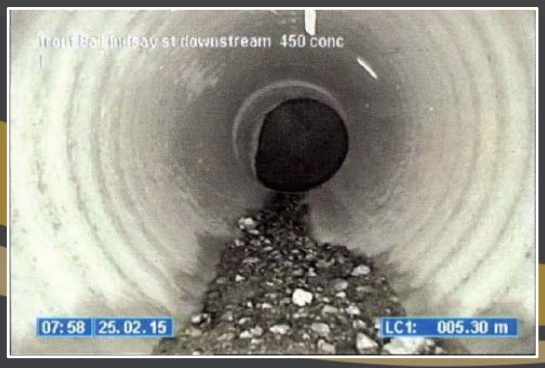


Drainage

Service-Driven Asset Management Plan 2015

Bayside CITY COUNCIL

Drainage Asset Management Plan

Contents

Executive Summary

Bayside City Council owns, operates and maintains an underground pipe network that provides drainage and flood mitigation services to the community with a replacement value of $175.6 million. Council's current annual expenditure on asset-based drainage services is $3.8 million, representing 3% of Council's total budget.

Drainage infrastructure provides for a city that is free from frequent surface stormwater flows so the community is able to go about its business unhindered. The drainage system also serves to reduce the risk of flooding of private property.

Purpose of the Drainage Service-Driven Asset Management Plan

The purpose of the Drainage Service-Driven Asset Management Plan (D-AMP) is to document a robust business case for the continued investment into asset-based drainage services to the Bayside community. In this sense, this document is a *Service-Driven* Asset Management Plan. This document demonstrates a commitment to *liveability (creating a great place to be)* through *delivery of excellent services*, which are key result areas of the Bayside Better Place Approach and aligns with the *Planning, Infrastructure and Transport* outcome of the Bayside Community Plan.

It is used to inform decision making about Council's existing long-life drainage infrastructure through a focus on improved asset data, the testing and validation of asset management assumptions and the prediction of long term financial renewal requirements. The D-AMP also includes the drivers for upgrading the capacity of existing assets and the construction of new parts of the network to improve the levels of service provided by drainage infrastructure in the future. As a demonstration of Council's long term financial sustainability, the 10-year financial requirements for the operation and maintenance, renewal and upgrading of Bayside's existing drainage infrastructure in addition to the construction of new assets are presented in this document.

Asset Description

The assets covered in this D-AMP include 410.8km of underground pipes and 14,853 pits, both of which having useful service lives potentially in excess of 100 years. Given that the majority of Bayside's drainage network was constructed between 1940 and 1970, the drainage asset stock overall is considered to be in good condition. Although the condition of the majority of drainage assets has not been directly assessed due to the difficulty and cost in accessing buried infrastructure, condition assessments of a sample of assets representing various age ranges validate this assumption through the use of CCTV inspections records.

Progression through the useful service life of these assets will trigger an increasing renewal demand in the period from 2030 to 2080. Over the next 10 to 20 years, an assessment of how to deal with the emerging renewal need in 2030 will need to be considered.

Operations and Maintenance

The current annual cost of Council's drainage asset maintenance program is $926,000 (2015/16) and is expected to increase to $1,218,000 in 2024/25 due to annual cost escalation and the additional maintenance requirements of new assets created over this period.

Renewal Financial Demand Forecast for Current Service Level

Renewal financial forecasting using the Moloney Model, which is based on the age and condition distribution of the asset stock, predicts a current 2015/16 renewal demand for drainage assets of $693,534, rising annually to $1,969,075 in 2024/25 and equating to an average annual renewal cost of $1.3 million over 10 years. Council is committed to meeting the renewal demand by annually updating the Long Term Financial Plan with current renewal forecasts. Bayside does not currently have a renewal gap or backlog of renewal works to address.

Drivers for Improved Levels of Service

A draft Drainage Upgrade Strategy has been developed to guide investment into increasing the capacity of Bayside's underground drainage network over the next 10 years. This strategy sets out a 10 year program of the highest priority drainage upgrade projects (40 in total) that aims to improve the performance standard of the underground pipe network that is under performing at locations known to be susceptible to damage from

flooding, with respect to the consequences of public safety and damage to property from flooding. In 10 years, 65% of the known under-performing parts of the network will have been addressed

The implementation of the Strategy requires an annual investment of approximately $2 million per annum. Some of this expenditure is accounted for as renewal, as a proportion of the cost of drainage upgrade projects is used replacing and effectively extending the useful service life of existing assets.

Council has recently adopted a 20 year Development Contribution Plan (DCP) for drainage infrastructure. The project areas identified in the DCP for attracting contributions (as they will serve developments in and around major activity centres) are derived from the same catchment analyses and drainage network planning used in the development of the draft Drainage Upgrade Strategy. It is expected that the majority of the projects listed in the drainage upgrade program over the next 10 years will fulfil Council's obligation within the DCP to undertake works within the nexus of the contributing development(s).

Environmental Considerations

The quality of stormwater flows is addressed through the reference in the D-AMP to the Drainage Upgrade Strategy, whereby Council's commitment to integrating measures to improve the quality of drainage flows to Port Phillip Bay within the scope of drainage projects wherever possible is enshrined. Such measures include detention systems, gross pollutant traps and water sensitive urban design initiatives like rain gardens. In some locations, there may be potential for stormwater harvesting for reuse, such as irrigation for sports fields.

Improvement Plan

This D-AMP includes an improvement plan with actions to address limitations in the scope of this Plan and drive improvements in asset management processes to ensure future versions of this document continue to support Council's commitment to the provision of affordable long term infrastructure-based services that meet the needs of the Bayside community.

1.0 Introduction

1.1 Scope and Purpose

The purpose of the Drainage Asset Management Plan (D-AMP) is to document a robust business case for the continued investment into asset-based drainage services to the Bayside community. In this sense, this document is a *Service-Driven* Asset Management Plan.

This document is used to inform decision making about Council's existing long-life drainage infrastructure through a focus on improved asset data, the testing and validation of asset management assumptions and the prediction of long term financial renewal requirements. The D-AMP also includes the drivers for upgrading the capacity of existing assets and the construction of new parts of the network to improve the levels of service provided by drainage infrastructure in the future. As a demonstration of Council's long term financial sustainability, the 10-year financial requirements for the operation and maintenance, renewal and upgrading of Bayside's existing drainage infrastructure in addition to the construction of new assets are presented in this document.

The infrastructure covered in this D-AMP includes:

- Pipes (generally concrete)
- Pits (generally Grated Pits, Junction Pits and Side Entry Pits)

Other drainage assets are not covered in this document, due to being a small component of the asset stock (relatively low material value) and having limited asset management data on which to base long term investment decisions. These asset types, which are planned to be progressively included in future revisions of the D-AMP are listed below:

- Open Channels
- Overland Flowpaths
- Other inlet/outlet structures
- Flood Flaps
- Gross Pollutant Traps (GPTs)
- Scour Protection
- Water Sensitive Urban Design (WSUD) features – a small number currently but planned to become more prevalent (Bio-retention systems, swales, rain-gardens or vegetation treatments, buffer strips, retarding basins, detentions systems and pump systems)

The D-AMP covers the proposed levels of service, future demand, routine maintenance, renewal/replacement, acquisition/creation and decommissioning of the Council's drainage infrastructure. It also outlines the financial requirements and the key assumptions made in the financial forecasts. It is also a means of outlining the key elements involved in managing the drainage asset stock. It combines management, financial, engineering and technical practices to ensure that the level of service required by the beneficiaries of the service is provided at the lowest long term cost to the community within the limits of any fiscal constraints that may be imposed by Council.

The key purpose of this D-AMP includes:

1. Identify the required asset management regime and forecast financial requirements for the current stock of drainage infrastructure for the next 10 years.
2. Identify the likely growth or change in asset–based drainage services identified by strategic service planning and predict the financial impact on capital works and operations/maintenance budgets of these changes over the next 10 years.

3. Identify improvement actions required to address limitations in the scope of this D-AMP and drive improvements in asset management processes.

This revision of the D-AMP is based on the best available information and represents the second generation of documenting Council's sustainable management of asset-based drainage service provision to the Bayside community.

1.2 Assumptions:

In developing this AMP, several assumptions have been made, including:

- Asset registers are accurate and complete
- Useful lives and predictive modelling (e.g. Moloney Model) are correct, however as further data and condition for assets is collected and will be revised to best represent the drainage network
- Current levels of service reflect the current community needs
- No known legislative changes or other influences that will impact on, or demand a change in level of service and associated funding throughout the period of the plan
- Current replacement costs (CRC) for all drainage assets are correct and all forecasts and assumptions are based on the figures provided within the Drainage Asset Revaluation Report 2014. The actual project cost of all works associated with the renewal or replacement of drainage in Brownfield is expected to be much higher when road, kerb, trees, traffic management, access, easement fences and structures etc. are also taken into consideration
- Operation and Maintenance budgets in the 10 year financial plan already allow for price escalation in subsequent years

1.3 Glossary and Abbreviations

ARI	Average Recurrence Interval
CRC	Current Replacement Costs
D-AMP	Drainage Asset Management Plan
LCC	Lifecycle Cost
UL	Useful Life
WDV	Written Down Value

1.4 Key Stakeholders

Assets controlled by Council are utilised by a broad cross-section of the community. It is therefore critical that assets are maintained based on need and fit for purpose. The best person to judge whether an asset is fit for purpose is likely to be the user of the asset. Hence asset users are key stakeholders of this D-AMP.

Stakeholders identified in this plan are the stakeholders that would need to be consulted when Council seeks input in relation to determination of Levels of Service and intervention levels.

Table 1: Key Stakeholders

Internal Stakeholders	
Stakeholder Group	Role or Involvement
Council	Custodian of the asset, with Councillors representing the residents and setting strategic direction as per the Council and Operational Plans.
Executive Team	To ensure that Asset Management policy and strategy is being implemented as adopted, and to ensure that long-term financial needs to sustain the assets for the services they deliver are advised to council for its strategic and financial planning processes.
Manager Infrastructure Assets	As the designated Strategic Custodian of Council's drainage assets, responsible for the overall strategic management of the assets including asset systems management, condition monitoring, renewal planning, design standards and the development, monitoring and updating of this plan; new and upgrade capital works programs.
Manager City Works	To ensure provision of the required/agreed level of maintenance services and renewal for asset components and delivery of upgrade and new capital works.
Service-driven Asset Management COG	To ensure AM planning meets requirements that optimise useful asset life and service provision.
Manager Corporate Finance	To ensure that adequate financial information is provided to Council and to the relevant asset managers to facilitate sound management of the assets
Manager Information Services	To ensure that the relevant IT systems are functioning and that any data within the systems is secure and its integrity is not compromised.
Manager Commercial Services	To ensure that risk management practices are conducted as per Council policy and assist operations managers with advice on risk issues.
Internal auditors	To ensure that appropriate policy practices are carried out and to advise and assist on improvements
External Stakeholders	
Stakeholder Group	Role or Involvement
Community	General users/beneficiaries of the service provided by the assets, including residents
Maintenance contractors (external)	To ensure provision of the required/agreed level of maintenance services for assets;
State and Federal Government Departments	Periodic provision of advice, instruction and support funding to assist with management of the drainage network.
Council's Insurer.	Insurance and risk management issues.

1.5 Legislative Requirements

The legislation relevant to the provision of asset-based drainage services are listed in Table 2 below.

Table 2: Legislation Relevant to Management of Stormwater Drainage Systems

Legislation	Requirement
Local Government Act 1989	Sets out role, purpose, responsibilities and powers of local governments including the preparation of a long term financial plan supported by asset management plans for sustainable service delivery.
Road Management Act 2004	Relates to management of the drainage system where it lies within the Public Road Reserve.
Water Act 1989	Applies to the management of the use of water resources including conservation, protection and quality of discharges into waterways
Subdivision Act 1988 and Subdivision Regulations (Procedures) 1989	Applies to works for drainage to connect the subdivision to the system serving properties outside it.
Building Act 1993, Building Regulations 2006 and Plumbing Regulations 2008	Provides for regulation of plumbing work and plumbing standards as it impacts discharge of water into the stormwater drainage system from private buildings.
ResCode	In relation to stormwater management, ResCode applies to the construction of new residential subdivisions to ensure environmentally sustainable residential development. This includes stormwater discharges from subdivision development
Environment Protection Act 1970	Relates discharge, emission or deposit of any substance that may pollute any segment or element of the environment – in this instance, by its introduction into discharge waters of the stormwater drainage system.
State Environment Protection Policy, Waters of Victoria	Sets the framework for government agencies, businesses and the community to work together, to protect and rehabilitate Victoria's surface water environments.
Emergency Management Act 1986	Requires a council to have a Municipal Emergency Management Plan to address local emergency risks. This may include hazards arising from storm flows in the drainage system and associated infrastructure.
Health and Wellbeing Act 2008	Allows the issue of a prohibition notice for the conducting of an activity that may damage public health - in this instance being illegal discharges into the stormwater drainage system
Occupational Health and Safety Act 1985	Applicable to working on stormwater infrastructure
Melbourne Water Standards	Used in conjunction with Council's Standards to determine standards for road construction and maintenance for stormwater drainage systems.
All other relevant Australian Standards	AS/NZ Standards such as Risk Management Standard.
Council Planning Scheme	Planning matters as they relate to the stormwater drainage system.
All other relevant State and federal Acts and Regulations	Where applicable.
Relevant Council Policies, Local Laws and Contracts	Amenity controls, construction standards, maintenance contracts etc.

1.6 Key Issues with Asset-Based Drainage Services

Auditor General's Recommendations, 2005 Report

In the 2005 Auditor General's Report on Managing Stormwater Flood Risks in Melbourne, it was stressed that key agencies, Melbourne Water and Municipal Councils, need to develop and apply strategies that provide a higher level of flood protection for the communities they serve. The Report recommended that Councils develop flood risk management practices consistent with best practice risk management and that these were to incorporate:

- specific flood risk management goals and objectives, which are supported by stakeholders and clearly linked to the Council's wider strategies, plans and budgets
- a risk assessment and prioritisation process based on a sound knowledge of flood exposure
- an option assessment process with clear criteria that would include costs of treatment options, effectiveness (in mitigating flooding risks) and impacts on the conservation and environmental goals of stormwater management
- a long-term flood risk management plan to achieve the objectives of these practices
- an ongoing targeted community education program to raise awareness of flooding issues, ascertain community expectations and encourage behaviour that will mitigate flooding risks
- performance indicators that measure the effectiveness of flood risk management treatments in mitigating flooding risk, the results of which should be regularly reported to the community.

Bayside Council and Melbourne Water completed a Flood Management Plan in October 2011 to outline the roles and responsibilities relating to flood management in Bayside.

The Legacy of Historical Design Standards on Drainage Capacity – Localised Flooding

The provision of drainage infrastructure is considered a key role of Council in providing a safe and functional built environment for its community. Given the unpredictability of storm events that result in damage from flooding, the provision of adequate drainage is not straight forward and is required to balance the competing objectives of community need (or level of service), cost and risk.

Council's role as defined by the Local Government Act 1989 (LGA) is to monitor incidents of flooding and to undertake works and measures to address these incidents. Whereas major outfall structures are within designated flood plans and generally administered by Melbourne Water, Council is directly responsible for the preparation and implementation of drainage networks within those areas outside of the major drainage system. The LGA specifies the functions of Council related to the drainage of roads and prevention and abatement of nuisance. Other relevant legislation includes the Planning and Environment Act 1987, Building Act 1993 and Emergency Management Act 1986.

Due to the age of the existing drainage network within Bayside and the lower design standards of the time of construction, much of the underground drainage system performs below current design standards and in some locations, the performance of the system has a detrimental impact on adjacent properties. When localised flooding occurs as a result of insufficient capacity of the drainage network, a range of impacts can result, from inundation of habitable floors of homes and businesses, to yard flooding and temporary ponding within the streetscape.

Much of the drainage system that performs below desired capacity cannot be upgraded without significant investment. Although it is neither practical nor affordable to retrofit upgrades to bring all parts of the drainage system up to current standards, it is reasonable to treat areas where flooding is demonstrated to have a negative impact on habitable rooms or business premises. This has led Council to undertaking infrastructure planning for drainage upgrades to address key sites and identifying that a program of works to the value of $24.5M (in 2014 dollars) is necessary.

Subsurface Water

Bayside has developed a policy to control the discharge of subsurface water to the kerb and channel (Discharge of Pumped Subterranean Water Policy). Many Bayside residencies now have basements which are prone to ingress of both storm runoff and groundwater. The internal drainage systems associated with private basements often discharge to the kerb and channel, where it can pond and become a nuisance for neighbouring downstream properties. Furthermore, the cumulative effect of such discharge from multiple properties within a catchment during rainfall can significantly reduce the capacity of the drainage network during an event.

2.0 Asset Function and Levels of Service

2.1 Levels of Service

Bayside City Council has determined the standard to which it will design, construct, inspect, maintain and repair its stormwater drain network. In developing these levels of service, Council has considered community expectations, current service levels, the level of risk imposed and available resources. Key performance indicators for Technical Levels of Service and Community Levels of Service are shown in Appendices 3.1 and 3.2. Appendix 3.3 includes a list of all common drainage assets and a description of their function.

A key objective of asset management planning is to align the level of service with the communities' expectations. The relationship with the cost of the service is evaluated to determine the optimum level of service the community is prepared to pay for. Current levels of service for maintenance are assumed to be reflecting the balance between customer expectations and financial affordability.

The target levels of service for the drainage system aim to reflect industry standards and are based on stakeholder consultation, Council Plan goals and priorities, the Long Term Financial Plan (LTFP), the 4 Year Capital Works Program and legislative requirements. Council has not conducted direct community consultation with respect the stormwater drainage network. The drainage network is, however inherently part of Council's service delivery and as such, contributes to the community's overall satisfaction with Council. Community feedback is received on the performance of the system following rainfall events.

More detailed service level expectations are sourced from feedback from residents, visitors, operational staff and more generally, from benchmarking within the local government sector.

2.2 Stormwater Drainage System Criticality Hierarchy

"Critical assets" are those components of the system where the consequences of failure for public safety, cost and social disruption justify the level of programmed inspections and preventative renewal works. Critical assets have a lower threshold for action than non-critical assets.

Council uses a Consequence of Failure Rating to identify critical drainage assets and prioritise drainage system works, based on the outcomes of the Bayside City Council Stormwater Drainage Network Improvement Project (SDNIP) which commenced in 2004 and concluded in 2009. The purpose of this planning work was to identify catchments and model the system to establish capacity deficiencies. The development of a program of drainage system upgrades arising from this planning work is discussed further in Section 3.0 Future Demand and the program of works is presented in Appendix 1.

2.3 Design Standards

Standards have been established for the design and construction of drainage infrastructure and are documented in the Bayside City Council *Standard Drawings* and *Requirements for the Design of Council Drains.* When appropriate, standards adopted by other relevant authorities such as Melbourne Water and VicRoads are also utilised.

For design purposes, storm event probabilities (average recurrence intervals – ARI) have been derived in conjunction with Australian Rainfall and Runoff – A guide to Flood Estimation by the Australian Institute of Engineers, 1987 and ResCode. Ideal rainfall probabilities for the design of underground pipes are:

- Urban Residential Areas: 20% probability of occurrence (5 year ARI)
- Industrial and Commercial Areas: 10% probability of occurrence (10 year ARI)

The hydraulic design for the entire system (the underground pipe plus the overland flow) is required to cater for flows with a 1% probability of occurrence (100 year ARI). Where existing roads and overland flow paths cannot cater for the 1% storm event, the pipes need to be increased to a size where the entire system can cater for the 1% storm unless costs are deemed unreasonable and alternative solution is determined. A draft Strategy is under development to guide investment decision-making in the design of upgrades to the drainage network. Due to the prohibitive costs and the limitations of the capacity of Melbourne Water's receiving drainage system, this Strategy acknowledges that it is not practical to plan to upgrade the entire underground drainage system to current standards and calls for the highest reasonable level of flood mitigation for that part of the network to be delivered.

2.4 Maintenance Function Service Levels

Details of the adopted maintenance Levels of Service are provided in the contract for maintenance of Council's drainage assets.

Levels of Service, including inspection frequencies, repair intervention levels and response times have been established for drainage, including stormwater pipes, open drains and drainage pits. The current maintenance service levels being delivered are assumed to reflect a balance between customer expectations and financial affordability. The levels of service are reviewed at least annually based on data, customer expectations and resource allocations.

2.5 Service Level Review

The objective of a service level review process is to gain a better understanding of the needs and expectations of existing and future service recipients over time. This allows for the definition of meaningful levels of service and performance measures.

The review process needs to be repeated on a 5 year cycle to ensure that knowledge of community needs and expectations remains current in the light of changing environmental, financial, political, social and technical factors. Changing customer needs and expectations, as determined by the review, are part of the continuous D-AMP improvement cycle.

3.0 Future Demand

3.1 Overview

Due to the age of the existing drainage network within Bayside and the lower design standards of the time of construction, much of the underground drainage system is in good condition but performs below current standard and in some locations the performance of the system has a detrimental impact on adjacent properties.

The storms of December 2003, January 2004 and in February 2011 caused some of the worst localised flooding metropolitan Melbourne had experienced in several decades. The worst affected areas were those established before the late 1970s.

Much of the drainage system that performs below desired capacity cannot be upgraded without significant investment. Although it is neither practical nor affordable to retrofit upgrades to bring all parts of the drainage system up to standards, it is reasonable to treat areas where flooding is demonstrated to have a negative impact on habitable rooms or business premises.

Melbourne Water and Bayside City Council face a number of challenges in reducing existing flood risks for their stakeholders:

- Increasing high-density development has reduced the area of pervious surfaces that absorb stormwater, as well as reducing the number of above-ground flowpaths for stormwater runoff find an inlet to the underground drainage system
- Some urban development has occurred without full knowledge of the flood risk of the location
- Flood mitigation work such as increasing the drainage capacity or constructing retarding basins is usually difficult and expensive because of the existing pattern of urban development.

In addition, climate change, further urban development and an ageing drainage asset base are likely to increase flooding risks. Therefore, Council faces the dual challenge of controlling new risks while effectively mitigating the risks arising from that portion of the drainage system built to historical standards.

System issues impacted by demand include:

- Asset Performance – the ability to provide the required level of service to customers. Generally, this can be measured in terms of reliability, availability and meeting customer demands and needs in an environmentally sustainable manner.
- Hydraulic capacity of the system - the ability of the system to meet the current design standards. Design standards have changed over recent decades and most of the Bayside drainage network is below current standards. Catchment analysis of susceptible locations has determined the proportion of the drainage system required to be upgraded where localised flooding has been demonstrated to have a negative impact on habitable rooms of residencies or business premises. The impact of overland flows in areas where the underground drainage system is under capacity also needs further assessment.
- Structural integrity of the pipes - a pipeline on the point of pressure collapse due to condition deterioration may still have good hydraulic performance. A periodic inspection process is required of the system to assess the structural condition of drainage system assets.

- Quality of discharge waters – the potential impacts on life expectancy from, for instance, flows from industrial areas where there is evidence of attack on pipeline material. The common attack in this scenario is from acid. Council developed a Bayside Stormwater Quality Management Plan[1] (2001) to address these types of issues.

3.2 Draft Drainage Upgrade Strategy

Planning for drainage upgrades to address key sites that are susceptible to localised flooding has determined that a program of works to the value of $24.5M (in 2014 dollars) is necessary. A draft Drainage Upgrade Strategy[2] has been developed that includes a 10-year capital works program aimed at addressing 65% of the known network capacity problems over that period (refer Appendix 1). This program involves 45 projects arising from complaints of flooding occurring during intense rainfall events in 2011 and from drainage capacity assessments undertaken between 2005 and 2009.

3.3 Climate Change

Council adopted the Bayside Climate Change Strategy[3] in May 2012 that sets Council's direction in terms of environmental sustainability and adaptation to the inevitable consequences of climate change, including storm events of increasing frequency and intensity. Although there is a reasonable limit to what extent the capacity of the underground drainage network can be upgraded to cater for runoff from intense storms, further planning is required to determine the following design criteria relating to the provision of drainage services in the context of climate change:

- Flood detention approaches
- Future design tail water levels
- Redevelopment floor levels.

3.4 Identifying Future Demand Factors

Community expectations of the stormwater network are increasing. The community is becoming less tolerant of stormwater runoff ponding in private yards or in the streets and expects that the stormwater system will collect and covey runoff from the street immediately.

Legislative change can significantly affect Council's ability to meet minimum levels of service and may require improvements to infrastructure assets. Future tightening of stormwater discharge standards may affect stormwater disposal options.

There is an increased concern regarding the quality of stormwater discharges and the impact of contaminants from urban run-off (e.g. oil, lead, fertiliser, rubbish, etc.). There is a need to focus on ways to cost effectively improve stormwater quality for the overall good of the environment.

Technological Change – New initiatives will be monitored to establish when changes occur that may bring benefits to council. Monitoring can be by way of media coverage, industry journals, workshops and conferences. Any changes to maintenance regimes will need to be scrutinised as to any impacts on the current maintenance contract arrangements.

[1] TRIM ref # 2010/0224469
[2] TRIM ref # DOC/15/86752
[3] TRIM refs # DOC/12/55184 & DOC/12/55185

Catchment Analysis – Periodic analysis of high-priority areas should be undertaken to reveal the current level of flood immunity of properties, the need to upgrade network capacity and the impact of overland flows in areas where the underground drainage system is under capacity.

Urban Consolidation - All new developments are being required to have detention systems to alleviate peak flows in the network and an increasing emphasis on the quality of storm water will also have a mitigating effect on peak flows.

Environmental issues - New developments are also required to incorporate appropriate environmental protection measures at the time of drainage design. In the future however, there is likely to be an increased demand for the retro fitting of existing storm water systems with similar protection. Stormwater reuse options are also likely to increase in frequency.

Affordability - Where affordability limits the ability to implement the usual engineering solution for asset upgrades or new works, non-asset based solutions should be considered. Non-asset based solutions may involve adoption of a lower level of service and subsequent acceptance of increased insurance costs and liability.

3.5 Future Outlook

Bayside has a relatively stable population level but is influenced by the process of urban consolidation. Urban consolidation is having an effect on the existing drainage network with an increasing percentage of the available surface area being made impermeable by larger individual dwelling sizes and reducing lot sizes and an increasing proportion of units in the dwelling stock.

Council has recently adopted a 20 year Development Contribution Plan (DCP) for drainage infrastructure and is currently seeking authorisation from the Minister for Planning pursuant to section 8(A)(3) of the Planning and Environment Act 1987 to prepare Amendment C139 to include the DCP in the Bayside Planning Scheme. The project areas identified in the DCP for attracting contributions are derived from the same catchment analysis and drainage network planning discussed in Section 3.2 above. It is expected that the majority of the projects listed in the drainage upgrade program over the next 10 years will fulfil Council's obligation within the DCP to undertake works within the nexus of the contributing development(s).

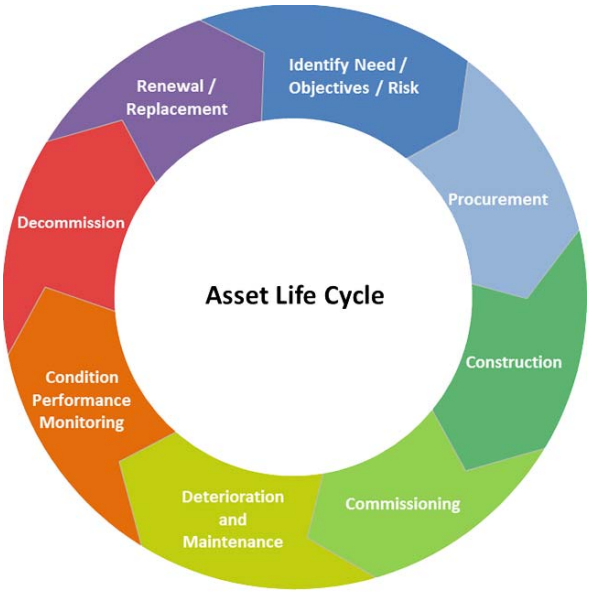
New technology will see the introduction of techniques and materials that bring about changes to management of stormwater assets. Technological advances applicable to the life cycle management of drainage assets are observed in the following areas:

- In-situ relining of pipes as an alternative to replacement. Industry experience indicates that the life of a well-constructed, reinforced concrete drain is likely to be in excess of the currently adopted 100 years and that future rehabilitation strategies will extend this even further.
- 'Trenchless' technology with which repairs and rehabilitation are undertaken without the traditional open trench excavation of pipelines. This technique offers savings and can decrease disruption to traffic and property owners, and
- Treatment system – new technologies for the removal of pollutants from stormwater are being advanced and becoming more affordable.

4.0 Life Cycle Management

The lifecycle management plan details how Council aims to manage and operate the drainage network at the agreed levels of service, while optimising the life cycle costs. This section outlines strategies to ensure sustainability. Based on predictive modelling, testing of assumptions, risk identification and sample testing, a determination has been made as to the necessary level of operations, maintenance and renewal funding to ensure desired levels of service are achieved on a whole of life basis. The figure below provides a graphical representation of the stages in the asset lifecycle.

Figure 1: Asset Lifecycle[4]



As custodian of the community's infrastructure, Council's function is to provide a drainage system involving the management of physical assets such as underground pipes and pits. The cost imposition to Council involves the following aspects:

- Identifying the need and planning for the infrastructure
- Procurement and construction
- Operations, maintenance and condition monitoring
- Decommissioning or renewal/replacement (end of the useful service life of the asset).

4.1 Asset Types and Quantity

Table 3 provides a summary of Council's drainage assets, their physical quantities and current replacement value[5].

[4] Source: http://www.dsidsc.com/images/ph-me-asset-management-life-cycle.png

[5] Brownfield replacement cost - refer to the totals of column BK in DOC/14/104106 and column CA in DOC/14/104109 (for Bayside assets only), both increased by 16% to cover the costs of construction in a developed and densely populated municipality (i.e. referred to as brownfield rates, as opposed to greenfield rates which are utilised in asset valuation)

Table 3: Asset Category Quantities and Replacement Costs

Asset Type	Quantity	Replacement Value[6]	Lifecycle (Years)	Average Annual Renewal Value[6]
Pipes and culverts	410.8 km	$116,371,877	100	$1,163,718
Pits	14,853 (no.)	$59,206,403	100	$592,064
Total		$175,578,280		$1,755,782

Although Bayside is an established area with a reasonably complete drainage network, the asset stock will grow annually as new assets are constructed as part of the capital works program and contributed as part of private developments. Also, new entries to the asset register will occur from time to time as a result of improved data collection, review of historical data and on-site investigations. These new assets will attract additional funding for future operations, maintenance and renewal.

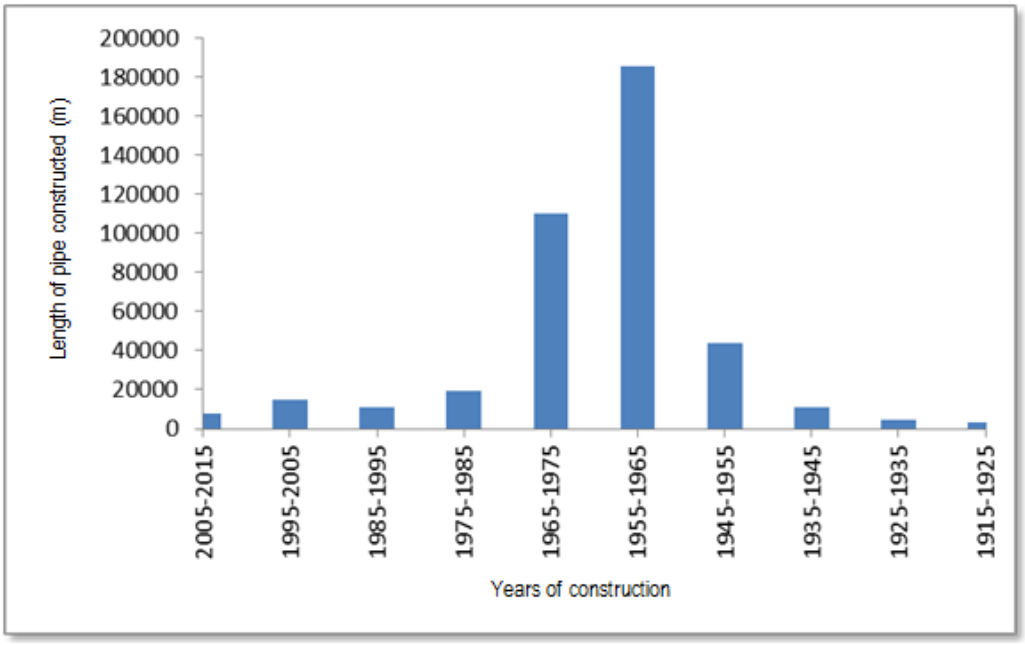
For specific drainage asset data records, refer to DOC/14/104106 (pipes) and DOC/14/104109 (pits)

The maintenance and management of non-structural components of the stormwater drainage system such as wetlands and retarding basins are within the scope of the Recreation and Open Space Asset Management Plan.

4.2 Asset Age (and useful lives)

The pipe network has largely been developed between 1940 and 1970 and is comparatively young in terms of the predicted average life of 100 years. The following chart shows the age profile by plotting lengths constructed during each 10-year period. It shows that the bulk of the system is currently around 60-70 years of age with a smaller amount between 70 and 80 years and a very small amount approaching 100 years.

Figure 2: Age distribution of drainage System



[6] Average annual renewal value is replacement value divided by useful life and is simply an indication of the order of magnitude of annual renewal funding requirements over the long term. Actual requirements are gained by modelling.

Drainage pipes and pits are considered to have useful service lives of 100 years, which are based on an estimated structural life and generally consistent with other Councils in the region. The useful service lives of pipes and pits are considered conservative and most assets are likely to exceed the 100 year useful lives used in renewal modelling, as the existing assets approaching 100 years old are not showing signs of imminent failure. Alternatively, some assets may need to be replaced prematurely (that is if the condition is still good) where part of the network is prioritised for upgrading due to hydraulic performance reasons (e.g. under capacity).

4.3 Asset Condition

The underground pipe network has largely been developed since 1930 and a large proportion of the asset stock has reached the half-way point in terms of the useful service life of 100 years. Reinforced concrete pipes make up over 93% of the pipe network with about 4% constructed from UPVC or HDPE while less than 3% is of other materials (e.g. brick lined). Pits and other structures are predominantly constructed of concrete.

Pits and other critical drainage structures are regularly inspected for maintenance and cleaning purposes, however their condition is not recorded during these inspections. Furthermore, the condition of the underground pipe network has not been directly assessed, due to the difficulty and cost in accessing buried assets. However, information gathered from local flooding history, CCTV inspections carried out on a sample of the network and given 70% of the assets are only halfway through their useful service lives, the network overall is considered to be in good structural condition. From this information, minimal renewal needs are expected for drainage assets as a result of structural problems over the next 20 years, however as more assets reach their 100 year age in the 2040 to 2060 period, renewal needs are likely to increase.

Ongoing samples of CCTV and manual pipe inspections of the network are required to test the assumptions outlined above.

The Moloney Model which is used for long term asset renewal forecasting is based on assessing asset condition on a 0-10 scale with clear condition rating descriptions for each rating score. Condition 0 represents a new asset while 10 is an asset with no remaining life. For buried network assets such as drainage systems that are difficult and costly to collect direct condition data for, the Moloney Model also caters for the use of asset age (from date of construction) in the renewal modelling of drainage assets. The Model converts the age profile of the network into the 0-10 condition rating scale based on estimated remaining life. This approach has been used in the financial modelling developed for this D-AMP.

Future CCTV condition surveys data collection (sample sets) will allow this modelling process to be reviewed, based on the progressive collection of actual condition data and refined where necessary, rather than just relying on the age of the asset.

4.4 Risk Identification

Council's Risk Management Process is an integral part of best practice asset management. The application of sound risk management allows for continual improvement in decision making and processes and is an essential consideration in determining appropriate levels of service.

Key risk issues for drainage systems in general include:

- Flooding resulting from insufficient hydraulic capacity of the system or structural failure causing blockages;
- Flooding resulting from blockages caused by non-system obstructions;
- Broken pit lids that may prove to be a hazard; and
- Unauthorised entry into the underground drainage system.

- Unfenced drains and retardation basins where the slope may be too steep for easy escape at time of inundation, or where batters/banks may even be undermined with the potential to collapse;
- Grates over inlet structures where bar spacing exceeds the maximum clearance of 100mm enabling unauthorised access.

It is not possible for Council to address all defects and eliminate all risks. However, risks are being minimised by the undertaking of inspections to identify risks.

4.4.1 Hydraulic Capacity and Performance

Asset performance relates to the ability of the asset to perform over time to meet its intended purpose. This involves the ability to meet hydraulic capacity demands (the ability to collect and convey storm runoff) as well as remaining structurally sound as the assets age and are potentially subjected to greater external loads than originally intended. Furthermore, an increasing percentage of the catchment area is being made impervious by larger individual dwelling sizes, reduction in lot sizes and an increasing proportion of units in the dwelling stock.

A catchment planning study documented in the report entitled *Stormwater Drainage Network Improvement Project (SDNIP)* was undertaken between 2004 and 2009. The purpose of this study was to assess the 30 main catchments and model the network to establish capacity deficiencies. The study involved an assessment of the risk of flooding within the drainage network based on pipe hydraulic performance and pipe criticality. Hydraulic failure was assessed in order to quantify incapacities within the existing network, whilst pipe criticality was assessed to measure the consequence of pipe failure, both structural and hydraulic (i.e. the potential impact that a failure will have on people, property and other assets).

Investigations adopted a Consequence of Failure rating of the pipes where previously Pipe Criticality had been used. To assess the consequence of failure of the stormwater assets, several criteria were taken into account. A score system was adopted to assess the consequence of failure for the assets. A total of five criteria were considered in the model and the severity of each criterion was determined for each asset, matched with the appropriate score and multiplied by a weighting factor. All five criterion scores were then summed to determine the consequence of failure rating of each pipe, based on a risk and prioritisation matrix score system shown in more detail in Appendix 4.

The outcomes from the modelling of the drainage network capacity were utilised to determine the upgrade requirements for the system to provide a level of service in residential areas to cater for a 20% probability storm, and a 10% probability storm in commercial and industrial areas. The investigation had identified approximately 17.2km of drains that need to be upgraded in order to achieve this increase in level of service. A drainage upgrade program[7] has been developed from this planning work comprising 45 projects (refer Appendix 1).

4.4.2 Structural Condition and Performance

Performance also relates to the ability of the asset to remain structurally sound as the assets age and are potentially subjected to greater external loads than originally intended. For instance, pipes at relatively shallow depth under roads will now be facing far greater impact loads from traffic than when constructed in the 1950s.

CCTV surveys of a sample of the network have been undertaken and are proposed on an ongoing basis to improve the knowledge of pipe condition. This will form the basis of future revisions of the D-AMP and allow more accurate long term predictions of drainage renewal requirements.

[7] Draft Drainage Upgrade Strategy TRIM ref # DOC/15/86752

4.5 Asset Data Storage Systems

Bayside City Council uses AIM as the asset register for drainage infrastructure. This database has pipe depth, size, pit type, age information and condition data where available. The GIS also has a layer which displays the location of all drainage assets.

The Moloney Modelling System is currently being utilised to determine future funding levels for renewal of Council's drainage assets. Ongoing analysis and predictive modelling is required to refine the assumptions and forecasts provided in this plan.

4.6 Operations and Maintenance

4.6.1 Maintenance Arrangements

Effective maintenance strategies are essential to ensure that an asset performs at the desired service level on a day-to-day basis. Council has a contract arrangement for the maintenance and repair of its drainage network assets.

The current Management and Operation Infrastructure Maintenance Services Contract No. 080977 commenced on 3 March 2010. The contract is for an initial period of Seven (7) years with a further option of three (1) year extensions to be exercised at Council's discretion.

The Contract requires the Service Provider to provide all management, supervision, labour, materials, plant, equipment, profit and overheads to carry out the required works throughout the municipality to Council requirements. The Contractor monitors performance levels, maintains updated records of assets associated with these works and reports to Council on a regular basis as set out in the Specification. The Contractor has a Maintenance Management System (MMS) to support the drainage maintenance services.

As part of Council's contract management procedures, there are monthly meetings to review the Infrastructure Maintenance Service Contract to ensure compliance with the requirements of the Contract. Various audits of Contractor performance are carried out by Council field staff on a weekly basis by undertaking a random audit of 20 percent (20%) of the Infrastructure network.

Pits and other structures are periodically inspected and cleaned to minimise the potential for blockages. Underground drainage pipes are only cleaned where a fault or blockage is detected as a result of the pit inspections or when a report is received.

4.6.2 Inspections

A key level of service is the regular inspection of the drainage network. This is essential for its safe and efficient operation. Inspection frequencies are set out in the Management and Operation Infrastructure Maintenance Services Contract and are monitored via the Maintenance Management System.

The inspection not only identifies safety hazards and facilitates timely repairs, it also feeds into and guides the development of maintenance and capital works programs.

4.6.3 Inspection Data Records

Council has an integrated asset management system (AIM) where all data in relation to drainage infrastructure is recorded. This information includes identifiers for all drainage infrastructure, all defects identified during proactive inspections, details of rectification works as well as asset condition captured during condition rating.

The Contractor's Maintenance Management System tracks programmed inspections, records defects identified during inspections, records action requests received from the community and tracks repairs, response times and other actions taken. The MMS will maintain a works history with clear audit trails. This data is then fed into AIM and is being stored for future analysis and reference. There is potential to link asset data stored in AIM with other systems such as Customer Service Request System and Intramaps (GIS).

4.7 Renewal, Upgrade and Disposal Plan

4.7.1 Renewal Prioritisation Process

Planned and reactive renewal works are prioritised in accordance with the consequence of failure rating for the asset in question.

Failure can arise from the following causes:

- a structural collapse of the pipe that causes partial or complete blockage; or
- the inability of the hydraulic capacity of the pipe to convey the flow; or
- a combination of the two, (i.e. hydraulic overloading of the pipe causing high pressures).

This Renewal Section relates specifically to the need to renew drainage assets for structural, rather than capacity reasons. Parts of the network with inadequate capacity will be prioritised for upgrades within the draft Drainage Upgrade Strategy. It is important to note that any proposal to renew a drain does have an assessment made of its capacity. The opportunity to upgrade a pipe during renewal works needs to be given careful consideration, given an increased pipe diameter is not a significant factor of the overall project cost.

With regard to the prioritisation of renewal works, critical drains will be programmed for rehabilitation or replacement when:

- the performance of the asset fails to meet the required level of service due to the poor condition of the pipe, and
- it is no longer cost effective to continue repairing the asset, and
- the risk consequence of asset failure and the associated financial and social impact of that failure justifies replacing the asset.

In addition to criticality rating, prioritisation will be rated on urgency of work in accordance with Table 4.

Table 4 Renewal Prioritisation Criteria

Priority	Renewal Criteria
5 (High)	• Failure has occurred and renewal is the most efficient life cycle cost alternative. • Asset failure of key system component is imminent. • There is a risk of the floor levels of habitable buildings being flooded on a frequent basis, and/or a serious risk to the personal safety of people in private property or in streets. • Regular maintenance required: > two visits per month. • Fault has, or is liable to cause flooding to houses or shops. • Upgrading of the road under which the drain lies is scheduled for the current financial year and cannot be deferred.
4	• There is a risk of the floor levels of habitable buildings being flooded on a periodic basis, and/or a moderate risk to the personal safety of people in private property or in streets. • Maintenance requiring more than one visit per two month period in past six months • Fault causes repeated complaints in excess of one in each two-month period. • Difficult to repair, due to fragile nature of material, or obsolescence.
3 (Medium)	• There is a risk of the floor levels of habitable buildings being flooded on an infrequent basis, and/or some risk to the personal safety of people in private property or in streets. • Pipe or Structure maintenance involving two to three visits annually.
2	• There is a minor chance of the floor levels of habitable buildings being flooded or risk to the personal safety of people in private property or in streets. • Existing assets have a low level of flexibility and efficiency of replacement alternative.
1 (Low)	• There is little if any chance of the floor levels of habitable buildings being flooded or risk to the personal safety of people in private property or in streets. • Existing asset materials or types are such that known problems will develop in time.

4.7.2 Renewal Strategy

The justification to renewal assets is based on the following criteria:

- Risk: The risk of failure and associated financial and social impact justifies action (e.g. impact and extent of resulting flooding due to inability of the drainage system to collect and convey stormwater runoff).
- Asset performance: the failure of an asset to meet the required level of service. Non-performing assets are identified by the monitoring of asset reliability, capacity and efficiency during planned maintenance inspections and operational activities.
- Economics: It is no longer economically prudent to continue repairing the asset (i.e. the annual cost of repairs exceeds the annualised cost of renewal).

Significant expenditure on renewal of drainage due to structural problems is not expected in the next 20 years given the age of the network. This assumption will continue to be tested by ongoing condition-based analysis of the network and adjusted in future plans.

Given the relatively young age of the network relative to the useful service life (100 years), it should only be necessary to address structural failure in drains that have experienced premature failure due to defective design or construction or damaged due to outside influences, such as heavy vehicles or tree roots. The extent of drainage works required by these events is unknown; however it is not expected to be significant in network terms. It is appropriate to budget for funding as determined by the financial forecast results from Moloney Model.

Renewal works identified in terms of these renewal strategies may be deferred if the cost is beyond the ability of the community to fund it. This can occur when higher priority works are required on other infrastructure assets, when there are short-term peaks in expenditure or if an inadequate rating base exists.

When renewal works are deferred, the percentage of the network that is at a condition beyond the condition intervention level and the future renewal demands need to be reported on an annual basis. Although the deferral of some renewal works may not impact significantly on the short-term operation of assets, repeated deferral will create a liability in the longer term and create a renewal gap which will affect the level of service to the community.

4.7.3 New and Upgraded Asset Requirements

Works required to cater for growth or higher levels of service include the creation of a new asset or an upgrade to increase the capacity of an existing asset.

For the drainage system, provision of new or upgraded works fall into the following categories depending upon the extent and type of works:

- Council funded,
- Developer funded as part of subdivisional development, or
- Contribution to the cost by either the developer and/or Council.

Where possible, developers of new subdivisions are required, as part of the development approvals process, to provide the basic internal drainage infrastructure to the standard appropriate for that development. Currently new developments are required to incorporate appropriate environmental protection measures at the time of drainage design. In the future however, there is likely to be an increased demand for retro-fitting of existing storm water systems with similar protection. The financial impact of this has yet to be assessed.

Council has recently adopted a 20 year Development Contribution Plan (DCP) for drainage infrastructure and is currently seeking authorisation from the Minister for Planning pursuant to section 8(A)(3) of the Planning and Environment Act 1987 to prepare Amendment C139 to include the DCP in the Bayside Planning Scheme. The project areas identified in the DCP for attracting contributions are derived from the same catchment analysis and drainage network planning discussed in Section 3.2. It is expected that the majority of the projects listed in the drainage upgrade program over the next 10 years will fulfil Council's obligation within the DCP to undertake works within the nexus of the contributing development(s).

A significant issue for Bayside are the deficiencies and critical under-capacities within the existing network that need to be addressed. The majority of Bayside's drainage network was constructed to standards of drainage design well below than if similar systems were to be implemented today. Much of the network was designed for typical, frequent, low intensity storms (a 100% chance of occurrence) and with little consideration of overland flow paths to convey large volumes of runoff during extreme localised rainfall. A draft Drainage Upgrade Strategy has been developed guide the investment into drainage capacity improvements over a 10 year program of the highest priority drainage upgrade projects (45 in total). The Strategy seeks to address 65% of the underground pipe network that is under capacity at locations that are susceptible to damage from flooding.

The incorporation of this information within the revised version of the D-AMP is a substantial improvement toward being a Service-Driven AMP that provides a strategic and systematic approach to the long term management of Council's asset stock by providing a service-driven assessment of asset performance, levels of service use and future needs.

When Council considers its discretionary capital expenditures for new or upgraded assets, it is essential to establish the consequential recurring operational and maintenance costs that will occur once the new or upgraded assets become operational. As new projects are brought forward for consideration in annual budget deliberations, they will have to include an assessment of these ongoing operational (recurrent) costs to be presented to Council as part of the overall project cost projections.

As Council acquires new assets through the subdivision development process, it is important that the consequential costs of maintenance are established and allowed for in future budgets. It is not reasonable to expect these costs to be absorbed into existing budgets without an increase in funding for operations and maintenance. A failure to provide additional funding for new assets is to effectively reduce the current levels of service across the remainder of the drainage asset stock.

4.7.4 Asset Disposal Plan

It is not envisaged that drains included in this D-AMP will be considered for decommissioning in the foreseeable future. Costs may be incurred associated with the removal or disposal of a decommissioned asset and this may also include any site rehabilitation after the structure has been removed. Where it is impracticable to remove decommissioned pipes, they are to be filled. Obsolete surface pits are to be removed.

When disposal does occur, recognition needs to be made in the Recurrent/Operating budget of the reduction of associated operating or maintenance costs of the decommissioned assets, as well as any removal and site rehabilitation costs.

5.0 Strategic Financial Management

5.1 Current Financial Position

Council's current expenditure for 2015/16 on asset-based drainage and flood mitigation services totals $3.8 million, representing approximately 3% of Council's total budget (capital works and maintenance). The breakdown between capital works and maintenance is presented in Table 5.

Table 5: Drainage Service Budget Allocations 2015/16

Budget Component	2015/16 Allocation
Capital Works (Renewal, Upgrade and New Assets)	$2,451,796
Operations and Maintenance	$926,183
TOTAL	$3,377,979

5.1.1 Maintenance Expenditure

Maintenance expenditure refers to all costs incurred to ensure that asset remains operational, such as repairs to cracks and cleaning. Maintenance does not include actions which affect the remaining useful service life of the asset (as this is defined as renewal).

Approximately 27% of Council expenditure on drainage assets is on maintenance activities and the current budget is considered to be in line with annual requirements to achieve the adopted level of service standards. Table 10 below provides a breakdown of the annual cost of maintaining the drainage system.

Table 6: Drainage System Maintenance Allocations 2015-16

Maintenance Activity	Budget (Proposed 2015/16)
Pipe Inspections and Cleaning Program	$481,037
Inspection of Critical Pits	$18,364
Drainage Maintenance General	$211,003
Drainage Pit Inspection and Cleaning	$121,561
Drainage Litter/Gross Pollution Traps	$94,218
TOTAL	$926,183

As can be seen from Table 6, inspections and preventative maintenance programs form the major part of the costs associated with drainage. The table also demonstrates the impact of the more frequent inspection and cleaning regime for the relatively small number (compared with other drainage structures) of gross pollutant traps.

While designed to achieve the adopted service levels in the D-AMP, these programs continue to be tested and their effectiveness monitored and measured over time to allow for a future review of the service.

Table 7 below shows the predicted increase in maintenance costs over the next 10 years due to annual cost escalation and the additional maintenance requirements of new assets created over this period.

Table 7: 10 Year Maintenance Cost Projections[8]

2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
926,183	955,108	984,965	1,015,558	1,047,074	1,079,529	1,112,893	1,147,188	1,182,506	1,218,853

5.1.2 Capital Expenditure

Capital expenditure covers renewals, upgrades and new assets and increases the value and extends the useful service life of an asset. Table 8 below lists all components of the 2015/16 capital works budget.

Table 8: Components of Drainage Capital Works Budget (2015/16)

Budget Component	2015/16 Allocation
Renewal capital works, including drainage capacity upgrades[9]	$1,194,590
Upgrade capital works	$781,396
New drainage infrastructure	$475,810
TOTAL	$2,451,796

Asset renewal arising from unforeseen asset failures, such as damage from point loads, is catered for within the Renewal allocation identified in Table 8 above.

Early renewal can be achieved through the replacement of an existing asset before it has reached a condition that warrants intervention, typically due to the need to upgrade the asset. Early renewal work provides for an asset with a full useful service life expectancy following the upgrade. For example, a 40 year old drain might need to be replaced and upgraded because it has inadequate hydraulic capacity and is causing flooding. The existing pipe is not at risk of failure, but it does not meet current service needs. By renewing and upgrading the pipe, the useful service life is extended by 60 years and the level of service is improved. This early renewal will also "even out" the expected renewal expenditure increase in 2040 to 2060.

The annual Capital Works Program therefore comprises the following components:

- Renewal Works due to poor structural integrity or hydraulic performance (asset failure),
- Under-Capacity remedial renewal works (a proportion of the expenditure associated with upgrades)
- Asset upgrades – increasing the capacity of existing parts of the network
- New assets

5.2 Renewal Forecasts - Moloney Model Results

The Moloney Renewal Model is a financial modelling tool used to predict future asset renewal expenditure requirements based asset condition (or age) profiles and using generic asset deterioration curves, the model estimates degradation/consumption of the asset. Two modelling outcomes are available within software:

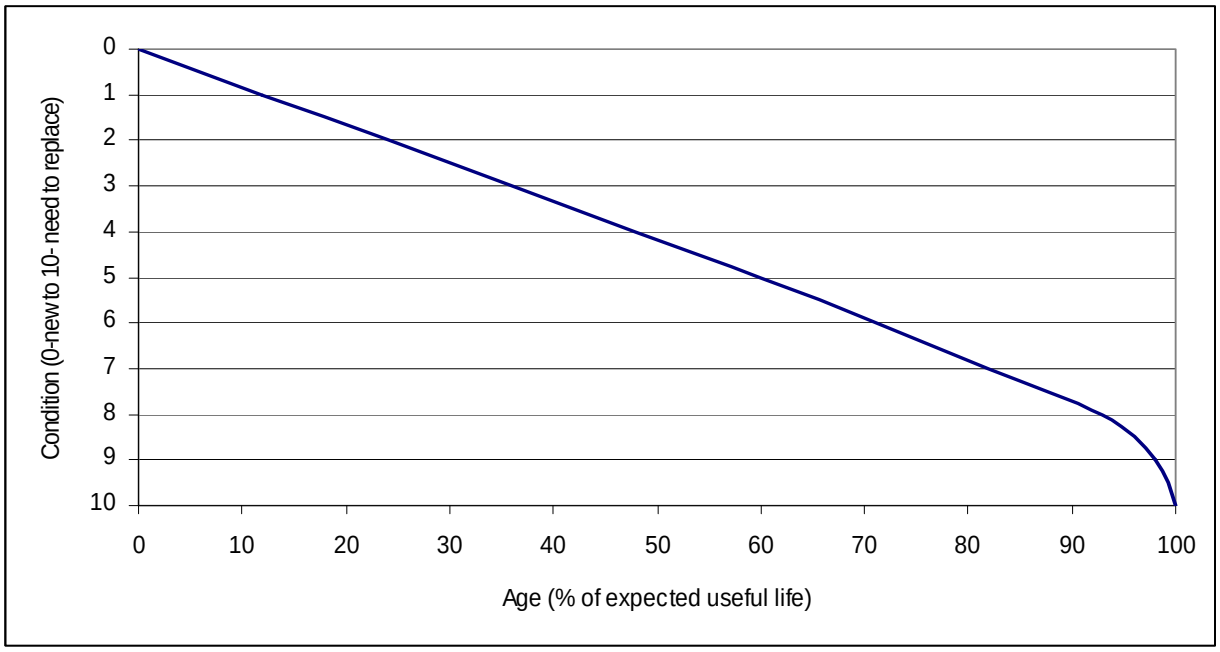
- Given a fixed, or pre-determined expenditure level, the model predicts the overall average asset condition rating at a future date and plots a bar graph of asset condition versus asset amount; or
- A desired minimum asset condition level is established and the model determines the required annual expenditure to achieve the pre-determined asset condition level.

[8] Budget 2015-16

[9] Under capacity works have been approximately split 60% renewal and 40% upgrade. Final apportionment may vary based on the nature of each project, change in pipe size, etc

In the Moloney Renewal Model, the intervention point is known as the Retreatment Intervention Condition Level (RICL). The RICL is the point at which the asset has deteriorated to such a condition that it is economically prudent to initiate restoration works to bring the condition of that component back to the new condition rating of zero (0).

Figure 3: Default degradation profile used for Moloney Modelling



The RICL range in the model is 0 to 10. A RICL of 10 was used for pipes and pits in the preparation of this D-AMP. The RICL of 10 is utilised to ensure that the full forecast asset life is utilised in the modelling. As the asset stock continues to age, this will need to be adjusted to mitigate the risk of asset failure.

The condition profile used in the model for pipes and pits were based on construction date ranges, due to the difficulty and cost in direct condition assessments for buried assets. CCTV inspections of a sample of drainage assets and the relatively young age of the network validate the use of asset construction dates in the model.

Figure 4 below demonstrates the Retreatment Intervention Condition Level (RICL) renewal funding requirements for the renewal of pits and pipes for the next 20 years. The renewal demand for drainage assets for 2015/16 is $693,534, rising annually to $1,969,075 in 2024/25, which equates to an average annual renewal cost of $1.3 million.

Council is committed to meeting the renewal demand by annually updating the Long Term Financial Plan (LTFP) with current renewal forecasts. As such, Bayside does not have a renewal gap or backlog of renewal works to address. Figure 5 below depicts the funding levels foreshadowed in the LTFP against the predicted renewal financial demand, with the resulting impact on asset condition plotted on the same graph. As Council is fully funding the renewal demand, the condition of the asset stock will not decline over the next 10 years.

The 10 year renewal works cost projections are listed in Table 9 below.

Figure 4: **Predicted Renewal Funding Requirements Split by Asset Type**

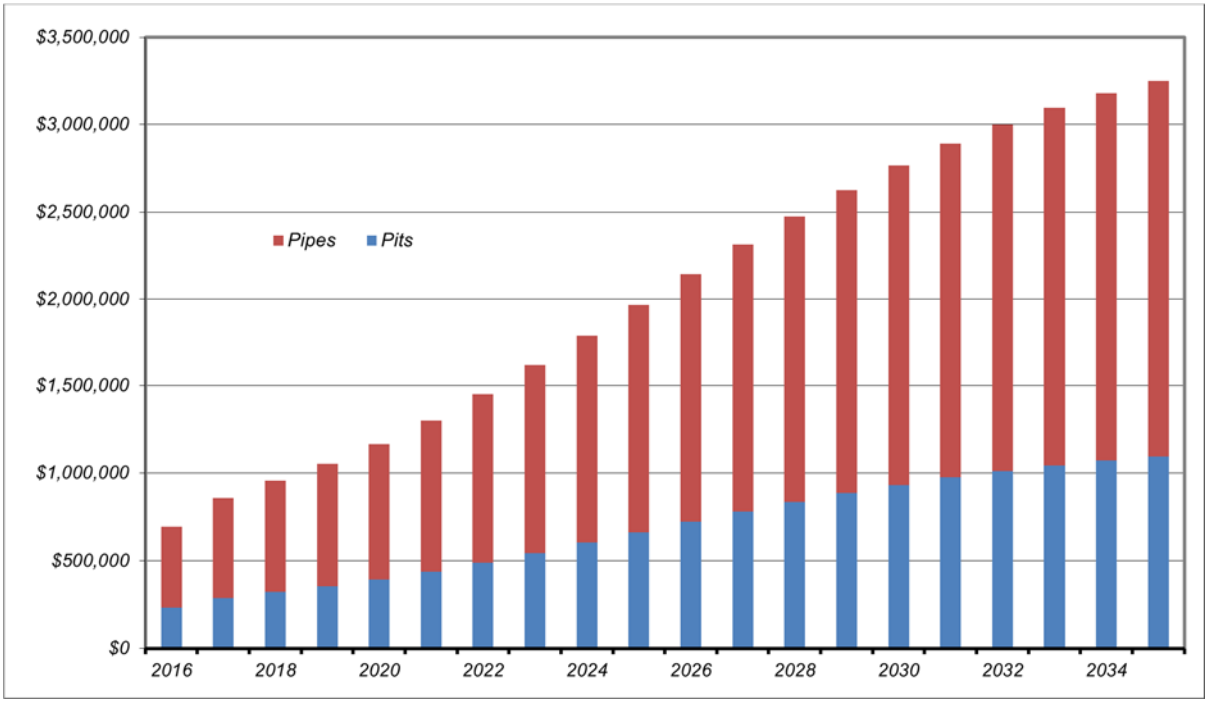


Figure 4: Proposed Expenditure vs **Predicted Renewal Demand**

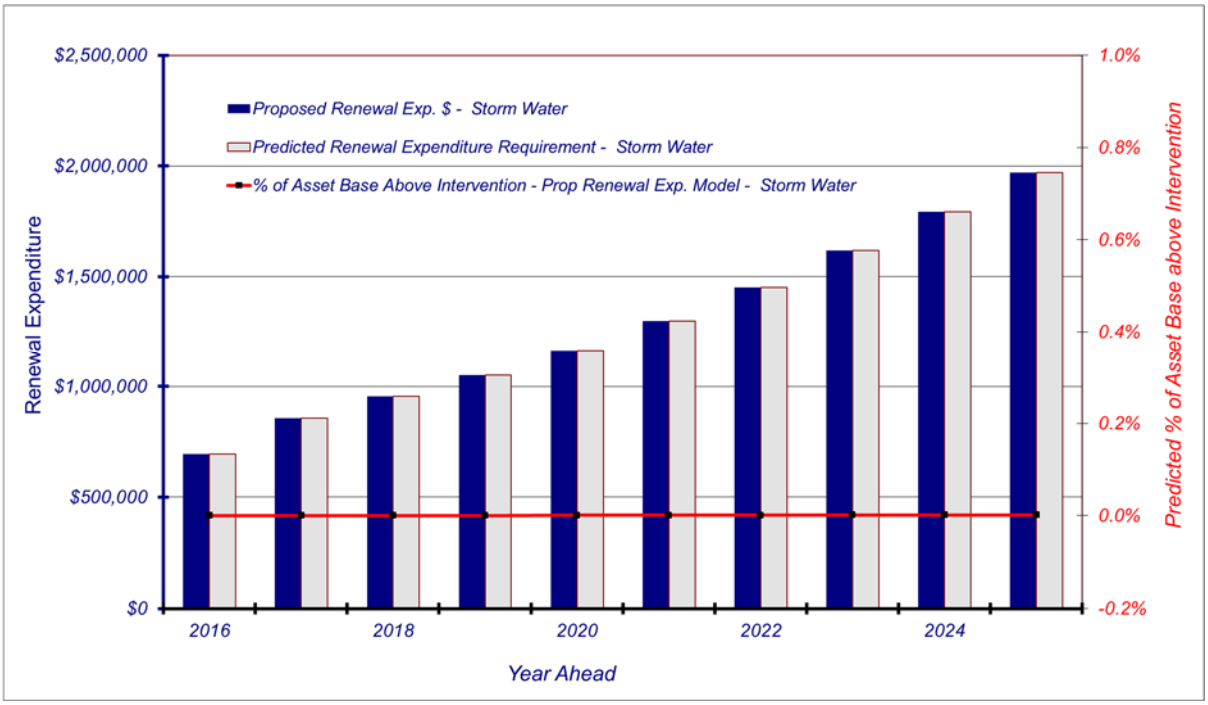


Table 9: 10 Year Renewal Works Cost Projections

2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
693,534	855,944	956,143	1,051,880	1,164,485	1,298,523	1,451,378	1,617,824	1,792,150	1,969,075

5.3 Drainage Upgrades and New Assets

Drainage upgrades and new drainage assets are coordinated within the draft Drainage Upgrade Strategy. As discussed previously, some of the upgrade expenditure can be accounted for as renewal, due to the fact that the upgrading works will renew existing pipes and extend their life.

A detailed prioritised drainage upgrade program is included in Attachment 1. This list of projects has been developed from investigations of direct flooding complaints and drainage network improvement planning work conducted between 2005 and 2009 which identified critical parts of the network that are under-capacity and locations susceptible to flooding within the municipality. Table 10 below tabulates the totals for each of the ten years of drainage upgrades recommended within the Strategy.

Table 10: 10 Year Works Totals - Drainage Upgrade Strategy

2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26
2,000,622	2,174,845	1,958,713	2,025,916	2,075,101	2,025,014	1,962,770	2,011,319	2,018,403	2,078,954

6.0 Inputs to the Drainage Service Financial Forecast

6.1 Overview

The financial requirements resulting from the information presented in preceding sections of this D-AMP are summarised below. These financial projections will continue to improve in accuracy as further information becomes available on the expectations of levels of service from the community and on current and projected asset performance.

These projections will need to be reviewed annually to reflect the actual funding allocated and the scope of the works achieved. For example, if only a fraction of the required renewal budget is allocated or a fraction of the renewal work can be completed within the allocated budget, the result will be a significant impact on the future funding needs and overall asset performance targets being met.

6.2 Service Financial Forecasts

The figures presented below in Table 11 summarise the funding requirements for drainage services over the next 10 years. The figures listed under *New Assets & Upgrades* in Table 11 differ from those listed in Table 10 to account for the asset renewal delivered in upgrade projects as useful service life of the assets are reset. This issue is described further in Section 5.2.

Table 11 Drainage Services Projected Funding Requirements

Year	Capital Expenditure			Operations & Maintenance Expenditure
	New Assets & Upgrades	New Assets & Upgrades with DCP applied[10]	Renewals	
2015/16	1,758,262	1,758,262	693,534	955,108
2016/17	1,313,408	992,048	855,944	984,965
2017/18	1,429,615	1,429,615	956,143	1,015,558
2018/19	1,170,474	342,187	1,051,880	1,047,074
2019/20	1,190,982	1,190,982	1,164,485	1,079,529
2020/21	1,188,516	942,749	1,298,523	1,112,893
2021/22	1,088,559	1,088,559	1,451,378	1,147,188
2022/23	1,050,844	272,321	1,617,824	1,182,506
2023/24	975,187	288,918	1,792,150	1,218,853
2024/25	1,047,953	330,961	1,969,075	1,256,291
Totals	12,213,800	8,636,602	12,850,936	10,999,965

[10] DCP funds may become available at any time during the 25 year DCP lifespan should the development occur within nexus of the project location within this period.

6.3 Key Assumptions

The financial forecasts are subject to and/or limited by the following key assumptions:

- The renewal costs are based on the asset data register (AIM) as at 30 June 2014.
- Modelled outcomes are derived using the Moloney Model and are therefore subject to the limitations of that model and data is used in it, which includes assumed performance of the asset types and trigger intervention levels.
- Useful Service Lives derived from the asset register are assumed to be a reasonable estimate of the life of the assets.
- Condition data used in the modelling is not current, but has been derived from the date of construction and validated CCTV investigations of a sample of the network.
- Asset quantities within the asset register are assumed to be correct.

7.0 Asset Management Improvements

An active and effective asset management strategy should include continuous review and improvement of the system, data and processes used to manage the assets. The sections below identity areas for potential improvements to facilitate better asset management planning and practice

7.1 Improvement Plan

Table 12 Required Improvements for the Drainage Asset Management Plan

Action No.	Action	Responsibility	Priority	Target
1	Audit and improve handover process to ensure that all new drainage assets are captured in the Drainage database	Coordinator Asset Management	High	2015/16
2	Review roles, responsibilities and coordination practices and implement any identified improvements.	Manager Infrastructure Assets	High	2015/16
3	Develop integrated project-based 10 year Capital Works Program for renewals, upgrades and new drainage works based on above and then update annually.	Manager Infrastructure Assets	High	2016/17
4	Review Long Term Financial Plan allocations in light of the above.	Manager Infrastructure Assets Manager Corporate Finance	High	2015/16
5	Undertake ongoing CCTV condition inspections of samples of the network and review Moloney assumptions.	Coordinator Asset Management	Medium	Ongoing
6	Review Asset Register including revaluation of assets and asset lives.	Coordinator Asset Management Manager Corporate Finance	High	Ongoing
7	Develop flood risk management practices consistent with best practice risk management, as recommended by the 2005 Auditor General's Report *(refer to Section 2.5.1).*	Manager Infrastructure Assets	Medium	2016/17
8	Determine performance targets for all Level of Service criteria and implement processes to measure actual performance	Coordinator Asset Management	Medium	2015/16
9	Monitor complaints and other community feedback on drainage issues and review Service Levels and/or undertake further consultation as required.	Manager Infrastructure Assets	Medium	Ongoing
10	As improved data comes to hand, review assumptions used in the Moloney model including process of calculation of remaining life and refine Model.	Coordinator Asset Management	Medium	2012-13
11	Review and update D-AMP Improvement Plan.	Manager Infrastructure Assets	Medium	Annually
12	Continue to assess the implications of Bayside's Climate Change Strategy and review D-AMP Improvement Plan as appropriate	Manager Infrastructure Assets	Medium	2015/16

8.0 Standards, Manuals, Guidelines and Reports

Key standards, manuals and guidelines include:

- International Infrastructure Management Manual Version 3.0 - 2006, IPWEA
- Risk Management Standard, AS/NZS 4360:2004
- All relevant Australian Standards and Codes of Practice
- 'Australian Rainfall and Runoff – A Guide to Flood Estimation' - Institution of Engineers Australia, 1987
- Bayside City Council Standard Drawings
- Requirements for the Design of Council Drains, February 2010
- Report of the Auditor General Victoria – "Managing Stormwater Flooding Risks in Melbourne", July 2005
- Urban Stormwater Best Practice Environmental Management Guidelines, CSIRO 1999
- WSUD Engineering Procedures: Stormwater, Melbourne Water, June 2005
- 'Bayside City Council Drainage Pipe Remaining Life Survey' – MWH Consultants, June 2005
- 'Bayside City Council Stormwater Drainage Network Improvement Project' – MWH Consultants, Final Report May 2004
- 'Bayside Stormwater Quality Management Plan' – Fisher Stewart, Mar 2001
- 'WSA 05 Conduit Inspection Reporting Code' – Water Services Association of Australia

9.0 Appendices:

APPENDIX 1 – LIST OF PRIORITY DRAINAGE UPGRADE PROJECTS FROM THE DRAINAGE UPGRADE STRATEGY

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APPENDICES 3.1 – COMMUNITY LEVELS OF SERVICE

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Appendix 1 –Priority Drainage Upgrade Program

Project	Suburb	2016/17 Year 1	2017/18 Year 2	2018/19 Year 3	2019/20 Year 4	2020/21 Year 5	2021/22 Year 6	2022/23 Year 7	2023/24 Year 8	2024/25 Year 9	2025/26 Year 10
Seaview Shops (Balcombe Road)	Beaumaris	$568,922									
New Street drain, Brighton (South Rd)	Brighton	$92,700									
Nepean Highway drain	Brighton East	$154,500									
Ardoyne Street drain	Black Rock	$721,000									
Kinane street Drain	Brighton	$463,500	$2,174,845								
Billson Avenue drain	Brighton East			$218,545							
Hanby Street Easement drain	Brighton			$76,491							
William Street	Brighton			$163,909							
Bath Street drain	Sandringham			$32,782							
Cheltenham Recreation Reserve drain (Mackenize Street)	Cheltenham			$229,473							
Were Street drain	Brighton			$65,564							
Champion Street drain	Brighton			$188,495							
North Road drain	Brighton			$764,909							

Project	Suburb	2016/17 Year 1	2017/18 Year 2	2018/19 Year 3	2019/20 Year 4	2020/21 Year 5	2021/22 Year 6	2022/23 Year 7	2023/24 Year 8	2024/25 Year 9	2025/26 Year 10
Victory Street drain	Sandringham			$218,545							
Head Street and Horton Close drain	Brighton				$2,025,916	$811,492					
Harold Street drain	Sandringham					$231,855					
Wagstaff Court drain	Brighton					$162,298					
Howell Avenue	Beaumaris					$869,456					
Mary Street drain	Beaumaris						$119,405				
west of St Kilda St	Brighton						$19,494				
west of Gillies and Kanowna Sts, Highett Rd & Bamfield St	Hampton						$872,389				
west of Pellew St	Sandringham						$1,013,725				
west of Wentworth Ave	Black Rock/ Cheltenham							$180,715			
west of St Kilda St	Brighton							$25,099			
west of Thomas St	Brighton East							$943,739			
west of and including Hartley and Mair Sts	Brighton							$35,139			

Project	Suburb	2016/17 Year 1	2017/18 Year 2	2018/19 Year 3	2019/20 Year 4	2020/21 Year 5	2021/22 Year 6	2022/23 Year 7	2023/24 Year 8	2024/25 Year 9	2025/26 Year 10
west of Fernhill Rd	Sandringham							$356,411			
south of Balcombe Rd, Balcombe Park Lane and its connections	Beaumaris							$321,273			
west of St Kilda St	Brighton							$15,059			
west of Bluff Rd	Sandringham/ Black Rock							$70,277			
south of Point Ave	Beaumaris							$15,059			
connections from the Melbourne Water main drain to the fourth pit	Hampton								$336,082		
Melbourne Water main drain connections to the fourth pit	Brighton East								$1,478,759		
west of Surf Ave	Black Rock/ Beaumaris								$196,479		
west of Bluff Rd	Hampton									$1,949,171	
west of New St	Brighton									$69,233	

Project	Suburb	2016/17 Year 1	2017/18 Year 2	2018/19 Year 3	2019/20 Year 4	2020/21 Year 5	2021/22 Year 6	2022/23 Year 7	2023/24 Year 8	2024/25 Year 9	2025/26 Year 10
south of and including Weatherall Rd	Black Rock/ Beaumaris										$351,063
Dendy St, connections between Kinross St and South Road, connections from Melbourne Water main drain to fourth pit, connections from South and Bluff Rds to fourth pit	Brighton East										$614,361
west of Fernhill Rd	Sandringham										$38,397
north of Tulip St	Sandringham/ Highett										$1,075,133
TOTALS		$2,000,622	$2,174,845	$1,958,713	$2,025,916	$2,075,101	$2,025,014	$1,962,770	$2,011,319	$2,018,403	$2,078,954

Appendix 2 – Checklist Drainage Elements at Risk of Climate Change

Drainage, Flooding and Storm Surge - Elements at Potential Risk from Climate Change		***Reference*** *Infrastructure and Climate Change Risk Assessment for Victoria – CSIRO Report to the Victorian Government 2007*		
	Area/Catchment:			
	Issue of Concern:			
	Asset ID and Location:	**Risk Assessment**		
Risk Scenario	**Element**	**Likelihood**	**Impact**	**Risk Rating**
Stormwater Drainage System				
• *Ability of the system to cater for the potential for increased extreme daily rainfall events (includes pipes, stormwater detention facilities and retarding basins, outfalls, erosion to open drains and at inlets and outfalls, weirs, etc).* • *Acceleration of the degradation of materials and structural integrity of the system may occur through increased ground movement and changes in groundwater.* • *Overland flows may also cause damage to private and public assets as well as erosion that may impact the local environment.*	Pipeline hydraulic capacity deficiencies			
	Pits and lids and their adequacy to cater for additional flows			
	Additional Overland flows			
	Specific catchments at risk			
	Stormwater detention facilities			
	Stormwater retarding basins			
	System structures (inlets, outlets, weirs etc)			
	Erosion from increased system flows or overflows			
	Pollution from increased flows			
Town Planning, Development and Building Applications				
• *Potential for an expansion of flood prone areas as well as coastal areas subject to storm surges.* • *This will potentially impact adopted floor levels in these areas.* • *There is a need to promote Water Sensitive Urban Design in new developments.*	Coastal storm surge boundaries			
	Flood prone land boundaries			
	Floor levels for structures in possible storm surge areas			
	Floor levels for structures on possible flood prone land			

Risk Assessment Notes: *Refer to AS/NZS 4360:2004 and Council's Risk Assessment Policy for guidance*

Likelihood: *Rate as Probable (likely to occur), Possible (may occur), or Improbable (conceivable but highly unlikely)*

Consequence/Impact: *Use Council's risk assessment policy or AS/NZS 4360 to establish severity level of consequence*

Risk Rating: *Use Council's risk assessment policy or AS/NZS 4360 to establish risk rating*

Appendix 3.1 – Community Levels of Service

Key Performance Indicator	Level of Service	Performance Measure	Target Performance	Current Performance	Actions to meet performance target
COMMUNITY LEVELS OF SERVICE					
Service Satisfaction	The drainage system meets user requirements for removal of stormwater	(a) Customer service requests relating to surcharging and flooding incidents e.g. 1. Total number of flooding incidents arising from blockages; 2. Number of incidents affecting an individual property (b) Periodic Customer Surveys undertaken by Council	Requests actioned as per Customer Service Charter	85% of CSRs actioned within 15 days	Monitoring of nature of CSRs and response. Contract management of Maintenance Contractor
Health and Safety	System is safe and hazard free	Absence of significant health and safety hazards	All hazards identified by risk assessment are removed or mitigated where practicable	No major issues	Audit of Safety Reports as part of the inspection program
Environmental Standards	Quality of discharge waters	Number of contaminated discharges likely to have a negative impact on waterways	Discharges as per performance objectives outlined by the CSIRO in Chapter 2 of the *Urban Stormwater Best Practice Environmental Management Guidelines 1999*"	No major issues	Audit of water samples Water sampling program to be initiated
Responsiveness	Council responds to issues raised by the community in a timely manner	Council's response time to various community raised issues ranging from calls about problems, response to and repair of problems, handling correspondence and service applications	Provide response within timelines set out in Customer Service Charter and Drainage Maintenance Contract 95% of time.	No major issues	Conduct service audits annually

Appendix 3.2 - Technical Levels of Service

Key Performance Indicator	Level of Service	Performance Measure	Target Performance	Current Performance	Actions to meet performance target
TECHNICAL LEVELS OF SERVICE					
System Capacity	Protection of property from surcharges caused by drains that have capacity below current design standards	Frequency of drain surcharge flooding in: (a) Arterial roads (b) Main outfall drains (c) Private property subject to flooding (d) local streets, active recreation areas and overland flow paths (e) passive parks and reserves	(a) < 1 flood event / 20 yrs (b) < 1 flood event / 10 yrs (c) < 1 flood event / 5 yrs (d) < 1 flood event / 5 yrs (e) < 2 flood event / year and 10 year upgrade strategies developed	Under capacity drains identified	Analysis of existing system capacity then fund works programs to progress improvements
Service Condition	Carry out routine maintenance activities as per service agreement	(a) Defect/Safety inspection frequency (b) Defect response times (c) Condition inspection frequency	(a) Inspections on time (b) Responses on time (c) Condition inspections conducted as scheduled.	Inspections carried out and recorded by Council's Infrastructure Maintenance Department and Contractors	Analyse reports and determine if works are being carried out in accordance with requirements.
Cost effectiveness	Provide and manage the drainage system in cost-effective manner	Maintenance and construction cost for key components	Maintenance services and construction works are competitively priced	All Maintenance Services and new works subject to public tender	
Standard of new works	Quality of new works taken over by Council and also renewals	Number of new assets designed and constructed/renewed in accordance with the relevant Council standards	100% of new assets taken over by Council	New drainage system works inspected by Council – handover not accepted until they meet requirements.	

Appendix 3.3 – Drainage Asset Types and Functions

Asset Type	Function and Purpose
Connections to Street	Convey stormwater run-off from private property to the kerb and channel. These drains are the responsibility of the property owner.
Property Connection	Various types of standard connections designed to facilitate the connection of property drainage to an underground drain within a road reserve or an easement.
Junction Pit	Pits designed to facilitate the connection or change in direction of underground drains.
Entry Pit	Pits designed to facilitate the collection of surface or channel water and convey this water to underground drains.
End Wall	Structures designed to facilitate the collection of surface water or channel water to underground drains or outfall from drains to open drains.
Underground Drain	Various forms of pipe or box drain that conveys the flow of water from point of entry to point of discharge.
Culvert	Various forms of pipe or box drain that conveys the flow of water under a road from an open channel to an open channel.
Overflow channel	Usually a formed channel (sometimes due to a road formation) which facilitates the flow of excess stormwater beyond the capacity of an adjacent underground drain.
Outfall channel	Various forms of open channel that facilitates the flow of water from an underground drain or an overflow channel to point of discharge.
Swale drain	Specific form of open drain designed and constructed to facilitate the flow of water from property or roadway and to achieve improvement to water quality and environmental outcomes.
Wetland	Specific infrastructure designed and constructed to retain water to improve water quality and environmental outcomes.
Litter Traps/Gross Pollutant Traps	Specific infrastructure designed and constructed to remove and retain litter and other gross pollutants from stormwater to improve quality of discharge flows and environmental outcomes.
Stormwater Detention	The temporary storage and controlled release of stormwater to delay the discharge by restricting peak outflows for selected design storms to the maximum capacity of the existing downstream drainage network. These outflow restrictions may apply to the hydraulic capacity of the downstream drainage system or to safety issues associated with an overland flow path. Traditional detention systems delay the discharge for a few hours, or fractions of an hour. Extended Detention Systems can be used to discharge run-off over a 1 to 2 day period. On-site detention systems can be used to alleviate downstream flooding, erosion due to rate of discharge and pollution control of discharge waters through settlement of sediment and particulates. NB: Sometimes referred to as Retardation Basins but by definition are really Detention Basins. These may be designed to cater for recreational uses when not carrying stormwater.
Stormwater Retention	Holding stormwater for considerable periods for re-use or allowing the water to continue in the hydrological cycle via infiltration, percolation, evapo-transpiration, but not for direct discharge to watercourses.

Appendix 4 – Risk Identification

Table 2: Consequence of Failure Criteria and Score System

	Criteria	Severity	Score	Weight	Point Score
1	Threat to public safety	No injury possible	0	6	0
		Remote chance of injury	1		6
		Single injury possible	3		18
		Multiple injury possible	5		30
2	Impact to community (zoning)	No customers affected	0	5	
		Residential	1		5
		Industrial	2		10
		Commercial	3		15
		Schools / Public venues	5		25
3	Disruption to transportation	No disruption	0	4	0
		Minor - cars/light commercial vehicles	1		4
		Moderate - includes trucks and buses	3		12
		Severe - all vehicles and trams or trains	5		20
4	Property or utility damage (Potential insurance claim costs)	Single property	1	3	3
		Minor roadway - minimum services	2		6
		Major road - maximum other utility assets	3		9
		Major road with tramline	5		15
		Crossing beneath rail line	5		15
5	Impact if storm occurs (size/capacity based)	No impact	0	1	0
		Contained locally	2		2
		Land absorption	3		3
		To U/Ground drain	**4**		4
		To open w/course	5		5

Table 3: Total Consequence of Failure Score Rating System

A (High Consequence)	>60
B (Moderate Consequence)	30 - <60
C (Low Consequence)	0 - <30

The study notes that cost of repair of the asset and time required to repair the asset were not included in this assessment, but could form part of the consequence of failure criteria. Thus the criteria and scoring system can be reviewed and changed by Bayside City Council to place a greater or lesser importance on each of the criteria. Drainage Improvement Plans were developed from the 5 and 10 year ARI modelling process, the results of the pipe hydraulics assessment, and the updated pipe consequence of failure ratings.

The proposed individual pipe upgrade requirements were prioritised with a rating out of 5, with 1 being the highest priority, by combining the pipe hydraulic and consequence of failure ratings as shown below in the Table.

Table 4: Drainage Pipe Upgrade Prioritisation Matrix

Pipe Hydraulic Rating Level	Consequence of Failure Rating		
	A	B	C
High	1	2	3
Medium	2	3	4
Low	3	4	5

The drainage improvement plans developed for Council were done so in view of drainage upgrade priorities, locations and costs. Priority values were assigned to each of the grouped drainage works based on the average of the upgrade priorities assigned to the individual pipes. These again ranged from 1 (high priority) through to 5 (low priority).

It should be noted that any Works Program developed by Council as a result of these plans will require the consideration of Council's other streetscape programs, which may ultimately affect priority. Projects within the Improvement Plans may warrant further hydraulic evaluation to establish if augmentation rather than replacement is more appropriate to achieve the required level of service or other catchment management measures such as Water Sensitive Urban Design.

Appendix 5 – Water Sensitive Urban Design (WSUD)

The key principles of Water Sensitive Urban Design as stated in the *Urban Stormwater - Best Practice Environmental Management Guidelines (Victorian Stormwater Committee, 1999)* are:

- Protect natural systems - protect and enhance natural water systems within urban developments. The development of water focussed drainage infrastructure promotes the waterways resulting in it becoming an asset that is to be protected and not exploited. The protected natural system is therefore able to function effectively.

- Integrate stormwater treatment into the landscape - use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments. The natural stormwater drainage system can be utilised for its aesthetic qualities within parklands and walking paths, making use of natural topography such as creek lines and ponding areas.

- Protect water quality - improve the quality of water draining from urban developments into receiving environment. Through filtration and retention, water draining from urban developments can be treated to remove pollutants close to their source. This approach reduces the effect that polluted water can have upon the environment and protects the natural waterways and environment.

- Reduce runoff and peak flows - reduce peak flows from urban development by local detention measures and minimising impervious areas. Local detention and retention enables effective land use for flood mitigation by utilising numerous storage points in contrast to the current practice of utilisation of large retarding basins. This approach subsequently reduces the infrastructure required downstream to effectively drain urban developments during rainfall events.

- Add value while minimising development costs - minimise the drainage infrastructure cost of the development. The reduction of downstream drainage infrastructure due to reduced peak flows and runoff minimises the development costs for drainage, whilst enhancing natural features such as rivers and lakes that add value to the properties of the area.

Treatment Measures

Key Reference:

CSIRO's Urban Stormwater: Best Practice Environmental Management Guidelines, 1999.

Litter Traps	Swales	Infiltration Trenches
The removal of large pollutant matter such as urban litter is a primary treatment method for urban stormwater runoff.	Swales are linear depression of channels that provide for stormwater collection and conveyance.	An infiltration trench is a shallow, excavated trench filled with gravel or rock, into which run-off drains.
Bio-Retention Systems	**Wetlands**	**Porous Paving**
Stormwater retention with vegetation types reduces downstream flow velocities and subsequent drain sizes whilst facilitating secondary treatment.	Wetlands are a series of distinct cells that serve to filter and bio-remediate the stormwater.	Porous paving is an alternative to conventional impermeable pavements with many stormwater management benefits.
Rain Gardens	**Rain Water Tanks**	**Rooftop Greening**
Rain gardens are designed for stormwater quality treatment and as an ornamental feature.	Rain water tanks can provide an opportunity to significantly reduce demand on potable (drinking water) supplies in certain areas of use.	Rooftop greening involves the establishment of vegetation to filter roof runoff and the capture and storage of that roof runoff for reuse.

Inter-relationship between site - precinct - regional stormwater management measures

Stormwater treatment can be broken down into three overlapping categories as demonstrated in the following table. Many treatment measures can be 'sized' to suit the land area available.

Site Elements	Precinct Elements	Regional Elements
· Allotment density and layout	· street layout and streetscape	· public open space · multiple use corridors
· on-site retention (infiltration) · porous pavement · sand filter· buffer strip · grassed or vegetated swales · bio-retention system · rain garden	· precinct retention (infiltration) · porous pavement · sand filter · buffer strip · grassed or vegetated swales · bio-retention system · urban forest	
· on-site detention · rainwater tank for stormwater reuse	· retarding basins · constructed wetlands and treatment ponds · stormwater reuse	· retarding basins · constructed wetlands and treatment ponds · stormwater reuse