EVALUATING ENVIRONMENTAL IMPACTS OF COMBINED SEWER OVERFLOWS ON THE TAMAR RIVER

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ABSTRACT

TasWater operates a combined sewerage system that services the greater Launceston area in northern Tasmania. The operation of the system is of interest to the local community and key stakeholders, who are concerned that the performance of the system is having significant impact on the receiving environment.

This paper discusses the development of a long-term strategy based on understanding the frequency, extent and environmental impact of overflows relative to other continual or intermittent discharges. Following initial data gathering and stakeholder engagement, the evaluation criteria established were:

- Responsibility to the community
- Public health
- River health
- Public perception

A long list of upgrade options was assessed at a high level against these criteria; four options were shortlisted. Each option addresses different stakeholder concerns at varying levels;

- Screening of overflows to reduce the visible material discharged.
- Provision of storage within the network to reduce the frequency and volumes of spill.
- Sewer separation to provide a new wastewater system, and converting the current combined network into a stormwater network.
- Conveyance / consolidation solutions to either consolidate existing overflows, or to direct the overflows to less sensitive receiving environments.

Each option has been assessed against the sub-criteria and concept costs were established.

KEYWORDS

Combined Sewer Overflow, Stakeholder, Effects Based, River Health, Options Analysis

1 INTRODUCTION

There is a 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, with 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.

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 CSO discharges occur. The combined sewerage system drains an area of approximately 11 square kilometres and provides stormwater and sewerage services to more than 15,000 Equivalent Tenements (ET). The combined sewerage system contains more than 60 overflow locations with a mix of pumped and gravity overflows.

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.) has made the operation of the combined system a major political issue in the local region. To that end there was 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.

The purpose of this project was to address the needs outlined above and to develop a long-term strategy based on an understanding of the frequency, extent and environmental impact of these discharges on the receiving environment relative to other continual or intermittent discharges. The assessment using an effects based approach will inform the development of a performance driven strategy that considers capital and operational based initiatives. Completing a range of stakeholder engagement activities will assist in building understanding of how combined systems operate and educate stakeholders about the health of the receiving environment in a more holistic sense rather than focusing exclusively on one discharge type.

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.

Figure 1: City of Launceston and the Tamar River

2 EFFECTS BASED ANALYSIS

2.1 OVERVIEW

The key goal of the project was to determine the frequency, volume and impact of CSO events on the receiving environment. It was essential to understand these parameters to allow meaningful stakeholder engagement and to determine and appropriately scope upgrade options. The approach used incorporated elements of the UK Urban Pollution Management (UPM) Manual and the completion of a mass balance model.

2.2 HYDRAULIC MODELLING

A consolidated hydraulic model for the entire system was built using existing TasWater models for the major sub-catchments. The model was completed in InfoWorks CS and overflow frequency and volumes were determined through applying five years of measured rainfall data from a Bureau of Meteorology (BOM) rainfall gauge in the catchment. The rainfall data was applied to the model in one minute timesteps to determine real-time frequency of overflow events (number of days in which an overflow occurred) and the volume of overflow.

The hydraulic modelling exercise identified a number of areas for further investigation and model calibration with some of the overflow locations predicted to overflow almost daily and ten overflow locations spilling on average more than weekly.

Table 1: Overflow Frequency (Top Ten Frequent Spillers) - 2011

Overflow Name	Spill Frequency
Lytton Street / Home Street intersection (Forster St Catchment)	379
York Street / Wellington Street intersection (Margaret St Catchment)	146
Esplanade / Tamar Street intersection (Esplanade / St John St Catchment)	89
Esplanade / Willis Street intersection (Esplanade / St John St Catchment)	81
Elphin Road.	69
Paterson Street (Margaret St Catchment)	63
Forster Street (Forster St Catchment)	62
Dowling Street / Racecourse Crescent intersection (Esplanade / St John St Catchment)	61
West Tamar Road (Tamar SPS No.1) (Margaret St Catchment)	51
Lytton Street - near Holbrook St.	50

The hydraulic modelling was also useful to determine hotspots for overflows; it was found that four of the 62 networks overflow locations contributed almost 80% of the total overflow volume and that the top nine spillers accounted for more than 95% of total overflow volume. This information was able to be used to determine the most appropriate locations for system upgrades such as screens or detention basins.

Table 2: Spill Volume Summary (Top Ten Spillers) - 2011

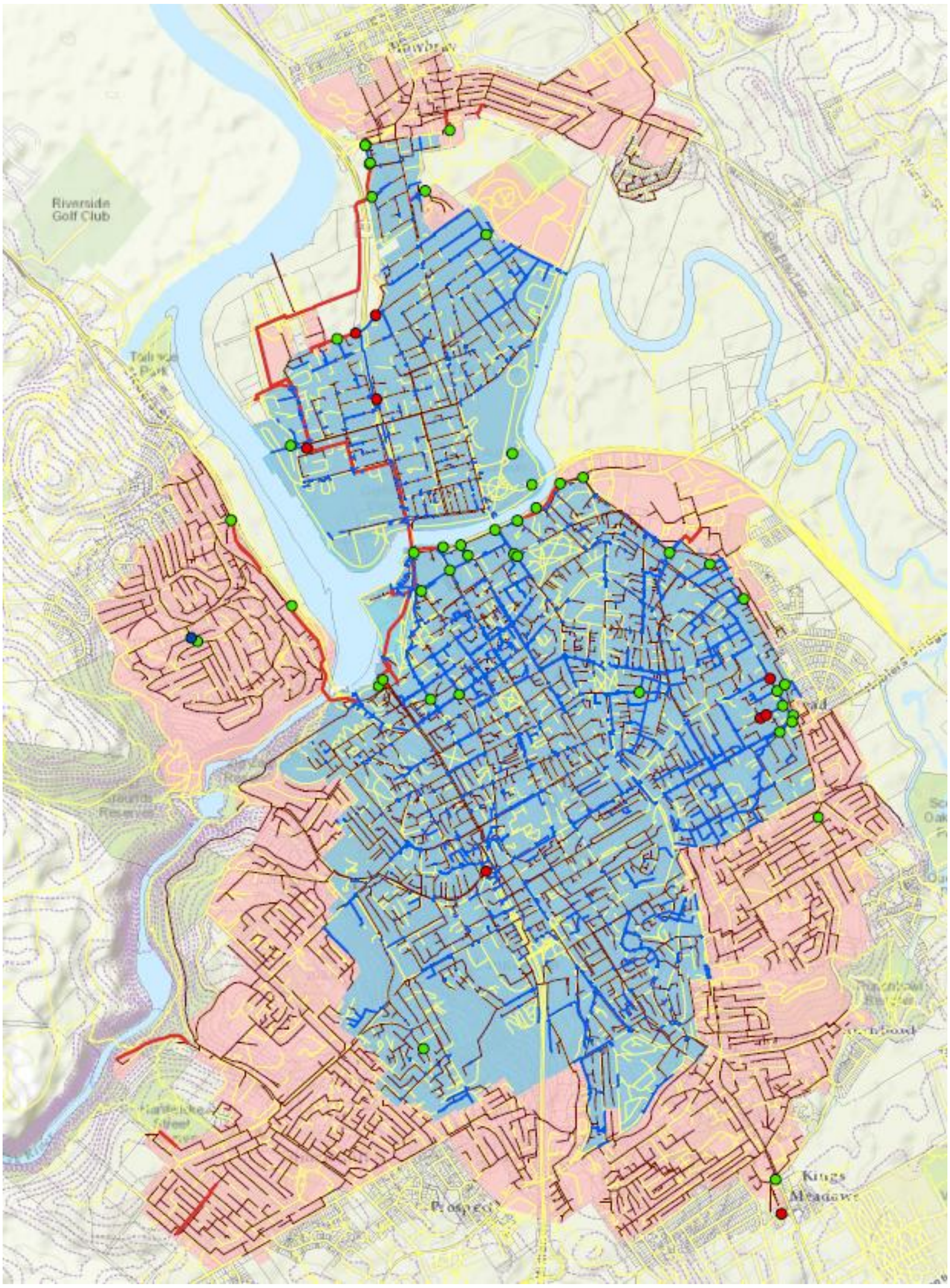
Overflow Name	Spill Volume (m^3)	Percentage of total spill
Paterson Street (Margaret St Catchment)	587,778	41%
Forster Street (Forster St Catchment)	243,560	17%
Esplanade / Willis Street intersection (Esplanade / St John St Catchment)	172,594	12%
Esplanade / Tamar Street intersection (Esplanade / St John St Catchment)	123,260	9%
Lytton Street / Home Street intersection (Forster St Catchment)	62,608	4%
Dowling Street / Racecourse Crescent intersection (Esplanade / St John St Catchment)	57,673	4%
West Tamar Road (Tamar SPS No.1) (Margaret St Catchment)	50,843	4%
York Street / Wellington Street intersection (Margaret St Catchment)	36,023	3%
Esplanade / Shields Street intersection (Esplanade / St John St Catchment)	29,331	2%

2.3 FORMULA A

Formula A is used to calculate an acceptable level of spill from an overflow. It has been used since the 1970s in managing combined drainage systems, and gives an indication of where visual impacts, water quality and dry weather discharges would be higher than expected based on the design criteria of the system and the applicable regulations. Formula A is a UK developed metric to determine an appropriate performance for overflow locations it is comparable to Peak Wet Weather Flow (PWWF) using the Water Services Association of Australia (WSAA) design codes and is approximately six times average dry weather flow (ADWF).

A total of 15 of the 62 overflows in the model were deemed unsatisfactory, as the pass forward flow during spill periods was less than Formula A.

Figure 2: Overflow Locations and Compliance with Formula A



2.4 MASS BALANCE ANALYSIS

2.4.1 METHODOLOGY

A mass balance analysis of volumes and mass loads of Biological Oxygen Demand (BOD) and Total Nitrogen (TN) was carried out at a coarse level to determine the relative contributions from the following sources:

- Ambient River Conditions
- Combined Sewer Overflow Discharges
- Discharges from the Wastewater Treatment Plants
- Discharges from Stormwater Systems *

Note that the model does not contain all stormwater infrastructure that impacts on the river.

The intention of the mass balance analysis was to determine on both an annualised and individual event basis the comparative pollutant load of the combined system against other pollutant sources and the ambient river conditions. The benefit of this was twofold in that it would help guide solution development and design and would be able to be used to engage with stakeholders.

The data sources used for the development of the mass balance model are outlined in the below tables.

Table 3: Data Sources Flow Volumes

Component	Source
River	Sum of Recorded data at North Esk and South Esk gauging stations
Combined Sewer Overflows	Revised model results
Stormwater System for Separated Areas	Revised model results
Sewerage Treatment Plants	Sum of licenced discharges for contributing STPs. Note that this is a conservative value as it is the STPs do not discharge their full licence volume continuously.

Table 4: BOD Event Mean Concentrations

Component	BOD Event Mean Concentration (mg/L)	Comments
River	3	No sampling data was available. A value of 3mg/l was selected on the basis of the 90th Percentile in-river BOD standard for a high value river.
Combined Sewer Overflows	125	Event mean concentration for Combined Sewer Overflows for Steep catchments (Table 4.2, UPM Manual Second Edition)
Stormwater System for Separated Areas	11	Based on the Leeds database 'The Quality of Urban Stormwater in Britain and Europe: Database and Recommended Values For Strategic Planning Model'
Norwood STP	5.5	Median of data from compliance sampling
Hoblers Bridge STP	7	Median of data from compliance sampling
Riverside STP	16	Median of data from compliance sampling
Ti Tree Bend STP	6.5	Median of data from compliance sampling
Newnham STP	17	Median of data from compliance sampling

Table 5: TN Event Mean Concentrations

Component	TN Concentration (mg/L)	Comments
River	0.7	The total nitrogen value was taken from the median of samples taken at Sample Station T3 on the Tamar Estuary
Combined Sewer Overflows	12	Event mean concentration for Combined Sewer Overflows for Steep catchments (Table 4.2, UPM Manual Second Edition)
Stormwater System for Separated Areas	3.2	Based on the Leeds database 'The Quality of Urban Stormwater in Britain and Europe: Database and Recommended Values For Strategic Planning Model'
Norwood STP	12.5	Median of sample data from compliance sampling
Hoblers Bridge STP	26	Median of sample data from compliance sampling
Riverside STP	48	Median of sample data from compliance sampling
Ti Tree Bend STP	13	Median of sample data from compliance sampling
Newnham STP	37	Median of sample data from compliance sampling

TasWater has collected some samples during overflow periods and NRM North a regional natural resource management group has collected stormwater samples and also completes ambient monitoring of the river. The sampling data for stormwater and CSO events is not exhaustive and may not be representative of typical stormwater and CSO pollutant loads so default values used in other jurisdictions were adopted for this study.

One of the key recommendations of the study was the development of a sample library for a range of typical storm or wet weather events and developing an understanding of the relationship between the antecedent dry period and pollutant loading associated with both the seasonal first flush and general first flush events.

2.4.2 ADDITIONAL WORK – TSS AND ENTEROCOCCI

The work completed in the initial study focused on TN and BOD due to ongoing stakeholder concern and interest in the impact that the combined system has on the receiving environment. Additional work was completed to understand the increased load in solids and pathogens associated with CSO events.

The data sources used to develop the additional parameters for the mass balance model are outlined below.

Table 6: TSS Event Mean Concentrations

Component	TSS Concentration (mg/L)	Comments
River	3	The total BOD value was taken from the median of samples taken at Sample Station T3 on the Tamar Estuary
Combined Sewer Overflows	150	Sourced from TasWater CSO sampling program and verified against samples collected in other combined systems
Stormwater System for Separated Areas	40	Sourced from stormwater sampling program completed by NRM North and verified against data in the International Stormwater BMP Database.
Norwood STP	9	Median of sample data from compliance sampling
Hoblers Bridge STP	19	Median of sample data from compliance sampling
Riverside STP	32	Median of sample data from compliance sampling
Ti Tree Bend STP	16	Median of sample data from compliance sampling
Newnham STP	28	Median of sample data from compliance sampling

Table 7: Enterococci Event Mean Concentrations

Component	Enterococci (cfu/100 mL)	Comments
River	105	The total Enterococci value was taken from annualised river flow data excluding STP discharges and CSO events and converted to a value.
Combined Sewer Overflows	62,000	Sourced from TasWater CSO sampling program and verified against samples collected in other combined systems
Stormwater System for Separated Areas	41,000	Sourced from stormwater sampling program completed by NRM North
Norwood STP	10	Median of sample data from compliance sampling
Hoblers Bridge STP	111	Median of sample data from compliance sampling
Riverside STP	639	Median of sample data from compliance sampling
Ti Tree Bend STP	58	Median of sample data from compliance sampling
Newnham STP	1,184	Median of sample data from compliance sampling

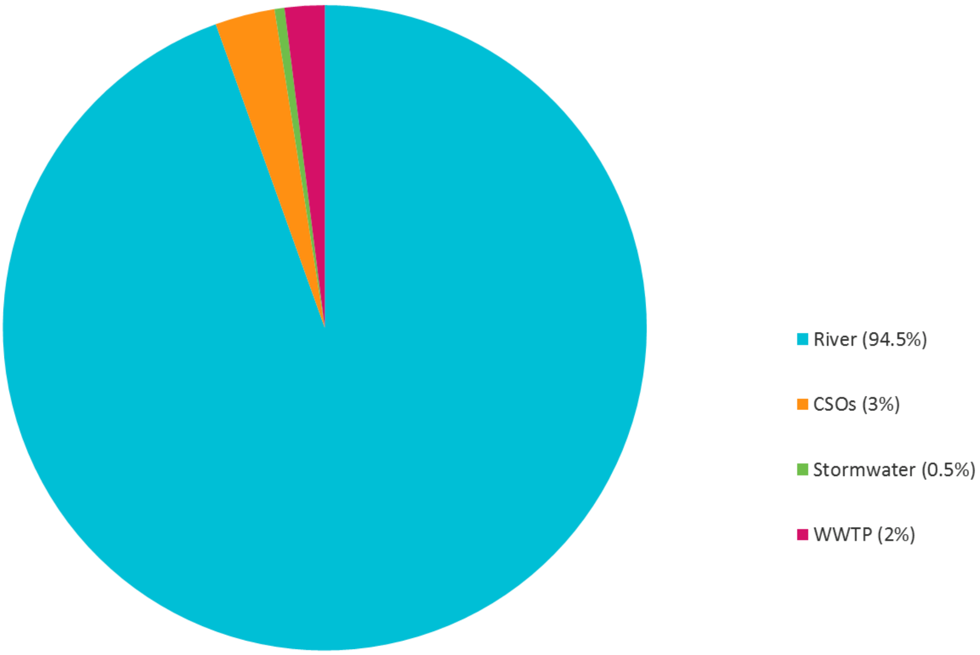
There are concerns about the use of enterococci as a pollutant load as it is a living organism and therefore subject to exponential growth in suitable conditions. However, due to significant stakeholder interest in this parameter, an assessment was completed to determine relative loadings.

3 RESULTS

The findings of the investigations and studies involved in the development of the strategy suggest that, on an annualised basis, the combined system is generally a minor contributor of pollutants to the Tamar River. The system contributions, and those impacts, include:

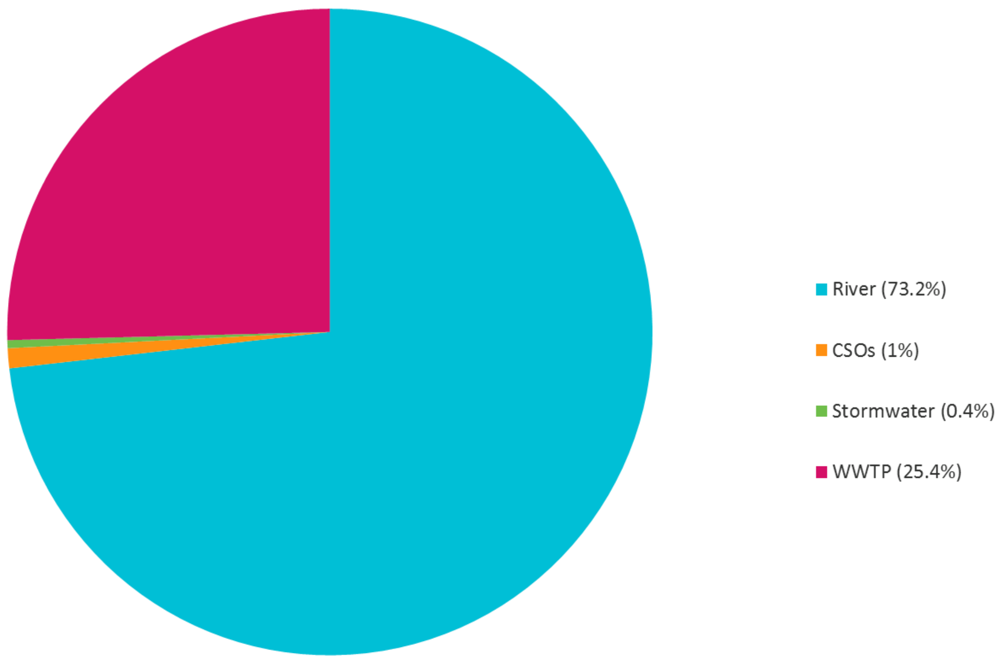
- 3% of Biochemical Oxygen Demand (BOD) – BOD can impact the amount of dissolved oxygen available and is a key river health indicator for aquatic life

Figure 3: Annual BOD Contributions (2011)



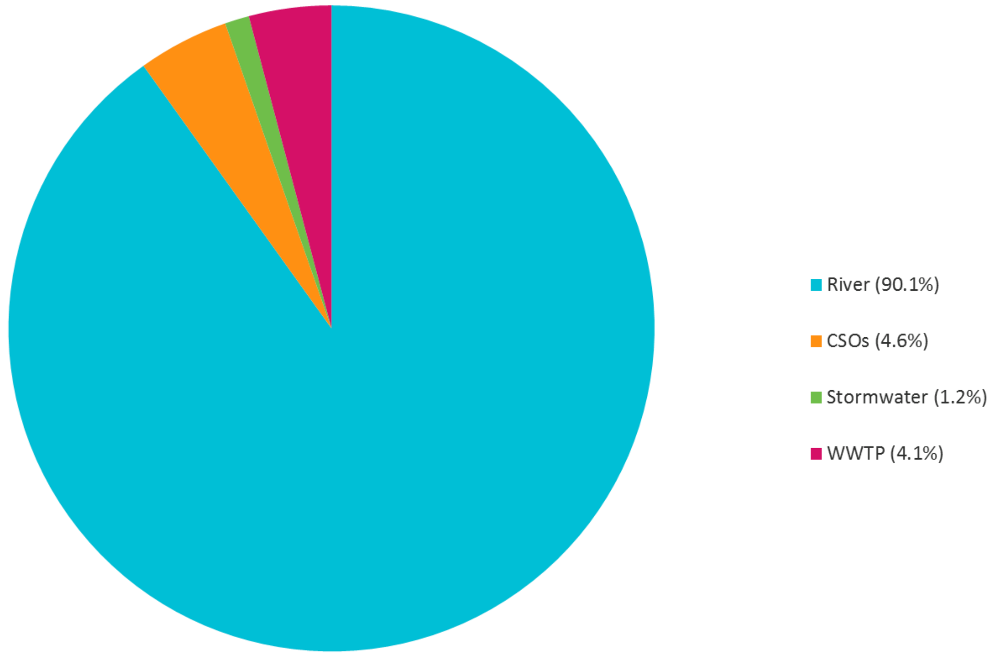
- 1% of Total Nitrogen – high nutrient levels contribute to algal blooms and impact river health and amenity

Figure 4: Annual TN Contributions (2011)



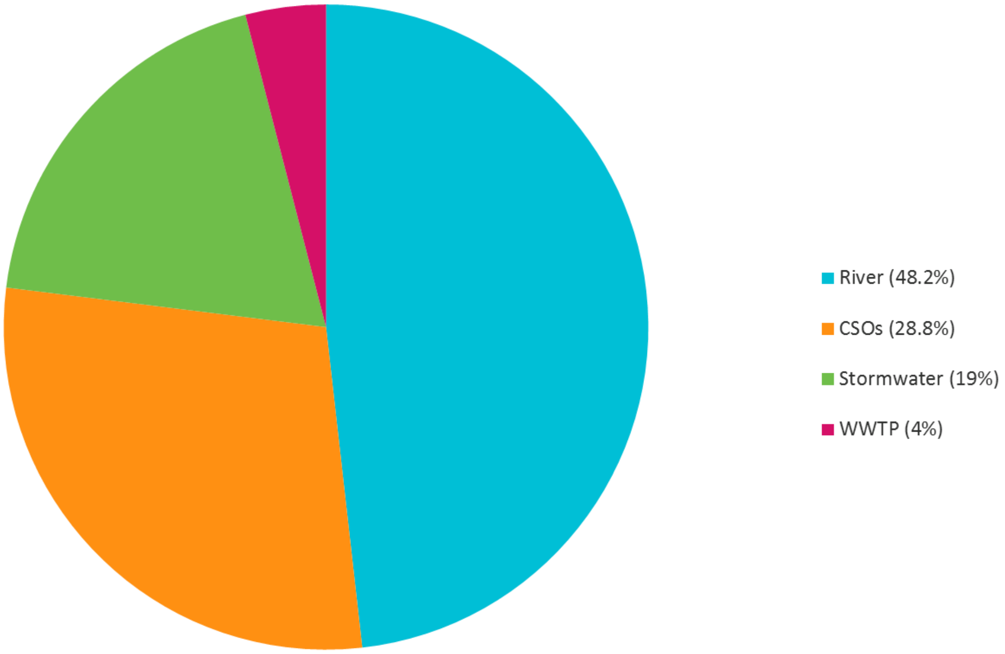
- 5% of Total Suspended Solids (TSS) – elevated levels makes the water appear cloudy and impact visual amenity. TSS can settle out of the water column and be deposited as silt/sediment

Figure 5: Annual TSS Contributions (2011)



- 29% of Enterococci – this is an indicator of faecal contamination and used to determine the suitability of water for primary and secondary contact.

Figure 6: Annual Enterococci Contributions (2011)



The contribution to pollutant load that the combined system makes to the river on a single event basis is higher than the annualised values, but still less than the total pollutant loading from diffuse sources such as agriculture, surface water runoff and stormwater. The strategy findings are consistent with the results obtained by NRM North in its Tamar Estuary Report Card and Tamar Estuary and Esk Rivers Water Quality Improvement Plan.

The mass balance analysis suggests that the river health issues are not highly driven by the performance of the combined system. The results of the analysis and modelling were key in the stakeholder engagement works completed during the project.

4 STAKEHOLDER ENGAGEMENT

The other major body of work completed in the project was a stakeholder engagement process. The intention of the stakeholder engagement work was to ensure that the solutions identified to improve the performance of the combined system would satisfy the major areas of concern for the project stakeholders. One of the key drivers for the completion of this project was to understand the frequency, volume and impact of CSO events on the receiving environment as the community in general consider the combined system to be the leading contributor to the poor condition of the Tamar River estuary.

Figure 7: Tamar River Silt @ Low Tide

There is significant ongoing media, political and community interest in the ‘third world’ and ‘antiquated’ combined system that TasWater operates. There are some community members that consider the silt loading in the river to be caused almost exclusively by CSO events and that the silt is raw sewage. The community also considers that river amenity and use is impaired due to the combined system with the river having pathogen levels more than 140 times above the limits for primary contact and almost eight times above that permitted for secondary use. The community perception is that the pathogen impacts are caused exclusively by the combined system. There is a very strong community push to separate the combined system to remove the problem.

Figure 8: Launceston Seaport @ Low Tide

The initial stakeholder engagement process was a series of one on one interviews with the key project stakeholders to gauge their understanding of the combined system, stormwater systems, the health of the receiving environment and catchment activities. The key stakeholders were also asked to identify what they thought the appropriate level of service was for the river (receiving environment) and how the combined system was impacting on their desired level of service.

Completing the one on one interviews revealed that the key stakeholder group had a limited understanding of, and experience with, combined systems, along with a general lack of awareness of the pollutant load associated with other activities within the catchment and the impact that these were having on river health. This was a key finding as it meant that the focus of the stakeholder engagement could shift to education and awareness and that the modelling results and mass balance works completed would be able to be used to support this effort.

The work completed in the one on one interviews guided the next stages of the stakeholder engagement with a number of sessions held to discuss the modelling and mass balance results to better educate and inform the stakeholder group about the entire contributing catchment rather than focusing solely on one pollutant input. Following these information sessions, workshops were held to develop a number of possible upgrade solutions and to build a multi-criteria assessment (MCA) tool based on some agreed key measures of performance for the combined system to assess the effectiveness of the solutions.

The approach used kept the stakeholder group engaged throughout the project and allowed for a sense of ownership of the solutions identified and the project outcomes. The initial focus on education and information delivered improved project outcomes as the stakeholder group was in a better position to identify potential solutions and to assess them appropriately using the MCA tool developed.

4.1 EVALUATION CRITERIA

Through development of the MCA tool, four key evaluation criteria were agreed with the stakeholders. These are listed below, along with their sub-criteria:

- Responsibility to the community
    - Stormwater flooding of the city
    - Cost and funding implications to the community
    - Heritage, Tourism and Industry
    - Public's ability to use the river for yachting, rowing, and walking trails
- Public health
    - Nutrients
    - Seasonality
    - Raw Sewage
    - Area of Influence
    - Trade Waste
- River health
    - Raw sewage
    - Seasonality
    - Stormwater Quality
    - Public's ability to use the river for yachting, rowing, and walking trails

  - Area of Influence
  - Frequency of Overflows
- Public perception
  - Timing
  - Community education
  - Visuals
  - Frequency of overflows

Each sub-criteria was understood in terms of current situation, what a moderate outcome might be, and what an ideal outcome might be. This understanding allowed assessment of the proposed solutions.

5 PROPOSED SOLUTIONS

The completion of the modelling, mass balance analysis and stakeholder engagement works resulted in the identification of four primary upgrade options: screening, storage, conveyance and separation. A description of the four options is provided below with each option having two levels of investment considered. The first level of investment considers a moderate outcome and the second an optimum or ideal outcome. The intention of using two different levels was to understand the extent of works that could be completed before the ratio of comparative benefit to project cost became unfavourable.

5.1.1 SCREENING

This option would involve screening of the more frequent or larger volume spill locations. Screening would remove the gross solids associated with combined sewer overflows and would include sanitary products and wipes as well as street litter such as bottles and cans.

Table 8: Comparison of Screening Option

Investment Level	Capital Cost	No. Screening Installations	Overflow Volumes Screened (%)	Operational Impact
Moderate	$16-21M	10	94.5%	Low
Ideal	$24-31M	24	99.6%	Low

Screening represents the lowest capital investment upgrade option and would improve the visual performance of the combined system as well as having a very minor environmental benefit (slight reduction in TSS and BOD), but would not reduce the frequency or volume of overflow events. Some of the stakeholder group expressed particular interest in screening due to the relatively low cost of implementation and improved community perception. The principle of diminishing returns is well demonstrated with the screening option where an ideal outcome would involve significantly more screens but offers only a modest increase in performance.

5.1.2 STORAGES

This option would involve the construction of additional tanks or storages similar to the Margaret Street Detention Basin. The storages would fill during wet weather periods and then slowly drain back into the sewerage network as pipeline capacity to transfer the flows to Ti Tree Bend STP becomes available.

Table 9: Comparison of Storages Option

Investment Level	Capital Cost	No. of Storages	Volume of Storages	Reduction in Overflow Volumes (%)	Operational Impact
Moderate	$108-140M	3	89 ML	79%	High
Ideal	$121-160M	3	103 ML	88%	High

The construction of additional network storages would significantly reduce the frequency, volume and pollutant loading of combined sewer overflows. This option would provide improved environmental outcomes with the reduction in overflows entering the Tamar River however it would require land acquisition to construct the storages and would be more costly and complex to implement than screening.

5.1.3 CONVEYANCE AND CONSOLIDATION

This option would involve the construction of a large diameter sewer interceptor that would convey flows from the largest spilling sites to a single large storage at the existing Ti Tree Bend STP. This option is very similar in operation to the storage option but rather than build three large storages across the network a single larger storage is constructed and a large diameter pipeline is used to carry flows to the storage.

Table 10: Comparison of Conveyance and Consolidation Option

Investment Level	Capital Cost	Volume of Storages	Reduction in Overflow Volumes (%)	Operational Impact
Moderate	$153-200M	89 ML	79%	Medium
Ideal	$167-217M	103 ML	88%	Medium

The construction of a sewer interceptor and large storage at Ti Tree Bend STP would significantly reduce the frequency, volume and pollutant loading of combined sewer overflows. This option would provide improved environmental outcomes with the reduction in overflows entering the Tamar River; however it would impact on land availability at the existing Ti Tree Bend STP site for the proposed new northern STP. This option is also much more expensive in terms of upfront capital cost than both screening and storage, although it would provide improved system resilience and redundancy for the existing critical city rising main.

5.1.4 SEPARATION

This option would essentially involve the duplication of the existing reticulated network to provide separate sewer mains through the combined system. The existing mains would become stormwater assets and would no longer carry sewage.

Table 11: Comparison of Separation Option

Investment Level	Capital Cost	Reduction in Overflow Volume (%)	Operational Impact	Comments
Moderate	$10-13M	17%	High	Dependent on completion of LSIP
Ideal	$438-560M	100% of sewer overflows	High	Stormwater flows will be untreated and discharged to the estuary

The moderate separation option which involves diverting the separated sub-catchments currently within the combined system to the proposed new northern STP that would be constructed as part of the Launceston Sewerage Improvement Plan (LSIP) presents an excellent value proposition in terms of reduction in pollutant load and overflow volume at a comparatively low cost. If LSIP proceeds the separation works discussed above should be completed as they will remove almost a third of the sanitary sewage load on the existing combined system, which will result in significant environmental and social improvements.

Full separation would be a very costly process that would remove the sewage component of overflow events however the pollutant load associated with stormwater would still be discharged to the estuary. There is substantive research and literature from other parts of the world with combined systems that strongly suggest full separation does not provide significant environmental improvements. Investment in these areas tends to be aimed at improving the system’s ability to store flows and treat when the system has capacity.

6 CONCLUSIONS

The use of an effects based approach in conjunction with hydraulic modelling to understand the quantum and impact of combined sewer overflows on the Tamar River estuary has been a success with the modelled results aligning strongly with existing river model works completed locally by NRM North. The use of a targeted stakeholder engagement approach to educate and inform the key project stakeholders has resulted in an engaged and informed stakeholder group who have developed a sense of ownership with the project.

The project results show that the combined system is a minor contributor to the overall health of the receiving environment however during individual overflow events the combined system is a significant pollutant load. Additionally the results show that stormwater runoff and other diffuse sources of pollutants require increased attention and effort to address. Finally the results show that the push for separation is not a sensible solution from an economic or environmental perspective, and that future investment should target improving the combined systems ability to capture, transfer and treat CSO events.

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