSO in CSS within America. There has been a substantial push in America to separate Combined Sewerage Systems (CSS) where possible it is estimated however that there are still almost 800 cities that have CSS (US EPA 2014).

The US EPA's CSO Control Policy developed in the early 1990's set clear targets for utilities operating CSS that included the following baseline parameters:

1. Proper operation and regular maintenance programs for the sewer system and the CSO
2. Maximum use of the collection system for storage
3. Review and modification of pre-treatment requirements to assure CSO impacts are minimized
4. Maximization of flow to the publicly owned treatment works for treatment
5. Prohibition of CSO during dry weather
6. Control of solid and floatable materials in CSO
7. Pollution prevention
8. Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts
9. Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls

These parameters were referred to as the nine minimum controls and represent a baseline expectation for utilities that operate CSS (US EPA 1995). The gap analysis completed in Chapter 8 assessed the performance of the combined system against the nine minimum controls.

3.7 Tamar River and North Esk River Performance and Health

The Tamar Estuary shows signs of environmental degradation in a number of areas and is unsuitable for primary contact recreation purposes in the upper reaches. This is thought to be due to faecal contamination associated with urban runoff, sewage, agricultural runoff and wildlife (Pirzl & Coughanowr 1997).

More recent environmental analysis (Locatelli 2015) has concluded that the majority of pollutants entering the Tamar Estuary are related to diffuse sources higher in the North and South Esk River Catchments. It is worth noting that these two catchments drain approximately 15% of the Tasmanian land mass into the Tamar Estuary. Diffuse sources are estimated to contribute the following loads to the Tamar Estuary:

- 72% of the total nitrogen (TN),
- 57% of the total phosphorous (TP),
- 99% of the total suspended solids (sediments), and
- 70% of the enterococci (faecal indicator bacteria).

Locatelli (2015) also notes that a further major contributor, particularly of pathogen loads, to the Tamar Estuary is CSO events. One of the primary objectives of this research is to identify the frequency, volume and pollutant loading of CSO events from the LCSS to understand what contribution these are making to the state of the Tamar Estuary.

4. Methodology

The performance analysis of the LCSS and the theoretical modelling of the system as separated, to compare the likely impact on the receiving environment required a substantial amount of data collation and input from a range of sources. Data was collected from the following sources:

- TasWater SCADA system
- Online monitoring for influent data
- Sample reports and laboratory test results for CSO events
- Sample reports and laboratory test results for stormwater discharges
- Operation and Maintenance Manuals (O&M Manuals)
- Environmental monitoring information for ambient receiving water

4.1 Collection of Rainfall Data

Rainfall data was collected from the TasWater SCADA system through mass data export to Microsoft Excel for analysis. The data for the Margaret Street Detention Basin rainfall gauge was selected for analysis as it is contained centrally within the LCSS.

The gauge at this site has not been recently calibrated so rainfall data was also sourced from the BOM for the Ti Tree Bend STP site to complete a data quality assessment. The assessment looked at comparative rainfall timing, duration, intensity and volume. The analysis showed good correlation between the two data sets with minor variation that would be expected within a large catchment area. It was determined that the rainfall data from the SCADA system would be appropriate for the purposes of the performance analysis.

The rainfall gauge installed at the Margaret Street Detention Basin measures rainfall through monitoring change in gauge depth. When the depth changes by 0.2 mm the SCADA system captures this change and time-stamps when the change occurred. This allows for rainfall intensity and duration to be determined and for a comparison to be made against ARI values for Launceston. The rainfall data was also aggregated into daily rainfall totals which was used to determine the total volume of rainfall over the monitoring period (2013 and 2014 calendar years).

4.2 Collection of Pump Station SCADA Information

Pump station data was collected from the TasWater SCADA system through mass data export to Microsoft Excel for analysis for each of the pump stations assessed as part of the investigation. A review of the data capture processes and parameters adopted in TasWater's existing SCADA system was completed to determine the most appropriate parameters to extract to create and analyse pump station profiles.

The parameter that was considered the most suitable was the pump running input status as this was a simple binary value (0-1) that indicated the status of the pump and was time-stamped at every change of state. This parameter indicated when each pump in a station was active, to determine total pump run times and hence pump volumes the previous time step was subtracted from the current time step and multiplied by the assigned pump rate. This method is somewhat simplistic as it assumes all pumps operate at a single duty point. This is considered a reasonable assumption however, as despite there being a number of variable speed drive (VSD) pumps installed within the system, the vast majority of pumps in the system are designed to operate at a preferred duty point.

The pump duty points were sourced predominantly from existing O&M manuals or process schematics. These were compared against operational records and existing pump station reports and investigations to check for currency. Pump stations that have the capacity to pump to either the STP or generate CSO were discussed with operational staff to understand the valve configuration in the pump stations that dictated which pumps were used for pumping to the STP and which pumps were used to discharge to the river.

The driver for developing pump station profiles was to understand how each pump station in the catchment that pumped to the STP or as a CSO to the river operated.

Capture of appropriate parameters would allow for an assessment of the following key CSO statistics:

- CSO date and time
- CSO frequency
- CSO duration
- CSO volume
- CSO probability based on catchment rainfall

Four dedicated SWPS were also investigated; three owned and operated by TasWater and a fourth operated by Launceston City Council the intention of this aspect was to understand the variation in the number of times the ejector pump stations operated as opposed to dedicated stormwater infrastructure. This analysis would help provide some indication of the combined systems ability to pass combined flows forward to the Ti Tree Bend STP for treatment prior to disposal as opposed to pumping direct to the river.

4.3 Calculation of Overflow Volumes, Frequency and Duration

As outlined above, overflow volumes were calculated using the assigned pump duty flow rate and applying it to the period of time the pump was operational for. This was completed for each pump in a station and the results aggregated to provide total daily flows for each pump station. The flow data was also compared against daily rainfall records to determine trigger rainfall events.

The calculation of overflow frequency, duration and volume was used to calculate pollutant loadings for CSO discharges to the receiving environment and was also used to determine compliance with regulatory guidelines (UK UPM) and against stakeholder expectations.

4.4 Collection of Influent and Effluent Data

Influent and effluent data was required for the Ti Tree Bend STP, the pump stations and dedicated stormwater infrastructure. The data for the Ti Tree Bend STP was sourced from a combination of existing annual environmental reporting to the EPA, monthly grab samples for operation purposes and a dedicated influent sampling program for the Launceston Sewerage Improvement Project (LSIP). CSO sampling has previously been completed for a small number of overflow events and stormwater sample data was provided by NRM North and Launceston City Council as part of an existing data share arrangement.

4.5 Calculation of Pollutant Loading

The calculation method adopted for the pollutant loading was a straight-forward mass flow calculation (flow x loading). This method was adopted as it was easy to apply particularly since a mass balance approach was used to determine the total system flows and is consistent with how TasWater completes annual environmental reporting to the EPA for STP performance. The pollutant values used in the calculation process are included as Appendices C through E.

The pollutant loadings assigned for each of the flows was determined based on the network conditions for the relevant period. The overflow samples collected each represent the performance of the network at that point in time. Network performance and overflow loading/quality in combined systems are heavily influenced by a number of key parameters these include:

- Rainfall volume, duration and intensity
- DAT – the period of time elapsed from the last significant rainfall event
- Network capacity to carry forward first flush
- Catchment flow profile – trade waste, domestic flows, etc.

With only a small number of overflow events and stormwater discharges collected the calculation of pollutant loadings will not be highly accurate but will provide sufficient information to make an assessment on the relative pollutant load of the combined system as opposed to a theoretical separated system.

5. LCSS Review and Hydraulic Performance (2013-2014)

One of the key focuses of the research project was to understand the operation and performance of the LCSS. Obtaining meaningful data for system operation allowed for an assessment of performance and calculation of pollutant loading on the receiving environment. This information was used to complete a high level pollutant assessment for the combined system as well as for theoretical separated systems for stormwater and sewage. The results of this assessment were used to address the issues raised in the stakeholder engagement process and as part of the gap analysis against the US EPA and UK UPM guidelines. Table 5-1 below shows high level performance results for the pump stations assessed in the study. Any pump station that could discharge wet weather flows to the receiving environment was assessed.

Table 5-1: Pump Station Overflow/Discharge to River - Summary

	No. Overflows/Discharges		Overflow Volume (ML)		90% likelihood of ejection rainfall
	2013	2014	2013	2014	
Willis St SWPS	173	232	728.9	556.9	2-3 mm
Shields St SWPS	131	77	275.7	155.7	4-5 mm
Tamar St SWPS	N/A	88	N/A	83.2	3-4 mm
Lower Charles St SWPS*	270	253	46	28.3	2-3 mm
Racecourse Cres SWPS**	341	285	220.5	89	1-2 mm
New Margaret St SPS	84	61	1,312.9	714.4	3-4 mm
Forster St SPS+	45	54	391.7	243.8	3-4 mm
Hope St SPS++	61	48	73.3	34.7	5-6 mm
Waltonia SWPS*	365	354	41.7	14.9	0-1 mm
Lytton St SWPS*	216	212	98.7	60.2	2-3 mm

*Pump station is a separated stormwater pump station

**Pump station is a separated stormwater pump station owned by LCC

+Pump station data not available before July 2013

++Pump station data not available before April 2013

5.1 Margaret Street Catchment

The Margaret Street Catchment services the oldest parts of the city and is the largest catchment within the LCSS with a service area of approximately 5.1 square kilometres. The Margaret Street Catchment captures sewage and stormwater from the suburbs of Trevallyn, West Launceston, Summerhill, Prospect and some parts of the CBD. The catchment drains generally south to north and sewage and stormwater is diverted to the New and Old Margaret Street SPS. The Old Margaret Street SPS was installed in the 1930’s and is one of the oldest SPS in the system still in operation. The operation of the New Margaret Street SPS is discussed further in Section 5.1.3.

During dry weather periods and low rainfall events flows are pumped from both Old and New Margaret Street SPS to the Ti Tree Bend STP. During wet weather events the New Margaret Street SPS pumps combined sewage to the river. The system is interconnected such that the New Margaret Street SPS will commence pumping combined flows first and if the stormwater pumps cannot match system inflows older gravity outfalls will commence operating.

Due to the size of the catchment and discharge location close to the centre of the city, the Launceston Yacht Club and Seaport, previous efforts to improve the management of the combined system have generally targeted the Margaret Street Catchment. Major improvement works completed in the area include the construction of the New Margaret Street SPS and the Margaret Street Detention Basin.

Investigation works for the catchment have focussed predominantly on the infrastructure that is most related to CSO events and that is possible to assess using existing data. This means that the research project has not considered gravity overflows from the catchment, smaller pump stations in the network and the larger Old Margaret Street SPS. Further investigations should consider the assets excluded from the current project.

5.1.1 Margaret Street Detention Basin - Overview

The Margaret Street Detention Basin is located at the southern end of Margaret Street. It was constructed in 2005 and is designed to capture and hold the 'first flush' of combined sewer during a rainfall event. The Detention Basin operates based on the level of the wet well at the New Margaret Street SPS. When the level nears a threshold that would cause the New Margaret Street stormwater pumps to eject to the Tamar River the radial gates at the detention basin outlet close and it commences capture and storage of combined flows. The detention basin is capable of holding 30 ML of combined sewage in a mix of a small underground covered storage (7 ML) and a larger in-ground open storage (23 ML).

5.1.2 Margaret Street Detention Basin - Operation

The operation of the detention basin is dependent on the levels in the downstream New Margaret Street SPS, Table 5.2 below shows the frequency with which the detention basin was used during the two years of data analysed.

Table 5-2: Margaret Street Detention Basin Usage

Year	Rain Days	Covered Storage	Open Storage	New Margaret St SPS CSO
2013	180	133	52	84
2014	130	108	31	61

The record of operation over the two years shows that the detention basin is potentially underused. There were seven overflow events where the detention basin was completely unused and a further 60 overflow events where only the small covered storage was used. These overflow events varied in volume from less than 0.01 ML to over 10 ML. Improved utilisation of the Margaret Street Detention Basin during the monitoring period would have reduced the number of overflow events by almost 50% and reduced the overflow volumes by approximately 130 ML.

The existing level controls and programmable logic controller (PLC) should be revisited as there appears to be significant opportunity to better utilise the open storage component of the Margaret Street Detention Basin.

5.1.3 New Margaret Street SPS – Overview

The New Margaret Street SPS is located at the northern end of Margaret Street within Kings Park reserve, it was commissioned in 1991 and at the time had reportedly the largest stormwater pump station capacity in the southern hemisphere (GHD, 2001). The station has a dual function of pumping sewage to Ti-Tree bend in normal dry weather conditions and combined sewage/stormwater to the Tamar River in wet weather conditions. It has a total outflow capability of approximately 10,000 L/s. The pumps operating at the New Margaret Street SPS are summarised below in Table 5-3.

Table 5-3: New Margaret Street SPS - Pump Station Summary

Feature	Function	Model	Power	Design Flow
Pump 1	High Flow SW	Flygt LL 3601	185 kW	~1500 L/s
Pump 2	High Flow SW	Flygt LL 3601	185 kW	~1500 L/s
Pump 3	High Flow SW	Flygt LL 3601	185 kW	~1500 L/s
Pump 4	High Flow SW	Flygt LL 3601	185 kW	~1500 L/s
Pump 5	High Flow SW	Flygt LL 3601	185 kW	~1500 L/s
Pump 6	High Flow SW	Flygt LL 3601	185 kW	~1500 L/s
Pump 7	Low Flow SW	Flygt 3300 LT	37 kW	320-380 L/s
Pump 8	Low Flow SW	Flygt 3300 LT	37 kW	320-380 L/s
Pump 9	High Head Sewage	Flygt CP 3201 HT	22 kW	60-90 L/s
Pump 10	Low Head Sewage	Flygt CP 3152 MT	13.5 kW	60-90 L/s
Pump 11	High Head Sewage	Flygt CP 3201 HT	22 kW	60-90 L/s
Pump 12	High Head Sewage	Flygt CP 3201 HT	22 kW	60-90 L/s
Pump 13	Low Flow Sump	Flygt CP 3085 MT	2 kW	10 L/s

The pump station configuration is such that during dry weather and low flow periods Pumps 9-12 will operate as required and pump all flows to the Ti Tree Bend STP. During wet weather periods Pumps 1-8 will pump to the river as required, the operation of the stormwater pumps is related to the operation of the Margaret Street Detention Basin.

5.1.4 New Margaret Street SPS – Infiltration Issues

It is considered that the New Margaret Street SPS does not have any major infiltration issues due to its design and condition.

5.1.5 New Margaret Street SPS – Discharge Volumes and Frequency

The New Margaret Street SPS overflowed 84 times in 2013 and 61 times in 2014. Figure 5-1 below shows the number of discharges exceeding selected volume thresholds in 2013 and 2014. It should be noted that 2013 had a considerably higher rainfall than 2014; the rainfall amounts were 883.6 mm and 605.2 mm respectively.

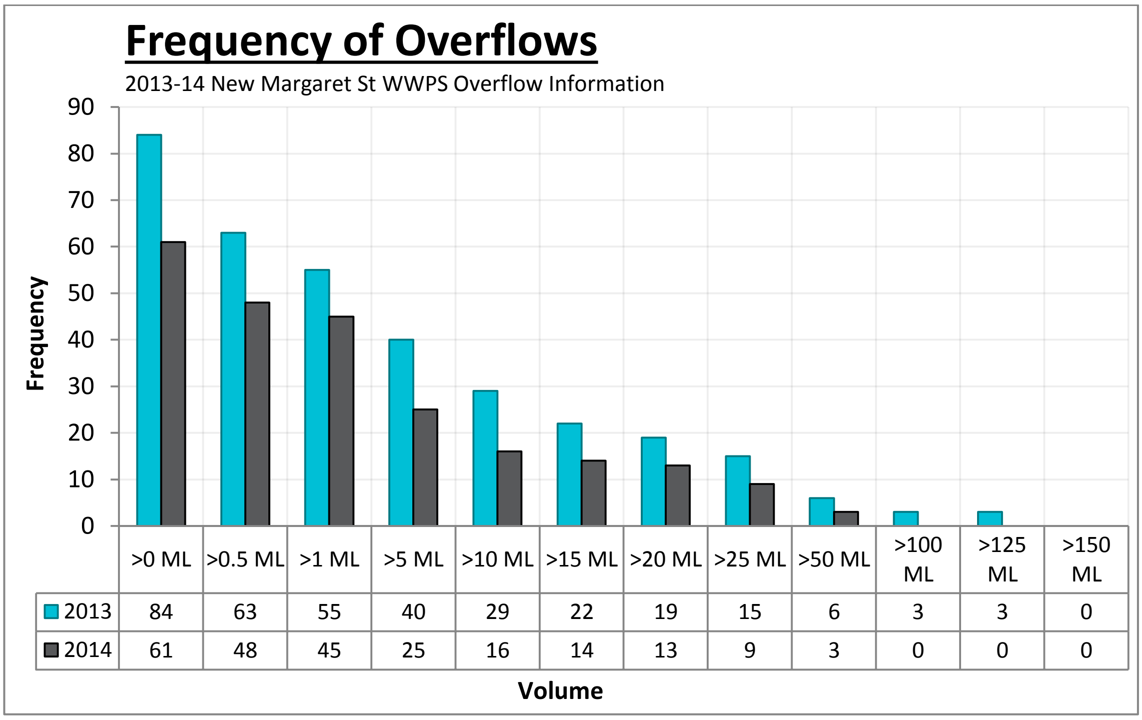


Figure 5-1: New Margaret Street SPS Overflow Information

Figure 5-2 below shows the percentile of overflows smaller than a given volume. As the largest pump station in the combined system, the New Margaret Street SPS has the largest combined sewer discharges. The majority (80%) of overflows were below 20 ML. The largest overflows were almost 140 ML; these occurred on two days with large rainfall events (37.4 and 51.4 mm).

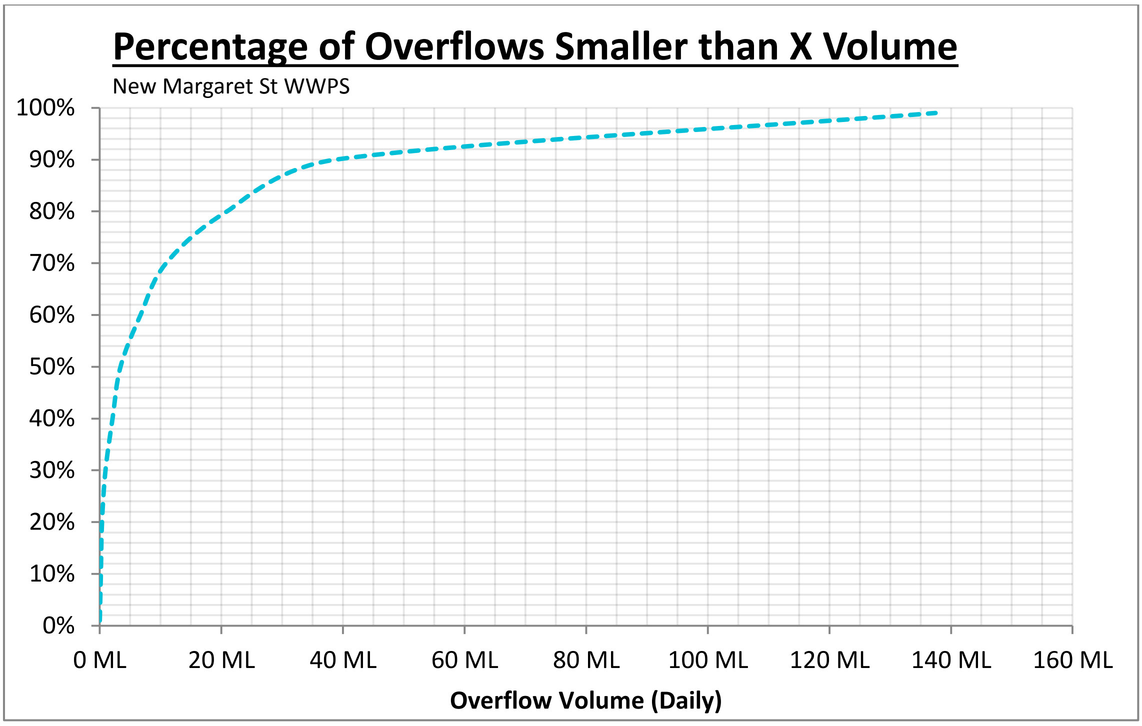


Figure 5-2: New Margaret Street SPS Percentage Overflows Smaller than X Volume

Plotted on Figure 5-3 are the recorded overflows for 2013 and 2014 for the New Margaret St SPS. The density shows that the majority of the overflows are of low volume and during low rainfall periods. Three overflows exceeded 125 ML, these were all in 2013. The remainder of the overflows were below 100 ML. These results support the conclusions made about the operation of the Margaret Street Detention Basin, improving the PLC and operating controls would reduce the number of low volume, low rainfall CSO events.

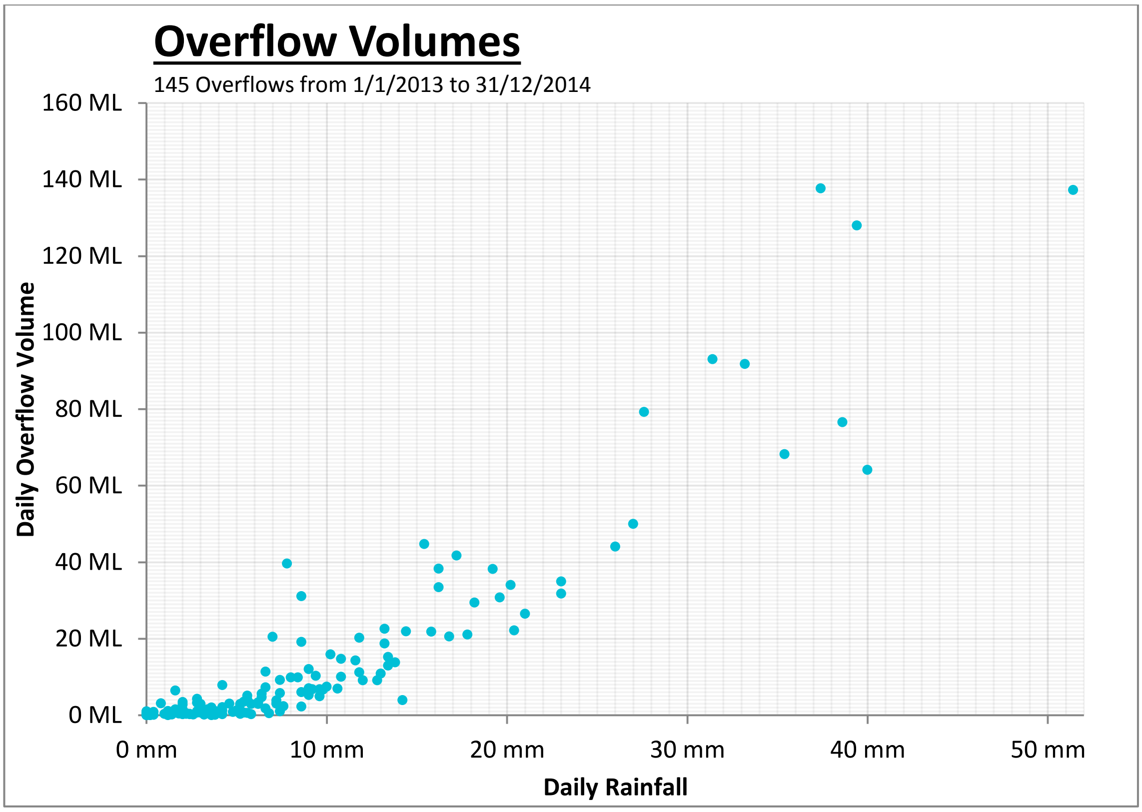


Figure 5-3: New Margaret Street SPS Details on all Overflows Measured in 2013 and 2014

The New Margaret Street Pump Station has the highest ejection volumes of the combined pump stations, with volumes of 1,312.9 ML and 714.4 ML in 2013 and 2014 respectively.

Figure 5-4, Figure 5-5, Table 5-4 and Table 5-5 show the New Margaret Street SPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data and pump rates for each of the low flow and high flow stormwater pumps in the station.

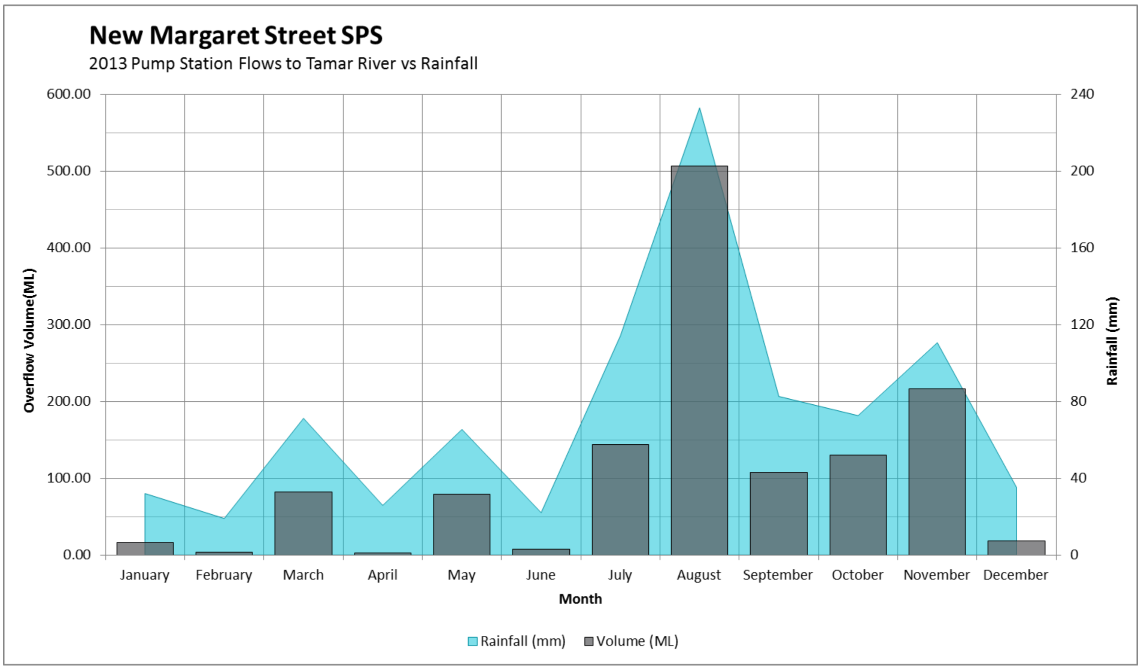


Figure 5-4: New Margaret Street SPS Monthly Volume Ejected vs. Rainfall (2013)

Table 5-4: New Margaret Street SPS Pump Station Monthly Volume Ejected vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Ejected (ML)	16.4	3.7	82.3	2.4	78.7	7.7	143	507	107	130	216	18.4	**1313**

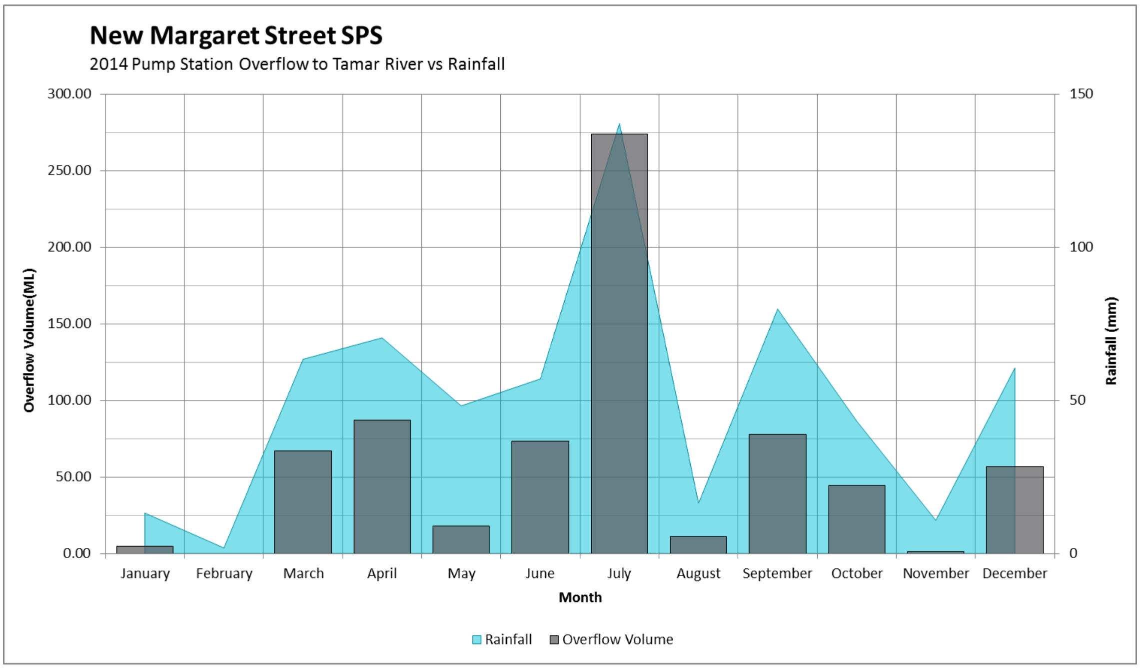


Figure 5-5: New Margaret Street SPS Monthly Volume Ejected vs. Rainfall (2014)

Table 5-5: New Margaret Street SPS Pump Station Monthly Volume Ejected vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Ejected (ML)	4.7	0	67	86.8	18	73.1	273.8	11.3	77.6	44.4	1.2	56.6	**714.4**

5.1.6 New Margaret Street SPS – Likelihood of Discharge

Figure 5-6 below shows the likelihood of the low and high flow stormwater pumps starting in relation to the daily rainfall amount. The likelihood of the pumps starting on a dry day is effectively zero; the small frequency is considered to be from data errors, system lag time and periodic testing of pumps by maintenance staff.

The low flow pump frequency of ejection follows a similar trend to the Esplanade pump stations (discussed below), with a daily rainfall of 4 mm or more essentially guaranteeing an overflow event. Whereas the high flow pumps are less likely to start, only becoming extremely probable with a daily rainfall in excess of 10 mm. The high flow curve has fewer data points due to the lack of pump starts, hence the sporadic trend. With a longer period of data capture the trend would be smoother and more representative of the true performance of the system.

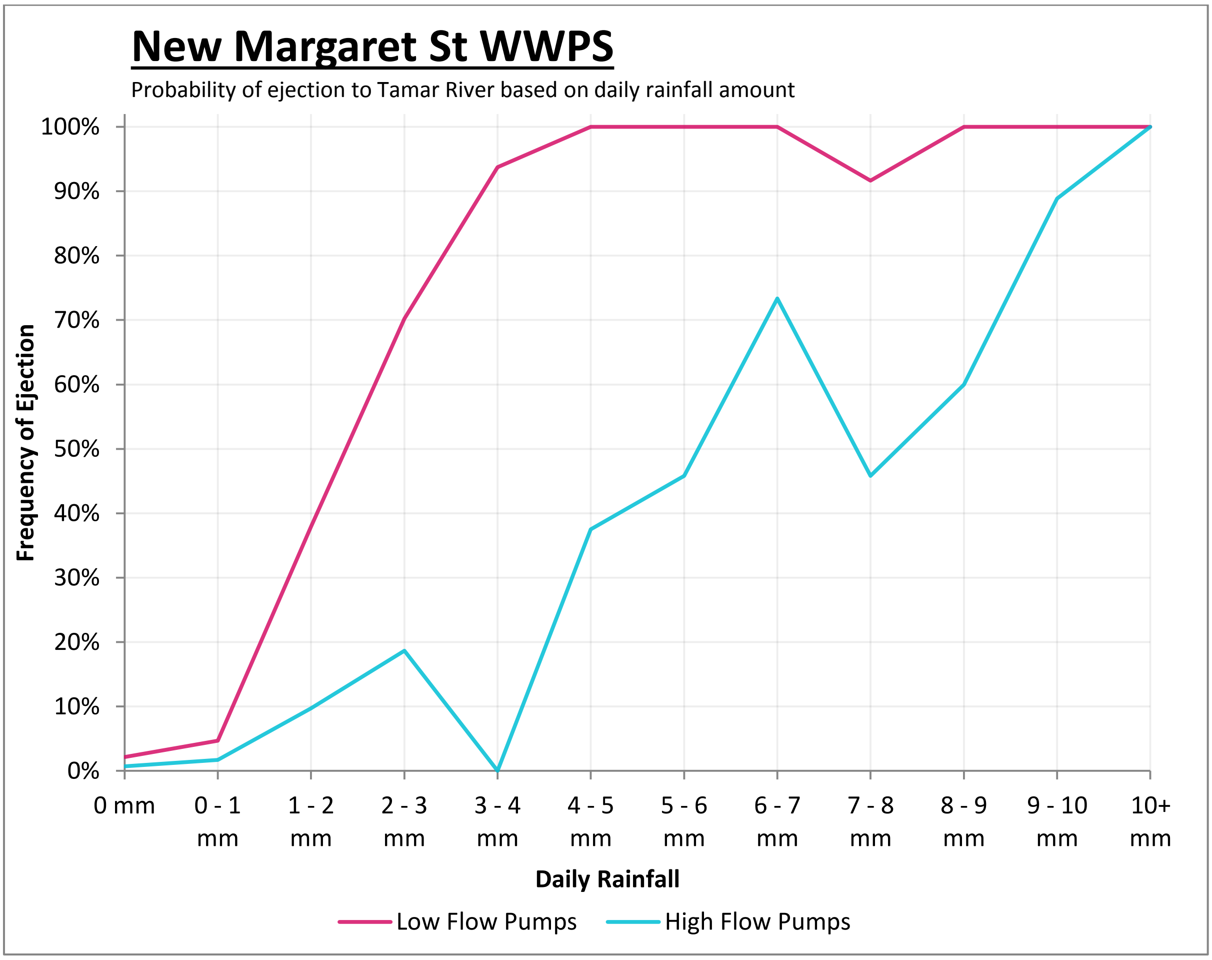


Figure 5-6: New Margaret Street SPS Probability of Discharge vs. Rainfall Amount

5.2 St. John Street/Esplanade Catchment

The Esplanade Catchment services the eastern and southern parts of the city and is the second largest catchment within the LCSS with a service area of approximately 2.9 square kilometres. The Esplanade Catchment captures sewage and stormwater from the suburbs of East Launceston, South Launceston, Newstead, Kings Meadows and parts of the CBD. The catchment drains generally to the south-east prior to hooking west as it enters the Esplanade.

There are a number of sub-catchments within the greater Esplanade catchment that are separated however all sections in the lower-lying parts of the catchment are combined. This catchment differs from the other catchments in the combined area in that the major pump station, St. John Street SPS, is designed to carry sanitary flows only and there are three dedicated stormwater ejector stations along the Esplanade, Shields Street SWPS, Tamar Street SWPS and Willis Street SWPS, designed to pump excess flows into the North Esk River.

During dry weather periods and low rainfall events, flows are pumped from the St. John Street SPS to the Ti Tree Bend STP, during wet weather events the Esplanade stormwater ejector pump stations commence operation and pump combined sewage to the North Esk River. The design of the ejector stations is described in detail in the following sections and demonstrated via Figure 5-7 below.

Figure 5-7: Esplanade Trunk Main – Shields Street Overflow Weir

During dry weather and low rainfall periods all flows are passed forward. In wet weather events the system fills and excess flow discharges over the weir (the left hand side of Figure 5-7 above) and flow into the ejector pump station where it is pumped to the North Esk River. The small polyethylene pipe shown is from the sump pump in the ejector station. Each ejector station is equipped with a sump pump to return overflows back into the combined system. The intention of the sump pump is to prevent CSO events that could be caused by a high intensity low volume rainfall or a hydraulic anomaly in the system.

Investigation works for the catchment have focussed predominantly on the infrastructure that is most related to CSO events and that is possible to assess using existing data. This means that the research project has not considered gravity overflows from the catchment and the St. John Street SPS. Further investigations should consider the assets excluded from the current project.

5.2.1 Willis Street SWPS - Overview

The Willis Street SWPS is a CSO ejector station on the Launceston esplanade adjacent to the North Esk River. The SWPS was constructed in the 1960's by the Launceston City Council. As shown in Figure 5-8 below the combined sewer trunk main and a separated stormwater pipeline run through a combined sewer manhole that is fitted with a side entry weir. The weir is designed to pass dry weather and low rainfall events down the esplanade and into the St. John Street SPS to be transferred to Ti Tree Bend STP. Under high flows the wastewater spills over the weir and into the Willis Street SWPS.

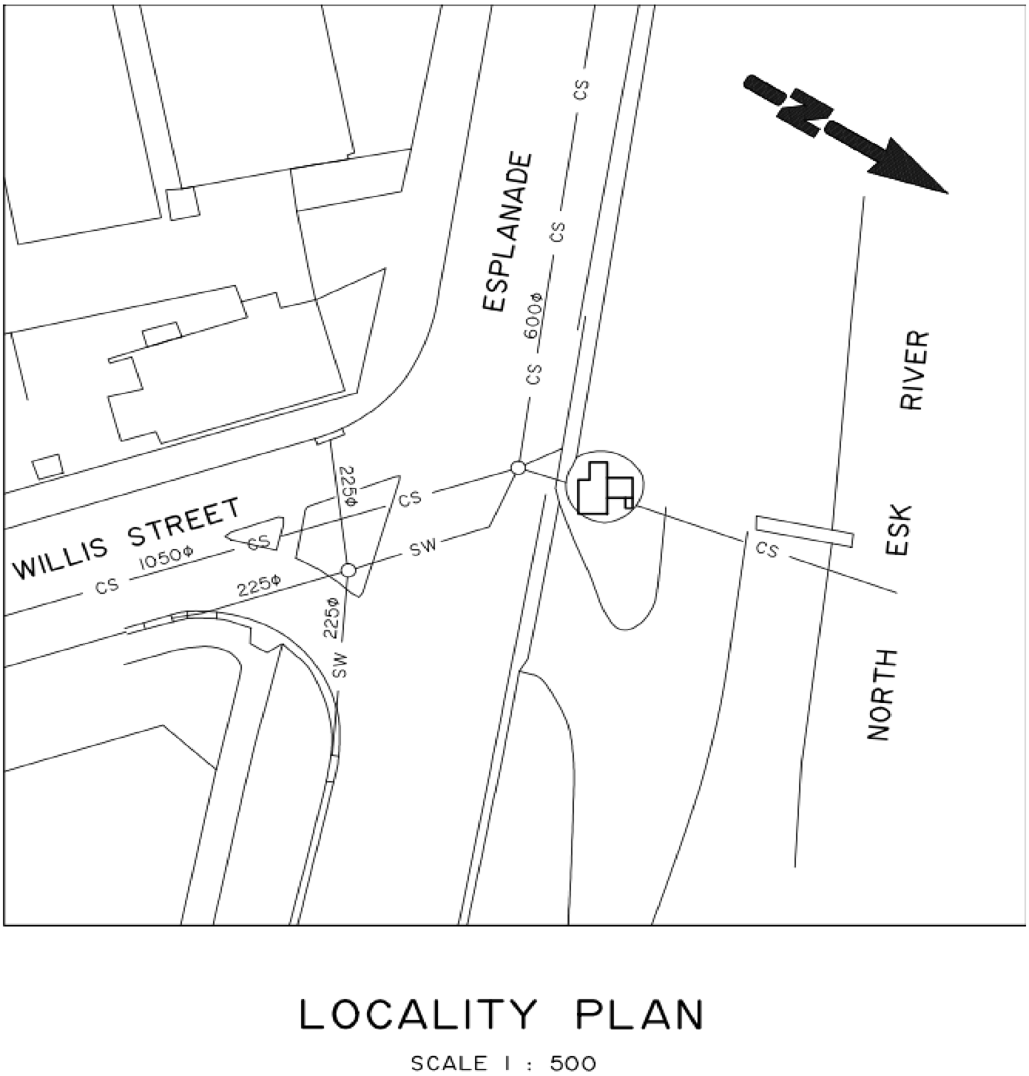


Figure 5-8: Willis Street SWPS Locality Plan (LCC, 2001)

A sump pump is located in the wet well to pump spilled wastewater back over the weir into the gravity system; this is to avoid ejecting combined sewage with a high contaminant loading into the North Esk River during dry weather or low rainfall events. Wet weather flows can cause the gravity system to spill over the weir, if the sump pump cannot transfer wastewater faster than the amount flowing over the weir; the well level will rise until the set point at which the stormwater ejection pump starts. The ejection pump has a nominal flow rate of approximately 910 L/s (dependent on tide level) and pumps into a pressure chamber that discharges through the flood levy into the North Esk River.

The Willis Street stormwater catchment is calculated to be 1.93 square kilometres from TasWater's GIS. The sewerage catchment that flows past the Willis Street SWPS is estimated, from geocoded billing data, to be 4943 ET. The geocoding process was imperfect due to an inability to achieve a 100% match of bills to properties; a more appropriate estimate would be of the order of 5500 ET.

5.2.2 Willis Street SWPS – Infiltration Issues

Due to the overflow pipe going through the flood levy and exiting below the river level, the pipe has a tide flap to prevent infiltration. Figure 5-9 below shows the clear relationship between cumulative pump starts and river height during a dry week in February 2014. The sharp increase in pump starts is due to tidal infiltration filling the pump station's well, causing the sump pump to start pumping the river infiltration over the weir into the gravity system. This indicates that the tide flap is not functioning correctly; ultimately, this causes tidal infiltration to be pumped to Ti Tree Bend STP for treatment.

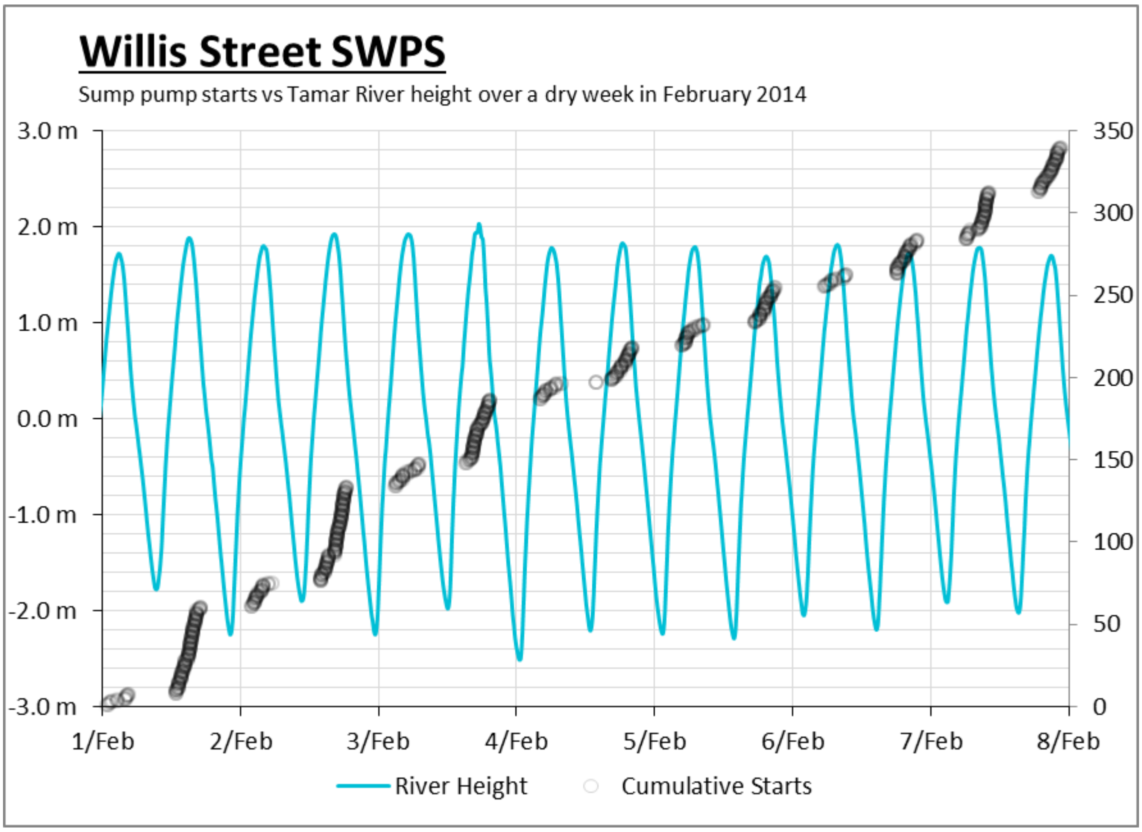


Figure 5-9: Willis Street SWPS Cumulative Pump Starts vs. Tide Height

Figure 5-10 below shows the extent of tidal infiltration into the Willis Street SWPS during the month of November 2014; at high tide the infiltration is so extensive that the large ejection pump runs in excess of 100 times in the month. It should be noted that November only received 8.2 mm of rainfall, which means the stormwater flows into the Willis Street SWPS were comparatively low. The infiltration appears to lessen considerably by the middle of the month. The mechanism for tidal water entering the pump well is unknown; it could be entering through the draft tube of the pump or through a stuck tide flap or a crack in the well itself.

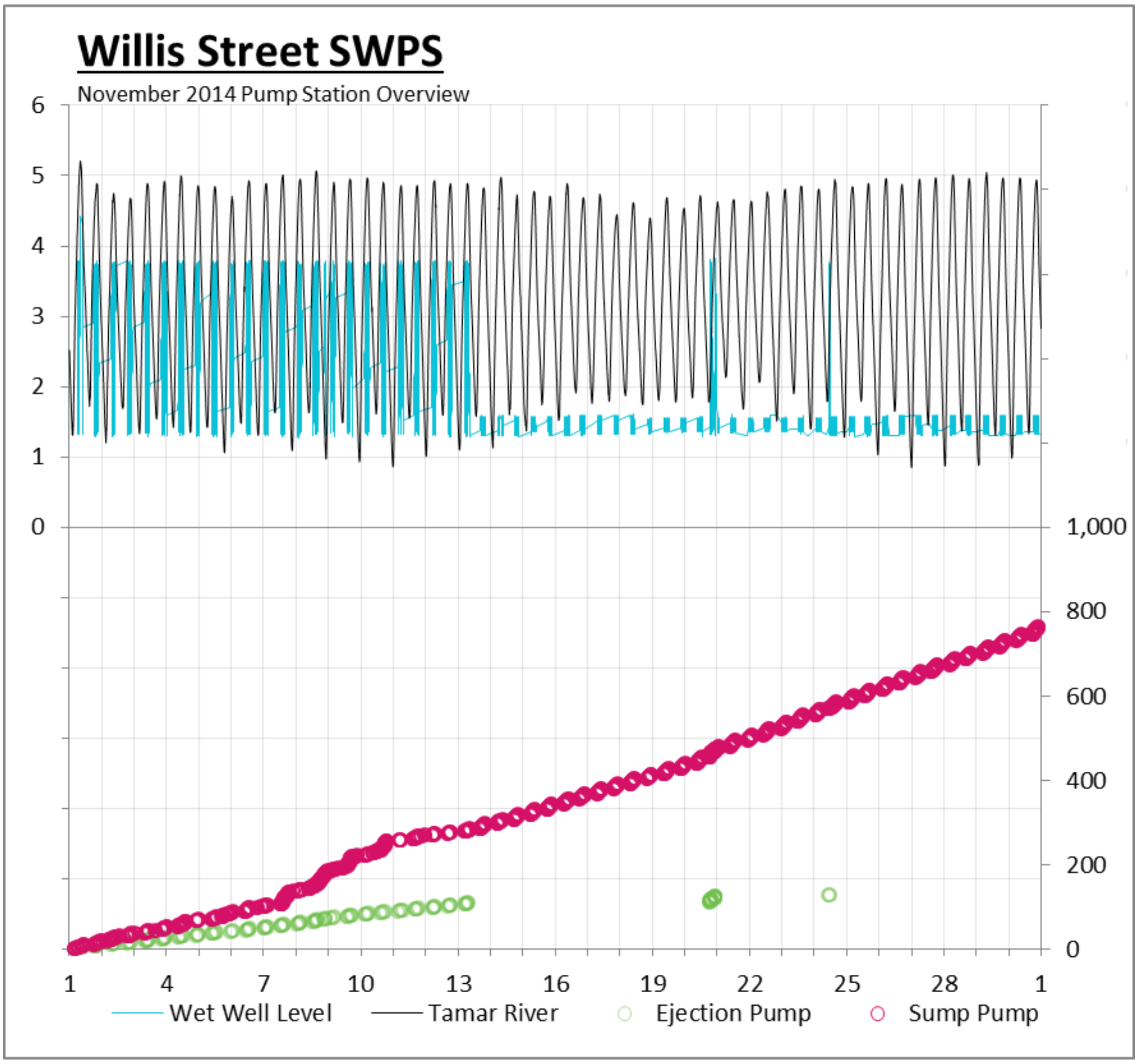


Figure 5-10: Willis Street SWPS November 2014 Pump Station Starts vs. Well Level and Tide Height

The tidal infiltration is an issue for two reasons, the first is increased operational cost and wear to the pumps caused by excessive pump starts, secondly reporting of overflow events are greatly increased.

5.2.3 Willis Street SWPS – Discharge Volume and Frequency

Figure 5-11 below shows the number of discharges exceeding selected volume thresholds in 2013 and 2014. The aforementioned tide flap issues are a likely cause for the large number of low volume overflows in 2014, whereas 2013 saw a higher number of large volume discharges due to the higher annual rainfall and more frequent high intensity rainfall events.

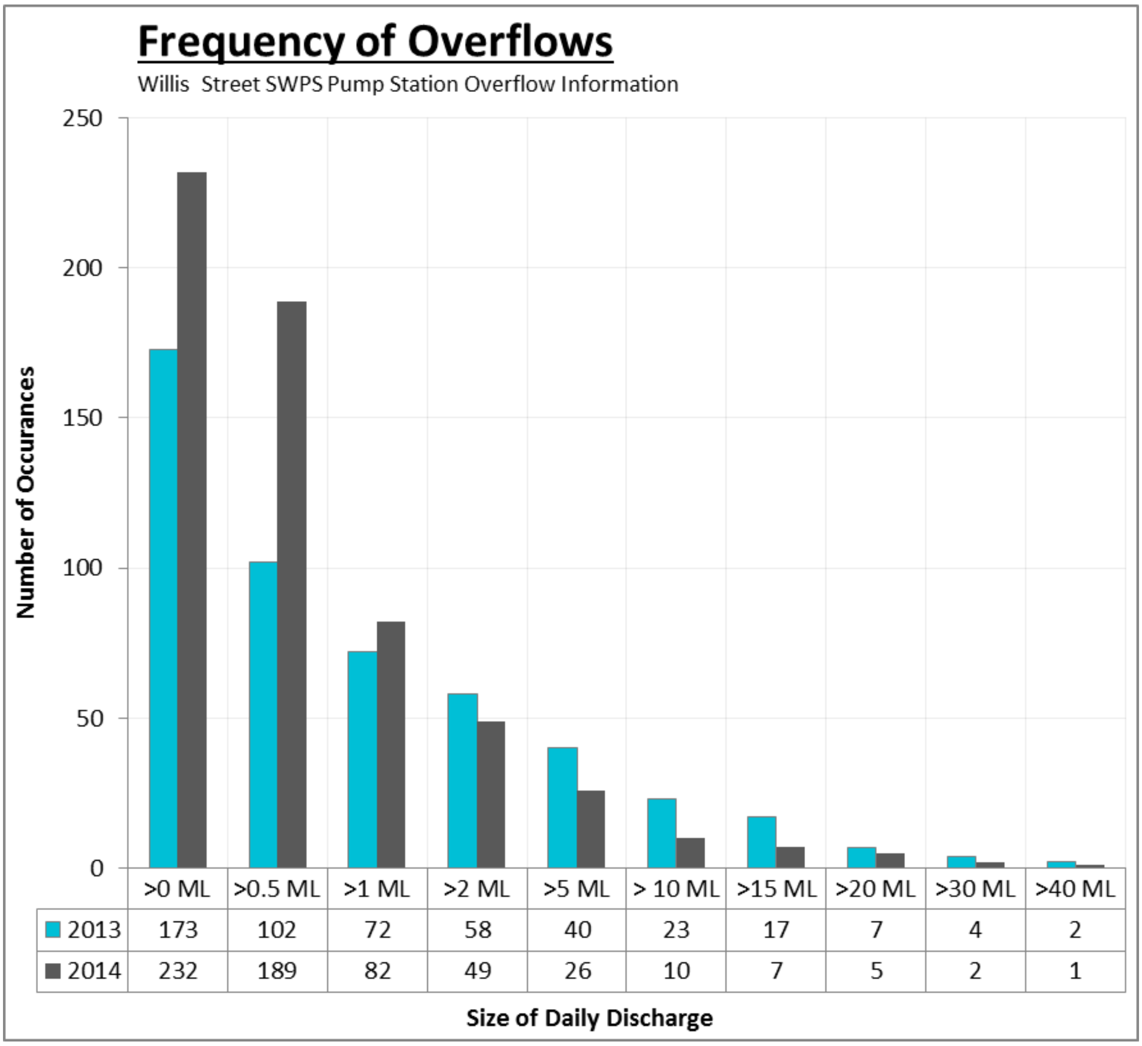


Figure 5-11: Willis Street SWPS Overflow Information

Figure 5-12 below shows the percentile of overflows smaller than a given volume. The sharp increase shows that the majority of overflows are low volume; 90% of overflows are under 9 ML. The last 10% of overflows range from 9-40 ML.

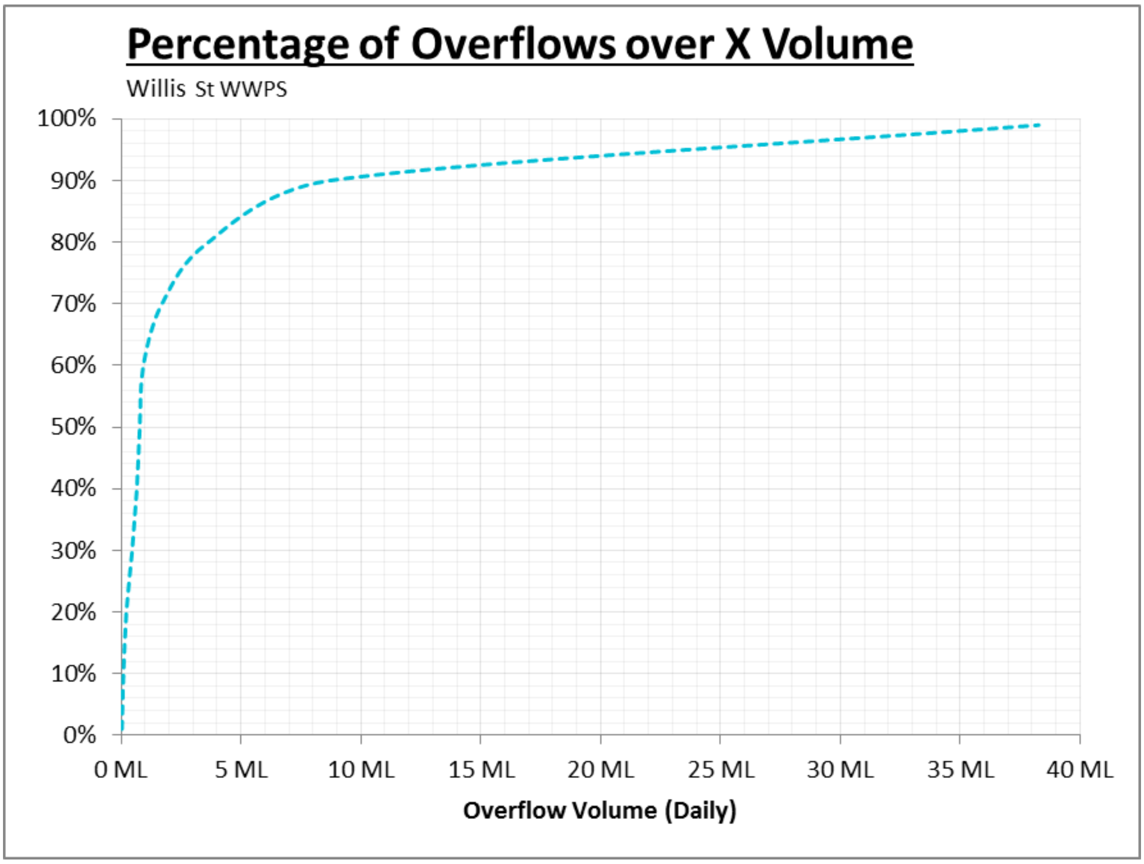


Figure 5-12: Willis Street SWPS Percentage Overflows Smaller than X Volume

Figure 5-13 below shows all overflow events for the Willis Street SWPS for the 2013 and 2014 calendar years. The high concentration of overflow events for zero and very low rainfall events is strongly indicative of significant issues with tidal infiltration and intrusion causing the ejector pump to start. It is possible that this is causing a loop whereby the tidal intrusion reaches a point that causes the ejector pump to start, the high pump out rate rapidly lowers the level in the well allowing the river water to 're-enter' the well to be pumped out again.

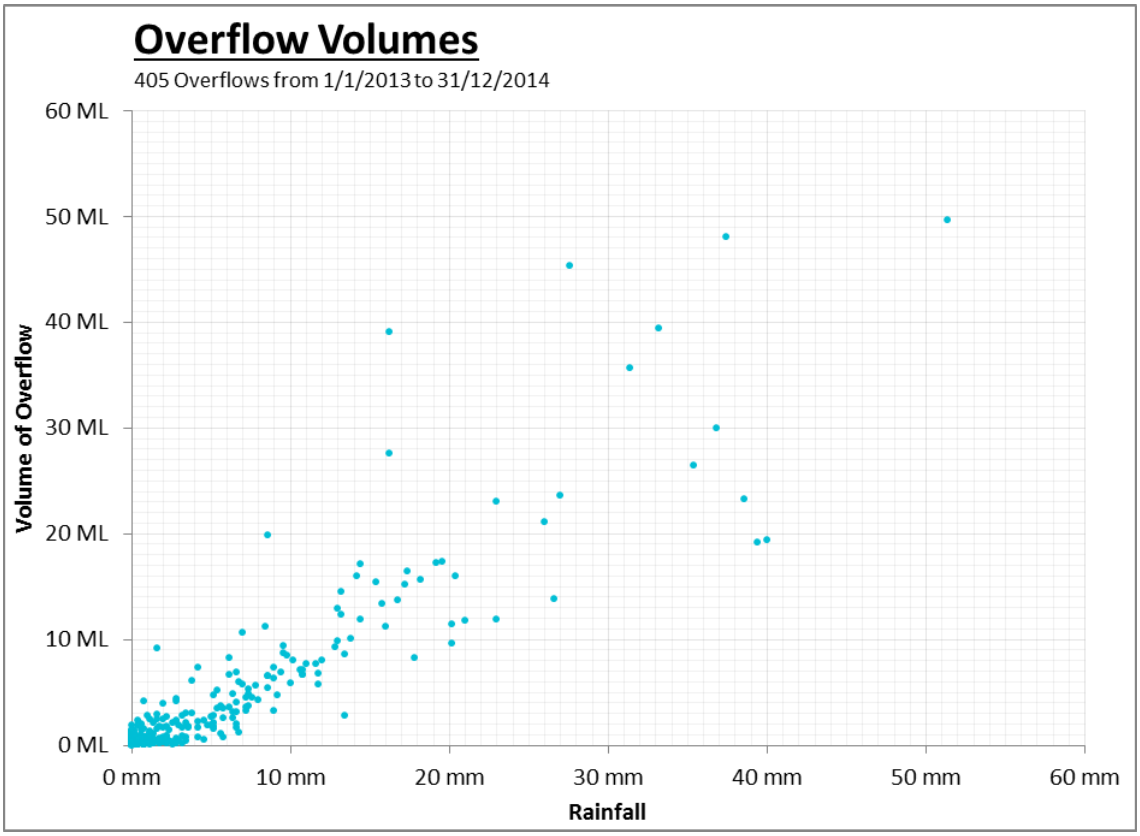


Figure 5-13: Willis Street SWPS Details on all Overflows Measured in 2013 and 2014

Figure 5-14, Figure 5-15, Table 5-6 and Table 5-7 show the Willis Street SWPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data with an assumed constant flow rate of 910 L/s and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge. Using a constant flow rate is considered a reasonable assumption for flows that are pumped to the North Esk River, although the pump flow rate does vary somewhat with the river level due to the change in pumping head.

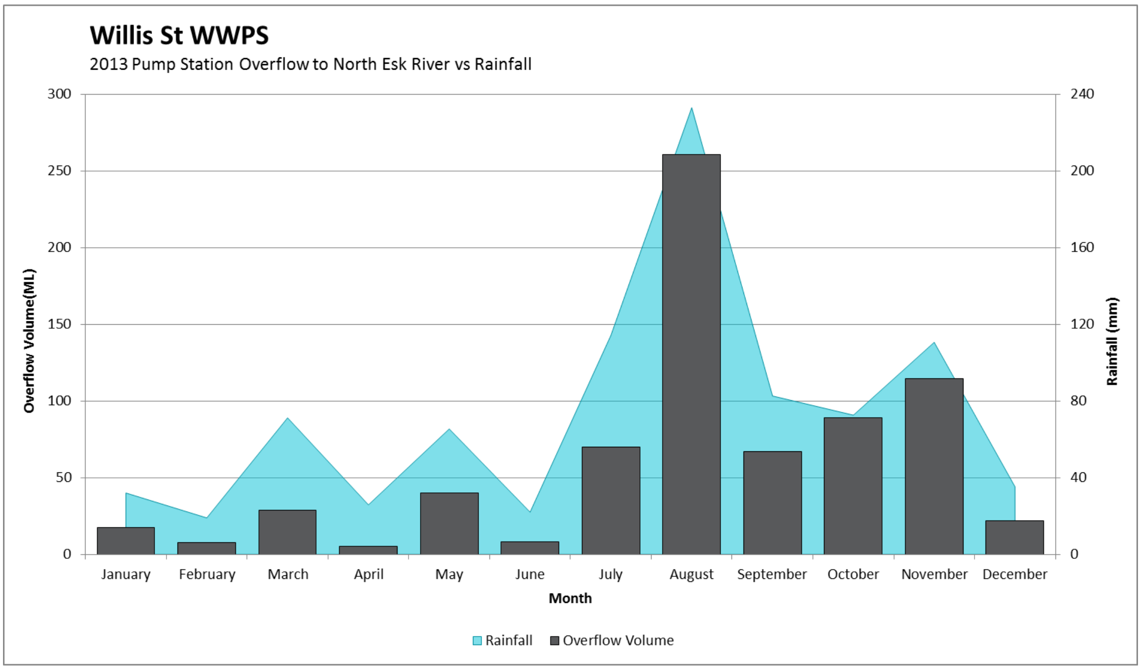


Figure 5-14: Willis Street SWPS Monthly Volume Ejected vs. Rainfall (2013)

Table 5-6: Willis Street SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Ejected (ML)	17.5	7.5	28.7	5.3	39.9	8.2	69.8	260.4	66.7	88.8	114.5	21.6	**728.9**

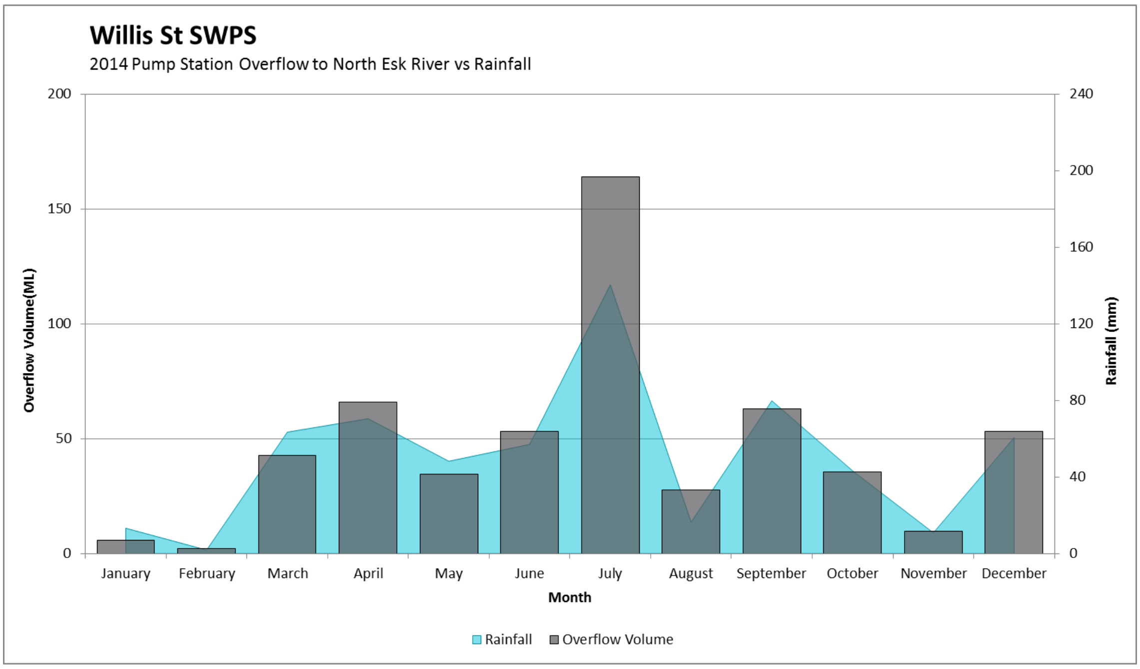


Figure 5-15: Willis Street SWPS Monthly Volume Ejected vs. Rainfall (2014)

Table 5-7: Willis Street SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Ejected (ML)	5.7	2.2	42.6	65.8	34.5	53.2	164.1	27.7	63	35.5	9.7	53.1	**556.9**

The Willis Street SWPS ejection volume shows strong correlation with rainfall data. The slight variance is likely due to varying rainfall intensities, tidal intrusion and infiltration and other conditions affecting stormwater capture. This correlation, other than the tidal infiltration, is expected for a CSO.

5.2.4 Willis Street SWPS – Likelihood of Discharge

The pump station ejected to the river on 40% of 0 mm rainfall days during 2013 and 2014. This number is considered to be inflated by tidal infiltration causing ejections and system lag (time of concentration) on rainfall occurring just before midnight. The performance of the weir in the diversion manhole is unknown, if the weir is spilling sewage into the wet well under normal flow conditions it is possible that it will be ejected to the North Esk River.

Figure 5-16 below shows the frequency of discharge for a given daily rainfall. This figure suggests that a daily rainfall greater than 4mm will likely result in a CSO. As above, it is likely that these figures are inflated because of the river infiltration leading to increased pump starts in both dry and wet weather. Until the infiltration problem is rectified it is very difficult to ascertain the actual performance of the pump station.

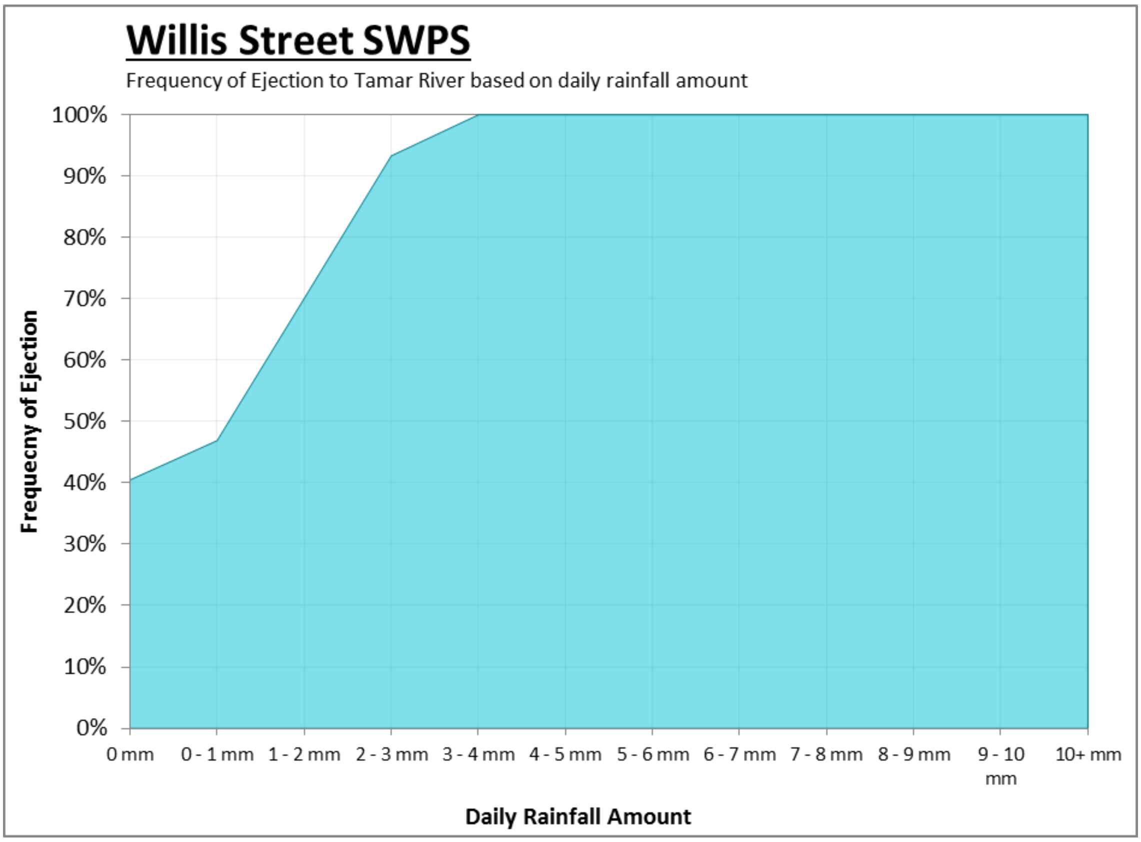


Figure 5-16: Willis Street SWPS Probability of Discharge vs. Rainfall Amount

5.2.5 Shields Street SWPS – Overview

The Shields Street SWPS is a CSO ejector station located on the Launceston esplanade adjacent to the North Esk River; its design function is similar to that of the Willis Street SWPS. As shown in Figure 5-17 below the combined sewer trunk main runs through a manhole with a side-entry weir for wet weather flows to enter the pump station's wet well. During dry weather and low rainfall periods the sewer is designed to flow through the manhole and continue to the St. John Street SPS to be transferred to Ti Tree Bend STP for treatment. During high flows the wastewater spills over the weir and into the Shields Street SWPS. There are also two dedicated stormwater pipes that discharge directly into the wet-well.

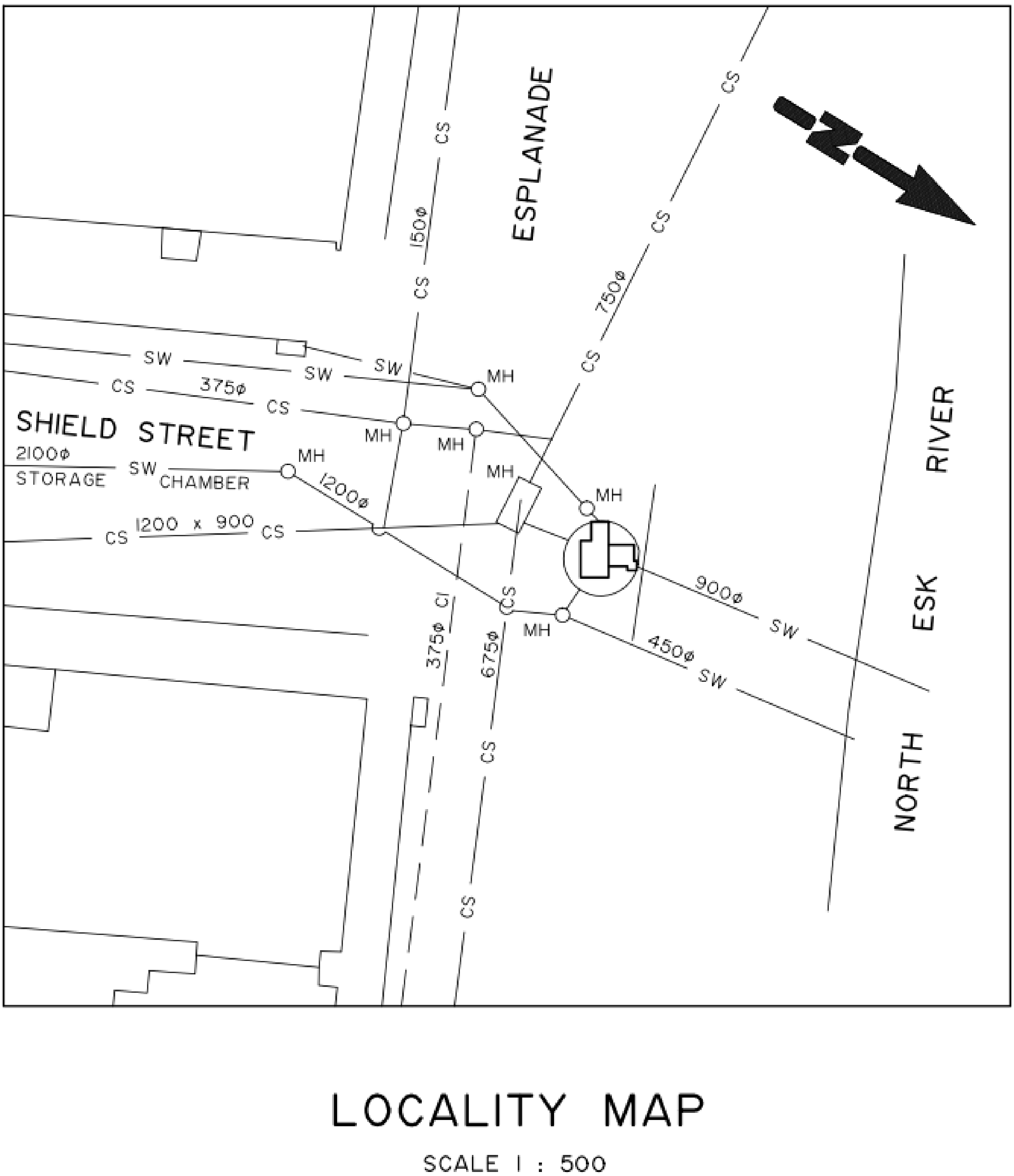


Figure 5-17: Shields Street SWPS Locality Plan (LCC, 2001)

A sump pump is installed in the wet well to pump overflows back over the weir into the gravity system. This is done to avoid ejecting combined sewage with a high contaminant loading into the North Esk River during dry weather or low rainfall events.

Wet weather flows can cause the gravity system to spill over the weir, if the sump pump cannot transfer wastewater faster than the amount flowing over the weir, the well level will rise until the set point at which the stormwater ejection pump starts. The ejection pump has a nominal flow rate of approximately 2,115 L/s (dependent on tide level) and pumps into a pressure chamber that discharges through the flood levy into the North Esk River.

The Shields Street stormwater catchment is calculated to be 0.454 square kilometres from TasWater's GIS. The direct sewage catchment is estimated from geocoded billing data to be 1538 ET. The geocoding process was imperfect due to an inability to achieve a 100% match of bills to properties; a more appropriate estimate would be of the order of is 1700 ET.

5.2.6 Shields Street SWPS – Infiltration Issues

The Shields Street SWPS configuration is similar to the Willis Street SWPS and it has similar issues with tidal infiltration. Figure 5-18 below shows the cumulative sump pump starts in comparison to the Tamar River height over a one week dry period in February 2014. The grouping of the pump starts are clearly related to the high tide of the river. The extent of the infiltration is far less than in the Willis Street SWPS, with approximately a factor of 10 less pump starts.

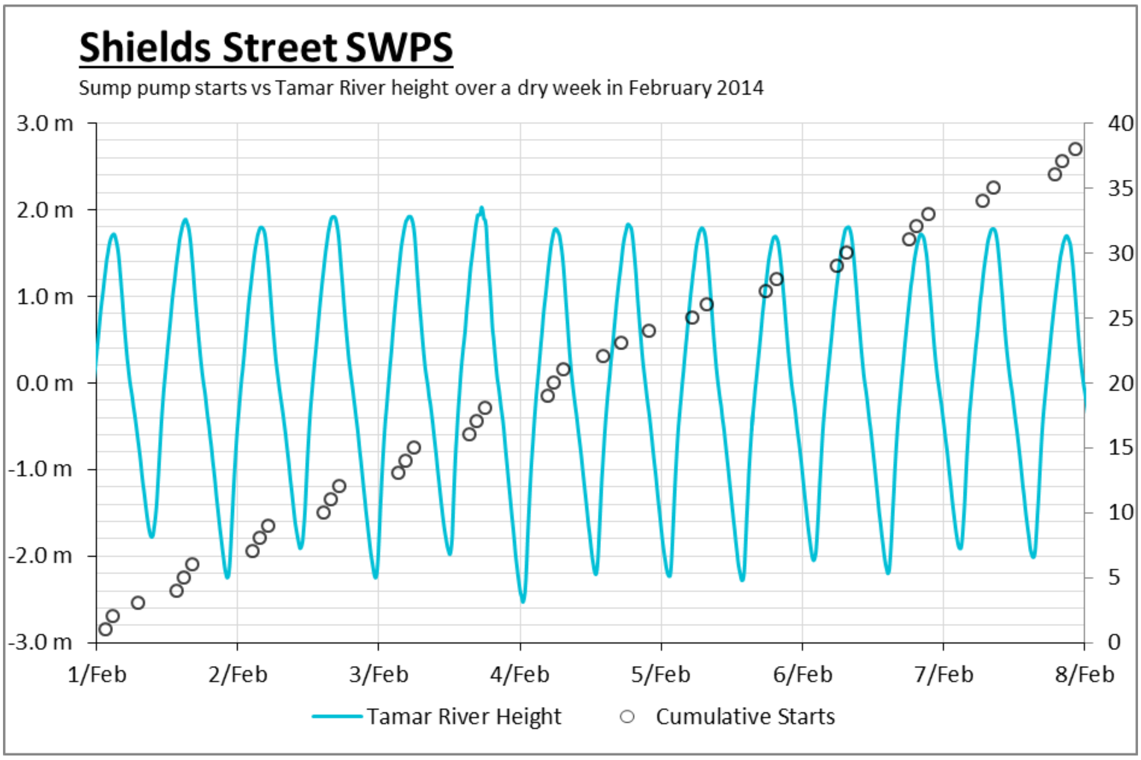


Figure 5-18: Shields Street SWPS Cumulative Pump Starts vs. Tide Height

Figure 5-19 below indicates that the Shields Street SWPS tidal infiltration rarely causes the ejection pump to run. It is not known at this stage if this is due to the tide flap working more effectively at the outlet than the tide flap at the Willis Street SWPS, the relative levels at the two stations or differences in design. The single start for the month was due to a rainfall event. The tidal infiltration problem at Shields Street SWPS is far less of a concern than at the Willis Street SWPS.

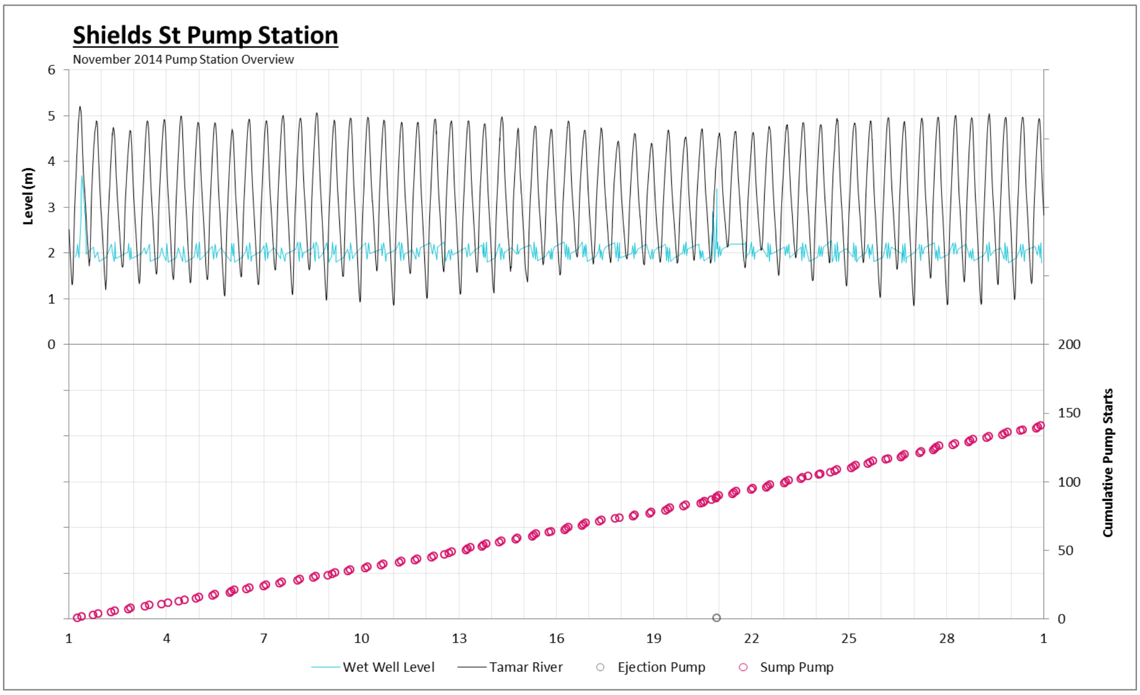
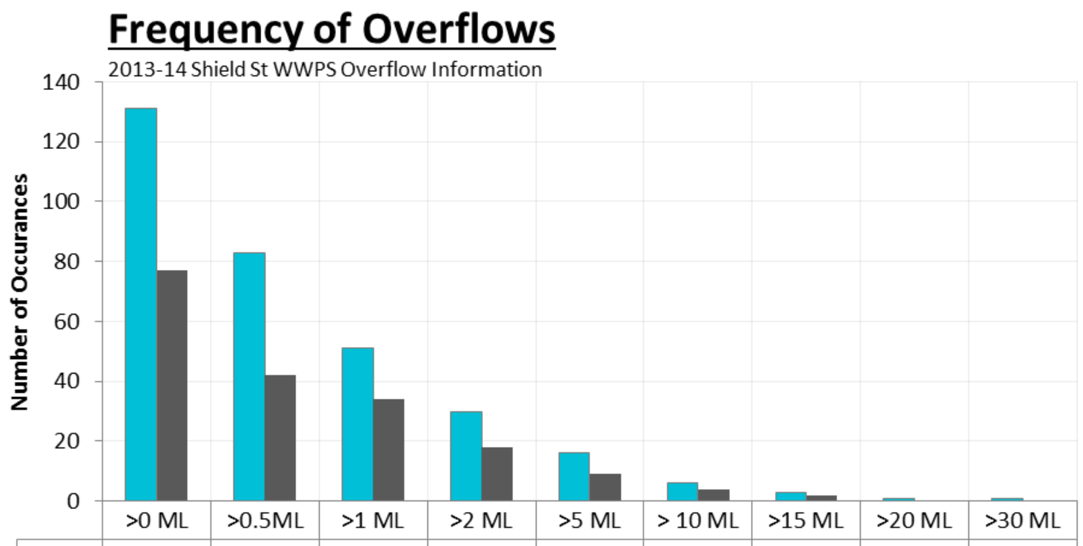


Figure 5-19: Shields Street SWPS November 2014 Pump Station Starts vs. Well Level and Tide Height

5.2.7 Shields Street SWPS – Discharge Volume and Frequency

Figure 5-20 shows the number of discharges exceeding selected volume thresholds in 2013 and 2014. Shields Street SWPS does not appear to have the extent of tidal infiltration issues that Willis Street SWPS has hence the number of discharges better reflects the variance in rainfall between the two years.



	>0 ML	>0.5ML	>1 ML	>2 ML	>5 ML	> 10 ML	>15 ML	>20 ML	>30 ML
2013	131	83	51	30	16	6	3	1	1
2014	77	42	34	18	9	4	2	0	0

Figure 5-20: Shields Street SWPS Overflow Information

Figure 5-21 below shows the percentage of overflows smaller than a given volume. The sharp increase shows that the majority of overflows are low volume; 90% of overflows are under 6 ML. The last 10% of overflows range from 6-21 ML.

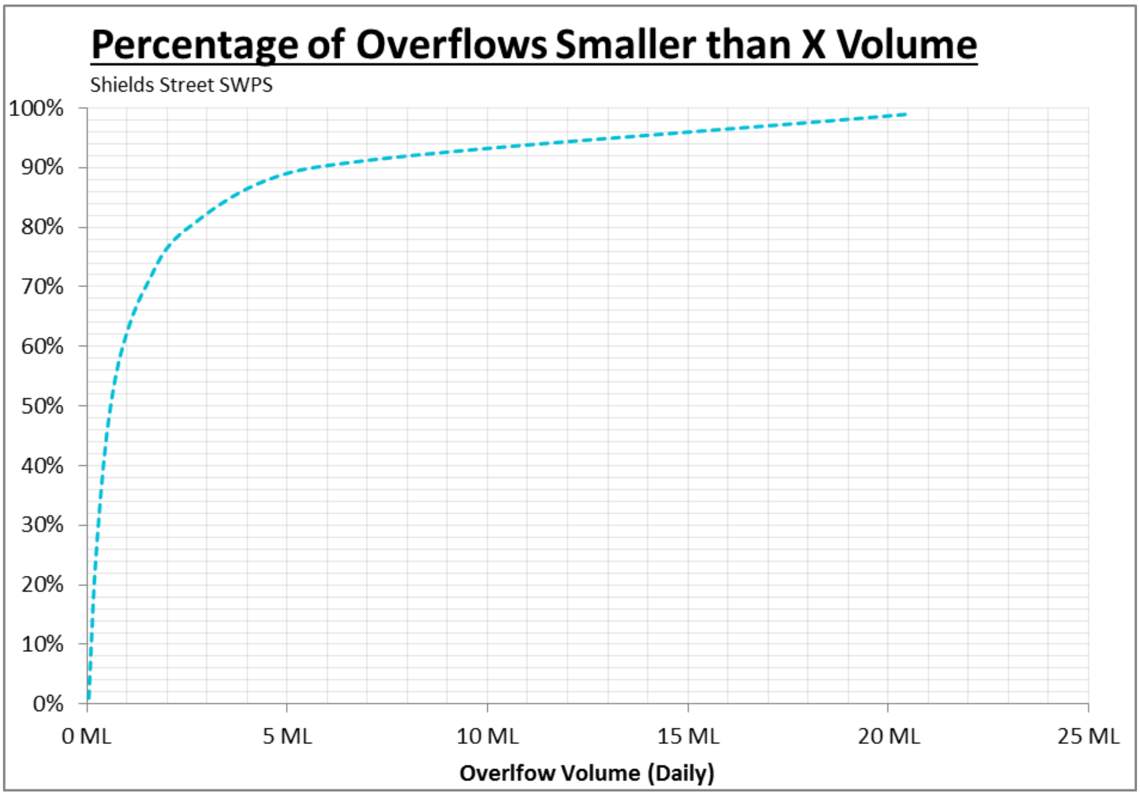


Figure 5-21: Shields Street SWPS Percentage Overflows Smaller than X Volume

Figure 5-22 below shows all overflow events for the Shields Street SWPS for the 2013 and 2014 calendar years. The highest ejection volume was approximately 30 ML which occurred with a daily rainfall amount of over 50 mm. There were numerous overflows on zero rainfall days, the cause of these are unknown, but may be due to the aforementioned tidal infiltration issue or erroneous rainfall readings.

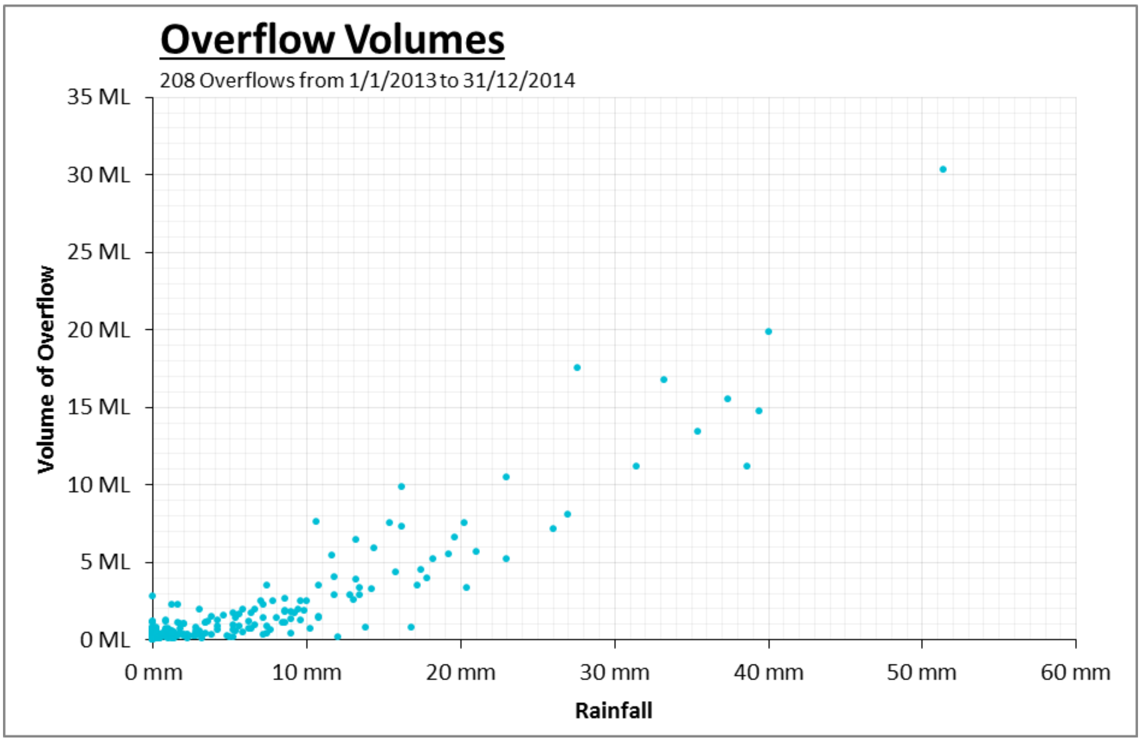


Figure 5-22: Shields Street SWPS Details on all Overflows Measured in 2013 and 2014

Figure 5-23, Figure 5-24, Table 5-8 and Table 5-9 below show the Shields Street SWPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data with an assumed constant flow rate of 2,115 L/s and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge. Using a constant flow rate is considered a reasonable assumption of flows entering the North Esk River, although the pump flow rate does vary somewhat with the river level due to the change in pumping head.

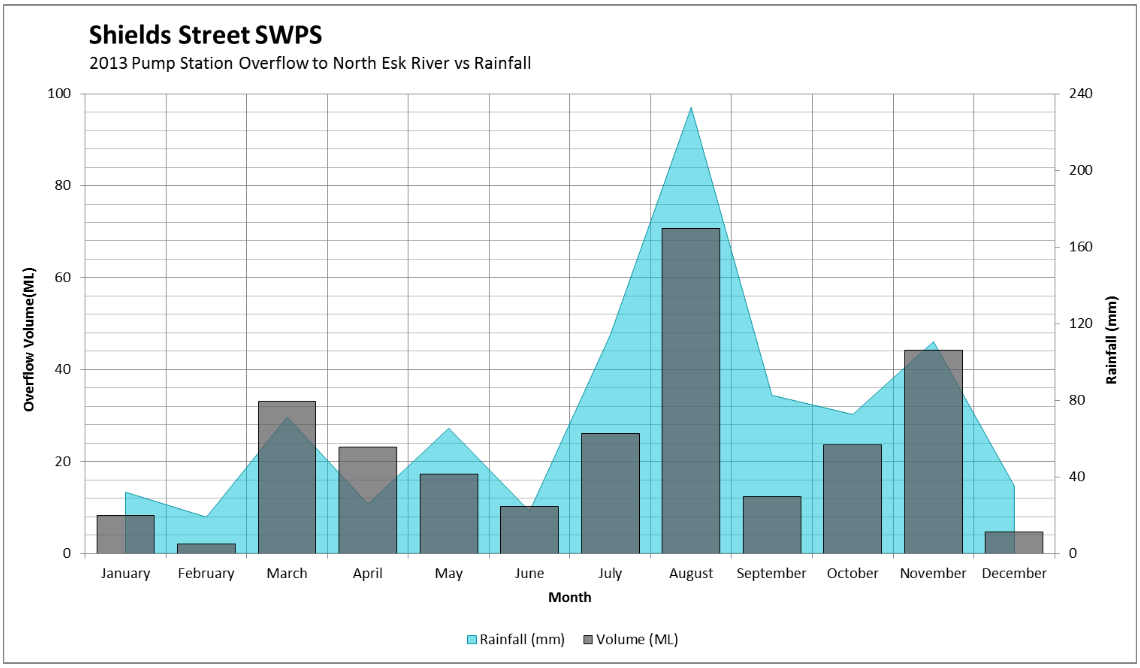


Figure 5-23: Shields Street SWPS Monthly Volume Ejected vs. Rainfall (2013)

Table 5-8: Shields Street SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Ejected (ML)	8.2	2.1	33.1	23.2	17.3	10.2	26.1	70.7	12.4	23.6	44.2	4.6	**275.7**

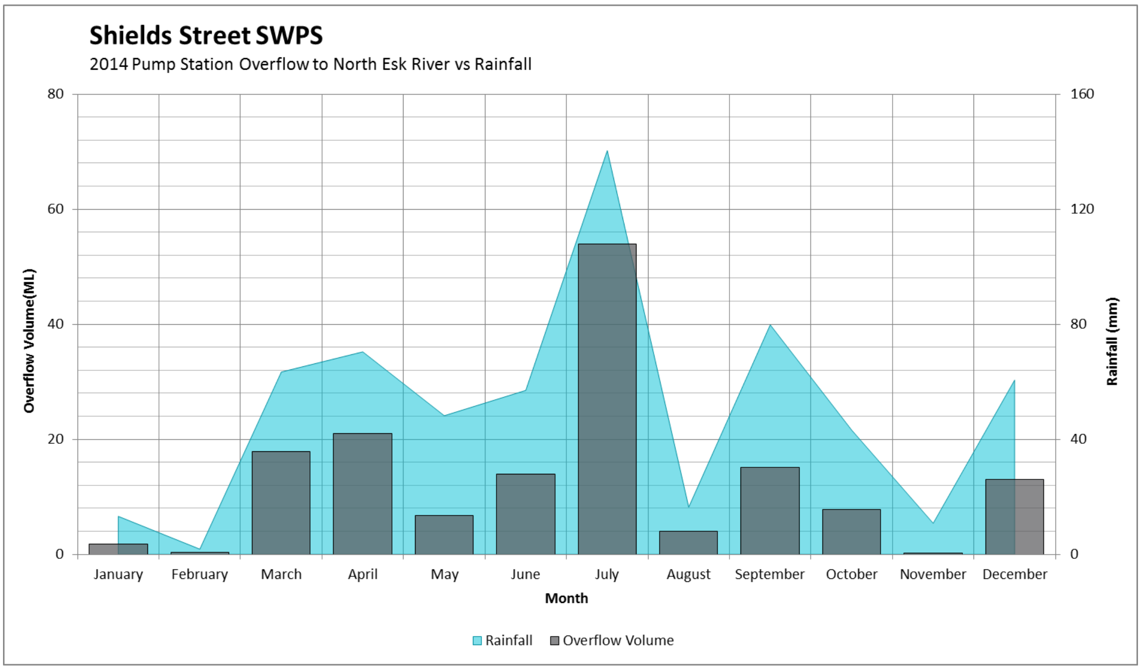


Figure 5-24: Shields Street SWPS Monthly Volume Ejected vs. Rainfall (2014)

Table 5-9: Shields Street SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Ejected (ML)	1.8	0.3	17.9	21	6.8	13.9	53.9	4	15.1	7.8	0.2	13	**155.7**

5.2.8 Shields Street SWPS – Likelihood of Discharge

The likelihood of ejection for Shields Street SWPS for a given daily rainfall is shown in Figure 5-25 below. The frequency of ejection follows a similar trend to Willis Street SWPS but with lower ejection frequencies and volumes. This is most likely due to a lower total tidal infiltration causing less ejection events from the pump station and difference in catchment characteristics.

Figure 5-25 suggests that a daily rainfall greater than 5mm will likely result in a CSO.

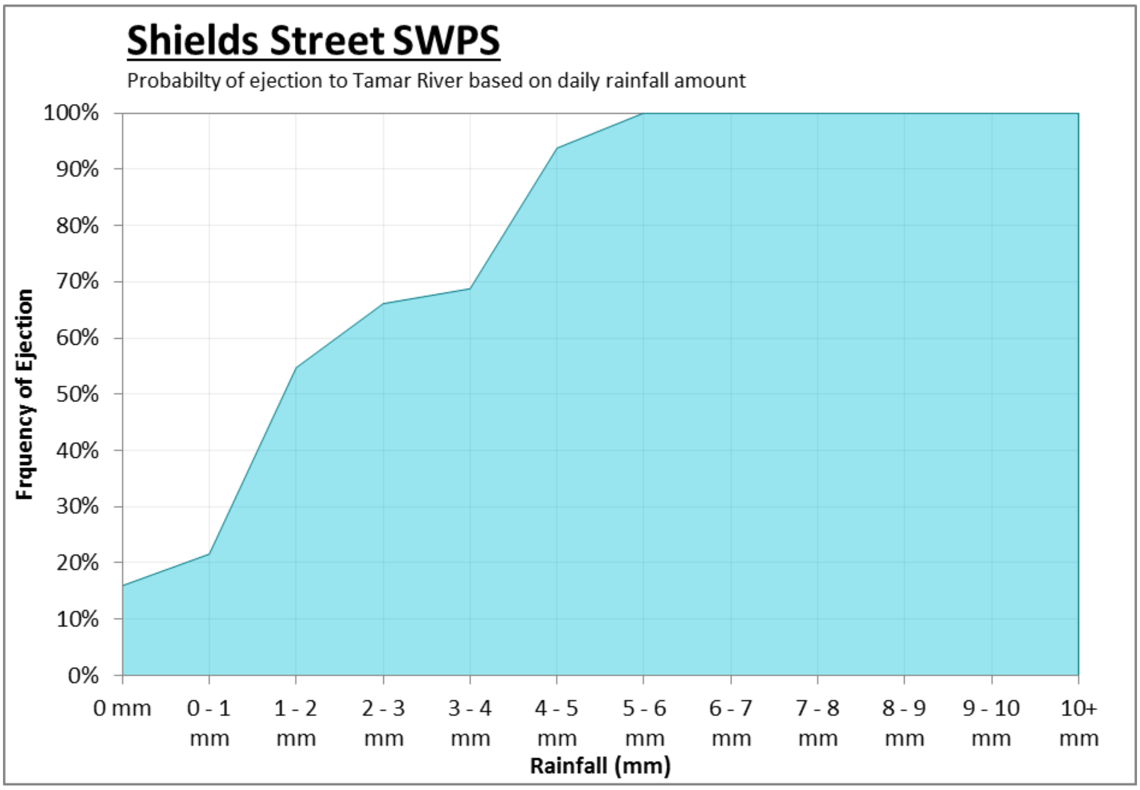


Figure 5-25: Shields Street SWPS Probability of Discharge vs. Rainfall Amount

5.2.9 Tamar Street SWPS – Overview

The Tamar Street SWPS is a CSO ejector station located on the Launceston esplanade adjacent to the North Esk River. The Tamar Street SWPS was upgraded in 2013. The existing wet well was reused and epoxy coated, but the internal assets were replaced and the overflow pipes were put over the flood levy to prevent tidal infiltration. Flow control into the pump station is very similar to Willis Street and Shields Street SWPS. The flow passes through a manhole with a weir that guides flow down the esplanade and ultimately to the St. John Street SPS. The station also has a dedicated stormwater inlet.

In normal dry weather operations the station will receive no or very little flow. There may be some overtopping of the weir in peak flows or inflow via the separate stormwater main from street runoff. Wastewater that enters the stations wet well will either be pumped back into the gravity system by the sump pump or ejected to the North Esk River if flows are large enough. The station contains two ejector pumps rated at 109 kW with a maximum duty point of 680 L/s at 7.0 m head; however these pumps are equipped with VSDs that ramp up in proportion to the wet well height to 92% of maximum frequency, see below Figure 5-26. SCADA information suggests that the VSD ranges from 35 to 46 Hz, representing 70-92% frequency. For the purposes of calculating overflow volumes the pumps have been assumed to run at an average of 80% at 7.0m head giving a duty flow rate of 510 L/s. The installed sump pump has a duty point of 14 L/s at 8.8 m head.

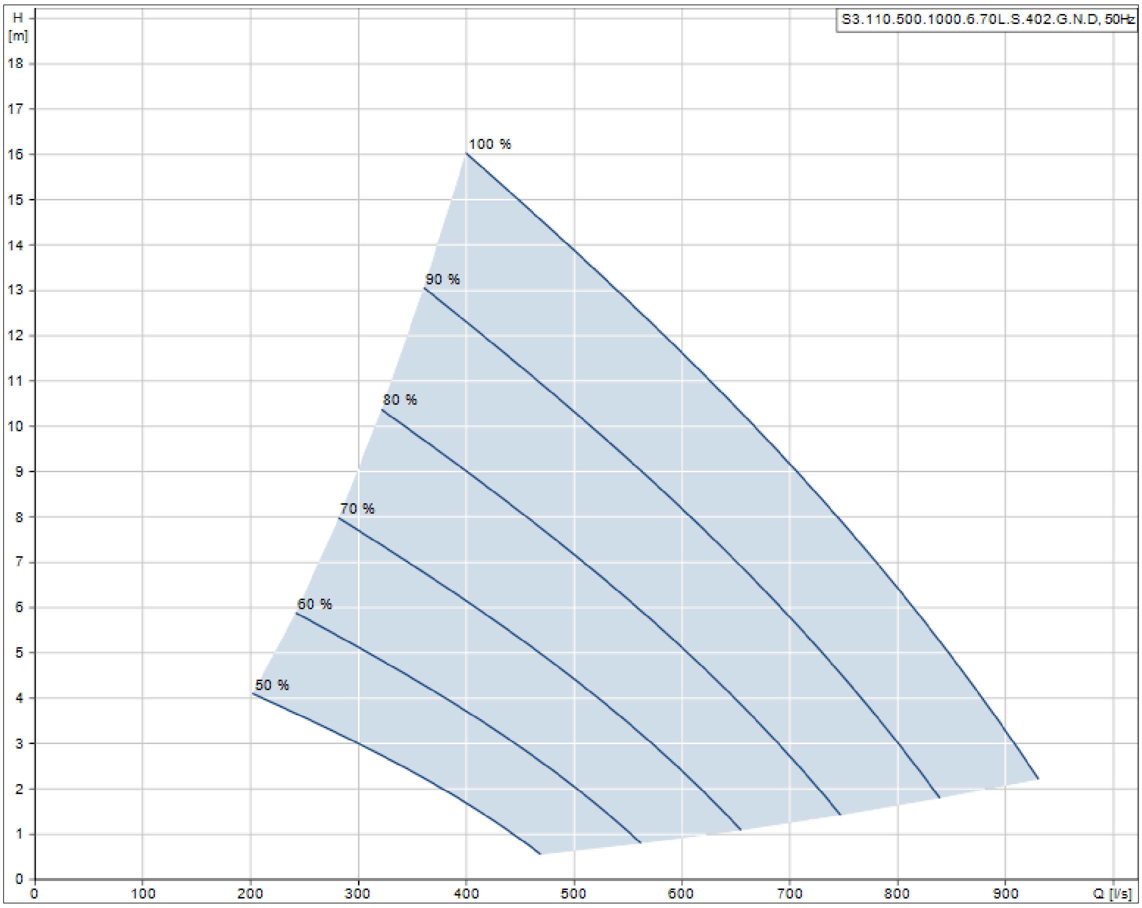


Figure 5-26: Tamar Street SWPS Ejector Pump with VSD Curves

5.2.10 Tamar Street SWPS – Infiltration Issues

The construction of the new overflow piping arrangement has remedied the issues with tidal infiltration into the pump station.

5.2.11 Tamar Street SWPS – Discharge Volumes and Frequency

Due to the upgrade works that were completed in 2013, only 2014 annual data is available for the Tamar Street SWPS. It is expected that with the reconfiguration of the overflow pipework that the volume ejected is not impacted by tidal infiltration. For the purpose of this report the ejection pump flow rates were assumed to be 510 L/s each.

Figure 5-27 below shows the number of overflow events at Tamar Street SWPS that were over a trigger threshold value. Tamar Street SWPS has the second lowest discharge volumes of the four SWPS in the St John Street/Esplanade Catchment.

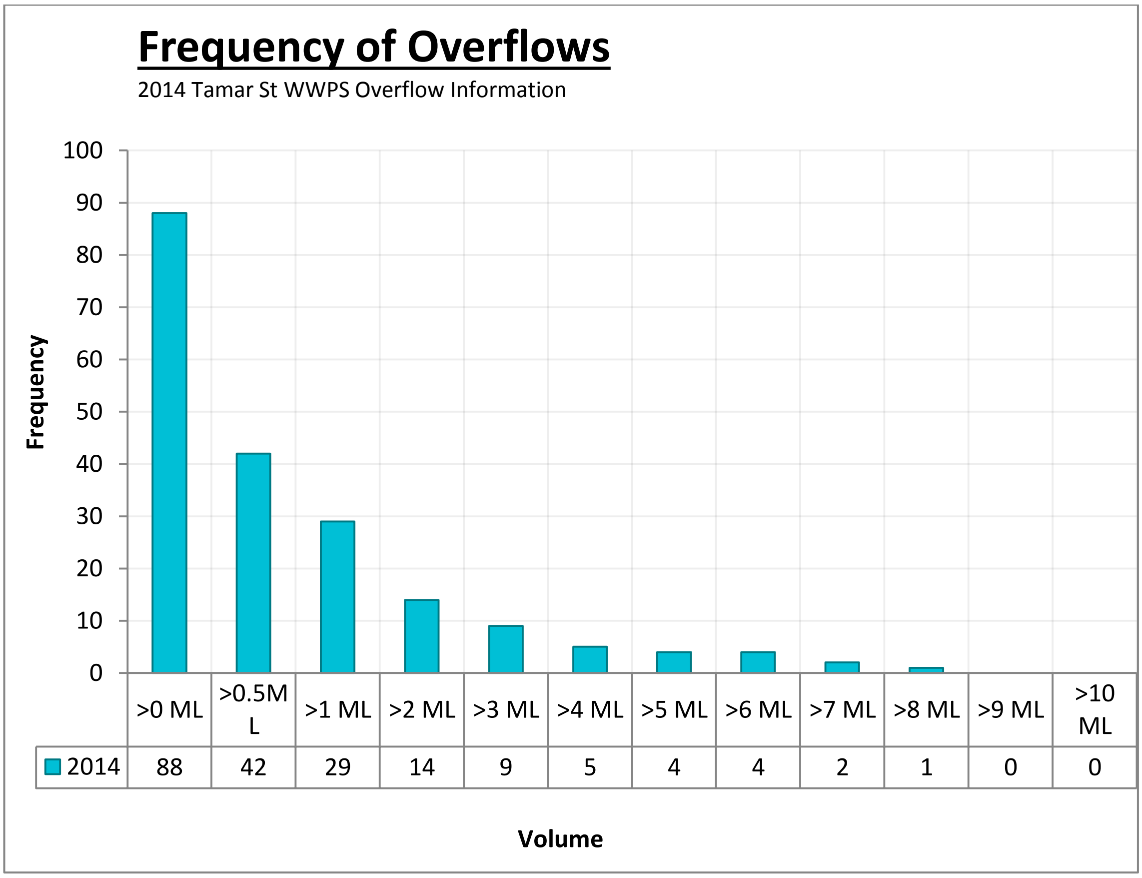


Figure 5-27: Tamar Street SWPS Overflow Information

Figure 5-28 below shows the percentage distribution of overflows under a certain volume. In comparison to Shields Street and Willis Street SWPS, Tamar Street SWPS has a relatively moderate distribution. The initial steepness remains but flattens off at a lower rate, indicating a more even distribution of overflow volumes.

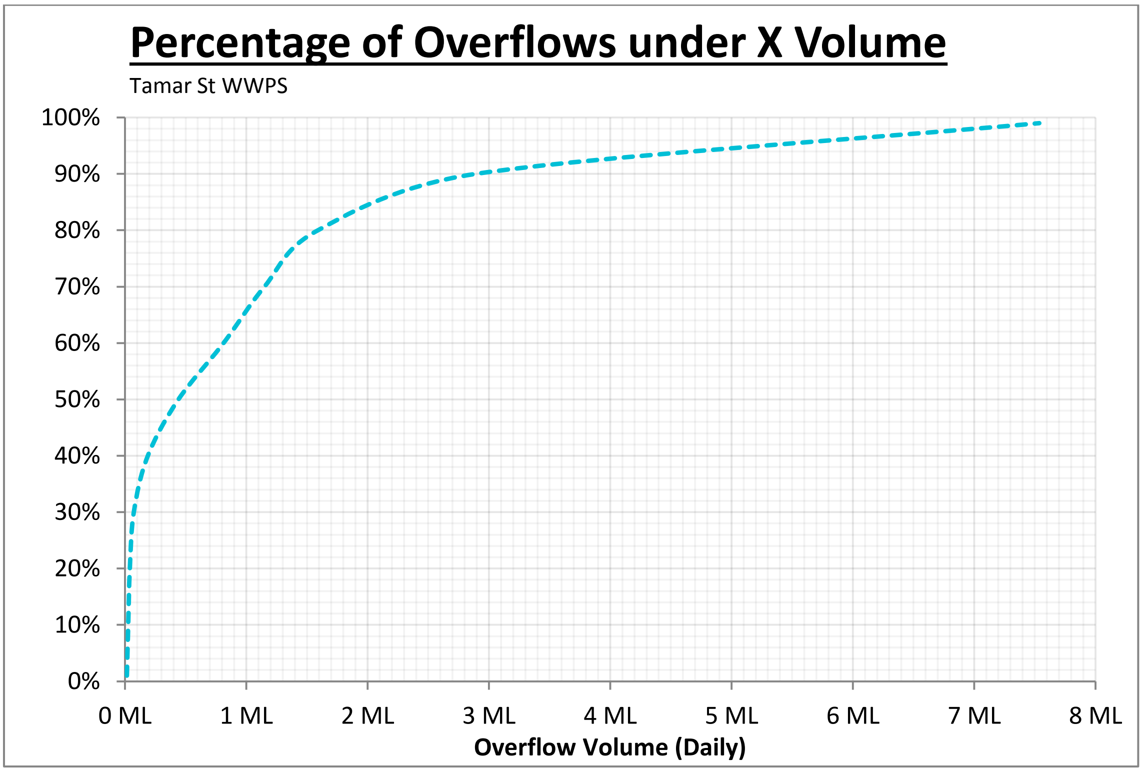


Figure 5-28: Tamar Street SWPS Percentage Overflows Smaller than X Volume

Figure 5-29 below shows all overflow events for the Tamar Street SWPS for the 2014 calendar years. The highest ejection volume was approximately 9 ML which occurred with a daily rainfall amount of almost 30 mm.

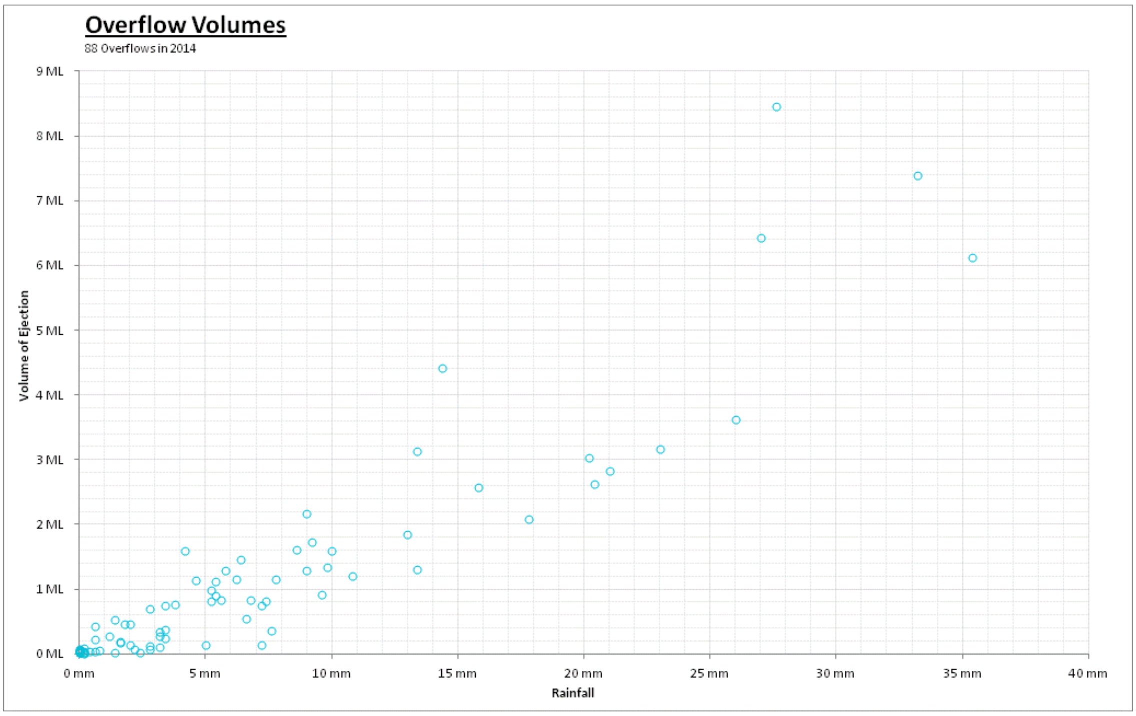


Figure 5-29: Tamar Street SWPS Details on all Overflows Measured in 2014

Figure 5-30 and Table 5-10 below show the Tamar Street SWPS monthly discharge volume against monthly rainfall for 2014. The information was derived using the pump start/stop data with an assumed nominal flow rate of 510 L/s and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge. Using a constant flow rate is considered a reasonable assumption of flows entering the North Esk River, although the pump flow rate does vary somewhat due to the VSDs ramping up and down and the variation in pumping head due to changing river level height.

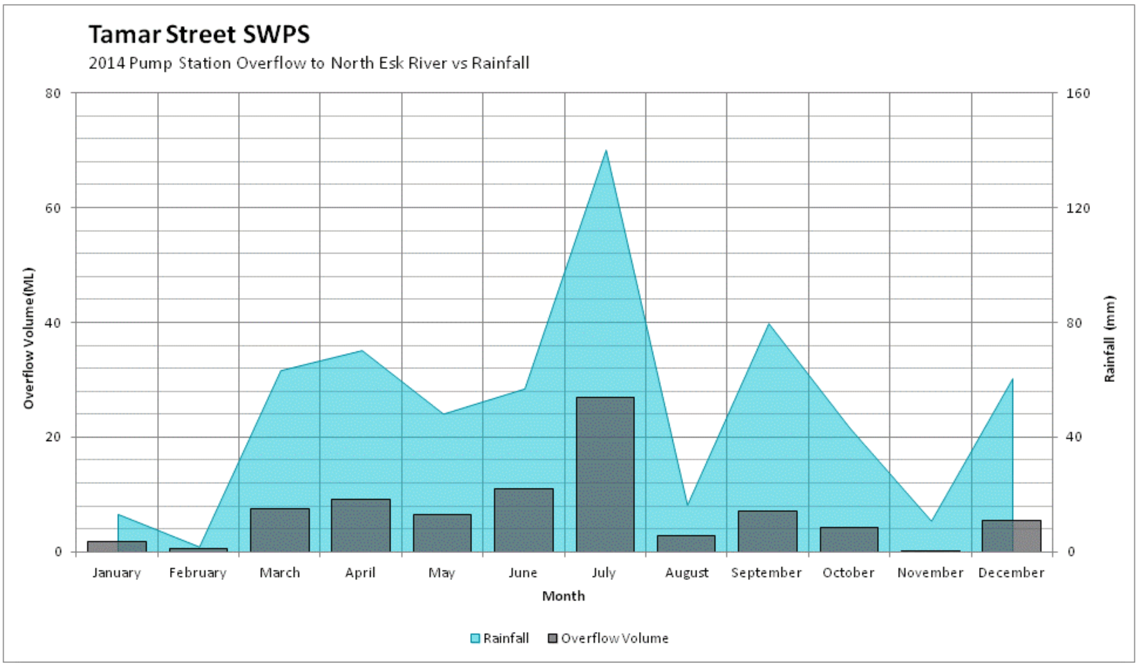


Figure 5-30: Tamar Street SWPS Monthly Volume Ejected vs. Rainfall (2014)

Table 5-10: Tamar Street SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Ejected (ML)	1.8	0.5	7.6	9.2	6.5	10.9	27	2.7	7.1	4.2	0.1	5.5	**83.1**

5.2.12 Tamar Street SWPS – Likelihood of Discharge

Figure 5-31 below shows the likelihood of discharge is below 10% on a dry day for the Tamar Street SWPS. This value is lower than the other SWPS along the Esplanade predominantly this is due to the lack of tidal infiltration. As expected the probability of discharge increases with the rainfall amount. There is a small anomaly where the probability of discharge decreases at 2-3 mm. It is expected that with a larger dataset would give the discharge probability a more consistent upward trend. Figure 5-31 suggests that a daily rainfall greater than 4 mm will likely result in a CSO.

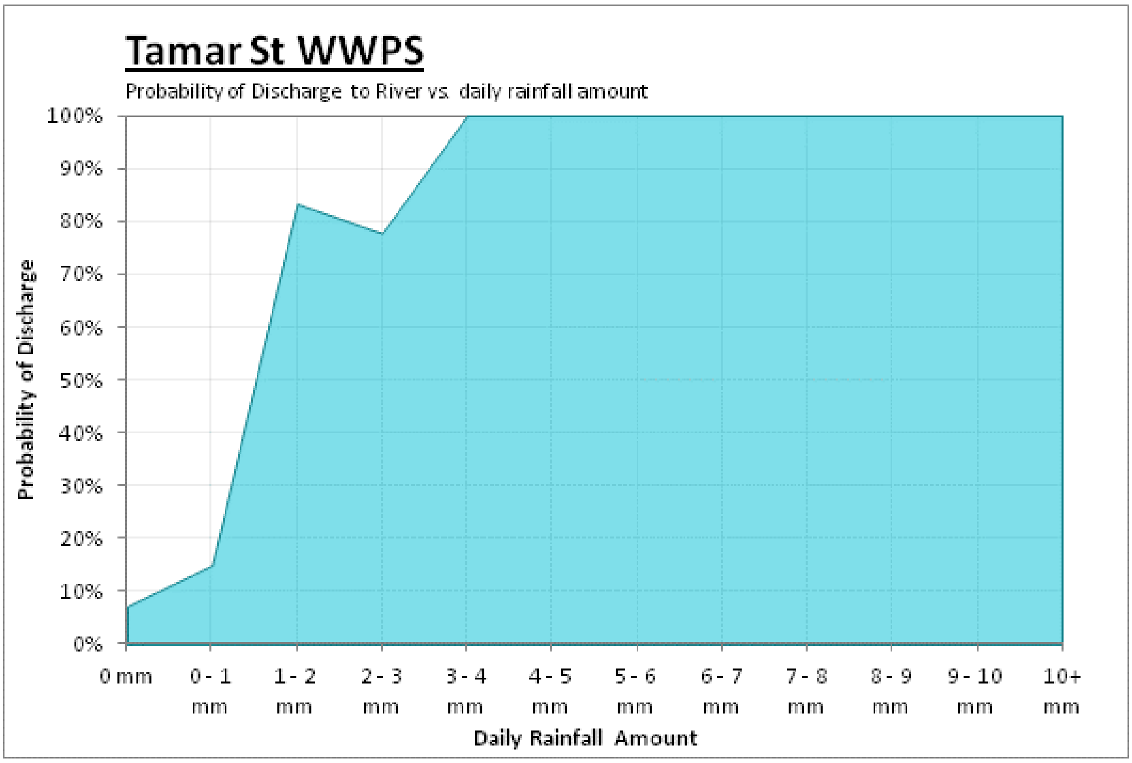


Figure 5-31: Tamar Street SWPS Probability of Discharge vs. Rainfall Amount

5.2.13 Lower Charles Street SWPS - Overview

The Lower Charles Street SWPS is located at the northern end of Charles Street and is approximately 200 metres from the nearby North Esk River. The Lower Charles Street SWPS was constructed in the 1980's by the Launceston City Council. There was a substantial amount of work completed at the time of construction to separate the sewer and stormwater infrastructure in this catchment. As shown in Figure 5-32 below the sewer trunk main bypasses the pump station and is directed to the St. John Street SPS for pumping to Ti Tree Bend STP. The stormwater in the catchment is all directed to the pump station. The SWPS is designed to pump stormwater over the levee and into the North Esk River however it is considered that there are still a small number of interconnections with the separated sewer mains in the catchment. Subsequently, during prolonged or high intensity wet weather periods it is possible that combined flows are pumped to the river.

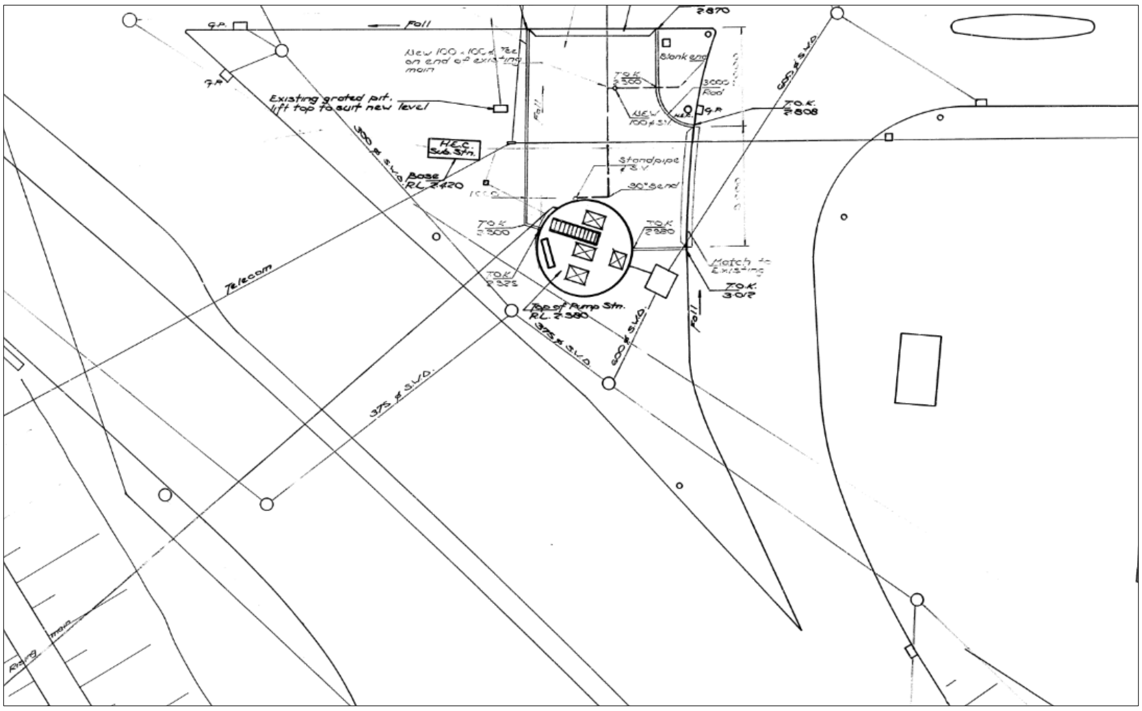


Figure 5-32: Lower Charles Street SWPS Locality Plan

5.2.14 Lower Charles Street SWPS – Discharge Volume and Frequency

Figure 5-33 shows the number of discharges exceeding selected volume thresholds in 2013 and 2014. Lower Charles Street SWPS is a much smaller catchment than the other stations in the Esplanade Sub-catchment and consequently records much smaller overflow volumes.

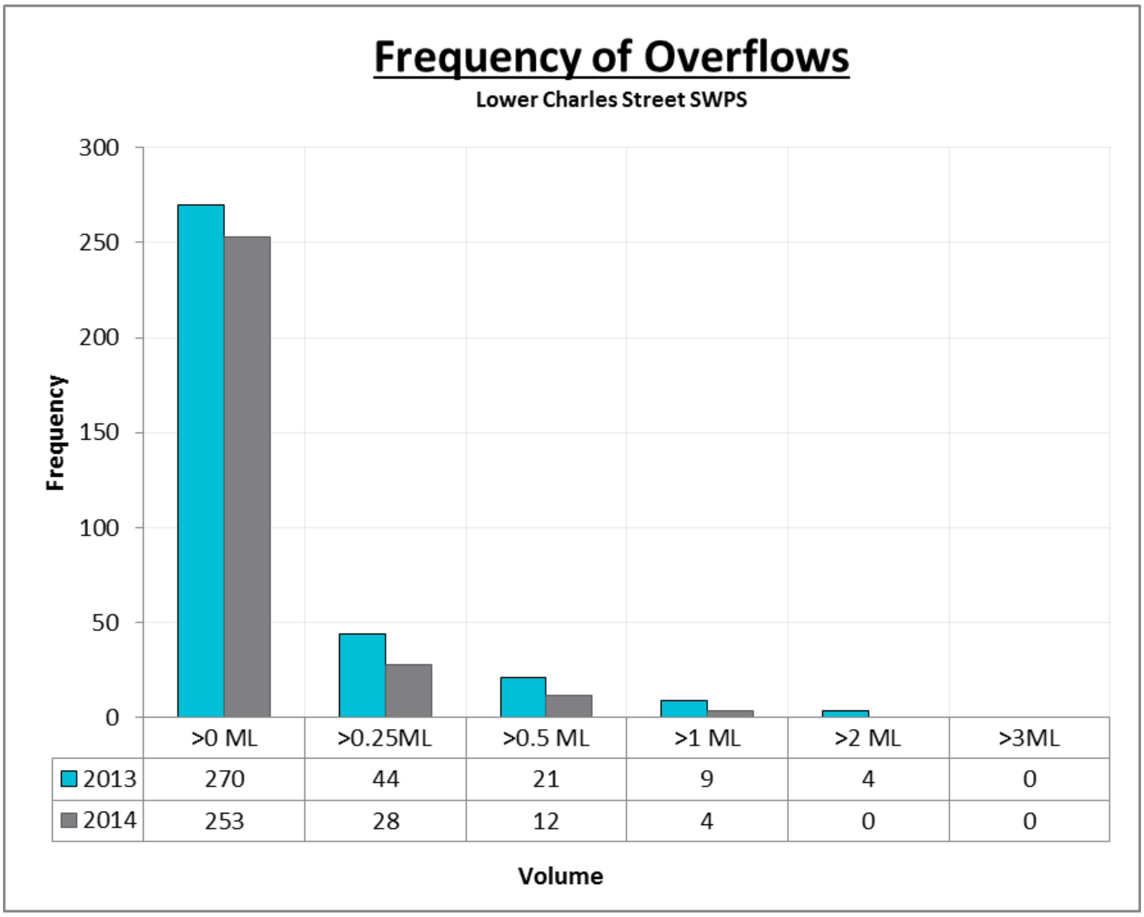


Figure 5-33: Lower Charles Street SWPS Discharge Information

It is worth noting that in the 2013 and 2014 period over which the assessment was completed of the 310 rainfall days across the two years, 266 days resulted in pumping to the river the other 44 either did not generate enough flow to cause the pumps to start and/or were absorbed by permeable surfaces in the catchment.

This result is of interest when assessing the performance of the ejector SWPS in the Esplanade catchment as it indicates that the combined system is completely capturing and carrying forward stormwater for treatment at the Ti Tree Bend STP during lower intensity or volume rainfall periods.

The other issue worth noting in this assessment is that there were 523 days over the two year period that the pump station ejected but only 310 rainfall days. This indicates the presence of a base flow into the station that is either groundwater infiltration or incomplete separation of the catchment.

Figure 5-34 below shows the percentage of overflows smaller than a given volume. The sharp increase shows that the majority of overflows are low volume; 90% of overflows are under 0.4 ML. The last 10% of overflows range from 0.4-2.5 ML. The volume of stormwater ejected is comparatively low due to the small size of the catchment.

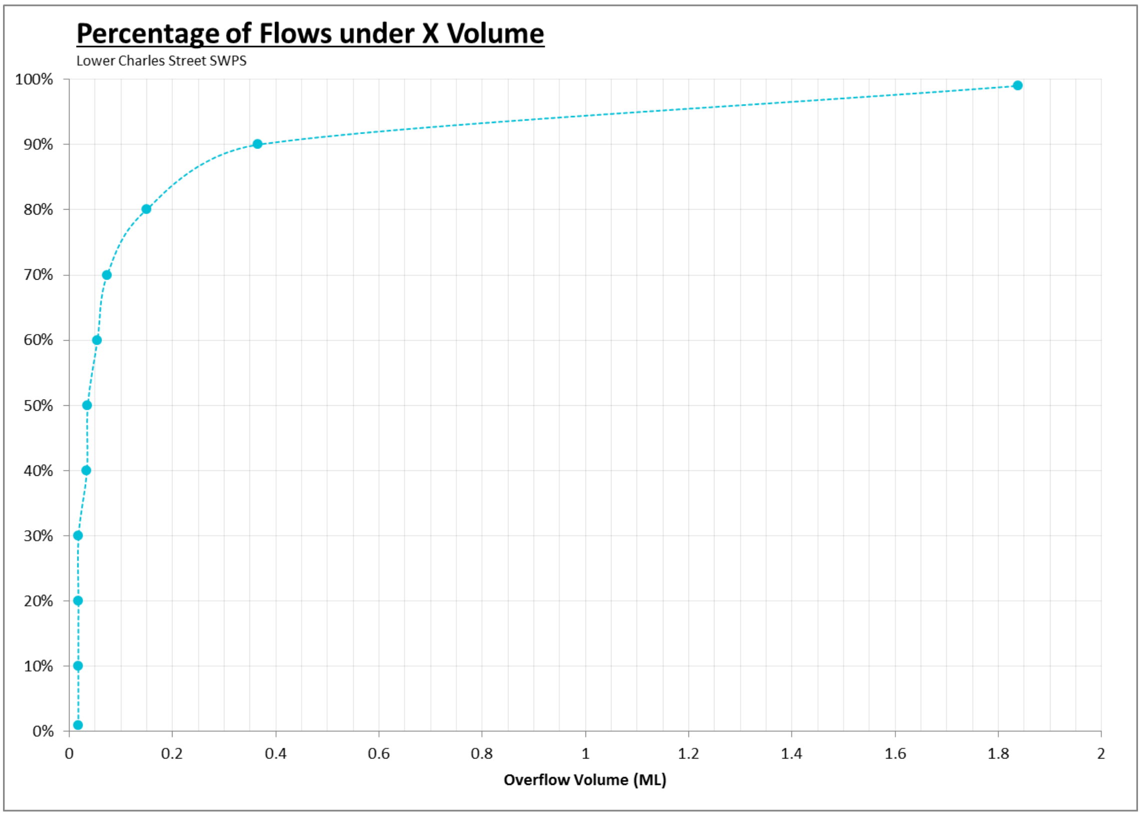


Figure 5-34: Lower Charles Street SWPS Percentage Flows Smaller than X Volume

Figure 5-35 below shows all flow events for the Lower Charles Street SWPS for the 2013 and 2014 calendar years. The largest volumes of stormwater pumped were four events during 2013 where almost 2.5 ML was pumped to the river, each of these events occurred on days with a rainfall amount of greater than 30 mm.

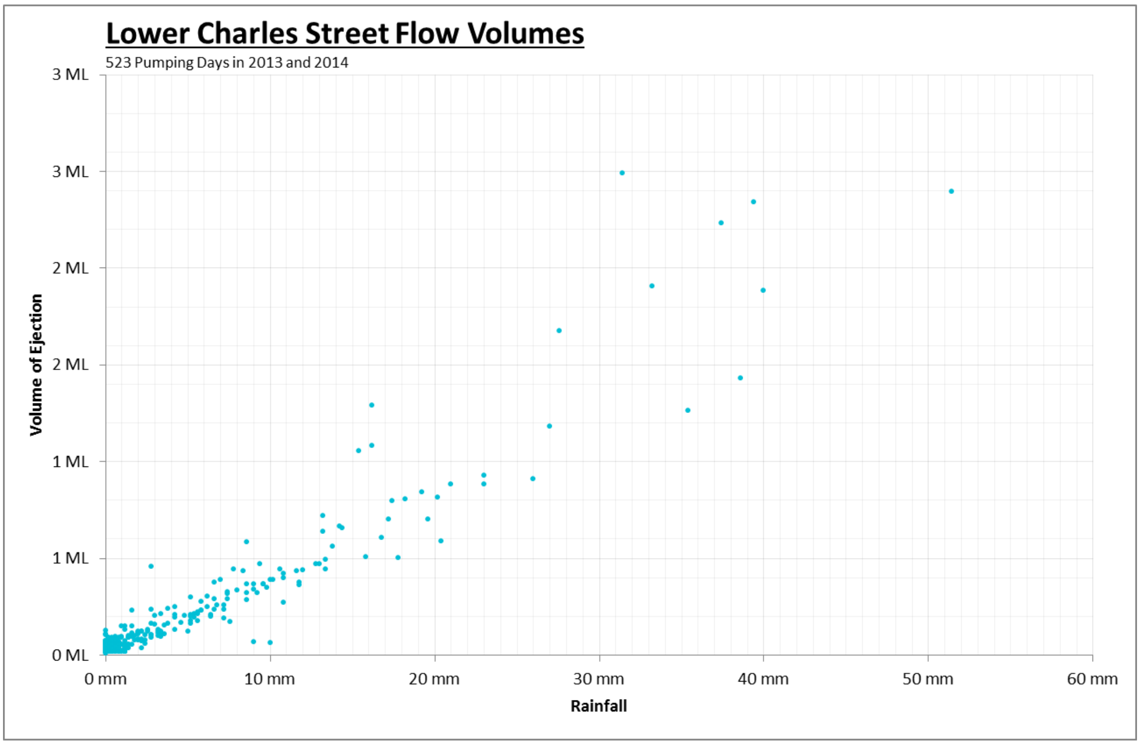


Figure 5-35: Lower Charles Street SWPS Details on all Flows Measured in 2013 and 2014

Figure 5-36, Figure 5-37, Table 5-11 and Table 5-12 show the Lower Charles Street SWPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data with an assumed nominal flow rate of 165 L/s per pump and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge.

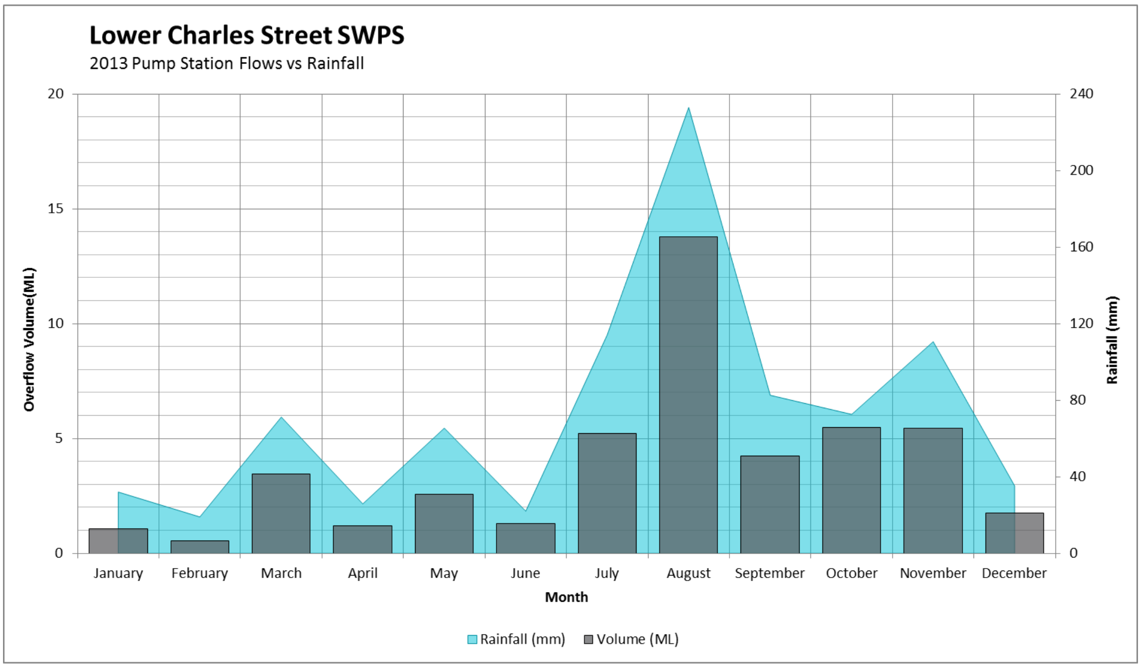


Figure 5-36: Lower Charles Street SWPS Monthly Volume Pumped vs. Rainfall (2013)

Table 5-11: Lower Charles Street SWPS Pump Station Monthly Volume Pumped vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Pumped (ML)	1.1	0.6	3.5	1.2	2.6	1.3	5.2	13.8	4.2	5.5	5.4	1.8	**46**

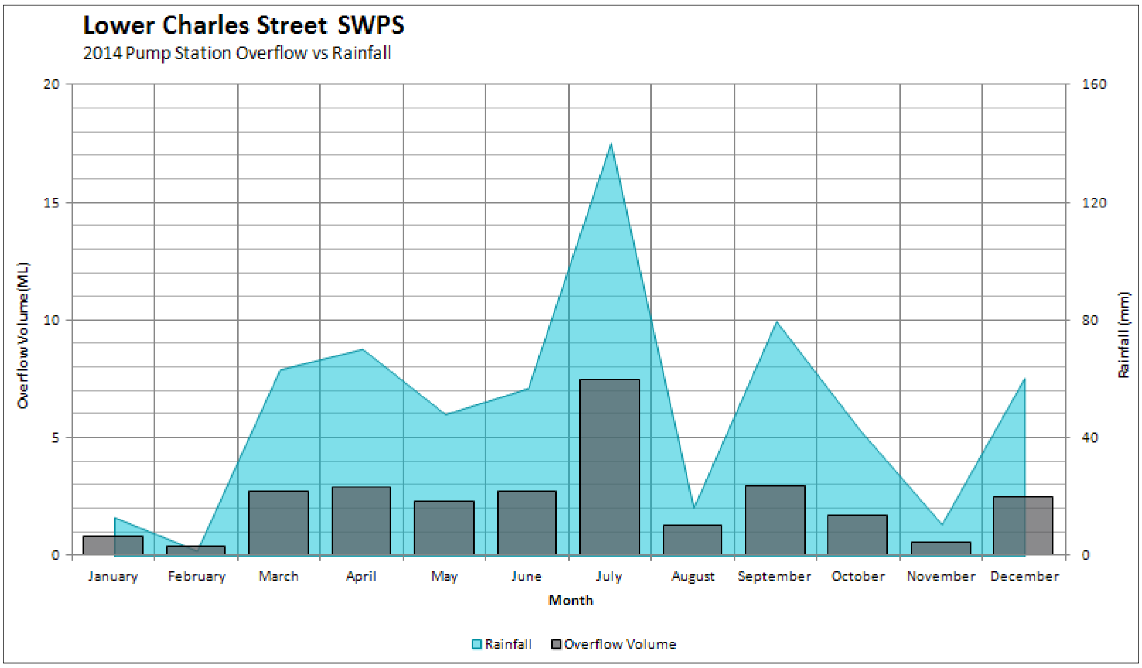


Figure 5-37: Lower Charles Street SWPS Monthly Volume Pumped vs. Rainfall (2014)

Table 5-12: Lower Charles Street SWPS Pump Station Monthly Volume Pumped vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Pumped (ML)	0.8	0.4	2.7	2.9	2.3	2.7	7.5	1.3	3.0	1.7	0.6	2.5	**28.3**

5.2.15 Lower Charles Street SWPS – Infiltration Issues

The number of days during which there was no rainfall recorded and pumping occurred at the Lower Charles Street SWPS would suggest that there is some form of base inflow issue. This is likely to be caused by a base flow to the SWPS from either groundwater infiltration or incomplete separation resulting in a small sanitary flow.

5.2.16 Lower Charles Street SWPS – Likelihood of Discharge

Figure 5-38 shows the likelihood of discharge is above 60% on a dry day for the Lower Charles Street SWPS. This is higher than all of the other TasWater Esplanade SWPS; this is likely to be caused by either a base sewer inflow suggesting that separation works were not completely successful it is also possibly caused by a base groundwater inflow or tidal infiltration. As expected the probability of discharge increases with the rainfall amount. It is highly probable (80%) that a daily rainfall of more than 2 mm will cause the Lower Charles Street SWPS to pump to the North Esk River.

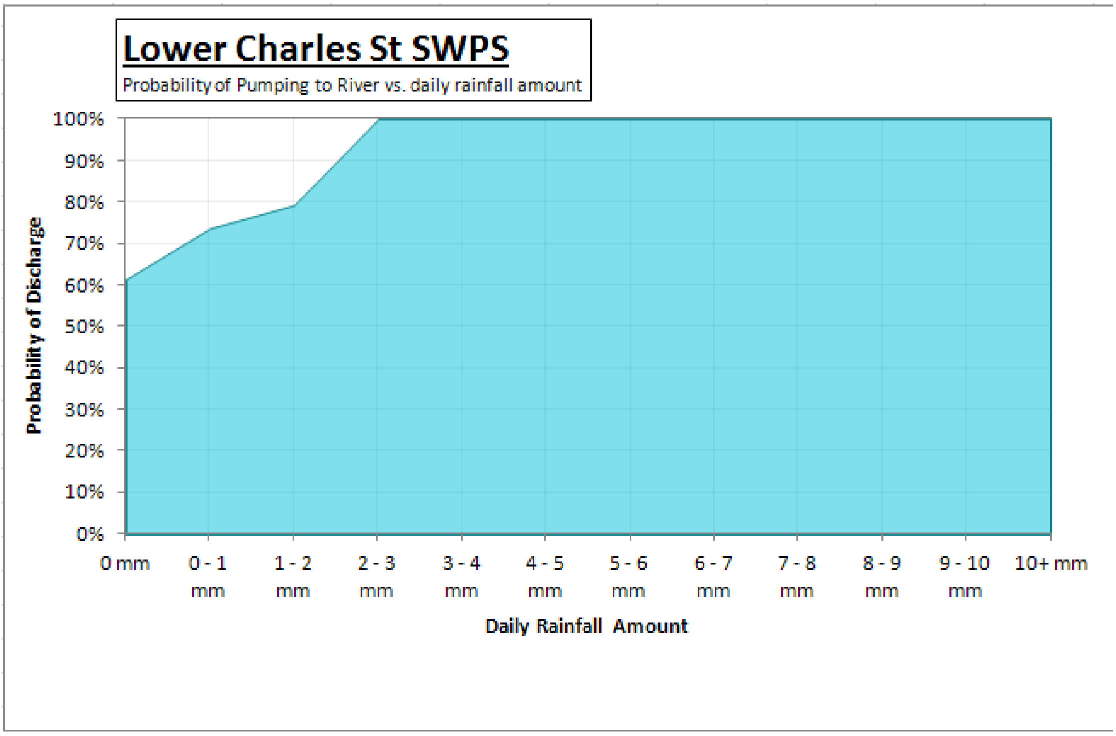


Figure 5-38: Lower Charles Street SWPS Probability of Discharge vs. Rainfall Amount

5.2.17 Racecourse Crescent SWPS - Overview

The Racecourse Crescent SWPS is located at the intersection of Racecourse Crescent and The Glebe and is approximately 100 metres from the nearby North Esk River. The catchment it drains is approximately 0.25 square kilometres. This SWPS is still owned by the Launceston City Council but was considered in the research project since it is immediately adjacent to the combined system and is still interconnected with some TasWater infrastructure. TasWater also monitors the station through SCADA so the pump station operating information could be extracted and used to develop pump station profiles.

The Racecourse Crescent SWPS was constructed in the 1970s by the Launceston City Council. There was a substantial amount of work completed at the time of construction to separate the sewer and stormwater infrastructure in this catchment.

The separated sewer trunk main bypasses the pump station and flows to Boland Street SPS from where it is pumped into the Esplanade combined trunk main. The stormwater in the catchment is all directed to the pump station. The SWPS is designed to pump stormwater over the levee and into the North Esk River however high levels in the mains leading to the Boland Street SPS can cause backflow into the stormwater pipes. Consequently during prolonged or high intensity wet weather periods it is possible that combined flows are pumped to the river.

5.2.18 Racecourse Crescent SWPS – Discharge Volume and Frequency

Figure 5-39 below shows the number of discharges exceeding selected volume thresholds in 2013 and 2014.

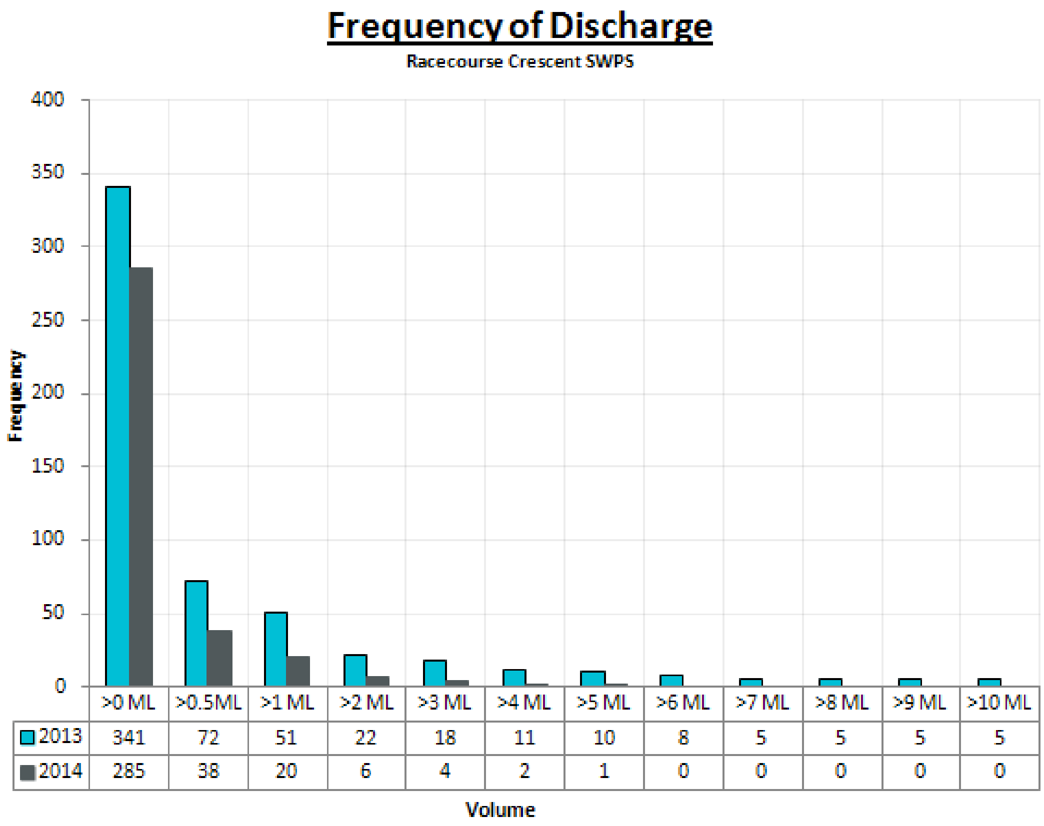


Figure 5-39: Racecourse Crescent SWPS Discharge Information

It is worth noting that in the 2013 and 2014 period over which the assessment was completed of the 310 rainfall days across the two years, 277 days resulted in pumping to the river the other 33 either did not generate enough flow to cause the pumps to start and/or were absorbed by permeable surfaces in the catchment.

This result is of interest for assessing the performance of the ejector SWPS in the Esplanade catchment as it indicates that the combined system is completely capturing and carrying forward stormwater for treatment at the Ti Tree Bend STP during lower intensity or volume rainfall periods.

Figure 5-40 below shows the percentage of overflows smaller than a given volume. The sharp increase shows that the majority of overflows are low volume; 90% of overflows are under 1.2 ML. The last 10% of overflows range from 1.2-15 ML.

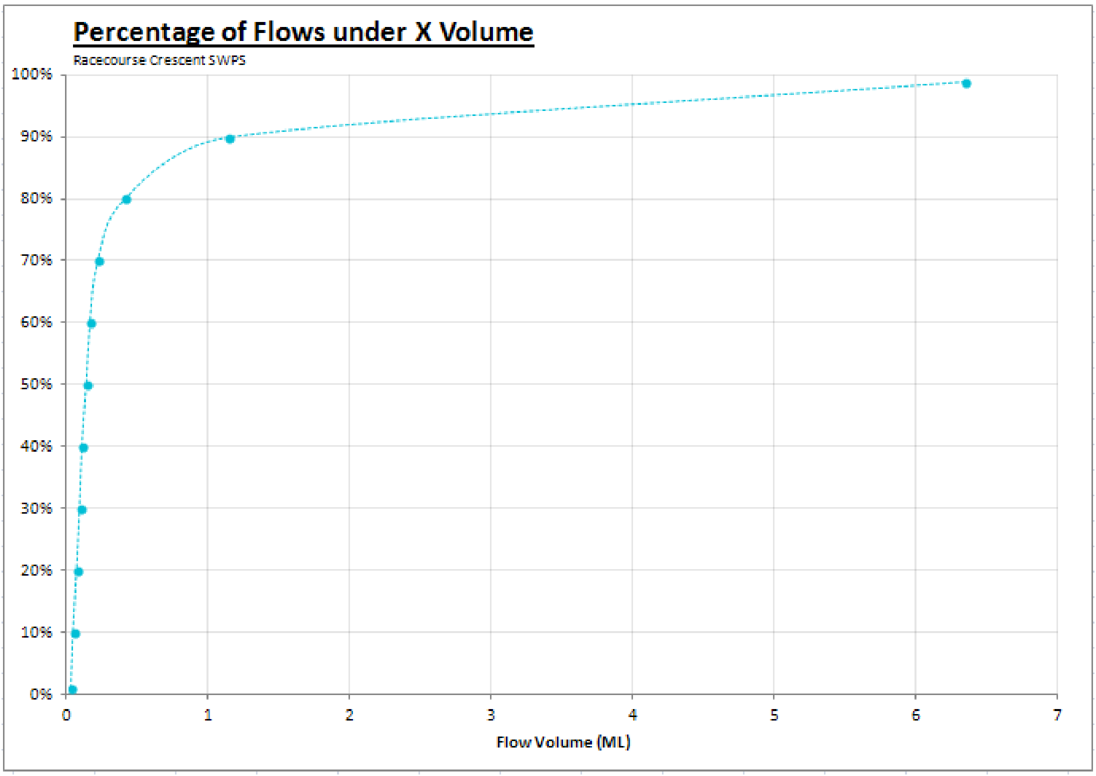


Figure 5-40: Racecourse Crescent SWPS Percentage Flows Smaller than X Volume

Figure 5-41 below shows all flow events for the Racecourse Crescent SWPS for the 2013 and 2014 calendar years. The highest volume of stormwater discharge was approximately 15 ML which occurred with a daily rainfall amount of just over 50 mm.

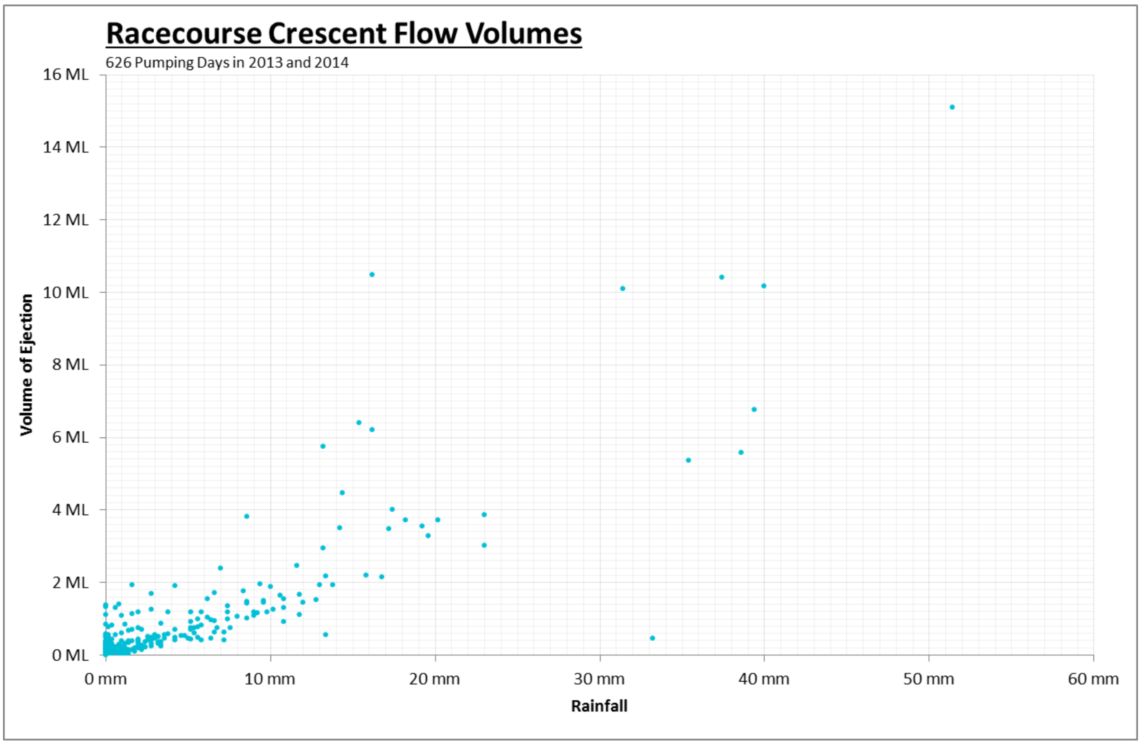


Figure 5-41: Racecourse Crescent SWPS Details on all Flows Measured in 2013 and 2014

Figure 5-42, Figure 5-43, Table 5-13 and Table 5-14 show the Racecourse Crescent SWPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data with an assumed nominal flow rate of 570 L/s per pump and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge. Using a constant flow rate is considered a reasonable assumption of flows entering the North Esk River, although the pump flow rate does vary somewhat with the river level due to the change in pumping head.

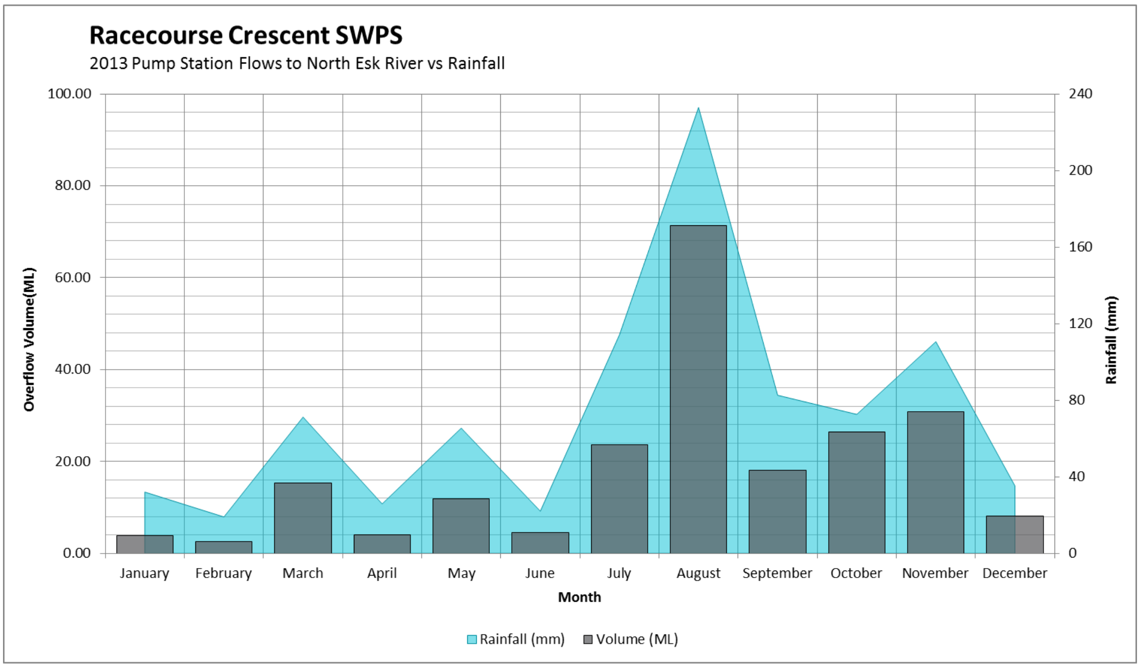


Figure 5-42: Racecourse Crescent SWPS Monthly Volume Pumped vs. Rainfall (2013)

Table 5-13: Racecourse Crescent SWPS Pump Station Monthly Volume Pumped vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Pumped (ML)	3.8	2.6	15.3	4.1	11.8	4.5	23.7	71.3	18.1	26.4	30.8	8.2	**220.5**

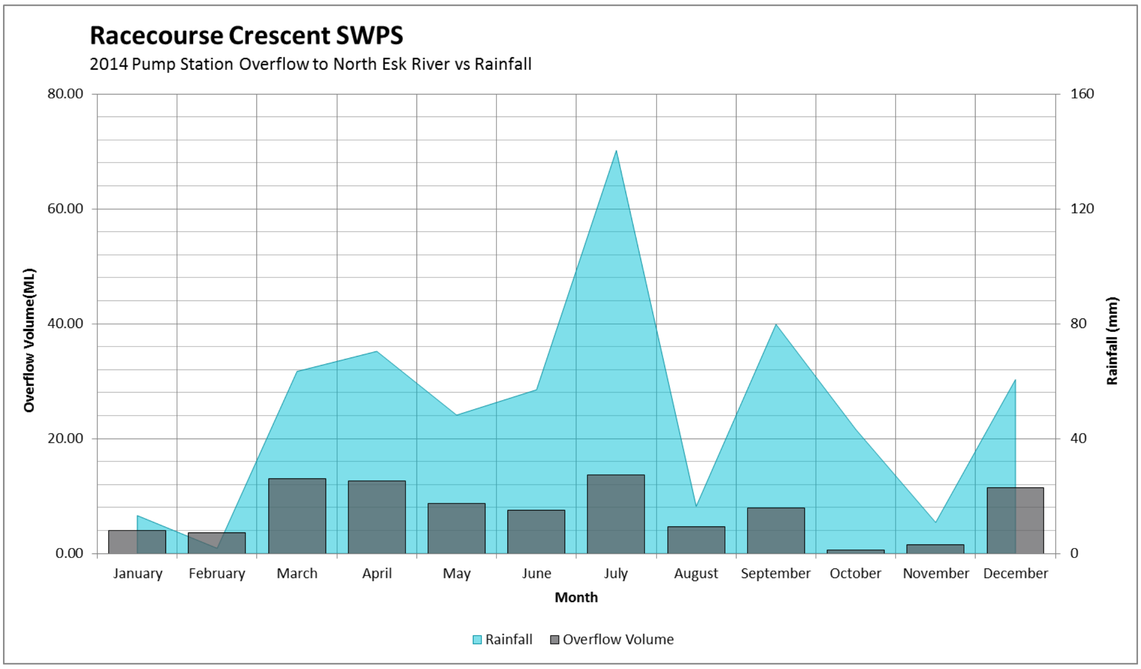


Figure 5-43: Racecourse Crescent SWPS Monthly Volume Pumped vs. Rainfall (2014)

Table 5-14: Racecourse Crescent SWPS Pump Station Monthly Volume Pumped vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Pumped (ML)	4.0	3.6	13.0	12.6	8.6	7.5	13.7	4.6	7.9	0.5	1.5	11.4	**88.9**

5.2.19 Racecourse Crescent SWPS – Infiltration Issues

The high number of days during which there was no rainfall recorded and pumping occurred at the Racecourse Crescent SWPS would suggest that there is some form of base inflow issue. This is likely to be caused either through tidal infiltration as at Shields Street and Willis Street SWPS or a base flow to the SWPS from either groundwater infiltration or incomplete separation resulting in a small sanitary flow.

5.2.20 Racecourse Crescent SWPS – Likelihood of Discharge

Figure 5-44 shows the likelihood of discharge is above 80% on a dry day for the Racecourse Crescent SWPS. This is higher than all of the SWPS in the Esplanade catchment; this is likely to be caused by either a base sewer inflow suggesting that separation works were not completely successful or caused by groundwater inflow or tidal infiltration. As expected the probability of discharge increases with the rainfall amount. It is highly probable (90%) that a daily rainfall of more than 1 mm will cause the Racecourse Crescent SWPS to pump to the North Esk River.

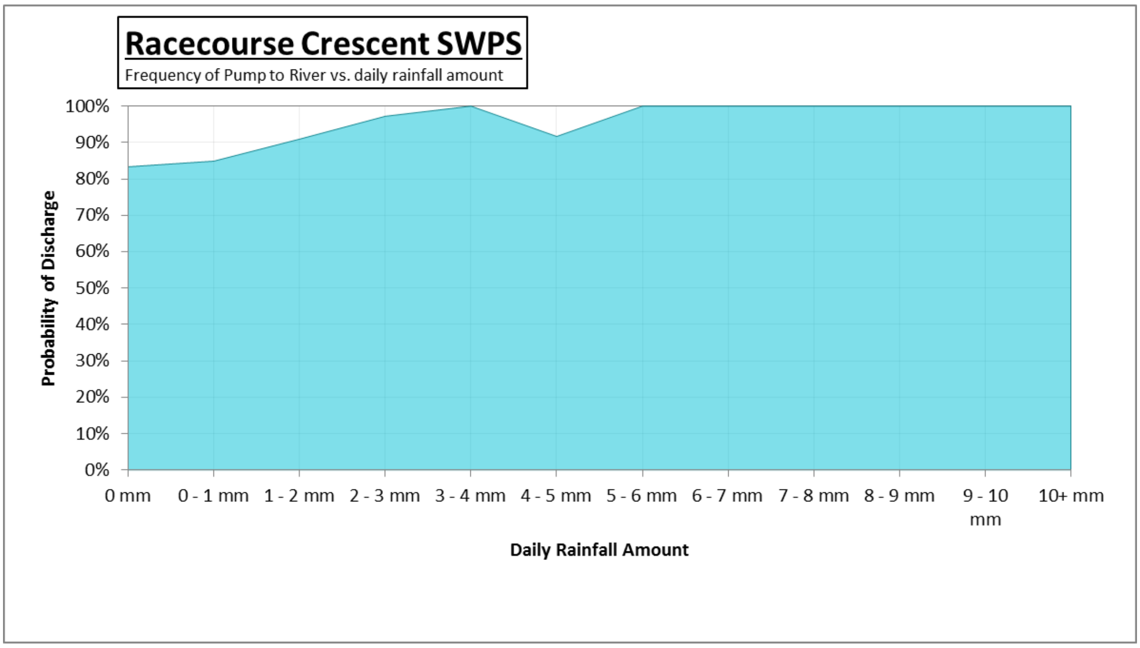


Figure 5-44: Racecourse Crescent SWPS Probability of Discharge vs. Rainfall Amount

5.3 Invermay (Forster Street) Catchment

The Invermay catchment is the third largest catchment within the LCSS with a service area of approximately 2.6 square kilometres. It captures sewage and stormwater from the residential area of Invermay located generally in the east of the catchment and trade waste flows from the south and west of the catchment. The catchment drains westerly to the Forster Street SPS.

Large sections of the Invermay catchment are on reclaimed land or in swampy areas and as such the catchment suffers from significant groundwater infiltration issues. The catchment is also very flat with a number of trunk mains laid at grades of 1: 1000 or less. The high water table and low soil bearing capacity in the local area causes settlement, as a result of which some pipes have moved overtime and are at negative grade. The ground movement has allowed solids to enter the pipe network and negative grades cause sewage settlement and ponding issues. The combined nature of the system is of benefit in this regard as it helps to periodically flush out low lying areas.

There are also two minor SWPS in the catchment that were considered in this study. The Waltonia SWPS that services a small industrial catchment on the river side of the flood levee and the Lytton Street SWPS that provides network relief to portions of the Forster Street SPS catchment. These two stations were both previously served by a single combined station however works have been completed over time to, as best possible, separate, the catchments so that the Waltonia and Lytton Street SPS both pump back into the Forster Street SPS catchment and the SWPS operate only during significant rainfall events.

5.3.1 Forster Street SPS – Overview

The Forster Street SPS is a combined sewer pump station located at the western end of Forster Street that services the entire Invermay Catchment. The SPS is one of the oldest operated by TasWater and was constructed in 1933 by the Launceston City Council.

During dry weather and low rainfall periods the two sewer pumps in the station pump flows into the City Rising Main for treatment at the Ti Tree Bend STP. In wet weather periods the four larger stormwater pumps operate and pump combined flows over the flood levee and into the Tamar River.

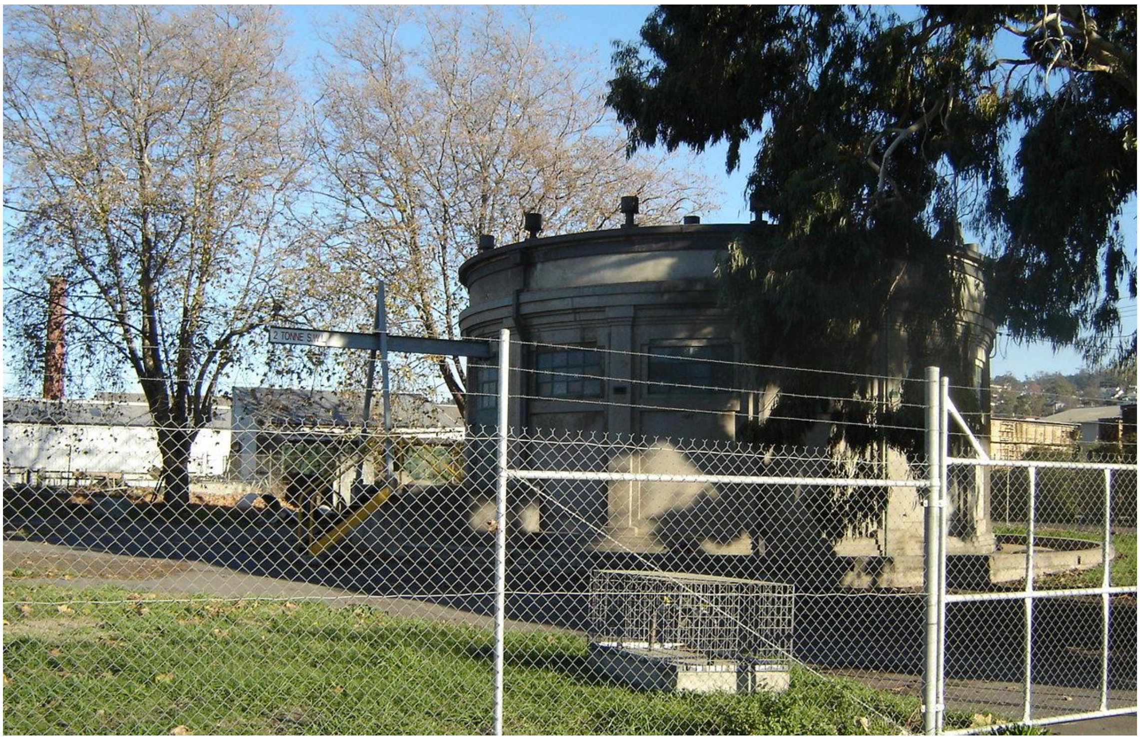


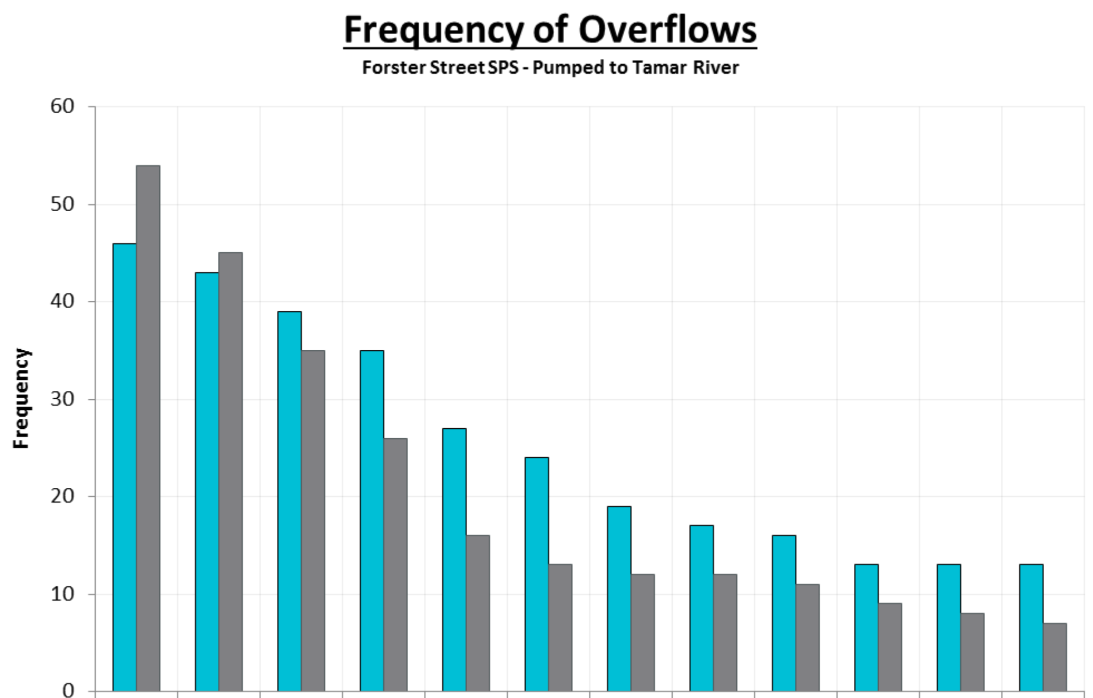
Figure 5-45: Forster Street SPS

5.3.2 Forster Street SPS – Infiltration Issues

The stormwater rising main from the Forster Street SPS was recently renewed as part of levee reconstruction works and has been reconfigured to pump over the levee. It is considered that with this change in operation that there is not an issue with tidal infiltration.

5.3.3 Forster Street SPS – Discharge Volume and Frequency

The Forster Street SPS overflowed 46 times in 2013 and 54 times in 2014. It should be noted that SCADA information for Forster Street SPS was not available before July 2013. Figure 5-46 below shows the number of discharges exceeding selected volume thresholds in 2013 and 2014.



	>0 ML	>0.5ML	>1 ML	>2 ML	>3 ML	>4 ML	>5 ML	>6 ML	>7 ML	>8 ML	>9 ML	> 10 ML
2013	46	43	39	35	27	24	19	17	16	13	13	13
2014	54	45	35	26	16	13	12	12	11	9	8	7

Figure 5-46: Forster Street SPS Overflow Information

Figure 5-47 below shows the percentile of overflows smaller than a given volume. As one of the largest pump stations in the combined system, the Forster Street SPS has significant combined sewer discharges. The majority (80%) of overflows were below 10 ML. The largest overflow was just over 50 ML; this overflow event occurred on a day with a large rainfall event (51.4 mm).

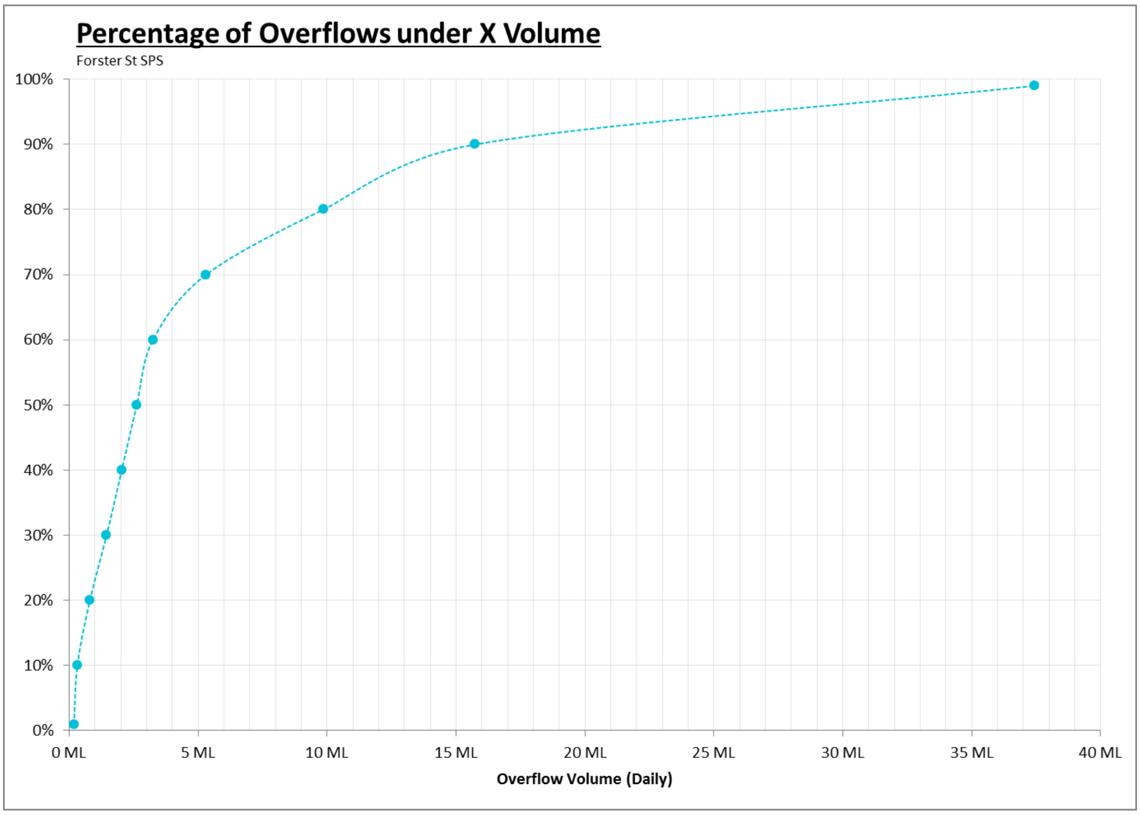


Figure 5-47: Forster Street SPS Percentage Overflows Smaller than X Volume

Plotted on Figure 5-48 below are the recorded overflows for 2013 and 2014 for the Forster Street SPS. The density shows that the majority of the overflows are of low volume and during low rainfall periods.

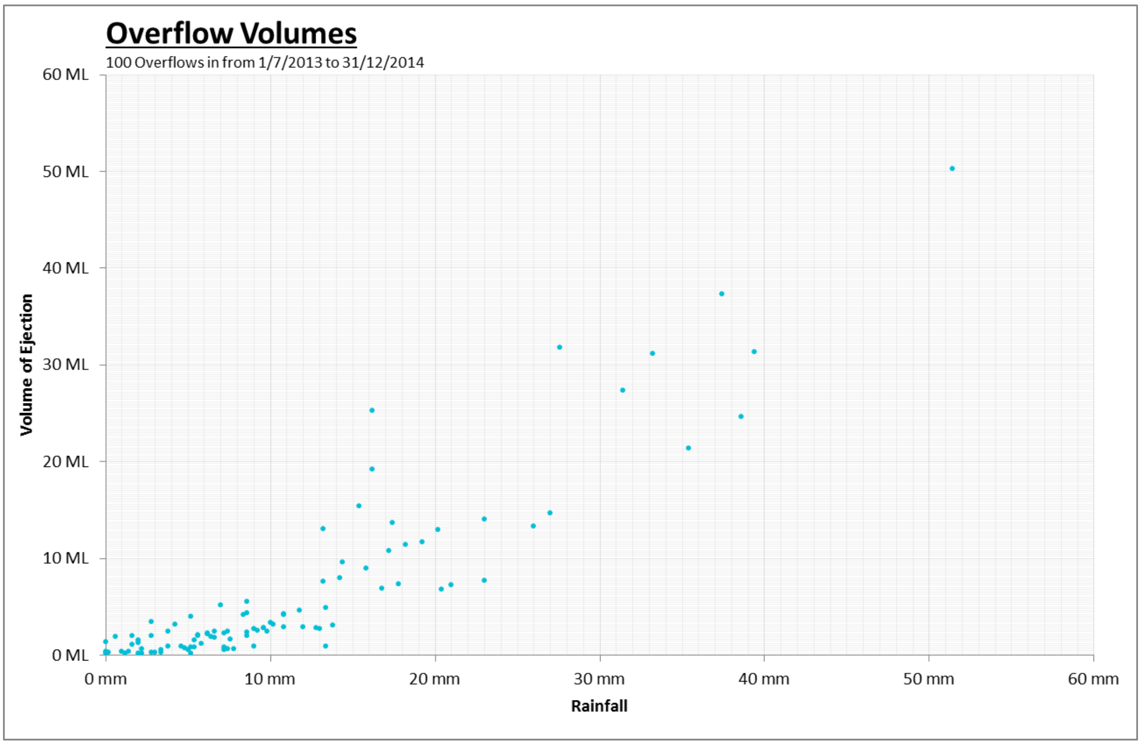


Figure 5-48: Forster Street SPS Details on all Overflows Measured in 2013 and 2014

Figure 5-49, Figure 5-50, Table 5-15 and Table 5-16 below show the Forster Street SPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data with an assumed constant flow rate of 400 L/s per stormwater pump and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge. Using a constant flow rate is considered a reasonable assumption of flows entering the Tamar River, although the pump flow rate does vary somewhat with the river level due to the change in pumping head.

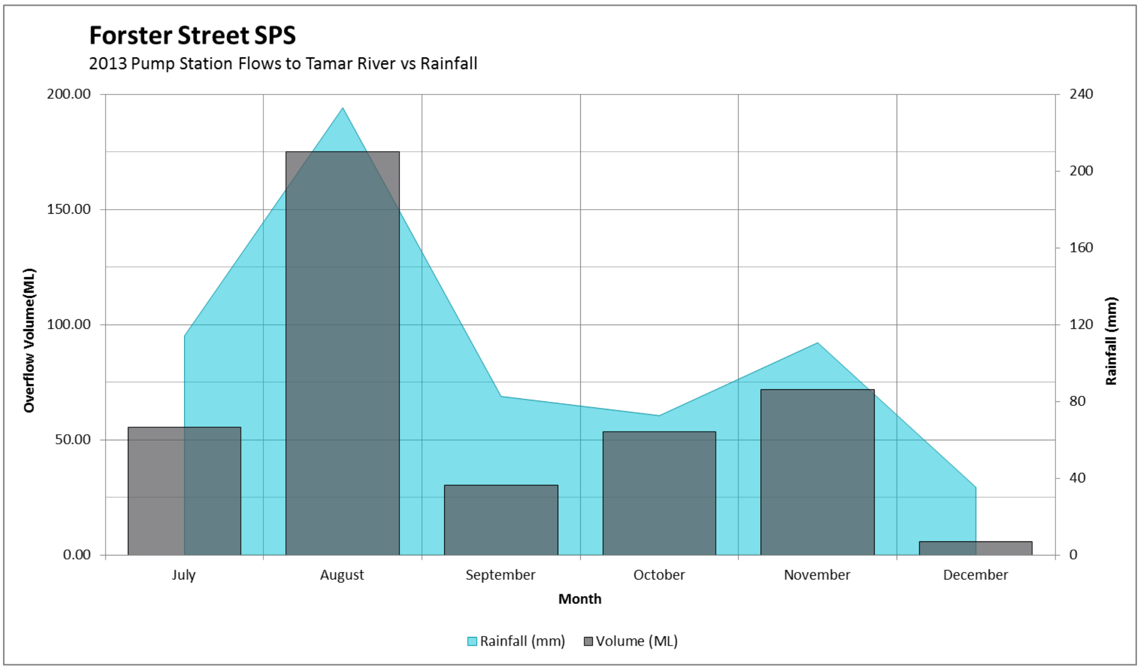


Figure 5-49: Forster Street SPS Monthly Volume Ejected vs. Rainfall (2013)

Table 5-15: Forster Street SPS Pump Station Monthly Volume Ejected vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Ejected (ML)	N/A	N/A	N/A	N/A	N/A	N/A	55.3	175	30.3	53.5	71.9	5.6	**393**

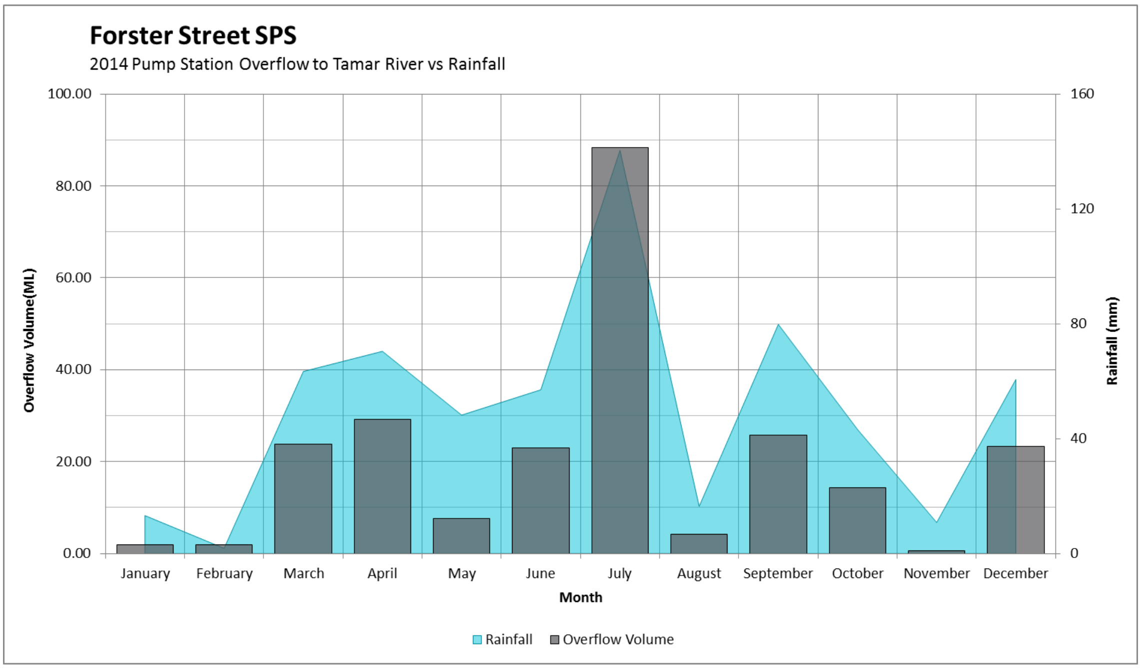


Figure 5-50: Forster Street SPS Monthly Volume Ejected vs. Rainfall (2014)

Table 5-16: Forster Street SPS Pump Station Monthly Volume Ejected vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Ejected (ML)	1.9	1.9	23.8	29.2	7.6	23.0	88.3	4.1	25.8	14.3	0.6	23.3	**243.8**

5.3.4 Forster Street SPS – Likelihood of Discharge

Figure 5-51 below shows the likelihood of discharge in relation to the daily rainfall amount. The likelihood of the stormwater pumps starting on a dry day is effectively zero; the small frequency is considered to be from data errors, system lag time and periodic testing of pumps by maintenance staff. As expected the probability of discharge increases with the rainfall amount. It is highly probable (80%) that a daily rainfall of more than 4 mm will cause the Forster Street SPS to pump to the Tamar River.

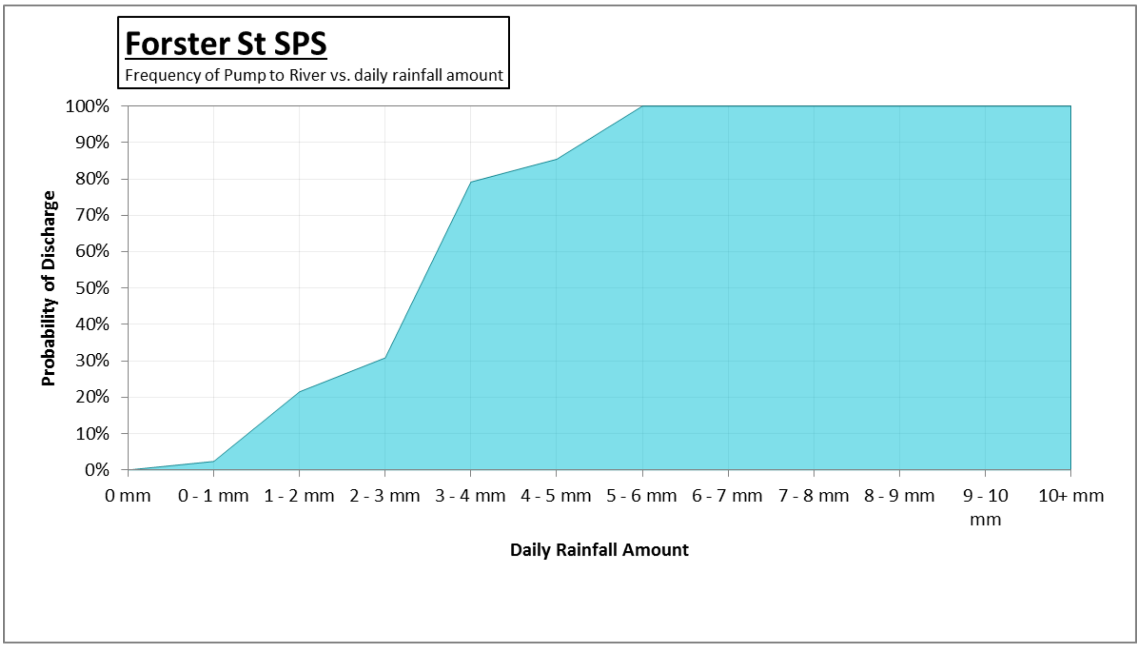


Figure 5-51: Forster Street SPS Probability of Discharge vs. Rainfall Amount

5.3.5 Waltonia SWPS – Overview

The Waltonia SWPS is a stormwater pump station located on the river side of the Forster Street Levee at the western end of Forster Street that services a small industrial catchment. The SWPS was constructed in 1990 by Launceston City Council following the separation of the existing catchment.

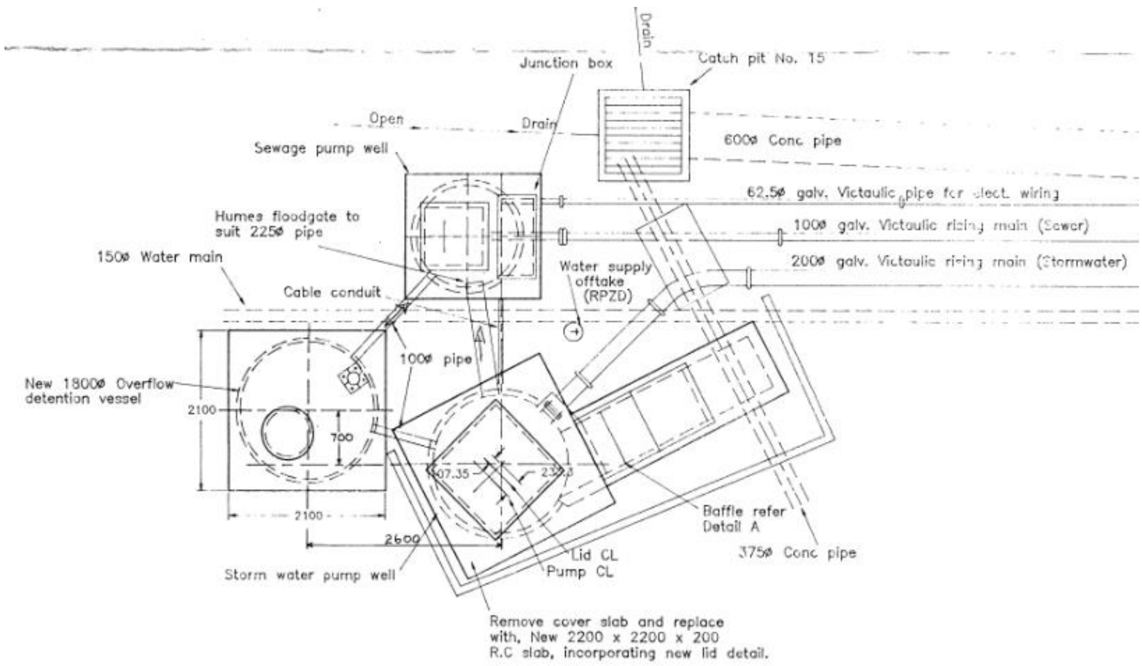
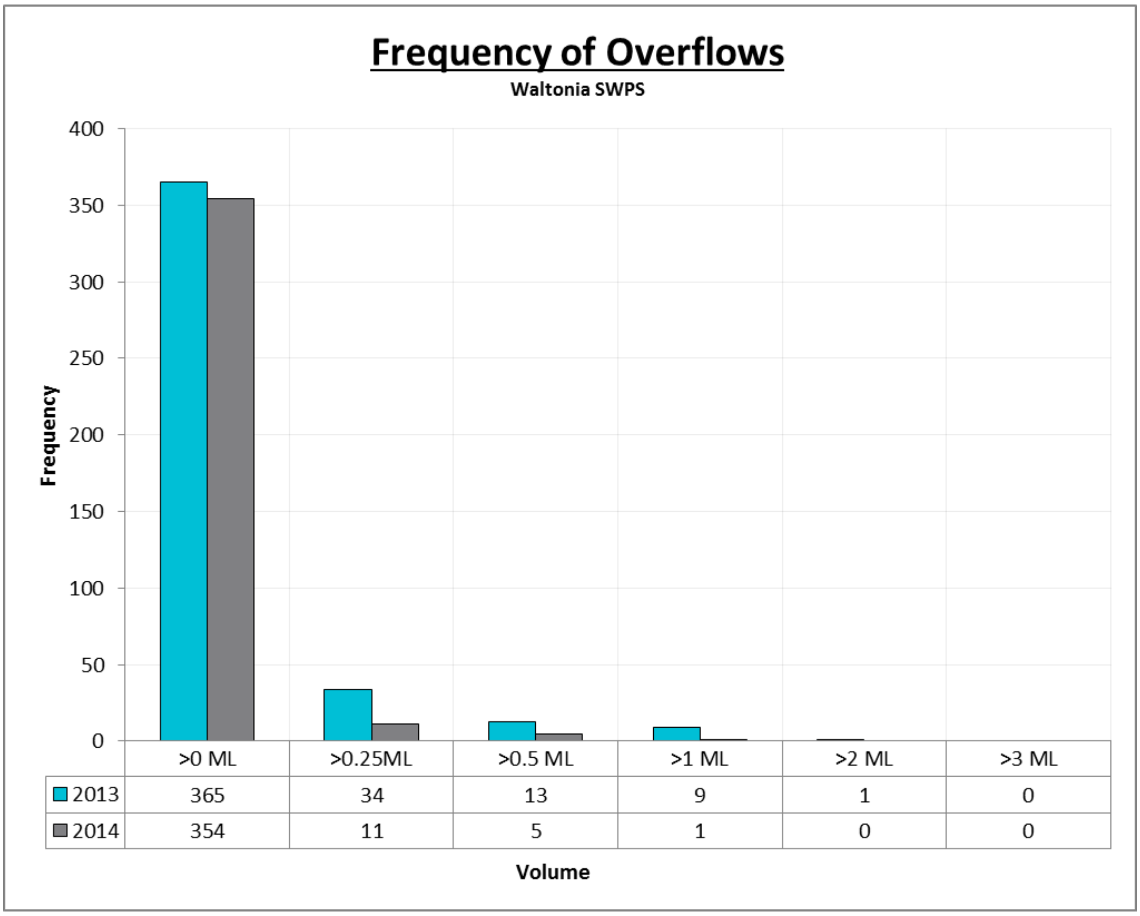


Figure 5-52: Waltonia Locality Plan (LCC, 1995)

5.3.6 Waltonia SWPS – Discharge Volume and Frequency

The Waltonia SWPS discharged every day of the year in 2013 and 354 days in 2014. This indicates the presence of a base inflow into the pump station; it is highly likely that this is caused by tidal infiltration.

Figure 5-53 below shows the number of discharges exceeding selected volume thresholds in 2013 and 2014. Waltonia SWPS has a very small catchment and as such records much smaller overflow volumes than most of the other pump stations considered in the research project.



	>0 ML	>0.25ML	>0.5 ML	>1 ML	>2 ML	>3 ML
2013	365	34	13	9	1	0
2014	354	11	5	1	0	0

Figure 5-53: Waltonia SWPS Overflow Information

Figure 5-54 below shows the percentage of overflows smaller than a given volume. The sharp increase shows that the majority of overflows are low volume; 90% of overflows are under 0.05 ML. The last 10% of overflows range from 0.05-0.35 ML. The volume of stormwater ejected is comparatively low due to the small size of the catchment.

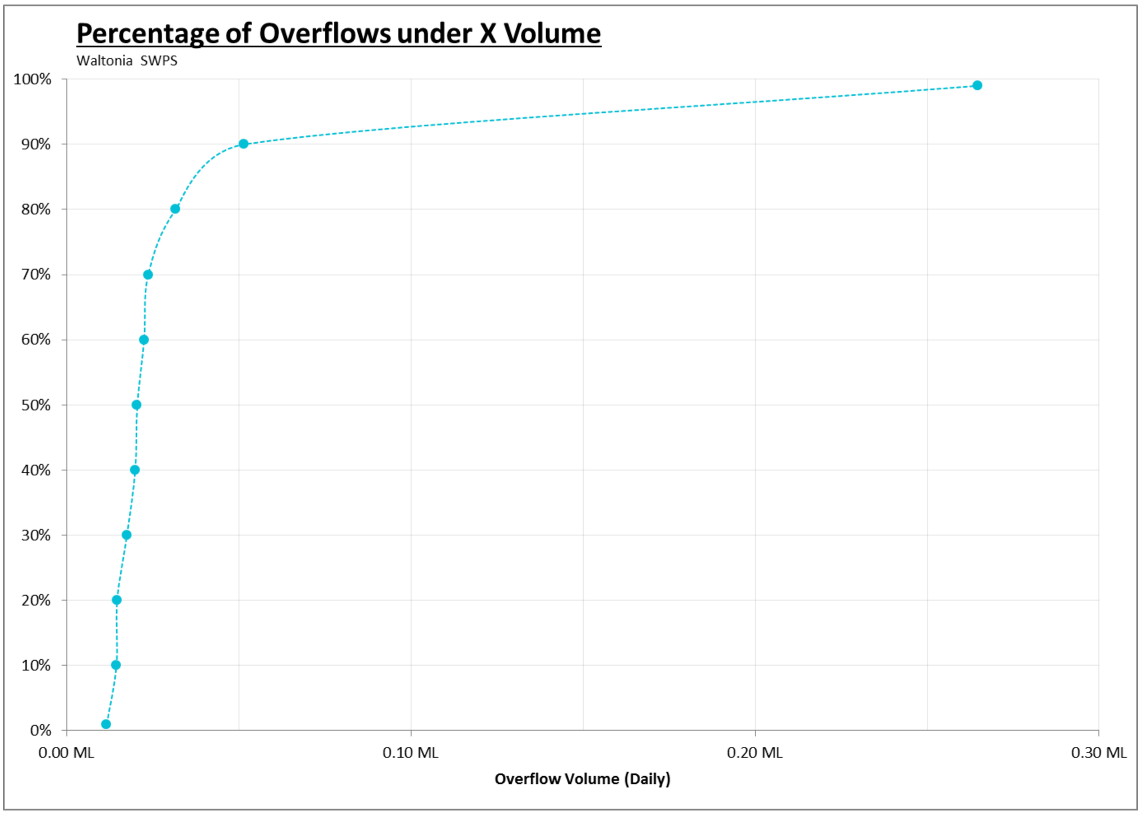


Figure 5-54: Waltonia SWPS Percentage Overflows Smaller than X Volume

Plotted on Figure 5-55 below are the recorded overflows for 2013 and 2014 for the Waltonia SWPS. The density shows that the overflows are universally low volume and are predominantly driven by sources other than rainfall. It is worth noting that due to the clustered nature of the vast majority of the overflow events outlying larger overflows were omitted from the figures for presentation purposes.

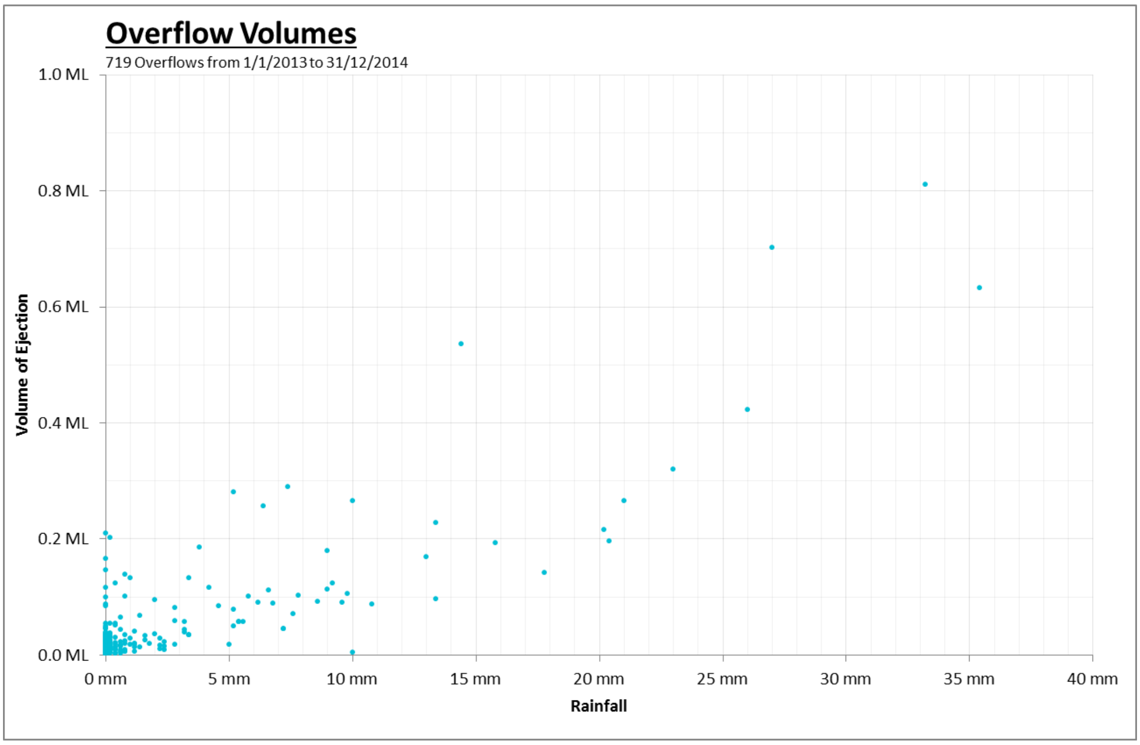


Figure 5-55: Waltonia SWPS Details on all Overflows Measured in 2013 and 2014

Figure 5-56, Figure 5-57, Table 5-17 and Table 5-18 below show the Waltonia SWPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data with an assumed constant flow rate of 150 L/s and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge. Using a constant flow rate is considered a reasonable assumption of flows entering the Tamar River, although the pump flow rate does vary somewhat with the river level due to the change in pumping head.

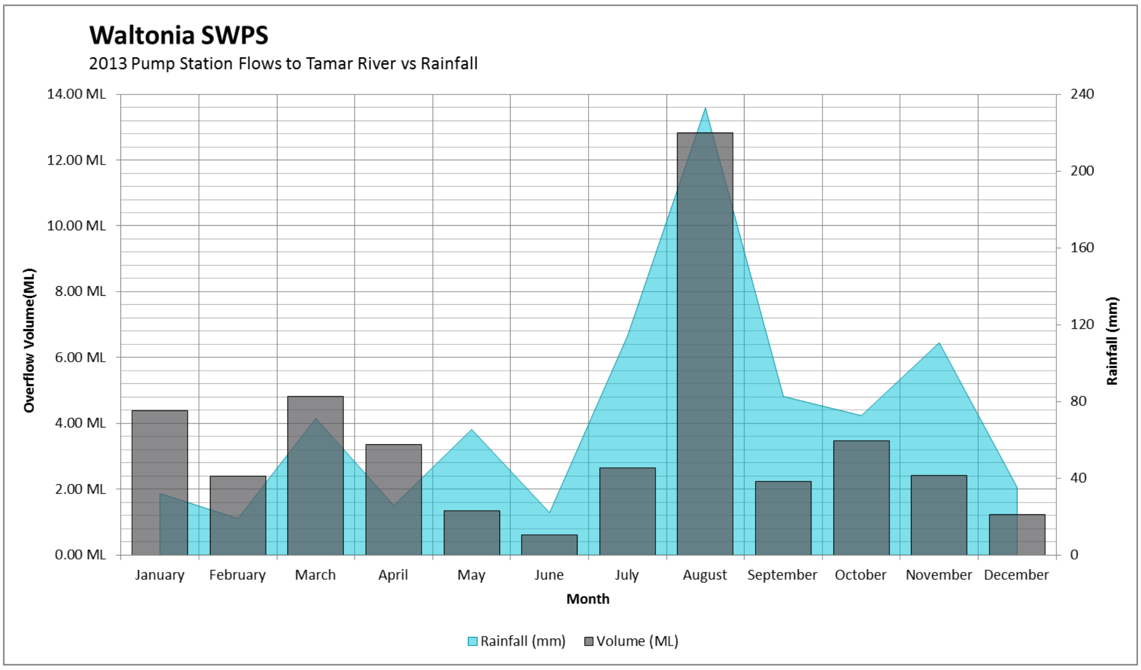


Figure 5-56: Waltonia SWPS Monthly Volume Ejected vs. Rainfall (2013)

Table 5-17: Waltonia SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Ejected (ML)	4.4	2.4	4.8	3.4	1.3	0.6	2.6	12.8	2.2	3.5	2.4	1.2	**41.7**

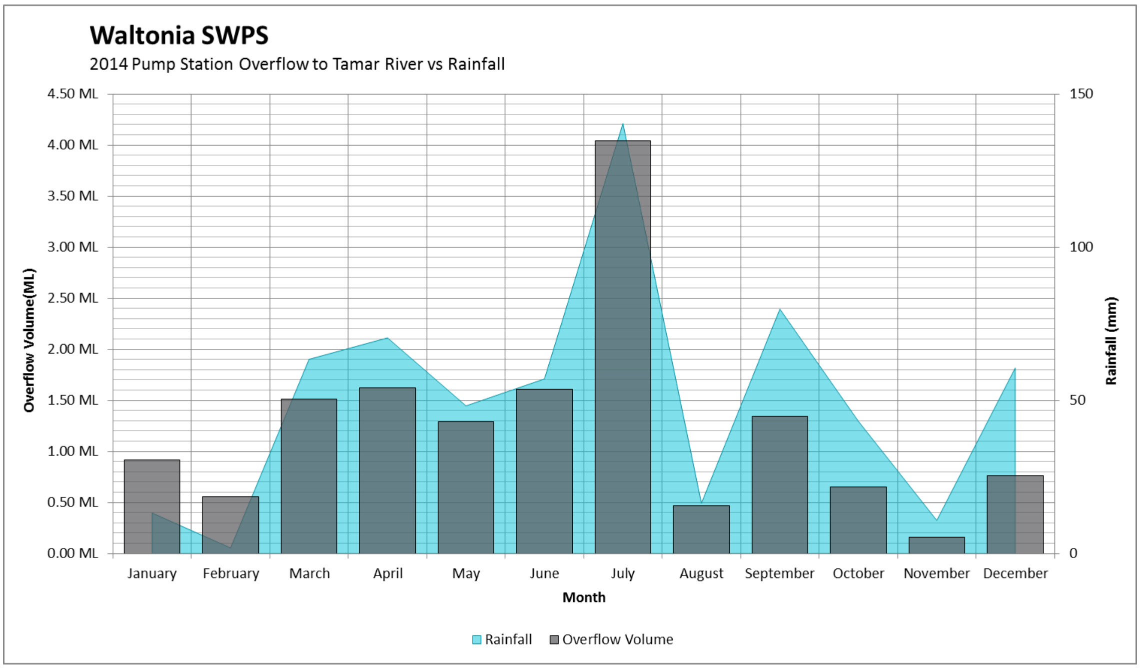


Figure 5-57: Waltonia SWPS Monthly Volume Ejected vs. Rainfall (2014)

Table 5-18: Waltonia SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Ejected (ML)	0.9	0.6	1.5	1.6	1.3	1.6	4.0	0.5	1.3	0.6	0.2	0.8	**14.9**

5.3.7 Waltonia SWPS – Infiltration Issues

The high number of days during which there was no rainfall recorded and pumping occurred at the Waltonia SWPS would suggest that there is some form of base inflow issue. This is highly likely to be caused by tidal infiltration. Other causes could be groundwater infiltration or incomplete separation resulting in a small sanitary flow.

5.3.8 Waltonia SWPS – Likelihood of Discharge

Figure 5-58 shows the likelihood of discharge is almost 98% on a dry day for the Waltonia SWPS. This is the highest likelihood of any of the pump stations considered in the research project. This is highly likely to be caused by tidal infiltration however it is possible that separation works were not completely successful or that the duty sewer pump cannot match inflows leading to an overflow into the stormwater wet well.

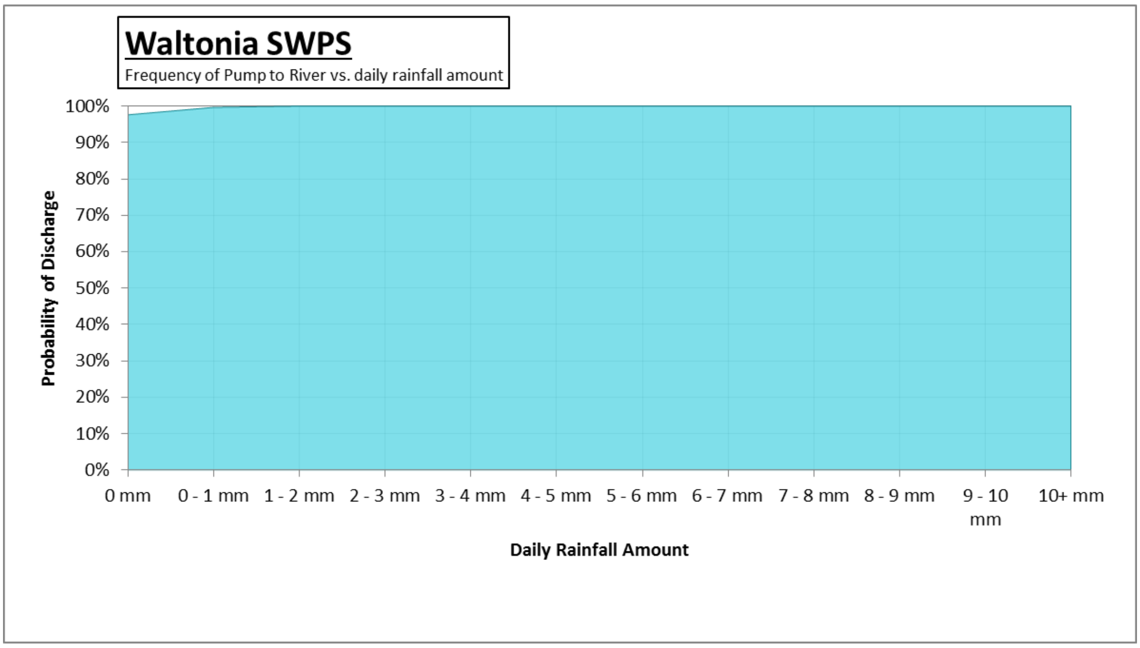


Figure 5-58: Waltonia SWPS Probability of Discharge vs. Rainfall Amount

5.3.9 Lytton Street SWPS - Overview

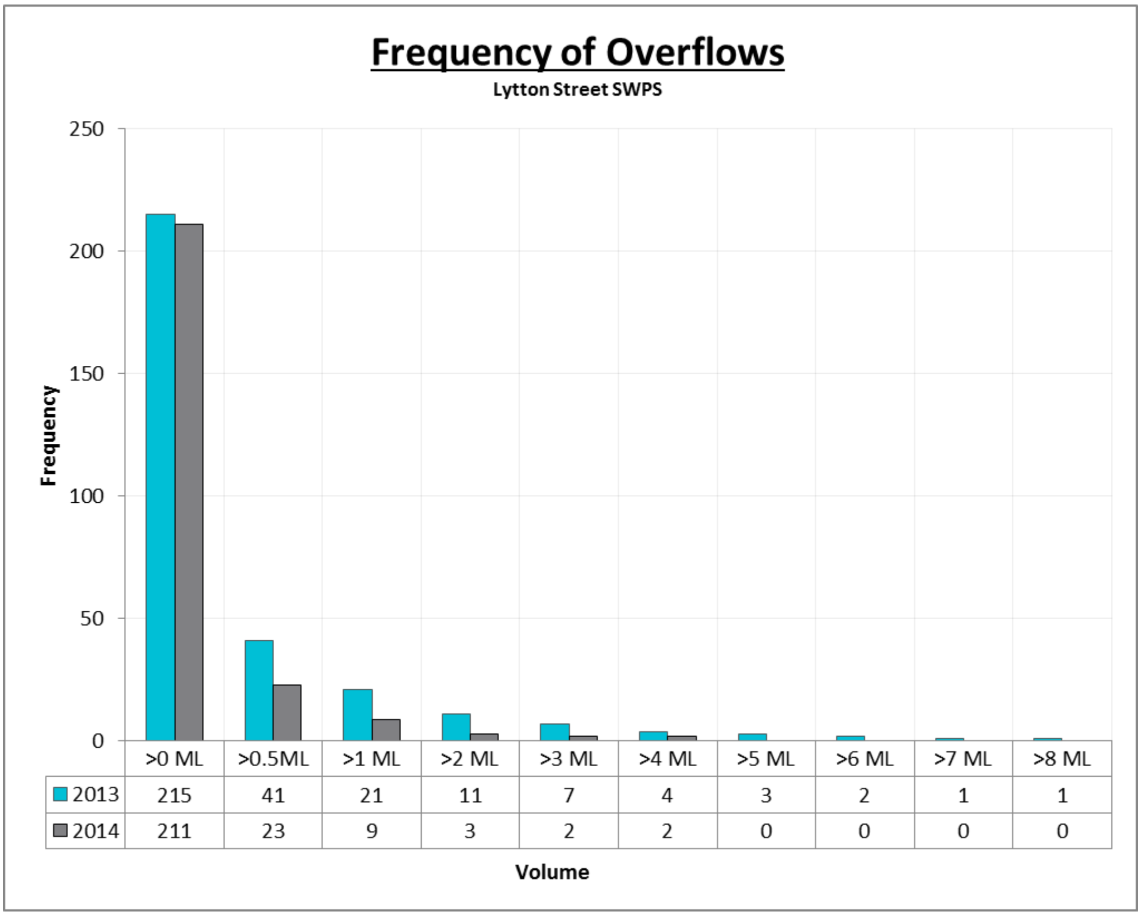
The Lytton Street SWPS is a stormwater pump station located at the eastern end of Home Street adjacent to the Northern Outlet. The Lytton Street SWPS was constructed in 1992 by Launceston City Council following the separation of the existing catchment. The SWPS is also designed to provide overflow relief to the separated sewer through an overflow point in the network, as shown in Figure 5-59 below.

Figure 5-59: Lytton Street Combined Overflow Manhole

5.3.10 Lytton Street SWPS – Discharge Volume and Frequency

The Lytton Street SWPS discharged more than 200 days each year in 2013 and 2014. This indicates the presence of a base inflow into the pump station. The inflow is likely to be caused by either groundwater or tidal infiltration.

Figure 5-60 below shows the number of discharges exceeding selected volume thresholds in 2013 and 2014. As can be seen the vast majority of discharges are less than 0.5 ML this is strongly indicative of tidal infiltration or a base sanitary flow.



	>0 ML	>0.5ML	>1 ML	>2 ML	>3 ML	>4 ML	>5 ML	>6 ML	>7 ML	>8 ML
2013	215	41	21	11	7	4	3	2	1	1
2014	211	23	9	3	2	2	0	0	0	0

Figure 5-60: Lytton Street SWPS Overflow Information

Figure 5-61 below shows the percentage of overflows smaller than a given volume. The sharp increase shows that the majority of overflows are low volume; 90% of overflows are under 0.75 ML.

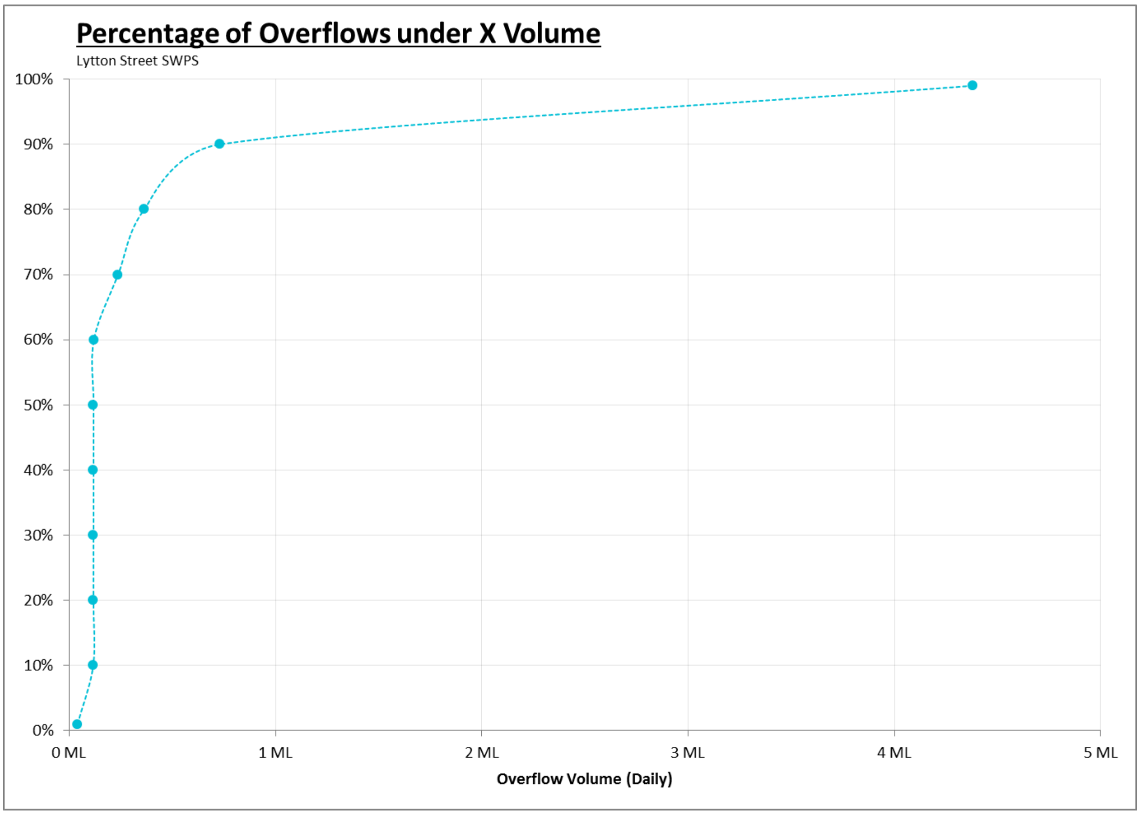


Figure 5-61: Lytton Street SWPS Percentage Overflows Smaller than X Volume

Plotted on Figure 5-62 below are the recorded overflows for 2013 and 2014 for the Lytton Street SWPS. The density shows that the overflows are generally low volume and appear to be driven by sources other than rainfall.

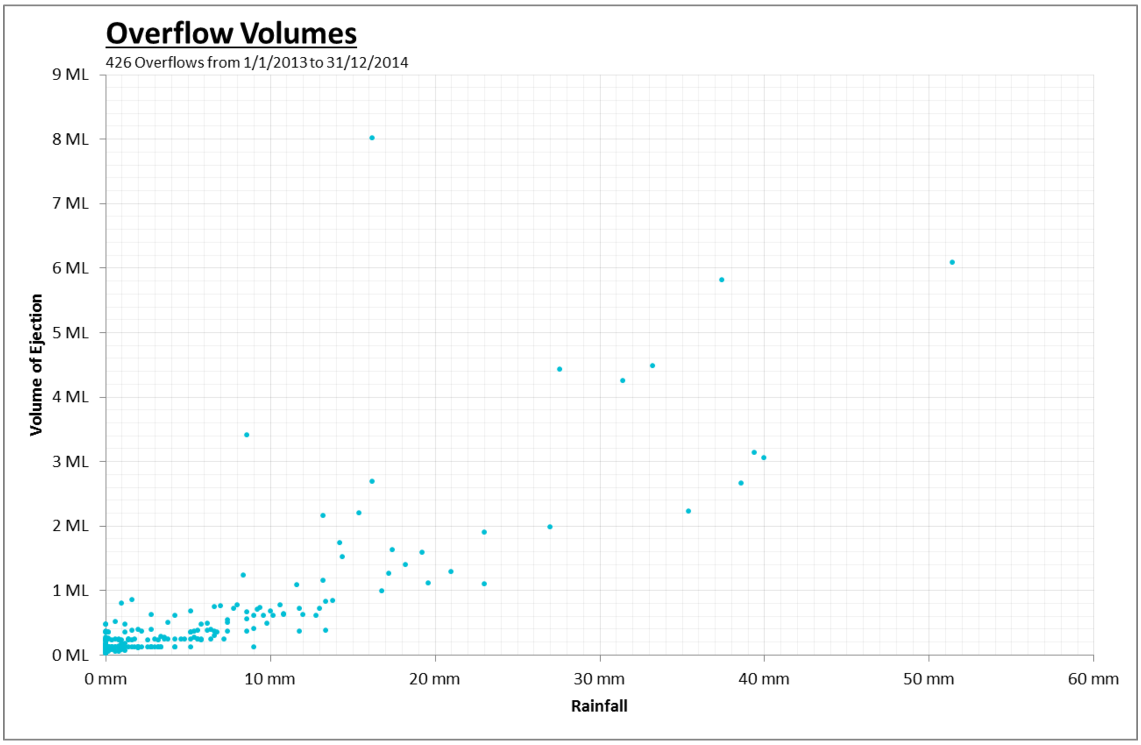


Figure 5-62: Lytton Street SWPS Details on all Overflows Measured in 2013 and 2014

Figure 5-63, Figure 5-64, Table 5-19 and Table 5-20 below show the Lytton Street SWPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data with an assumed constant flow rate of 1080 L/s and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge. Using a constant flow rate is considered a reasonable assumption of flows entering the Tamar River, although the pump flow rate does vary somewhat with the river level due to the change in pumping head.

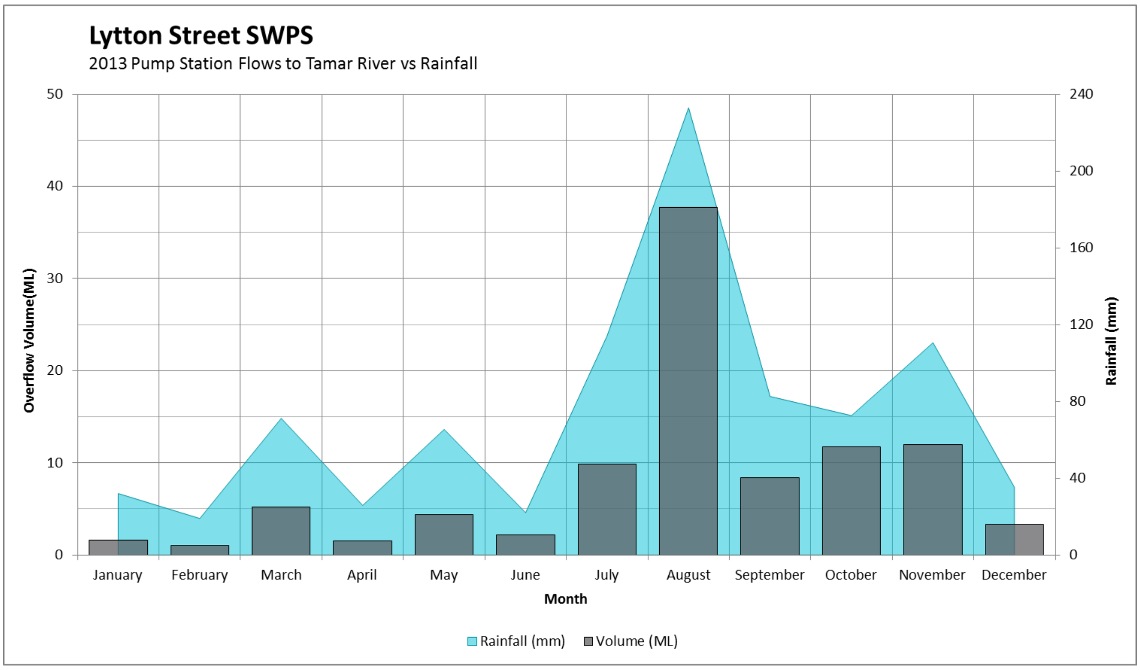


Figure 5-63: Lytton Street SWPS Monthly Volume Ejected vs. Rainfall (2013)

Table 5-19: Lytton Street SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Ejected (ML)	1.6	1.0	5.2	1.5	4.3	2.2	9.9	37.7	8.4	11.7	12.0	3.3	**98.7**

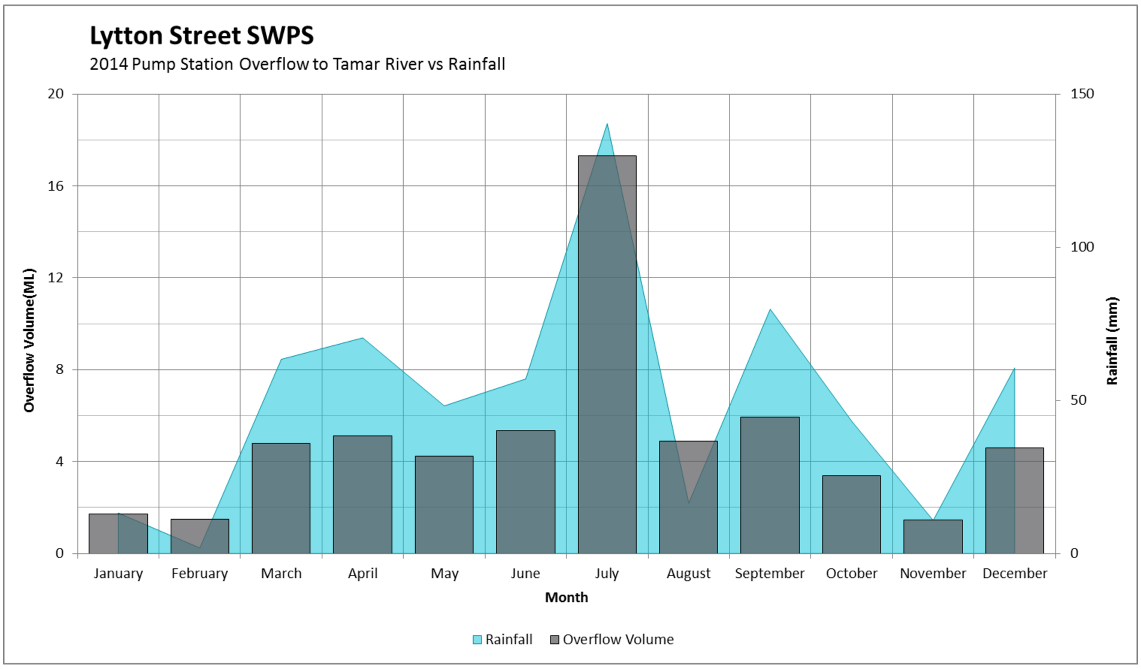


Figure 5-64: Lytton Street SWPS Monthly Volume Ejected vs. Rainfall (2014)

Table 5-20: Lytton Street SWPS Pump Station Monthly Volume Ejected vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Ejected (ML)	1.7	1.5	4.8	5.1	4.2	5.3	17.3	4.9	5.9	3.4	1.4	4.6	**60.2**

5.3.11 Lytton Street SWPS – Infiltration Issues

The high number of days during which there was no rainfall recorded and pumping occurred at the Lytton Street SWPS would suggest that there is some form of base inflow issue, likely to be tidal infiltration. Other causes could be groundwater infiltration or incomplete separation resulting in a small sanitary flow.

5.3.12 Lytton Street SWPS – Likelihood of Discharge

Figure 5-65 below shows the likelihood of discharge in relation to the daily rainfall amount. The likelihood of the pump starting on a dry day is almost 50%. The relatively high probability of discharge for dry days is a strong indication that tidal infiltration, groundwater or base sanitary flows are entering the pump station. As expected the probability of discharge increases with the rainfall amount. It is highly probable (80%) that a daily rainfall of more than 3 mm will cause the Lytton Street SWPS to pump to the Tamar River.

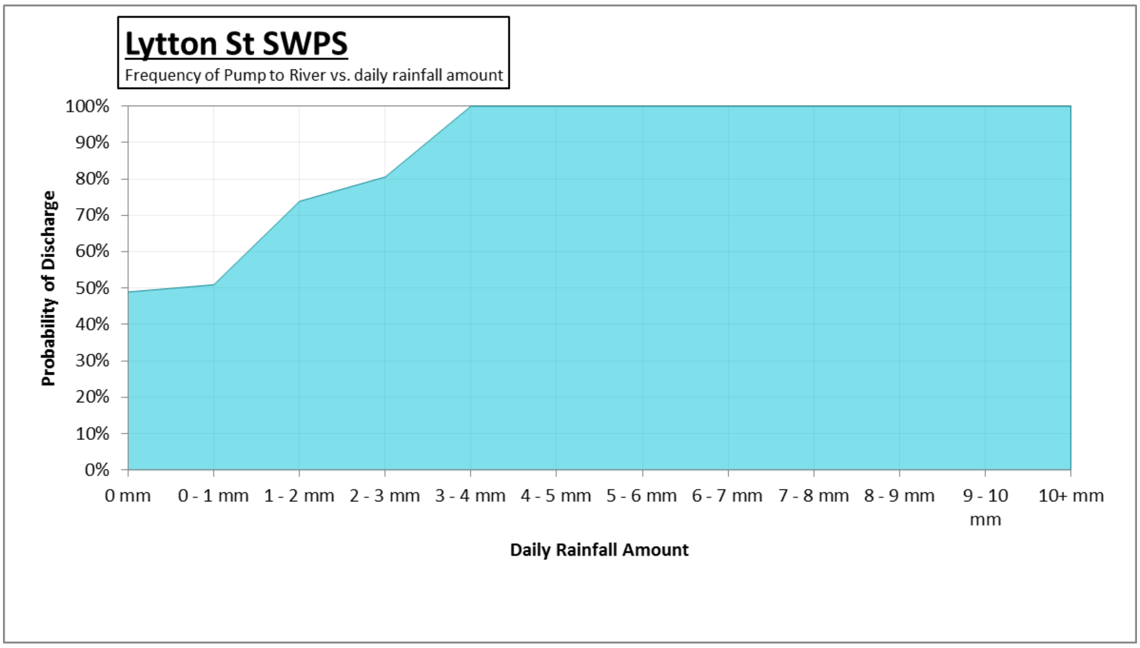


Figure 5-65: Lytton Street SWPS Probability of Discharge vs. Rainfall Amount

5.4 Mowbray (Hope Street) Catchment

The Mowbray Catchment services the northern end of the suburb of Invermay and lower parts of Mowbray and Mowbray Heights. It is the smallest catchment within the LCSS with a service area of approximately 0.2 square kilometres. The Mowbray Catchment captures sewage and stormwater from the southern and western residential areas of Mowbray and services a number of trade waste customers in Invermay. The catchment drains generally westward to the Hope Street SPS.

5.4.1 Hope Street SPS - Overview

The Hope Street SPS is a combined sewer pump station located at the western end of Hope Street adjacent to the Northern Outlet. The Hope Street SPS was constructed in the 1980's by Launceston City Council.

During dry weather and low rainfall periods the two sewer pumps in the station pump flows to the Ti Tree Bend STP. In wet weather periods the larger stormwater pump operates and pumps combined flows into the Tamar River.

Figure 5-66: Hope Street SPS

5.4.2 Hope Street SPS – Infiltration Issues

Analysis of the overflow data suggests that there are no major concerns with tidal infiltration.

5.4.3 Hope Street SPS – Discharge Volume and Frequency

The Hope Street SPS overflowed 61 times in 2013 and 48 times in 2014. It should be noted that SCADA information for Hope Street SPS was not available before April 2013. Figure 5-67 below shows the number of discharges exceeding selected volume thresholds in 2013 and 2014.

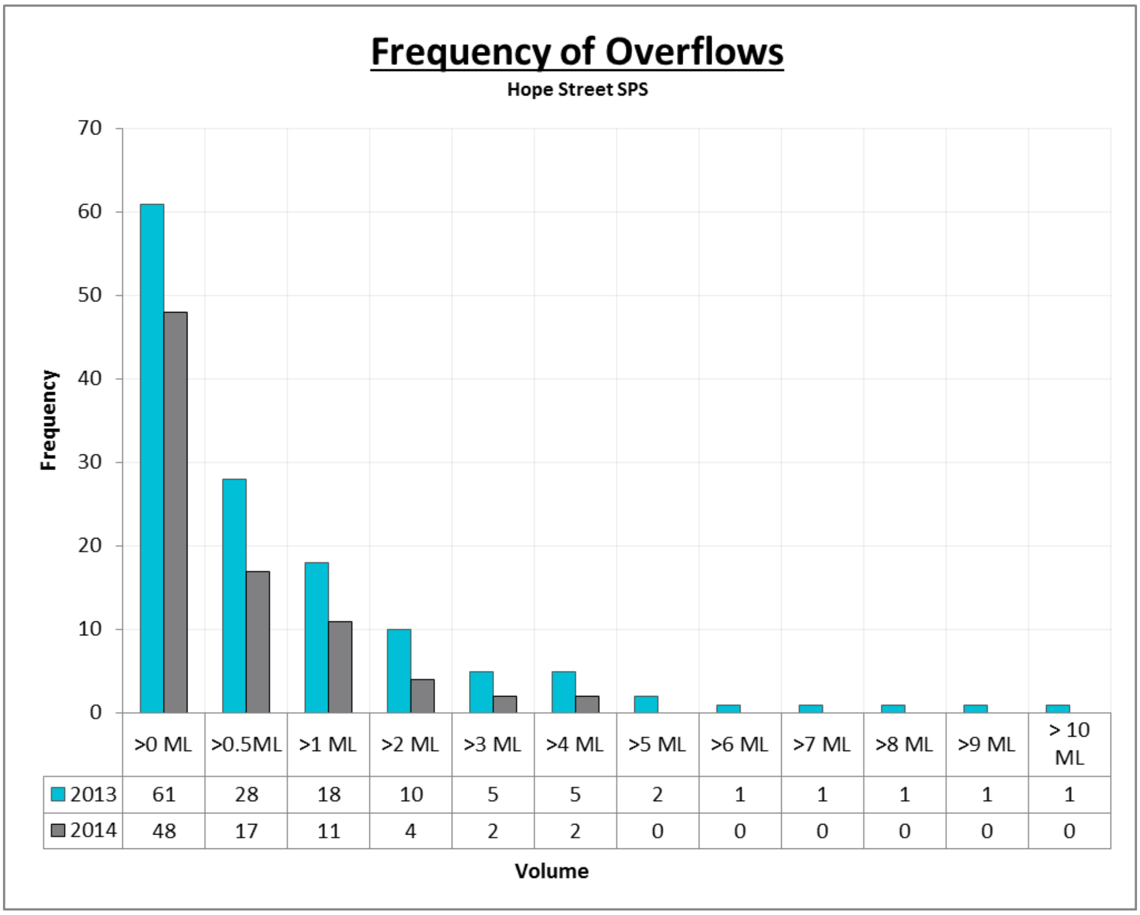


Figure 5-67: Hope Street SPS Overflow Information

Figure 5-68 below shows the percentile of overflows smaller than a given volume. The majority (80%) of overflows were below 1.50 ML. The largest overflow was approximately 16 ML; this overflow event occurred on a day with a large rainfall event (37.4 mm).

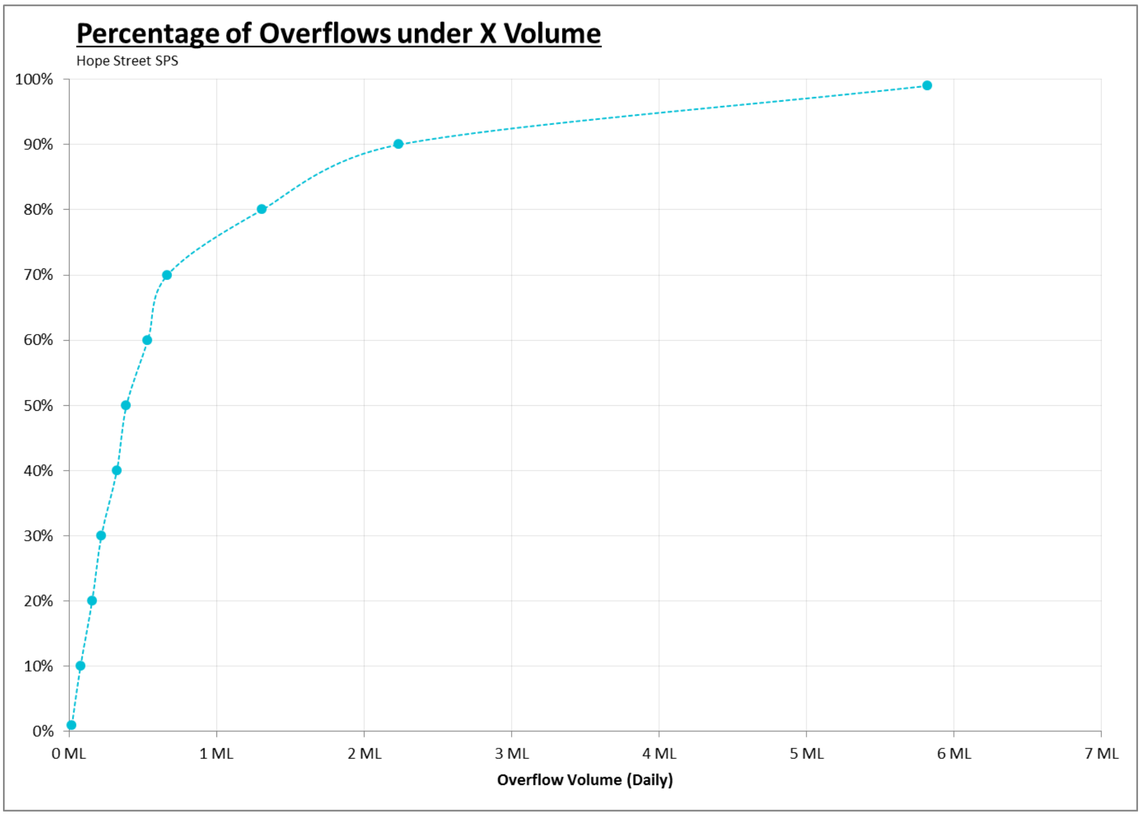


Figure 5-68: Hope Street SPS Percentage Overflows Smaller than X Volume

Plotted on Figure 5-69 below are the recorded overflows for 2013 and 2014 for the Hope Street SPS. The density shows that the majority of the overflows are of low volume and during low rainfall periods.

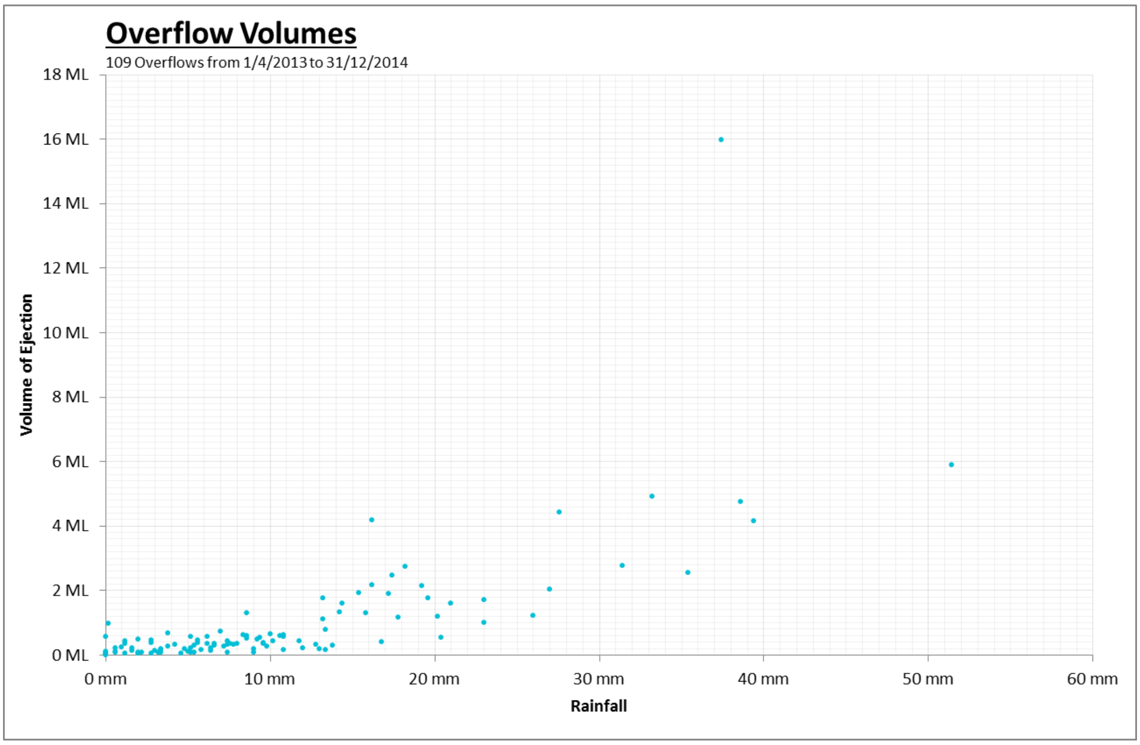


Figure 5-69: Hope Street SPS Details on all Overflows Measured in 2013 and 2014

Figure 5-70, Figure 5-71, Table 5-21 and Table 5-22 below show the Hope Street SPS monthly discharge volume against monthly rainfall for 2013 and 2014. The information was derived using the pump start/stop data with an assumed constant flow rate of 180 L/s and the daily rainfall measured at the Margaret Street Detention Basin rainfall gauge. Using a constant flow rate is considered a reasonable assumption of flows entering the Tamar River, although the pump flow rate does vary somewhat with the river level due to the change in pumping head.

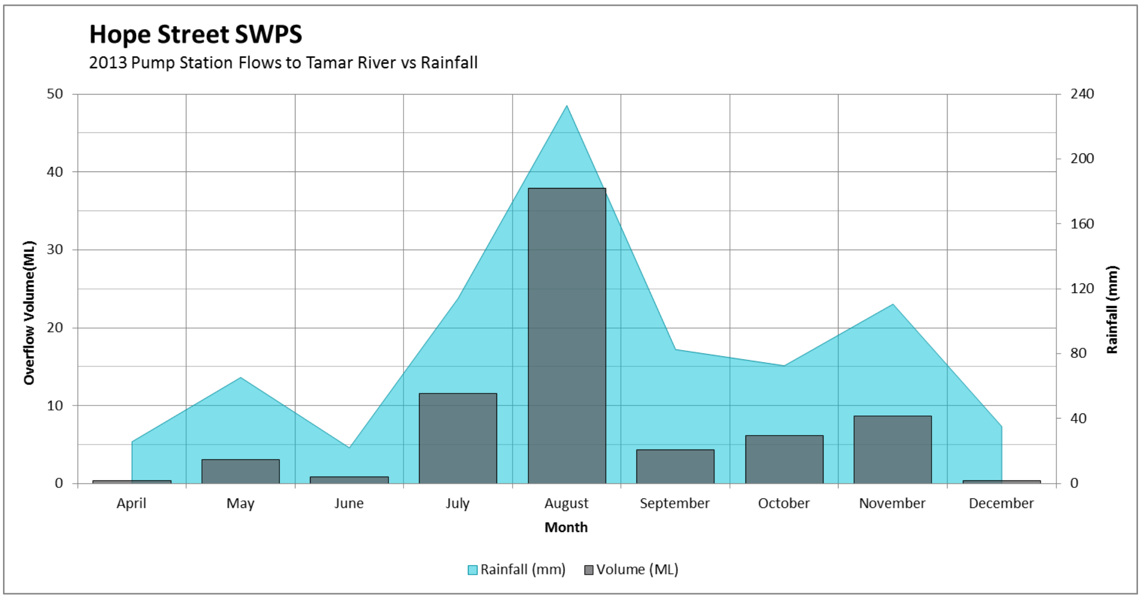


Figure 5-70: Hope Street SPS Monthly Volume Ejected vs. Rainfall (2013)

Table 5-21: Hope Street SPS Pump Station Monthly Volume Ejected vs. Rainfall (2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Rainfall (mm)	32	19	71.2	25.8	65.4	22	114.2	233	82.6	72.6	110.6	35.2	**883.6**
Volume Ejected (ML)	N/A	N/A	N/A	0.4	3.1	0.8	11.6	38.0	4.3	6.2	8.7	0.3	**73.3**

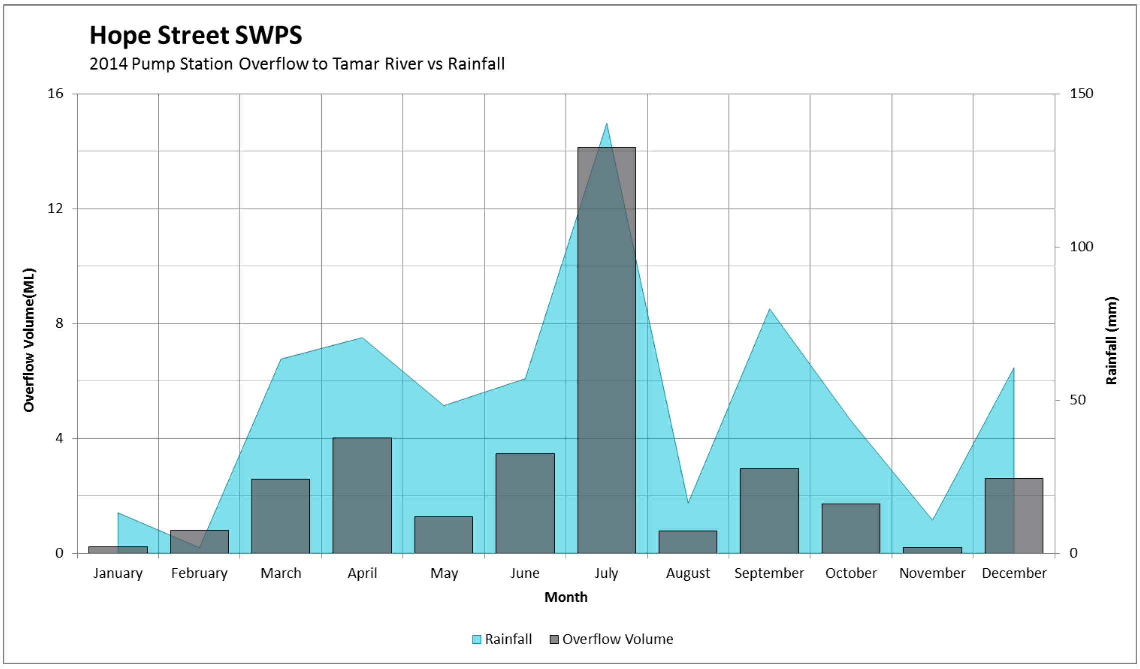


Figure 5-71: Hope Street SPS Monthly Volume Ejected vs. Rainfall (2014)

Table 5-22: Hope Street SPS Pump Station Monthly Volume Ejected vs. Rainfall (2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	13.2	1.8	63.4	70.4	48.2	57	140.4	16.4	79.8	43.2	10.8	60.6	**605.2**
Volume Ejected (ML)	0.2	0.8	2.6	4.0	1.3	3.5	14.1	0.8	2.9	1.7	0.2	2.6	**34.7**

5.4.4 Hope Street SPS – Likelihood of Discharge

Figure 5-72 below shows the likelihood of discharge in relation to the daily rainfall amount. The likelihood of the stormwater pump starting on a dry day is effectively zero; the small frequency is considered to be from data errors, system lag time and periodic testing of pumps by maintenance staff. There is a small anomaly where the probability of discharge decreases at 4-5 mm. It is expected that with a larger dataset would give the discharge probability a more consistent upward trend. As expected the probability of discharge increases with the rainfall amount. It is highly probable (80%)

that a daily rainfall of more than 4 mm will cause the Hope Street SPS to pump to the Tamar River.

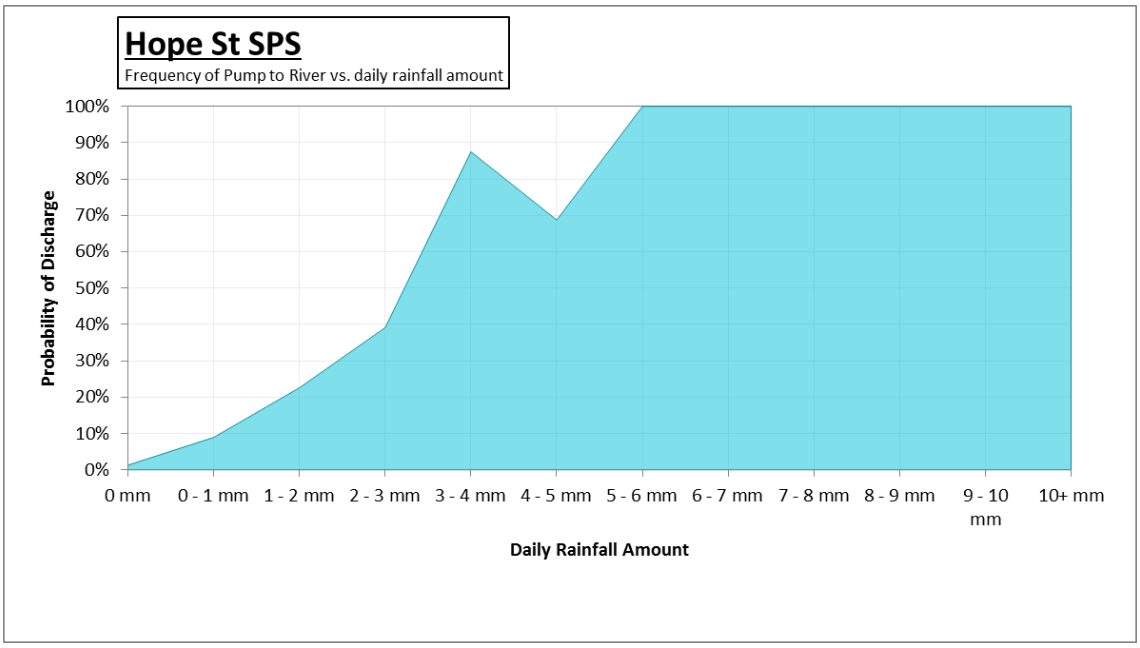


Figure 5-72: Hope Street SPS Probability of Discharge vs. Rainfall Amount

5.5 Ti Tree Bend STP

The Ti-Tree Bend is the largest STP in Tasmania with a licensed ADWF of 25 ML/day. It services more than 22,500 ET and has a significant trade waste input. The first stage of the STP was constructed in 1972 and has since been further upgraded in 1978, 1988-1992 and 2000. The Ti Tree Bend STP uses the activated sludge process to provide secondary level treatment. The major components of the STP are:

- Inlet Works – Screening and Grit Removal;
- Four Primary Sedimentation Tanks;
- Two Activated Sludge Tanks (aerated);
- Two Anaerobic Sludge Digesters;
- Two Secondary Clarifiers;
- Chlorine Contact Tanks;

- Sludge Dewatering; and,
- Iron Salt Dosing System (Odour Control).

There are multiple system bypasses at the STP. The first bypass, located after the inlet works, bypasses primary sedimentation and receives chlorine dosing before discharge to the Tamar River. The second bypass receives primary sedimentation but bypasses the aeration tanks and is dosed with chlorine before entering the Tamar River. The primary treatment process capacity is 120 ML/day and the secondary treatment process capacity is 60 ML/day. The limiting capacity of the process components is detailed in Table 5-23:

Table 5-23: Ti-Tree Bend Process Components Capacity

Process Component	Capacity (ML/day)	Capacity (L/s)
Screening	197	2,280
Screw Pumps	197	2,280
Primary Sedimentation	120	1,389
Aeration Tanks	60	694.5
Secondary Clarifiers	60	694.5

The ability of the Ti Tree Bend STP to provide some form of treatment to wet weather flows helps to reduce the solids load on the receiving environment. Figure 5-73 below shows the screenings bin at the Ti Tree Bend STP. The screening unit is able to remove gross solids, grit and other particulates from combined inflows for all flows up to 2,280 L/s. The separated stormwater system has no such ability. During prolonged wet weather periods the screenings bin will fill in approximately two weeks, compared with four to six weeks during dryer periods.

Figure 5-73: Inlet Screenings at Ti Tree Bend STP

The Ti Tree Bend STP is also capable of providing secondary level treatment for up to 60 ML/day. As discussed in Chapter 6 a true ADWF for the Ti Tree Bend STP would be of the order of 12.2 ML/day. This means that the STP is capable of providing full treatment for five times expected ADWF. Most plants in Tasmania are designed to have a Peak Wet Weather Flow (PWWF) capacity of six times ADWF, although typically this capacity is hydraulic capacity or primary treatment capacity not full treatment capacity. This demonstrates the capacity of Ti Tree Bend STP and the combined system to provide some form of treatment for stormwater flows. Figure 5-74 shows the aerated basins in operation.

Figure 5-74: Aerated Basin at Ti Tree Bend STP

5.5.1 Plant License

The Ti-Tree Bend STP operates under a contemporary license issued in 2013 (EPN 8102/1). It is licensed for an ADWF of 25 ML/day, which it did not exceed under dry weather conditions for the 2013 and 2014 years.

According to TasWater's 2014-18 Wastewater Management Plan (WWMP) STP summary the Ti Tree Bend STP overall sample compliance was 97%. The plant only failed tests for three of the license parameters; these were Total Nitrogen (TN), Total Phosphorous (TP) and Thermotolerant Coliforms. Table 5-24 below shows the STP performance for the 2013/14 Financial Year.

Table 5-24: Ti-Tree Bend 2013/14 Compliance

2013/14 Sample Compliance Factor	Compliance
Flow Distribution	100%
Ammonia-N	100%
Biological Oxygen Demand	100%
Chlorine	100%
Total Nitrogen	92%
Oil & Grease	100%
Total Phosphorous	92%
Thermotolerant Coliforms	92%
Suspended Solids	100%
pH	100%
Overall Compliance	**97%**

5.5.2 Flow Data

Appendix F shows the effect that rainfall has on the combined system, with large inflow peaks directly corresponding to rainfall events. The average daily inflow for FY13/14 was 24.8 ML per day and the average flow on a dry weather day was 16.8 ML. The peak inflow was 127 ML, this occurred on the 26/9/2013 on a day with only 12.3 mm of rainfall. It is a possibility that on days with a higher total rainfall the increased intensity causes the added stormwater to be ejected to the river resulting in reduced inflows to Ti-Tree Bend STP.

6. Performance Analysis of LCSS

The performance analysis focussed on three performance areas to determine the impact of the existing combined system on the receiving environment, and the likely impact that a separated system serving the same region would have on the environment. The key performance areas related to nutrient loading, pathogen loading and metal contamination. Future research should focus on sample collection of more stormwater discharge and CSO events to improve the accuracy of the model in determining pollutant loads. Additionally future work should explore the impact that the DAT and rainfall intensity has on pollutant loading; analysis of the small sample set collected indicated that these are key parameters impacting pollutant loading.

Figure 6-1: Samples collected for overflow analysis

6.1 Mass Balance Calculation – Flow and Load

The mass balance model was developed to understand the inflows and outflows from the combined system. Figure 6-2 shows the sources of inflows and outflows within the system and how these are handled in the model.

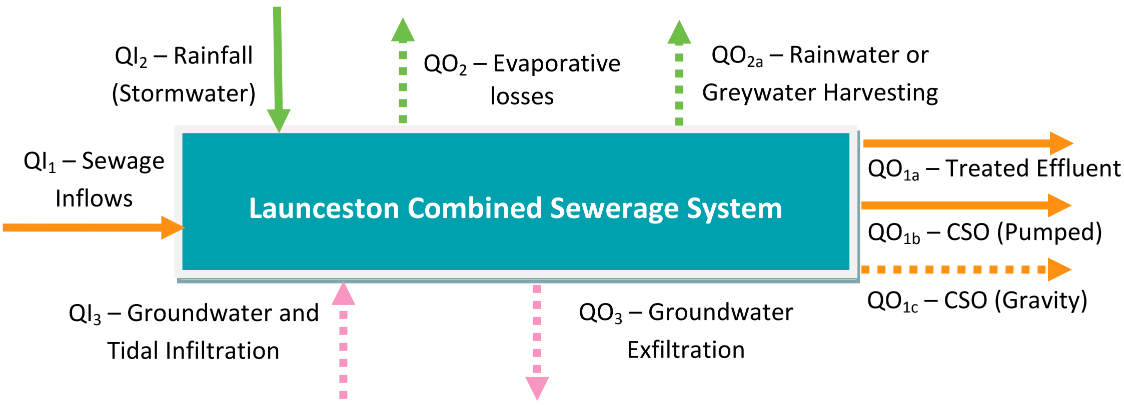


Figure 6-2: Mass Balance Model

The solid arrows represent flows considered in the research project, and the dashed lines represent flows that were not accounted for in this project. These flows were excluded from the scope of the project as a lack of data would have resulted in a low level of accuracy for calculation purposes. Preliminary review of the influent and effluent volumes suggest that the flows excluded only represent around 5-6% of total system flows, therefore excluding these flows is considered reasonable. Calculation of these flows should be considered in future works to refine the accuracy of the pollutant model and to further inform discussions on upgrade options or system separation.

Tidal infiltration was also found to be a factor in the frequency and volume of overflow/discharge events at a number of pump station sites. The volume discharged on each zero rainfall day was considered to be a result of tidal infiltration. A base daily tidal infiltration discharge volume was estimated using this total zero rainfall day volume divided by the total number of zero rainfall days across the data period. This base tidal infiltration was then taken off each wet weather day overflow volume to exclude tidal infiltration from the calculations.

6.2 Total Volume and Pollutant Load – Ti Tree Bend STP

In 2013 there was approximately 9,130 ML of combined sewage pumped to the Ti Tree Bend STP. This gives an average daily inflow (AF) of 25 ML/day to the STP, with approximately 22,500 ET served by the STP, resulting in an average flow per ET of 1.11 kL/day. This is significantly higher than the average flow per ET and ADWF per ET that TasWater is using for design purposes for the LSIP, shown in Table 6-1 below, and shows the impact that stormwater has in terms of total flows treated at Ti Tree Bend STP.

Table 6-1: Determination of ADWF and AF for Ti Tree Bend STP

Parameter	Value	Comments
Design ADWF	410	L/ET/day
Multiplier for Average Flow (AF)	1.2	Accounts for permanent infiltration
Design AF	492	L/ET/day
Industry Modifier	1.1	Accounts for major trade waste flows
ET Count	22,576	Sourced from GIS and Gentrack Data
Design ADWF	10.2	ML/day
Design AF	12.2	ML/day

A comparison of inflow data and ET served was completed against the Macquarie Point and Selfs Point STP in Hobart. These are two large separated systems that have similar catchment characteristics to the LCSS. The results for this comparison are shown in Table 6-2 below.

Table 6-2: Comparison of ET and Inflows

System	ET Count	Average Daily Inflow (ML/day)	Average Daily Inflow (L/ET/day)
Selfs Point	17,240	10.0	580.0
Macquarie Point	20,648	10.4	503.7
Ti Tree Bend - Combined	22,576	25.0	1,107.8
Ti Tree Bend – Theoretical Separated	22,576	12.2	540.4

To determine the pollutant load the monthly effluent sample results for a number of parameters was applied to the inflows to the STP. The sample results are included as Appendix C.

This method induces some inaccuracies. Firstly, it is using plant inflow data to determine pollutant loading. Inflow data is used due to ongoing issues with accuracy of the existing outflow meter. The model assumes 100% of inflows become outflows; which is a conservative approach as there are typically losses in the treatment process associated with evaporation.

Secondly, the model assumes that the treatment performance for the plant is the same across every day of the month; however, in the absence of daily effluent quality data, this assumption was used to complete the assessment. It is worth noting that this is the current method required by the state EPA for annual reporting of STP performance and calculating STP pollutant loads, so was considered appropriate for the research project.

The pollutant loads calculated for the Ti Tree Bend STP are shown below in Table 6-3 and Table 6-4 below. Note that metal contaminant values are reported as dissolved not total, which is in alignment with ANZECC guidelines for determining environmental impacts and compliance.

Table 6-3: Ti Tree Bend 2013 Pollutant Loads – Nutrient and Pathogen

Month	Measured Flows (ML)	TN (tonnes)	TP (tonnes)	SS (tonnes)	Enterococci (cfu)
Jan	678.48	21.03	4.59	14.93	1.36E+11
Feb	672.68	20.18	3.22	18.16	2.02E+11
Mar	522.41	17.76	4.58	15.15	1.04E+11
Apr	468.25	14.89	2.98	14.98	4.68E+10
May	635.15	13.78	3.52	5.72	6.35E+10
Jun	514.62	12.45	3.35	11.84	2.57E+11
Jul	944.11	20.77	4.02	17.94	7.55E+11
Aug	1529.25	18.35	1.13	12.23	1.38E+12
Sep	921.92	3.23	11.06	10.14	1.38E+11
Oct	858.19	17.16	4.98	9.44	3.86E+11
Nov	839.90	21.84	3.44	18.48	2.10E+11
Dec	545.48	3.06	2.07	12.55	4.91E+11
Total	**9130.43**	**184.51**	**48.94**	**161.55**	**4.17E+12**

Table 6-4: Ti Tree Bend 2013 Pollutant Loads – Metal Contaminants

Parameter	Annual Sample Result (mg/L)	Annual Load (kg)
Cr	0.001	9.1
Cu	0.007	63.9
Pb	0.005	40.2
Zn	0.064	584.3

The results show that the Ti Tree Bend STP contributes a substantial nutrient and solids load to the Tamar River with approximately 200 tonnes of nitrogen, 50 tonnes of phosphorous and 160 tonnes of solids discharged. It is worth noting that the actual treatment performance of the STP is quite good; the high nutrient load discharged has more to do with the large flows that the plant processes. This is confirmed by comparison of average influent strength against average effluent strength and license limits, as shown in Table 6-5 below.

Table 6-5: Ti Tree Bend Nutrient and Solids Reduction

Parameter	Typical Influent Strength (mg/L)	Average Effluent Strength (mg/L)	License Limit (mg/L)	Reduction
TN	45.1	19.1	40	236%
TP	6.9	5.4	10	128%
SS	210	17.1	60	1228%

6.3 Total Volume and Pollutant Load - CSO

The total volume of CSO events and the associated pollutant load is summarised in Table 6-6 and Table 6-7 below.

Table 6-6: CSO Events 2013 Pollutant Loads – Nutrient and Pathogen

	Calculated Flows (ML)	TN (tonnes)	TP (tonnes)	SS (tonnes)	Enterococci (cfu)
Margaret St SPS	1312.97	5.29	0.54	95.17	7.72E+14
Willis St SWPS	693.35	2.55	0.27	61.05	3.74E+14
Shields St SWPS	262.28	0.87	0.10	25.54	1.32E+14
Lower Charles St SWPS	46.02	0.17	0.02	4.04	2.52E+13
Hope Street SPS	90.20	1.13	0.10	8.67	5.39E+13
Waltonia SWPS	23.30	0.14	0.03	3.18	1.42E+13
Lytton St SWPS	77.41	0.48	0.10	10.69	2.75E+13
Forster St SPS	450.41	3.44	0.74	70.63	2.15E+14
Total	**2948.71**	**14.07**	**1.93**	**278.97**	**1.61E+15**

Table 6-7: CSO Events 2013 Pollutant Loads – Metal Contaminants

	Calculated Flows (ML)	Cr (kg)	Cu (kg)	Pb (kg)	Zn (kg)
Margaret St SPS	1312.97	2.63	6.56	13.13	152.96
Willis St SWPS	693.35	1.39	3.47	6.93	80.77
Shields St SWPS	255.05	0.51	1.28	2.55	29.71
Lower Charles St SWPS	46.02	0.09	0.23	0.05	5.38
Hope Street SPS	90.20	0.14	0.72	0.09	9.25
Waltonia SWPS	23.30	0.04	0.04	0.02	0.76
Lytton St SWPS	77.41	0.12	0.12	0.08	2.52
Forster St SPS	450.41	0.68	0.68	0.45	14.64
Total	**2948.71**	**5.58**	**13.09**	**23.71**	**295.99**

The flows adopted for determining the pollutant load vary from those calculated in Chapter 5 as flows determined to be tidal infiltration have being excluded as these will not have the same pollutant load as a 'true' CSO event.

To determine the pollutant load the CSO sample results for a number of parameters was applied to the CSO discharges at each pump station. The sample results are included as Appendix D. The values for each parameter were assigned using logic statements in Microsoft Excel based on the total rainfall that fell on the day of the CSO event. The accuracy of these calculations are somewhat limited by the small number of samples collected; however, they provide a starting point for future investigations and ongoing engagement with key stakeholders about the impact that CSO events have on the receiving environment.

The results of the calculations indicate that CSO discharges are depositing a substantial amount of solids and pathogens to the receiving environment. The results suggest that CSO discharges have more impact in terms of solids and pathogens on the receiving environment than the STP. It is worth noting that the determination of pathogen loading is harder to quantify than solids loading due to the exponential growth rate of colony forming units; however, it is still considered in the research project due to community and stakeholder concern about elevated pathogen levels in the receiving environment and the assessment of recreational amenity.

6.4 Total Volume and Pollutant Load - Theoretical Separated Systems

One of the key issues that the research has sought to address is a recurring theme amongst the general community and some key stakeholders that to address the health of the receiving environment the combined system should be separated. This issue was raised in three of the four stakeholder interviews, with one stakeholder in favour of this outcome and two other stakeholders suggesting that the option needs to be investigated to understand what, if any, impact separation would have on the receiving environment.

The calculation of discharge volume from CSO events and observed inflow data for the Ti Tree Bend STP gave a total flow for the system over the observed time period. To create the theoretical separated sewerage and stormwater system there were a number of high level principles assumed:

- The total flows within the system would be unchanged $Q_{combined} = Q_{separated}$
    - where $Q_{combined} = Q_{STP} + Q_{CSO}$
    - where $Q_{separated} = Q_{STP} + Q_{SW}$
- Inflows to a revised separated Ti Tree Bend STP were calculated using TasWater design parameters for LSIP (Section 6.2)
- Remaining flows assigned as stormwater discharges
- Stormwater discharges apportioned between existing pump stations based on flows calculated in Section 5
- Effluent quality for the revised Ti Tree Bend STP assumed to be the same as existing combined Ti Tree Bend STP
- Stormwater discharge quality assigned based on stormwater sampling information provided by NRM North (refer Appendix E)

- Stormwater pollutants were assigned by working out a typical parameter value depending on the total rainfall that fell on a given day. The two values used were low rainfall events (<10 mm) and high rainfall events (>=10 mm)
- Sites used were Mowbray Creek for the Mowbray and Invermay catchments and Trevallyn Creek for the Margaret Street and Esplanade catchments

The results of the theoretical separated model are shown in Table 6-8 and Table 6-9 below.

Table 6-8: Theoretical Separated System 2013 Pollutant Loads – Nutrient and Pathogen

	Calculated Flows (ML)	TN (tonnes)	TP (tonnes)	SS (tonnes)	Enterococci (cfu)
Ti Tree Bend STP	4459.62	97.02	25.76	87	1.81E+12
Margaret St SPS	3392.73	6.21	1.70	120.44	7.03E+14
Willis St SWPS	1791.63	3.28	0.90	58.23	3.32E+14
Shields St SWPS	659.05	1.21	0.33	21.42	1.22E+14
Lower Charles St SWPS	118.92	0.22	0.06	3.51	1.95E+13
Hope Street SPS	233.09	0.60	0.07	24.82	4.89E+13
Waltonia SWPS	60.21	0.13	0.02	5.06	9.61E+12
Lytton St SWPS	200.03	0.46	0.05	18.60	3.59E+13
Forster St SPS	1163.87	3.02	0.34	123.95	2.44E+14
Total	**12079.15**	**112.13**	**29.22**	**463.35**	**1.52E+15**

Table 6-9: Theoretical Separated System 2013 Pollutant Loads – Metal Contaminants

	Calculated Flows (ML)	Cr (kg)	Cu (kg)	Pb (kg)	Zn (kg)
Ti Tree Bend STP	4459.62	4.46	31.22	19.62	285.42
Margaret St SPS	3392.73	22.90	78.88	10.18	179.81
Willis St SWPS	1791.63	12.09	41.66	5.37	94.96
Shields St SWPS	659.05	4.45	15.32	1.98	34.93
Lower Charles St SWPS	118.92	0.80	2.76	0.36	6.30
Hope Street SPS	233.09	1.52	3.73	0.70	17.95
Waltonia SWPS	60.21	0.39	0.96	0.18	4.64
Lytton St SWPS	200.03	1.30	3.20	0.60	15.40
Forster St SPS	1163.87	7.57	18.62	3.49	89.62
Total	**12079.15**	**55.48**	**196.36**	**42.48**	**729.03**

6.5 Performance Comparison

The results of the theoretical separated model were compared to the model for the existing combined system to determine the likely impact separation would have in terms of pollutant load entering the receiving environment. The results for the two models are shown in Table 6-10 below.

Table 6-10: Performance Comparison – Combined System vs. Theoretical Separated System

	Combined	Separated	% Improvement
Flows (ML)	12116.15	12116.15	N/A
TN (tonnes)	198.79	112.21	44%
TP (tonnes)	50.88	29.24	43%
SS (tonnes)	444.44	465.94	-5%
Enterococci (cfu)	1.636E+15	1.523E+15	6%
Cr (kg)	14.74	55.72	-278%
Cu (kg)	77.12	197.01	-155%
Pb (kg)	43.16	42.59	34%
Zn (kg)	884.42	731.69	17%

The model results suggest that separation would significantly reduce the total nutrient load entering the river and would cause a slight reduction in pathogen loading, two areas that have being identified as critical to stakeholders. Separation would however appear to increase the total amount of solids entering the receiving environment and would result in a significant increase in the discharge of chromium and copper contaminants. The issue of siltation in the river is of key interest to stakeholder groups and increasing solids loading would cause increased deposition of silt. This increase in deposited silts would also coincide with increased metal particulates and contaminants in the solids deposited.

It is worth noting that the model was constructed using only a limited number of sample results and with some high level assumptions. The assumptions made will need refinement in future modelling and a comprehensive sampling program should be initiated to capture CSO and stormwater discharges for a range of rainfall events.

Notwithstanding some of the issues with quantity of sample data, the results suggest that separation is not the cure-all to pollutant loading in the Tamar River.

7. Stakeholder Engagement

7.1 Background

The LCSS is an area of intense local interest and concern to the Launceston community and a number of other key stakeholders. TasWater is a member of the Tamar River Recovery Plan (TRRP) Committee and has received federal funding as part of this group to complete a range of short term improvements in the LCSS, and to develop a long term strategy to improve the performance of the LCSS. TasWater has recently engaged Beca to develop and deliver this strategy.

The community engagement work completed, of which the author was a member of the communication team, as part of the related Launceston Sewerage Improvement Project (LSIP) found that sewage treatment and particularly sewage disposal was a very emotive subject for people. People wanted to be consulted and feel that they could make a contribution to the direction of the project

To complete the gap analysis appropriately, stakeholder engagement was conducted in conjunction with regulatory and technical assessments of the LCSS performance. This would allow the strategy to target areas that were of concern to the public and for initiatives identified to be assessed using a multi-criteria assessment process that considered economic, environmental and social outcomes of the initiative or project.

7.2 Development of Stakeholder Questionnaire

To achieve the objectives of the stakeholder engagement process the questionnaire needed to be high level so that a range of responses could be offered, this would allow for the identification of key or recurring themes. The questionnaire was structured such that there were a small number of questions asked about the performance of the LCSS, the performance of Launceston's stormwater infrastructure and a larger number of questions about the performance and overall health of the receiving environment.

The questions were developed in conjunction with consultant Beca who as noted previously are working on the development of a formal strategy for the LCSS. The stakeholder questionnaire is included in Appendix G.

7.3 Results of Stakeholder Engagement with TRRP Committee

The results from the stakeholder engagement work completed with the TRRP Committee are presented below in an anonymous fashion to preserve the identity of the committee members and their comments on the performance of the LCSS, local stormwater system and health of the receiving environment.

7.3.1 Interview 1

Completion of the first interview raised the following key discussion points:

LCSS

- Concerns about performance during wet weather periods
- Considers lack of social awareness and education a challenge
- Combined system is an easy target for criticism
- The presence of human waste in sediment is undesirable
- Expects capital works to lead to system improvement within 10 years.

Stormwater System

- Considered suitable for all purposes
- Performing well
- Unaware if there is a significant pollutant load associated with stormwater.

Receiving Environment

- Concerns about water quality, NRM reporting shows upper reaches of the Tamar River to be in a degraded state

- Issues with accumulation of sediment and impact on flood protection
- Health of the Tamar and Esk Rivers is crucial to both the economic and social health of the city
- The current state of the river limits recreational use (rowing and sailing clubs)
- Not aware of anyone injured or sick because of contact with the river.

Other Key Themes/Concerns

- Favours education of the community with a focus on school based education in the areas of sewage treatment, environmental health of the rivers and public health implications
- Considers the major limitation river use and health to be the hydro-electric dam on the South Esk River that limits flows in the South Esk to 2.5 cubic metres per second
- Insufficient flows to prevent siltation and solids settlement at the freshwater – saltwater interface
- Issues with accumulation of sediment and impact on flood protection
- Health of the Tamar and Esk Rivers is crucial to both the economic and social health of the city
- The current state of the river limits recreational use (rowing and sailing clubs).

7.3.2 Interview 2

Completion of the second interview raised the following key discussion points:

LCSS

- There are reputational issues associated with CSO that are visible regardless of possible environmental and public health impact
- The combined system was purposely designed as a combined system, consequently spills are inevitable, the challenge is managing spill frequency and impact

- Combined system is unable to cope with high flows during significant wet weather periods
- Better to have CSO to the environment than surcharging and overflows in the streets and people's properties
- Need to understand issues with infiltration within the system and impact it has on performance
- Construction of additional storages should be considered in any works to limit overflow volumes
- Rolling 5 year programs of work on the combined system similar to the UK with a focus on effects based analysis and performance.

Stormwater System

- Considered to operate well
- Limited issues with local flooding that will be improved through completion of stormwater capture and routing strategy
- Considers that stormwater discharge quality is quite good, little requirement for treatment of stormwater
- Recent re-assessment of Kings Meadows Rivulet as an urban waterway consequently the rivulet is not considered unhealthy.

Receiving Environment

- South Esk River is in a degraded state at lower levels due to outflow issues at the hydro-electric dam
- Tamar River suffers from significant visual amenity issues and river user ignorance of the nature of the river. Siltation is naturally occurring, the Tamar River will never look like the Derwent River
- North Esk River considered to be in quite good health other than at the tidal interface with the Tamar River
- There are concerns about siltation, the state of the river edges, health notices in the South Esk River, colour and turbidity issues impacting people's perception of the rivers

- Primary function of the rivers is as a conduit of surface water flow however the city relies on the health and aesthetics/amenity of the rivers
- People want rivers that are suitable for primary contact (swimming and rowing)
- Not aware of anyone sick or injured from contact with the rivers.

Other Key Themes/Concerns

- Need to change people's perception of what a healthy Tamar River should look like unsure how to achieve this due to issues with stakeholder engagement and education programs
- Responsibility for the health of the rivers should not lie solely with TasWater or any other organisation, need government leadership and support to address river health issues
- Insufficient flows to prevent siltation and solids settlement at the freshwater – saltwater interface
- Issues with accumulation of sediment and impact on flood protection
- Health of the Tamar and Esk Rivers is crucial to both the economic and social health of the city
- The current state of the river limits recreational use (rowing and sailing clubs)
- Need a definitive document outlining what is possible and practicable within the combined system and set timeframes and budgets to deliver improvements
- Any strategy developed must consider separation as it is the fallback position for many river users but the cost and impact is not well understood
- The endgame of any strategy should be to reduce the frequency and severity of CSO events and provide satisfaction to the community that river health is improving and TasWater is effectively managing its infrastructure.

7.3.3 Interview 3

Completion of the third interview raised the following key discussion points:

LCSS

- During dry weather and low rainfall periods the system is fine, during wet weather there are issues with spills into the receiving environment
- Significant potential with a combined system to improve environmental outcomes through secondary treatment of stormwater that makes it to the Ti Tree Bend STP
- Should consider principles of water sensitive urban design (WSUD) to improve source control and flow attenuation to limit the impacts of CSO events
- Significant community education and engagement required there is a perception in the community that silt = sewage.

Stormwater System

- Considered to be effective at reducing flooding
- Currently too much focus on quantity of stormwater discharged and little to no focus on quality of stormwater discharged
- There is a perception within the Council and the local community that quality of stormwater discharge is not important. Not a good understanding within the community of pollutant load associated with stormwater discharge.

Receiving Environment

- Upper areas of the Tamar River are in reasonably poor condition however it is fed by the South and North Esk rivers which collectively drain more than 15% of Tasmania
- Upper catchment of the South and North Esk rivers are in generally good condition, some concern about metal contaminants from mining activities in the South Esk Catchment

- The lower bounds of the catchments are heavily impacted by land and farm management issues that will increase into the future with the rapid expansion of the dairy industry in both catchments
- Strong community feeling about the impact of sewage and silt on the health of the Tamar River, there is ongoing work to manage community expectations
- TasWater responsible for sewage and faecal contamination of the Tamar River
- The power authority (hydro-electric dam) and farming activities are largely responsible for siltation issues in the upper reaches of the Tamar River
- Nutrient load (nitrogen, ammonia and phosphorous) is a major concern
- Pollutant loads are impacting on river health and ecology
- Issue with the community understanding that the Tamar River is a tidal estuary not a true river this impacts on visual amenity
- The river is important to the community and considered to be a part of the city
- Anecdotal evidence of primary contact with the river causing sickness and illness
- Public health risk in working on or around the river in either a personal or professional capacity
- Primary function for the river is conduit of surface water and runoff however it is also considered the lifeblood of the community
- There is going to be increasing strain on the river system into the future with changing land use in the catchment, the river health must be at a minimum maintained at current levels but optimally improved.

Other Key Themes/Concerns

- Responsibility for the health of the rivers sits with everyone but not all are willing to participate in river health programs
- Need to understand the balance (triple bottom line approach) of trying to improve river health
- Improving community understanding of what a healthy Tamar River looks like and how it performs

- The health of the river directly impacts the prosperity of the city particularly tourism based business activities
- Educational material is a key to help drive change and improve community understanding
- TasWater has a rod to carry due to prevailing community perception about the cause of the silt and public health issues in the Tamar River
- Need to ensure that the community is engaged and understands the approach and options identified for improving the performance of the combined system.

7.3.4 Interview 4

Completion of the fourth interview raised the following key discussion points:

LCSS

- Major concerns about the performance of the combined system
- Has seen ejector pump stations operating during dry weather periods, considers that during this period raw sewage is pumped into the river
- Frequency of overflows is of concern and is annoyed that overflows occur
- Considers the system needs significant improvement to prevent ejector pump stations operating in dry weather
- Heavily reliant on the City Rising Main, if it were to have a major failure the entire system would be compromised
- Considers separation is the only logical outcome to improve river health and social perceptions.

Stormwater System

- Considered to have issues with hydraulic capacity
- The system needs additional storage constructed to attenuate peak flows and prevent localised flooding
- Limited used of water sensitive urban design (WSUD) is a current weakness of the system and needs further investigation.

Receiving Environment

- All river systems are considered to be in poor health in the vicinity of urbanised areas, this is caused by stormwater and sewage impacts on receiving environment
- Water quality issues reduce the recreational use of the receiving environment
- Significant concerns about sediment issues in the rivers and the impact of metal and wastewater contaminants
- To improve river health sediment needs to be better managed/controlled and there needs to be a major improvement in the performance of the LCSS and stormwater systems to reduce pollutants entering the catchment.
- Other catchment users also need to be aware of the impact that they are having on river health, in particular increasing agricultural activity in the North and South Esk catchments are causing significant issues with nutrient loading in the Tamar River
- Primary function of the river is drainage of surface water however the river has intrinsic value to the people/community
- It is essential that the health of the river is improved and brought up to an acceptable level of service.
- The current health of the river is similar to that of watercourses in third world countries and is a poor state of affairs for a developed country
- The health of the river poses a significant public health concern, surprised that local schools allow students to use the river for rowing
- There are records of contractors injured while working on the river and injuries getting infected due to poor condition of the river.

Other Key Themes/Concerns

- There are currently up to 30 entities that are responsible for the health and management of the three receiving environments, this is not a satisfactory state of affairs
- The current state of the rivers is an issue that is beyond the power of TasWater or LCC to resolve

- There are no quick fixes to the issues with the health of the river
- Capital improvements will need to be implemented over a 15-20 year period and will involve gradual separation of the system
- Use of a well conducted, targeted and articulate education program would be of benefit as there are a number of major mistruths and urban myths that are prevalent in the community.

7.4 Results of Community Engagement

The number of responses to the uploaded community engagement survey was not sufficient for use in this study. It is hoped that the development of a revised questionnaire and an improved user interface for the web based survey will provide for an improved response rate and important feedback for future studies and investigation works into the LCSS.

7.5 Key Themes and Messages

The key themes that were identified during the stakeholder engagement are outlined below:

- LCSS performance is generally acceptable during dry weather
- Issues with stormwater quality performance is generally not well understood
- Some understanding that the LCSS provides treatment for low flow stormwater but unsure what difference or impact this is having
- Faecal contamination in the rivers is perceived to be caused completely by LCSS
- Only one respondent considered separation was the only logical outcome
- Understanding and managing community expectations are critical to the success of any project
- Stakeholders understand that river health is a complex issue and that the LCSS is only one contributor to the current health of the rivers however there is an expectation that TasWater invest capital to improve the LCSS performance.

These key themes are addressed in the performance analysis work completed in Chapters 5 and 6. The results of the performance analysis and stakeholder engagement process will help drive the development of the strategy and recommendations for future investigative works.

8. Gap Analysis

8.1 Background

The completion of the gap analysis is intended to highlight how the combined system performs against regulated standards used internationally where combined systems are still in use. The reason for this gap analysis is that comparison of performance against local regulated sewage standards is only practical during periods of no or low rainfall.

8.2 Assessment of LCSS Performance against UK UPM Parameters

The Foundation for Water Research Urban Pollution Management Manual (UPM) document was used to determine performance of the LCSS against performance standards in use within the UK. The guideline was selected as the UK has a large number of combined systems, a similar climate to Launceston and the UK water industry has undergone a period of significant reform that was in part driven by a desire to improve system performance and environmental outcomes.

The assessment process considered the performance criteria discussed in the UPM guidelines as well as the wet weather standards for protecting aquatic life, protecting nominated bathing waters, protecting amenity use of the river and location of outfalls. The assessment is able to be completed predominantly using yes/no type responses.

Table 8-1: Performance Criteria for CSO

Parameter	Response	Comments
CSO events cause significant visual or aesthetic impact due to solids (sewage derived) or sewage fungus?	**Yes**	There is limited screening in place within the combined system this means that CSO events can discharge sewage solids. There is ongoing community concern about solids in the receiving environment that are perceived to be caused exclusively by CSO events. Performance assessment has indicated that solids loading is an issue with the combined system but is possibly more of an issue for the local stormwater system.
CSO events cause or make a significant contribution to deterioration in river chemical or biological quality`	**Yes**	Performance assessment of the combined system indicates that there is a significant pollutant load associated with the operation of the combined system. This needs to be further quantified through collection of upstream and downstream water quality data to determine extent of impact. **This is an area that needs to be addressed as a priority.**
CSO causes or makes a significant contribution to a failure to comply with Bathing Water Quality Standards	**Yes**	The performance assessment indicates that CSO events are discharging a significant pathogen load to the receiving environment. This has major impacts on recreational use. The performance assessment also indicates that stormwater pollutant loading is impacting amenity and use of the receiving environment. **This is an area that needs to be addressed as a priority.**
CSO operates in dry weather conditions	**Yes**	Results of performance assessment indicates that a number of the pump stations discharge on zero or low rainfall days (<1 mm). A contributing factor appears to be tidal infiltration. **This is an area that needs to be addressed as a priority.**
CSO causes a breach of water quality standards and other EC directives	**Yes**	The ANZECC guidelines were used in place of UPM and EC values as they better represent Australian river and estuarine conditions.
CSO causes unacceptable pollution of groundwater	**Unknown**	Investigation of impact on groundwater outside scope of research project.

Parameter	Response	Comments
Maximum number of independent storm event discharges via CSO events to identified bathing waters, or in close proximity to such waters, must not, on average, exceed the spill frequency standard of 3 spills per bathing season	**>3 (Fail)**	All pump stations discharged more than 3 times over the bathing (summer) period. There is community expectation that the receiving environment should be available and suitable for recreational use. Current performance of combined system and assessment of theoretical system indicates that water quality is not to an acceptable standard for recreational use.
Screening to be installed at CSO locations where there are discharges to the receiving environment and receiving environment considered to be of moderate amenity	**No**	Moderate amenity is for watercourses that are used for recreation and contact sport (non-immersion eg. boating), popular footpaths are adjacent to the watercourse or watercourse passes through areas of high social use. The Tamar and North Esk rivers are both considered to be of moderate amenity. UPM guidelines suggest that CSO sites with less than 30 spills/year require screens capable of 10 mm solids separation and that CSO sites with more than 30 spills/year require screens capable of 6 mm solids separation. The performance assessment of the combined system suggests that all pump stations will require screens to be installed capable of solids separation to 6 mm apertures. **This is an area that needs to be investigated as a priority.**

8.3 Assessment of LCSS Performance against US EPA Parameters

The US EPA Combined Sewer Overflows – Guidance for Nine Minimum Controls document was used to determine areas for improvement of the LCSS. The guideline was selected as it allows for a high level assessment of combined system assets, performance, operation and maintenance, environmental and community impact. The guidance was also selected for the assessment process as it can be completed without detailed operating performance data. The performance of the LCSS against the nine parameters is discussed below. A scoring system has been adopted to measure how TasWater is currently operating the combined system. Four values were adopted for scoring:

- 1 – Not in Place: This score means that TasWater has not applied or does not understand this parameter
- 2 – Poor: This score means that there is a mechanism in place but either not formalised, completed on an ad hoc basis or to a low standard
- 3 – Adequate: This score indicates that the process in place is acceptable and performing as expected
- 4 – Advanced: This score indicates that TasWater is performing above the expectation in the guideline.

Table 8-2: Minimum Control 1 – Proper operation and regular maintenance programs for the sewer system and the CSO

Parameter	Performance	Comments
Does the organisation have a structure and people responsible for operation of combined systems?	**3 – Adequate**	The current TasWater structure does not specifically allow for dedicated combined system staff however there are a number of staff in the area with extensive experience with the operation of the combined system.
Are there resources allocated for combined system O&M activities?	**2 – Poor**	The existing process needs to be refined; there is limited data capture about system performance to inform capital and operational requirements.
Are planning documents and procedures for O&M of the combined system in place?	**2 – Poor**	There are existing procedures for O&M activities within the combined system however the documents are dated, not easily accessible and workforce turnover and transition has resulted in a loss of knowledge.
Is there a list of facilities critical to the operation and performance of the combined system	**2 – Poor**	There is a general understanding of the major system infrastructure in the combined system across the organisation as a whole but very few employees have a detailed understanding of how the system performs and critical control points (CCP) for key infrastructure.

Parameter	Performance	Comments
Procedures in place for routine inspection and periodic maintenance of major and critical sites	2 – Poor	This issue is well understood by key operational employees but there is little in the way of dedicated process and procedure. TasWater is currently implementing a new Asset Management Information System (AMIS) that will improve the ability to store work procedures and generate maintenance schedules based on time and performance parameters.
Emergency Response Processes	3 – Adequate	TasWater has an incident management protocol that can be implemented when a potential incident occurs. An incident is generally defined as an event that could cause significant safety, environmental or reputational harm.
O&M manuals have been developed for critical sites	3 – Adequate	There are existing O&M manuals for all pump stations in the catchment, a high level O&M manual for the Ti Tree Bend STP as well as a number of detailed work method statements.

Table 8-3: Minimum Control 2 – Maximise Use of the Collection System for Storage

Parameter	Performance	Comments
Are maintenance activities performed to maximise system storage capability	2 – Poor	Current maintenance processes are highly reactive and O&M employees are often over allocated. Not a strong understanding of the choke points in the system or the most appropriate means of removing debris in the pipes.
Are tide gates/flaps appropriately maintained and repaired	1 – Not in Place	The research work completed has identified serious issues with the performance of a number of tide gates on pumped CSO locations. Gravity overflows were not considered in the research project, it is likely that the gravity overflows also have issues with tidal infiltration. **This is an area that needs to be addressed as a priority.**

Parameter	Performance	Comments
Has system configuration testing being completed and are system levels understood	3 – Adequate	There are records of system overflow levels and system storage capacity in terms of total volume and time however the research project has identified scope for improvement in this area. Although performance is considered adequate there is scope to significantly reduce the frequency of CSO in some catchments. **This is an area that needs to be addressed as a priority.**
Has flow retardation being investigated or considered?	1 – Not in Place	Due to the peculiarities of the ownership of the combined system between TasWater and Launceston City Council there is little scope to install flow retarding capacity in street infrastructure (gully pits). This could be further discussed with Launceston City Council to develop a partnership agreement.
Has upstream detention being investigated or considered?	3 – Adequate	The installation of the Margaret Street Detention Basin is a good indicator that flow retardation has been considered and successfully implemented in some areas of the system. There is scope for this to be further investigated particularly in the Esplanade area based on the overflow frequency and volumes spilled in this catchment.

Table 8-4: Minimum Control 3 – Review and Modification of Pre-treatment Requirements

Parameter	Performance	Comments
Have major trade waste inputs being identified?	3 – Adequate	TasWater has a dedicated trade waste team that have identified and commenced negotiation on a trade waste agreement with the majority of trade waste customers in the combined system. There has been particular effort made to date with the major customers who tend to have the highest discharge volumes and influent strength.

Parameter	Performance	Comments
Are there sufficient controls on trade waste input?	2 – Poor	TasWater is moving major customers to contemporary trade waste agreements that put the onus on the customer to reduce their influent strength however many customers are still on transition arrangements that have less control and lower quality standards.
Can existing trade waste customers install additional pre-treatment to reduce influent strength	2 – Poor	This ties in strongly with the above as contemporary trade waste agreements come into effect existing trade waste customers will be required to install additional pre-treatment infrastructure. This process is well established but will take time to develop hence the lower score.
Have system modifications being considered to reduce the impact of trade waste inputs on CSO events?	1 – Not in Place	Some high level concept discussions have occurred in this space but not progressed any further. This item will need to remain in consideration until new agreements for trade waste customers come into play. **This is an area that will need ongoing monitoring.**

Table 8-5: Minimum Control 4 – Maximise Flows to the STP for Treatment

Parameter	Performance	Comments
Has additional flow handling capability at the STP being considered?	3 – Adequate	The existing STP site will be used as part of the LSIP project to house another separated STP. This means that the existing site is constrained with limited ability to store or handle additional flows
Is there scope to incrementally increase flows to the STP?	3 – Adequate	The STP was designed to have multiple bypasses to account for the combined nature of the system, this means that the STP is able to provide at least primary treatment and partial disinfection for flows of up to 200 ML/day. Currently the City Rising Main is the limiting factor in getting flows to the STP.

Parameter	Performance	Comments
Has a performance assessment been completed to optimise treatment performance against inflows?	2 – Poor	The design and operation of the STP shows awareness of the competing desires for maximising hydraulic capacity through the STP while maintaining an appropriate level of treatment. The limiting issue however is as outlined above, the capacity of the City Rising Main.

Table 8-6: Minimum Control 5 – Elimination of CSO during Dry Weather

Parameter	Performance	Comments
Is there frequent inspection of weirs, pump stations and hydraulic regulators?	2 – Poor	The larger pump stations are frequently inspected however the smaller pump station sites and the weirs and flow regulating equipment are inspected infrequently.
Is there a maintenance program in place for repair and rehabilitation of flow regulating assets?	2 – Poor	Maintenance program in place for pump stations however resource capacity means that the maintenance schedule is sometimes deferred. No current maintenance program in place for weirs and flow regulating assets.
Has telemetry/ monitoring equipment been installed at key sites?	3 – Adequate	TasWater is performing quite well in this area with all sites available to view on the SCADA system however improvements could be made through installation of additional monitoring equipment such as flow meters or inline quality probes.
Is there a cleaning program in place to prevent solids build-up?	2 – Poor	There is not a formalised program for mains cleaning in the combined system however some hot spots are inspected and periodically cleaned. Implementation of the CCTV program will improve performance in this area.
Is there a CCTV or relining program in place to limit groundwater infiltration?	2 – Poor	A $4 million annual statewide CCTV programme has been implemented by TasWater there are currently CCTV works in progress within the combined system to better understand asset condition and performance.

Parameter	Performance	Comments
Are tide flaps adequately maintained and replaced to prevent tidal infiltration?	**1 – Not in Place**	This research project has highlighted serious issues with tide flap performance, O&M employees have commenced inspection and remediation works at Willis Street. Additional inspections and remediation works are still required for Shields Street SWPS, Lytton Street SWPS and Waltonia SWPS. **This is an area that needs to be addressed as a priority.**

Table 8-7: Minimum Control 6 – Control of Solid and Floatable Materials in CSO

Parameter	Performance	Comments
Are there controls in place to reduce/remove solids and floatables from CSO events?	**2 – Poor**	There are limited controls in place to reduce the presence of solids or floatables during CSO events. Margaret Street Detention Basin and the New Margaret Street SPS are the only facilities capable of handling removing gross solids. **Further work on screening of pump station and gravity overflows needs to be completed as a priority.**
Are high impact discharge locations understood and solids control in place?	**2 – Poor**	High impact discharge locations are generally well understood, particularly for pumped CSO, there is a lesser understanding for gravity CSO. As noted above there is limited solids handling equipment (screens, detention/flow retarding assets) installed. **This needs to be investigated and addressed as a priority.**
Has modification of street infrastructure been considered to limit solids entry to the system?	**1 – Not in Place**	As noted above control of street infrastructure (kerb and gutter, gully pits) has remained with Launceston City Council. TasWater has limited ability to influence/change operation of street infrastructure. This could be further discussed with Launceston City Council to develop a partnership agreement.

Table 8-8: Minimum Control 7 – Pollution Prevention Programs to Reduce Contaminants in CSO

Parameter	Performance	Comments
Is there a street cleaning program in place?	2 – Poor	Launceston City Council has a street cleaning program in place however TasWater has little detail about the size, extents and timing of the street cleaning program and has little ability to influence or alter the program. This is another area that could be further investigated and discussed with Launceston City Council.
Is there a community education program in place?	1 – Not in Place	NRM North are completing some community education and engagement works in relation to the health of the Tamar and Esk rivers that does talk in very general terms about the combined system. The combined system is almost universally poorly understood by the local community and most key stakeholders. **The development of a targeted community engagement and education program needs to be completed as a priority. The findings of this research project should be used to help develop educational material.**
Is illegal dumping of waste monitored or controlled?	1 – Not in Place	TasWater does not have a well developed illegal dumping or monitoring program in place, it is suspected that there are periodic illegal dumping events occurring causing process failure at the Ti Tree Bend STP. This is an area that will need investigating at some point but is not considered a high priority as there are still a number of permanent trade waste customers either without a trade waste agreement or not signed onto a contemporary trade waste agreement.
Are there hazardous waste collection facilities installed?	3 – Adequate	TasWater has installed a tankered waste facility at the Ti Tree Bend STP to handle periodic high strength discharges. Launceston City Council has installed about the city at most public toilets hazardous waste disposal bins. It is considered that the existing controls are sufficient.

Parameter	Performance	Comments
Have product bans or substitutions been considered?	1 – Not in Place	TasWater is not advanced enough in system monitoring and understanding to provide informed opinion on the impact that individual products or brands of products have on the performance of the CSO. Additionally TasWater is unlikely to have much influence in product control and distribution. This area is not considered a high priority for investigation,

Table 8-9: Minimum Control 8 – Public Notification to Ensure Adequate Notification of CSO Occurrences and Impacts

Parameter	Performance	Comments
Are the public notified when CSO events occur?	1 – Not in Place	There is not a formal notification process for when CSO events occur however there is broad community awareness that the lower reaches of the North Esk River and the upper areas of the Tamar River are not safe for primary contact due to a number of causes.
Are public places in the vicinity of CSO outfalls appropriately signed?	1 – Not in Place	As above there is broad understanding that the receiving environment is not suitable for primary contact and so CSO discharge locations are not currently signed.

Table 8-10: Minimum Control 9 – Monitoring to Effectively Characterise CSO Impact and Efficacy of CSO Controls

Parameter	Performance	Comments
Is monitoring of the receiving environment upstream and downstream of CSO outfalls regularly completed?	1 – Not in Place	TasWater is completing monitoring works upstream and downstream of the Ti Tree Bend STP to inform design and approvals requirements for LSIP. There is limited monitoring undertaken upstream and downstream of CSO discharge locations and only a limited number of samples for CSO events. **A comprehensive monitoring program is recommended to fully understand the impact that CSO events are having on the receiving environment.**
Does the authority understand CSO event frequency, volume and duration?	2 – Poor	A high level understanding of combined system performance can be obtained through analysis of the SCADA system but this information is not easy to access or interpret. Completion of this project has made system performance information for CSO events more accessible for TasWater employees. **It is strongly recommended that flow meters and inline sampling probes are installed on pump stations that generate CSO to understand frequency, volume and impact of CSO events.**
Are visual inspections completed after CSO events?	1 – Not in Place	Visual inspections are not routinely completed following CSO events. **Development of an inspection program is a key recommendation to understand the visual impact of CSO events. This will also expose employees to the reality of the operation of a number of the pump stations that generate overflows almost daily.**

Parameter	Performance	Comments
Is appropriate automatic measurement equipment installed to measure duration, volume and pollutant loads of CSO events?	2 – Poor	There is limited equipment installed to automatically measure CSO events, it is possible to determine duration, volume and loading of CSO events using TasWater SCADA information and overflow sampling results however this is a time consuming and complex process. **As noted earlier installation of flow monitoring equipment and inline sampling probes is recommended.**
Does the authority report major incidents relating to CSO impacts?	2 – Poor	TasWater records and reports to the EPA on spills within the combined system however due to quality and availability of data actual impact of spills is difficult to quantify and report.

8.4 Results of Gap Analysis

Completion of the gap analysis has highlighted that there are a number of areas for improvement within the combined system and that TasWater needs to investigate partnerships with Launceston City Council, NRM North and the Launceston Flood Authority to improve operation of the combined system and reduce CSO events. This will be through understanding and improving street cleaning programs, continued and improved community and stakeholder education and improved performance of tide flaps.

The gap analysis has also highlighted that TasWater needs to significantly improve monitoring of the combined system and the receiving environment to get better understand the impact that CSO events are having on the receiving environment.

Assessment against the UK UPM guidelines suggests that TasWater will need to commit capital expenditure to investigate and install screening capability at all of the existing pump stations that generate CSO based on the assessed user amenity of the receiving environment.

9. Strategy Development

9.1 Results of Investigation

The results of the research project have identified a number of areas for immediate improvement that can be easily implemented in the capital or operational program. Implementation of these improvement works will reduce the frequency and volume of CSO events, increase understanding of the combined system and be able to be used to inform stakeholder education and future capital and operational investment strategies.

Longer term works will need to consider methods to improve capture of first flush runoff flows, reduce/retard inflows to pump stations and consider screening works to reduce visual impacts of CSO events.

Additional sampling and further refinement of the performance analysis and theoretical separated model needs to be completed as a short-term improvement activity. Results obtained to date indicate that separation does not appear to be the most effective method of improving the system. This aligns with works completed in the UK over the past twenty years where capital and operational investment has looked at ways to improve the performance of the existing combined systems rather than separate.

The results of this research project suggest that, while there is significant works required to improve the performance of the combined system, the system does provide opportunities to improve the level of treatment that stormwater receives. Furthermore, results indicate that the performance of existing separated stormwater systems is also causing environmental impact.

9.2 Short Term Improvements

The completion of the performance analysis highlighted infiltration, most likely tidal infiltration, at a number of pump stations is causing overflow events. It is strongly recommended that there are further investigation works completed at the following pump stations to understand and address the causes of the overflow events:

- Willis Street SWPS
- Shields Street SWPS
- Lower Charles Street SWPS
- Waltonia SWPS
- Lytton Street SWPS

The performance analysis also suggested that there is an opportunity to optimise the operation of the Margaret Street Detention Basin and the New Margaret Street SPS. This would reduce the number of small volume discharges by increasing the use of the open storage component of the detention basin.

The gap analysis against the UK UPM and US EPA guidelines identified a number of areas for immediate attention. These mostly relate to improved inspection and maintenance activities. The recommended actions for immediate implementation are:

- Implementation of a monitoring program upstream and downstream of major CSO discharge locations to better understand localised and total impact of CSO events
- Collect additional CSO and stormwater samples for a range of rainfall events to confirm and refine results obtained in the performance analysis
- Reduce dry weather overflows (days with less than <1 mm of rain), this aligns with the recommendations from the performance analysis
- Investigate likely screening requirements suggested from UPM gap analysis
- Implement tide gate/flap maintenance and inspection program
- Conduct system configuration modelling and testing to understand storage capacity of the system as a whole

- Investigation of system modification for areas serviced by major trade waste customers, e.g. system storage or partial separation in these areas
- Improve understanding of visual and social impacts from CSO discharges in sensitive locations
- Develop/build upon existing community education and engagement programs that discuss the combined system, combined sewer overflows, stormwater contamination and discharges, impact of diffuse sources for pollutant loading and overall health of the receiving environment
- Investigate the installation of flow meters and inline sampling probes at CSO discharge locations.

9.3 Long Term Improvements (Future Strategy)

The development of long term improvement initiatives and future capital and operational strategies will largely be driven by the outcomes achieved in the short term works. The most important factor in the development of the long term strategy will be the implementation of a comprehensive sampling program to fully understand the pollutant loading of CSO events and the health of the receiving environment, both upstream and downstream of CSO discharge locations.

If the results of a detailed monitoring program support the findings of this research then the most appropriate outcome for the long term strategy will include:

- Elimination of dry weather overflow events
- Improved capture of low intensity and low total rainfall storm flows
- Screening of high priority CSO discharges
- Possible targeted separation in high risk areas
- Real time monitoring information acting as a trigger for maintenance and operation activities to prevent CSO events, where possible or practicable
- Implementation of predictive maintenance programs including weather monitoring and system flushing to reduce the severity of CSO events

- Community and stakeholder education and engagement to understand the role that the combined system plays in the overall health of the receiving environment and the extent to which TasWater can improve environmental outcomes
- Community and stakeholder support of the projects outlined above.

10. Conclusion and Opportunities for Future Research

The research project has identified a number of issues with the performance of the existing combined system and a number of gaps against contemporary US and UK regulatory standards for performance. The project has also shown that separation of the existing combined system would not provide substantive improvements to river health for the capital investment required.

The research results suggest that there are some opportunities for improved performance of the combined system in the short term and that, subsequent to refinement of the pollutant model, future investment should seek to improve the storage capability within the system. The best performance outcomes for the system, the receiving environment and the city as a whole are achieved when both sanitary and storm flows are treated fully by the Ti Tree Bend STP. Additionally screening should be investigated at all discharge sites to improve visual amenity of the receiving environment through the removal of sewage trash from CSO events.

Future research opportunities include:

- Refinement of the pollutant model and performance analysis process with the collection of additional sample data
- Investigation of gravity outfalls within the system
- Detailed gap analysis against US EPA and UK UPM requirements
- Design of future detention storages and CSO screening installations
- Flow retardation and capture strategies for above ground infrastructure such as kerb and gutter, gully pits, stormwater harvesting and bio-retention and treatment in parks, sports fields, etc.
- Confirming community, stakeholder and regulatory expectations for levels of service from the combined system, the receiving environment and likely impacts using a triple bottom line approach.

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Appendix A Project Specification

<u>ENG 4111/4112 Research Project</u>

PROJECT SPECIFICATION

FOR: Cameron Paul Jessup

STUDENT NO.: 0061035089

TOPIC: Launceston's Combined Drainage System – Investigation into the operation of the combined system and development of a strategy for the future.

SUPERVISORS: Dr Vasantha Aravinthan

Andrew Truscott, TasWater

STUDY MODE: External

ENROLMENT: ENG4111 – S1, 2015

ENG4112 – S2, 2015

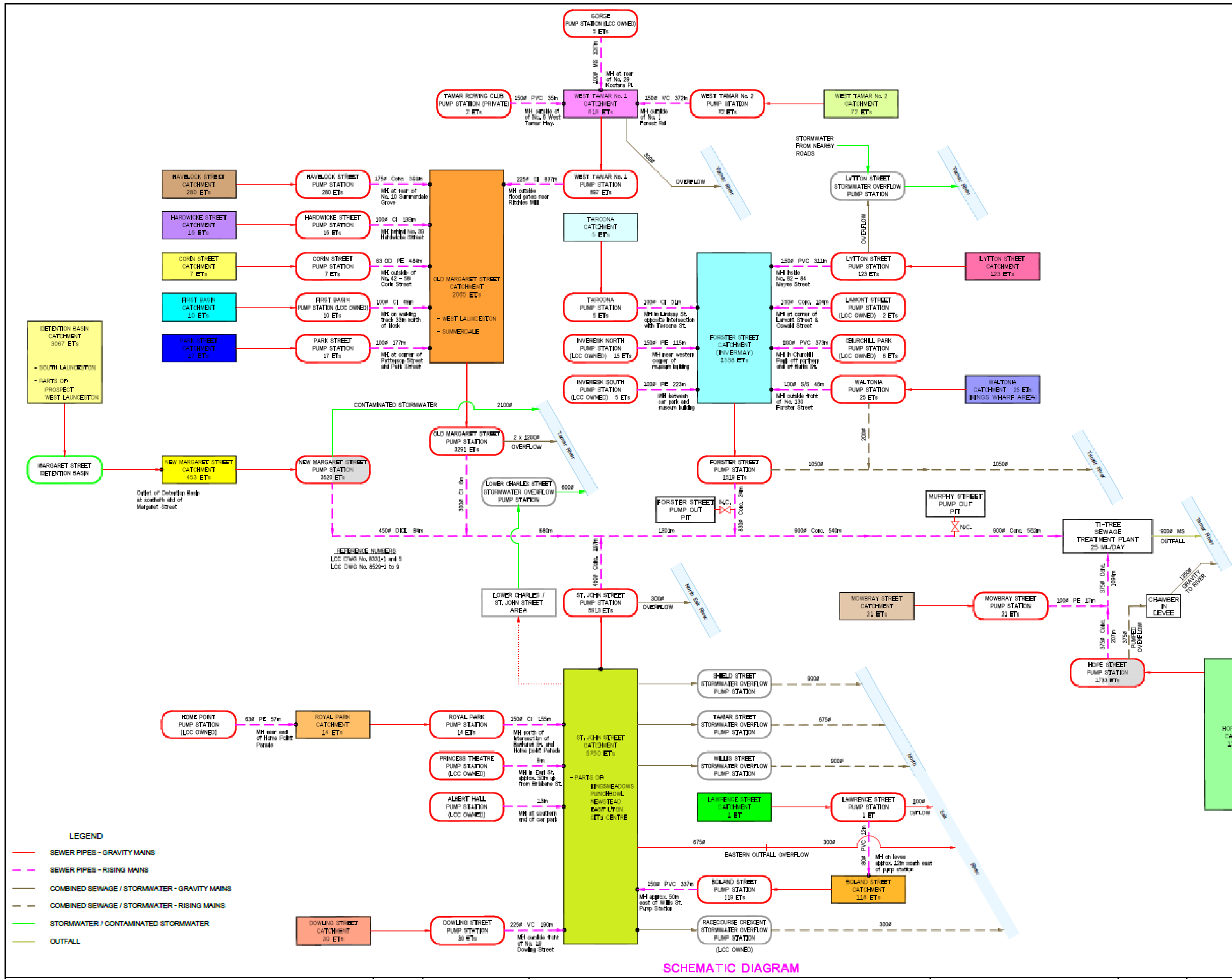
PROJECT AIM: This project seeks to investigate the operation of the existing Launceston Combined Drainage System and to determine a strategy for the system into the future. The Launceston Combined Drainage System dates back to the 1850's and is the last significant combined drainage system still in operation in Australia. The system provides sewage and stormwater services to approximately 16,000 customers in and around the Launceston CBD and older residential districts. The system is designed to handle and treat the 'first flush' of stormwater however it will overflow during peak rainfall events. There is significant stakeholder and community concern about the impact of the overflow events on the receiving water. A key part of the project will be to understand the conditions leading to overflow events and the frequency, volume and pollutant loading of these events.

SPONSORSHIP: TasWater

PROGRAM: Preliminary

1. Research and review the existence and performance of combined drainage systems across the country and internationally.
2. Collect hydraulic loading data on Launceston Combined Drainage flows during different flow conditions such as dry weather flows, average flows and wet weather flows and correlate them with rainfall data obtained from the Bureau of Meteorology (BOM).
3. Collect organic and nutrient loading information for influent and effluent from the system during the scenarios mentioned in Step 2 above.
4. Analyse the data obtained in Steps 2 and 3 above critically to determine the trigger rainfall event/amount leading to combined sewer overflows (CSO) and the volume and loading associated with CSO events.
5. Repeat the process indicated in Steps 2, 3 and 4 for separate drainage networks that have dedicated stormwater and sewage systems with similar characteristics to the Launceston Combined Drainage System.
6. Compare the performance of the combined system with regulated performance standards (US EPA and UK UPM) and against other dedicated stormwater and sewage systems using the results obtained in Steps 4 and 5.
7. Investigate critically the quality of water discharged during different flow conditions instigated by rainfall events of varying intensity and duration.
8. Develop a system wide strategy based on research completed and data analysis to improve performance of the existing system.
9. Discuss and evaluate potential alternatives for handling combined flows into the future. These alternatives will consider system improvements as well as separation of the combined drainage system into dedicated sewerage and stormwater systems.
10. Submit an academic dissertation on the research.

Appendix B Launceston Combined Sewerage System Schematic



PUMP STATION / CATCHMENT E.T. LOADINGS

CATCHMENT NAME	ETs FROM IMMEDIATE CATCHMENT	ETs FROM ADJACENT CATCHMENT(S)	CUMULATIVE ETs
WEST TAMAR No. 2	72	-	72
TAMAR ROWING CLUB	2	-	2
GORGE	5	-	5
WEST TAMAR No. 1	818	79	897
HAVELOCK STREET	280	-	280
HARDWICKE	15	-	15
CORIN STREET	7	-	7
FIRST BASIN	10	-	10
PARK STREET	17	-	17
OLD MARGARET STREET	2065	1226	3291
DETENTION BASIN	3067	-	3067
NEW MARGARET STREET	453	3067	3520
ROYAL PARK	14	-	14
LAWRENCE STREET	1	-	1
BOLAND STREET	118	-	118
DOWLING STREET	30	-	30
ST. JOHN STREET	5750	163	5913
TAROONA	5	-	5
LYTTON STREET	123	-	123
WALTONIA	25	-	25
FORSTER STREET	1338	181	1519
REMOUNT ROAD	352	-	352
CONWAY STREET	8	-	8
McKENZIE STREET	10	-	10
WHITE CITY	20	-	20
HOPE STREET	1343	390	1733
MOWBRAY STREET	21	-	21

Appendix C Ti Tree Bend STP Sampling Results

Sample Date	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	BOD (mg/L)	Suspended Solids (mg/L)	Ammonia-Nitrogen (mg/L)	Enterococci (cfu/100 ml)
08/01/13	31	6.77	7	22	0.1	20
05/02/13	30	4.78	5	27	0.1	30
05/03/13	34	8.76	8	29	0.6	20
16/04/13	31.8	6.36	6	32	0.6	10
09/05/13	21.7	5.54	4	9	0.5	10
19/06/13	24.2	6.51	9	23	0.5	50
17/07/13	22	4.26	5	19	1	80
20/08/13	12	0.74	3	8	0.023	90
12/09/13	3.5	12	5	11	0.092	15
16/10/13	20	5.8	6	11	0.14	45
12/11/13	26	4.1	7	22	0.15	25
10/12/13	5.6	3.8	12	23	0.31	90
22/01/14	4.2	4.6	5	10	0.11	20
19/02/14	7.7	7.5	6	20	0.14	440
11/03/14	44	8.9	6	31	0.19	10
10/04/14	11	7.5	24	28	4.9	40
13/05/14	20	4.3	5	9	0.059	10
12/06/14	19	7.3	12	13	0.14	110
16/07/14	11	2.9	7	12	4.5	110
13/08/14	12	2.3	3	6	0.08	40
10/09/14	14	1.4	3	10	0.05	10
14/10/14	40	6.9	25	16	0.02	310
12/11/14	8.3	6.8	10	9	1.6	10
11/12/14	5.5	0.9	14	10	0.08	10

Parameter	Sample Result (mg/L)
Cr	0.000001
Cu	0.000007
Pb	0.0000044
Zn	0.000064

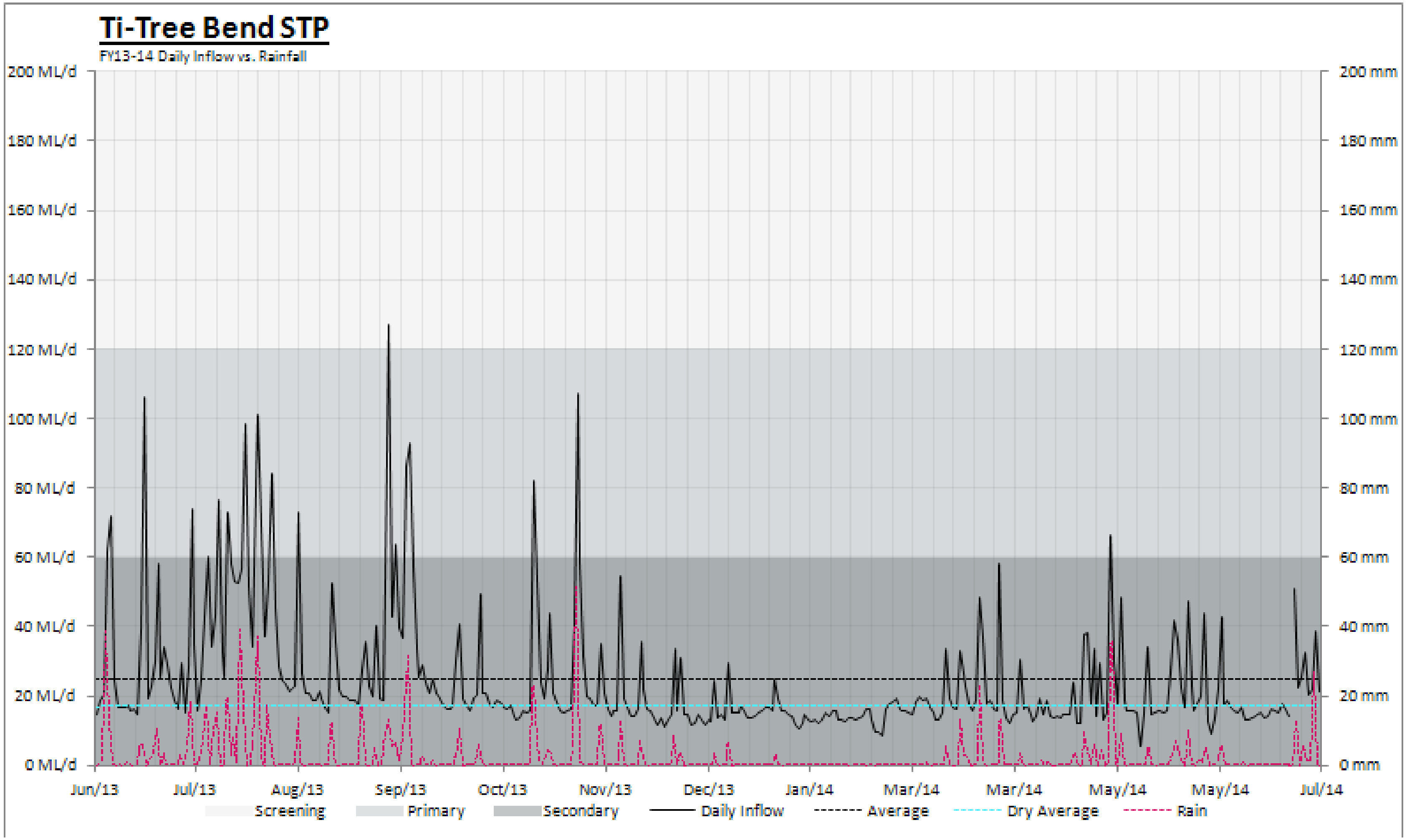
Appendix D CSO Sampling

Date	Location	O&G	pH	COD	TDS	Conductivity	BOD5	TSS	Coliforms	Enterococci	E. Coli	DO	NH4	Temp	Turbidity	TN	TP	Cr	Cu	Pb	Zn	TPH
21/11/2013	Forster St SPS	7	7.50	47	84	100	7	91	80000	80000		9.5	0.21	14.9	69	2.4	0.43	<2	3	<10	25	<40
9/09/2014	Forster St SPS	16.5	7.60	320	79	145	120	160					0.84		70	7.9	1.7	203	<2	<10	40	4400
27/10/2014	Forster St SPS								130000	46000	110000		0.72			3.8	0.73					410
21/11/2013	Margaret St SPS	18	7.20	50	74	71.3	5	160	68000	41000		10.1	0.11	13.9	110	2.1	0.29	<2	4	<10	62	<40
9/09/2014	Margaret St SPS	1.1	7.30	95	180	132	16	60					1.3		28	4.3	0.43	<2	6	<10	171	340
27/10/2014	Margaret St SPS								200000	62000	160000		0.7			2.5	0.42					280
21/11/2013	Hope St SPS	20	7.30	80	130	166	14	80	120000	68000		9.6	1.3	14.6	34	6.2	0.85	<2	6	<10	105	<40
9/09/2014	Hope St SPS	3.4	7.50	130	81	378	50	110					12		41	18	1.4	3	10	<10	100	830
27/10/2014	Hope St SPS								91000	49000	910000		4.5			8.4	1.1					750

Appendix E Stormwater Sampling

Date	Location	pH	TSS	Enterococci	Temp	Turbidity	TN	TP	Cr	Cu	Pb	Zn
17/10/2013	Distillery Creek		0	0		<1	0	0	0	0	0.000	0.000
23/10/2013	Distillery Creek	7.6	15	1400	13	15	0.2	0.02	0.001	0.003	0.001	0.005
13/11/2013	Distillery Creek	7.7	3	1600	13.7	10	0.8	0.05	0.01	0.002	0.001	0.003
21/11/2013	Distillery Creek	7.1	60	8600	11.6	45	0.4	0.03	0.003	0.005	0.002	0.008
17/10/2013	Jinglers Creek		10	2400		40	0.6	0.08	0.003	0.095	0.006	0.120
23/10/2013	Jinglers Creek	7.6	5	2000	13.7	20	0.5	0.32	0.001	0.01	0.003	0.040
13/11/2013	Jinglers Creek	7.6	10	2200	15.5	60	0.9	0.08	0.016	0.01	0.003	0.045
21/11/2013	Jinglers Creek	7.1	210	24000	12.4	200	1.8	0.19	0.007	0.021	0.008	0.080
17/10/2013	Mowbray		3	200		5	0.2	0.84	0.001	0.002	0.001	0.003
23/10/2013	Mowbray	7.4	35	5600	13.4	60	0.6	0.14	0.002	0.01	0.003	0.075
13/11/2013	Mowbray	7.2	30	2200	14.2	65	1.1	0.18	0.018	0.014	0.004	0.080
21/11/2013	Mowbray	7.0	120	24000	12.3	175	2.9	0.32	0.005	0.038	0.005	0.150
17/10/2013	Trevallyn		15	1200		30	0.7	1.16	0.001	0.016	0.003	0.040
23/10/2013	Trevallyn	7.7	5	2200	13.9	3	0.9	0.02	0.001	0.004	0.001	0.050
13/11/2013	Trevallyn		480	2200	18.5	255	2.8	0.84	0.019	0.06	0.060	0.470
21/11/2013	Trevallyn	6.9	40	24000	12.8	45	2.9	0.2	0.001	0.013	0.005	0.070
17/10/2013	Newnham Creek 1		5	1400		3	0.8	0.01	0.001	0.004	0.001	0.060
23/10/2013	Newnham Creek 1	7.6	10	9400	13.7	10	0.5	0.12	0.001	0.005	0.020	0.040
13/11/2013	Newnham Creek 1	7.8	15	2400	14.4	15	0.8	0.04	0.012	0.006	0.001	0.045
21/11/2013	Newnham Creek 1	6.8	40	13400	11.4	20	0.5	0.03	0.001	0.006	0.001	0.030
17/10/2013	Newnham Creek 2		3	1800		3	1.3	0.08	0.001	0.003	0.001	0.035
23/10/2013	Newnham Creek 2	7.6	3	5800	13.3	5	0.6	0.18	0.001	0.004	0.001	0.030
13/11/2013	Newnham Creek 2	7.9	3	2200	14.5	10	1.9	0.06	0.013	0.004	0.001	0.035
21/11/2013	Newnham Creek 2	6.9	75	17400	11.5	40	1.8	0.12	0.001	0.012	0.001	0.025
17/10/2013	Newnham Creek 3		15	200		30	1	0.08	0.001	0.007	0.003	0.015
23/10/2013	Newnham Creek 3	7.5	10	600	14	15	1	0.24	0.001	0.006	0.001	0.010
13/11/2013	Newnham Creek 3	7.6	5	1800	14.6	25	0.7	0.02	0.013	0.007	0.001	0.005
21/11/2013	Newnham Creek 3	7.2	335	24000	13.8	355	0.7	0.08	0.011	0.033	0.008	0.045
17/10/2013	Newnham Creek 4		3	2000		5	1.4	0.06	0.001	0.004	0.001	0.010
23/10/2013	Newnham Creek 4	7.8	10	20000	13	25	0.7	0.16	0.001	0.008	0.003	0.015
13/11/2013	Newnham Creek 4	7.8	5	2200	14	25	0.9	0.24	0.012	0.007	0.001	0.015
21/11/2013	Newnham Creek 4	7.1	70	24000	12.5	50	1.7	0.14	0.002	0.01	0.004	0.020
17/10/2013	Newnham Creek 5		3	0		<1	9.4	0.18	0.001	0.007	0.005	0.040
23/10/2013	Newnham Creek 5	7.3	3	1200	14	3	7	0.02	0.001	0.006	0.003	0.040
13/11/2013	Newnham Creek 5	7.6	50	600	15.1	20	8.8	0.14	0.012	0.009	0.006	0.040
21/11/2013	Newnham Creek 5	7.0	40	12000	13	25	3.9	0.38	0.002	0.012	0.008	0.075
17/10/2013	Newnham Creek 6		2	1800		15	1.4	0.04	0.001	0.006	0.001	0.035
23/10/2013	Newnham Creek 6	7.6	20	9400	14.3	25	0.7	0.22	0.001	0.007	0.001	0.050
13/11/2013	Newnham Creek 6	7.8	15	2400	14.5	35	1.6	0.12	0.015	0.01	0.003	0.055
21/11/2013	Newnham Creek 6	7.0	80	20000	12.8	55	0.6	0.12	0.003	0.009	0.004	0.050
17/10/2013	Newnham Creek 7		60	2400		25	0.7	0.21	0.002	0.009	0.009	0.060
23/10/2013	Newnham Creek 7	7.6	15	13000	13.4	25	0.6	0.16	0.001	0.007	0.003	0.060
13/11/2013	Newnham Creek 7	7.5	3	2400	14.1	20	1	0.17	0.018	0.007	0.004	0.050
21/11/2013	Newnham Creek 7	7.0	120	20000	12.2	95	0.6	0.1	0.007	0.016	0.012	0.085

Appendix F Ti Tree Bend STP Inflows (2013/14 FY)



Appendix G Stakeholder Engagement Questionnaire

1. In your opinion, how does the combined sewer system operate in dry weather and in wet weather?
2. What would you do to improve it, if anything?
3. In your opinion, how does the stormwater system operate?
4. What would you do to improve it?
5. Rate the current river system: 1 – 5 (1=poor, 2= below average, 3= acceptable, 4 = good, 5 = excellent)
6. What are the most crucial factors that currently prevent the river system from being perceived as “excellent”?
7. What does an “ideal” or “optimum” river system look like to you?
8. What do you believe are the biggest challenges in achieving that ideal?
9. What do you think is acceptable in terms of river quality?
10. How important is the river to you either personally or commercially?
11. What do you think is the river system’s primary function?
12. How important is it to you that the river be brought to, and maintained at an optimum state?

13. Do you think the current state of the river poses a health and safety risk to either you personally or your organisation?

14. In your opinion who do you believe is “responsible” for the state of river system and the maintenance of it?

15. In terms of time, what are your expectations of reaching optimum levels?

16. If the river system was in an ideal or optimum state in the future, how would it serve you then? Do you think you’d interface with it more or less as a result?

17. Would your (or your organisations’) future demand on the river be larger or smaller than what is currently being experienced?

18. Do you feel that distributed educational material about river management and the role the community/industry plays therein, would be beneficial or wasted?

19. How do you believe your (or your organisations’) current behaviours or activities impact on the river system?