Gannawarra Shire Council

Drainage Asset Management Plan
Final Report

February 2011

Halcrow Pacific Pty Ltd

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Drainage Asset Management Plan
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Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Prepared by	Checked by	Authorised by
1	1	Draft Report	01.12.10	DMM	JM/MY	JM
2	2	Final Report	22.02.11	DMM	DMM	JM

Contents

Executive Summary

Gannawarra Shire Council (Council) is seeking to improve its understanding of the condition of its drainage system's general condition and remaining life based on construction material and year of construction. This Drainage Asset Management Plan (DAMP) captures information about asset condition, and allows Council to move forward with regard to some of its key challenges affecting the drainage network, such as salinity, climate change and planning for the future. It also provides a strategy and action plan to optimise stormwater drainage maintenance and capital works programs into the future.

Key outputs of this DAMP include:

- Drainage asset condition rating of sample of drainage pipes
- Deterioration profile of network based on the asset condition rating
- Implementation Plan

The environment in Gannawarra Shire, and Kerang in particular, includes areas of expansive soils, a high groundwater table, flat topography and land affected by salinity. Such conditions can accelerate deterioration and reduce the life of drains. Small areas of future growth and development are anticipated in parts of Kerang, Cohuna and Koondrook. A number of discrete locations with reported localised flooding from the drainage system, or 'hot spots', have also been identified in Kerang, Koondrook and Quambatook.

Projections of Victoria's future climate indicate an increase in temperature, decrease in total annual rainfall and an increase in potential evapotranspiration due to climate change. The potential effects of climate change can directly and indirectly impact the performance and state of a drainage system in a number of different ways, namely:

- More extreme rainfall events and increased rainfall intensity leading to reduced serviceability of drains and increased risk of flooding.
- Increased soil movement contributing to increased pipe displacement and cracking, and ultimately shorter asset life.

It is important that Council plans responses to the potential impacts of climate change. Planning ahead can lead to cost-effective adaptation.

A well defined methodology was developed to complete the asset condition assessment, deterioration profile modelling and compilation of the DAMP. The methodology provided a sound basis for extrapolation of the condition data and the justification for selecting drain assets to be CCTV surveyed. The work required to complete the asset condition assessment and deterioration profile was divided into five key tasks:

1. Review of available information
2. Selection of CCTV Surveys for Review
3. Review of CCTV survey
4. Strategy Development
5. Action Plan

A representative sample of Councils drains were selected for CCTV survey for the purposes of asset condition assessment. A total of 2.49 kilometres of pipeline was reviewed, representing 4.4% of Council's drainage network. All of the assessed pipes were made of concrete and ranged between 28 and 52 years old. The structural condition of the drain assets reviewed was estimated through the use of condition ratings.

Whilst defects typically affected some sections of the drains, the vast majority of the length of drains reviewed showed good structural condition,. A number of structural failures were found in some sections of drainage pipe due to major circumferential cracking or large, defective repairs. These pipes should be replaced in the near future.

A deterioration profile was created by plotting average condition ratings against the age of pipe using results from the condition assessment of the representative sample. The deterioration profile indicates that a drain will reach condition rating 10 and will be in need of replacement, after approximately 94 years on average. That is, the average asset life is estimated to be 94 years.

Climate change is expected to cause increased soil movement contributing to increased pipe displacement and cracking. The severity of displaced joints and cracked pipes may vary, though the frequency of their occurrence is likely to increase. The rate of deterioration is likely to increase, placing extra pressure on the structural condition of drainage assets, causing the assets to fail prior to the estimated end of life shown in the deterioration profile.

Planning ahead for the potential impacts of climate change on the drainage system includes gaining a better appreciation of the current condition of drainage pipes, the remaining life, and how that may change. Future drainage works and upgrade should consider use of collared pipes and the effect of change in rainfall intensities due to climate change.

The five year implementation plan identifies priority actions and high level, indicative cost estimates that will guide Council in management of problems with the drainage network and in a way that is compatible with Council's resources and funding. Application of a risk-based approach to Gannawarra Shire Council's drainage assets and the outcomes of the asset condition assessment and deterioration profile, highlights the following:

1. Those pipes that are older or in very poor condition are generally more likely to fail and should be monitored more regularly, commensurate with their age and condition, and a decision made about when intervention or asset replacement is needed.
2. High priority should be given to those drains found to have failed pipe segments due to significant cracking
3. Drains that are subject to an aggressive environment are more prone to soil movement and accelerated deterioration, and consequently have a higher priority for CCTV monitoring than other drains.
4. Council will need to do more flushing and cleaning of drains in reactive and proactive maintenance. Initial priority should be guided by known trouble areas, surface indicators (e.g. vegetation above drain line) and manhole lift-and-look inspections.
5. The pumping stations in Kerang (in particular) and Koondrook are essential for managing stormwater outflows from the townships. The reliable and effective operation of these pumping stations is critical to preventing flooding and therefore maintaining the pumping stations holds a very high priority.
6. Focus investment on drainage hotspots to address flooding issues.
7. Drainage expenditure and investment should be focussed on (in order): Kerang, Cohuna and Koondrook. Historically, Council's operation and maintenance expenditure is the greatest in these towns. Asset monitoring, maintenance and replacement should be prioritised based on risk.

In addition to Gannawarra Shire Council's routine annual operating and maintenance activities, it is recommended that additional actions are implemented over the next five years from 2011/12 to 2015/16 as shown in the following table.

Year	Action	Costs	Optional Costs
2011/12	Drain cleaning and maintenance	$10,000	
	Construction dates update & develop hot spot register. (Optional)		$10,000
	General annual expenditure	$298,200	
	Total	**$308,200**	**$10,000**
2012/13	Drain cleaning and maintenance	$10,000	
	Hot spot investigation in Kerang (review and update Drainage Study) (Optional)		$50,000
	General annual expenditure	$308,600	
	Total	**$318,600**	**$50,000**
2013/14	Drain cleaning and maintenance	$10,000	
	Pipe replacement in Cohuna	$10,000	
	General annual expenditure	$319,500	
	Total	**$339,500**	**$-**
2014/15	Drain cleaning and maintenance	$10,000	
	Pipe replacement in Kerang and Quambatook	$15,000	
	General annual expenditure	$330,600	
	Total	**$355,600**	**$-**
2015/16	Drain cleaning and maintenance	$10,000	
	Update of DAMP: including CCTV survey, deterioration profile and review of actions/priorities. (Optional).		$60,000
	General annual expenditure	$342,200	
	Total	**$352,200**	**$60,000**

Note: *These costs are estimates only. General annual expenditure extrapolated from 2009 figure.*

1 Introduction & Background

1.1 Background

Gannawarra Shire Council (Council) is seeking to improve its understanding of the condition of its drainage system's general condition and remaining life based on construction material and year of construction. Drain asset condition has generally been considered to be acceptable until a problem arises at which time action is usually taken to address the issue with the investigation of condition sometimes occurring. At present Council has very little CCTV survey footage of its drainage network. Typically, CCTV survey data has been collected as a response to actual or suspected drainage failure and locations surveyed are unlikely to be indicative of the entire system.

Gannawarra Shire Council, like most Councils, operates in an environment where there are many competing priorities and a limited budget available to respond to these priorities. It is therefore critical that the budgets allocated are used efficiently, to extract the maximum value and to achieve optimal outcomes.

The key driver for this project is therefore the need to improve Council's understanding of the drainage asset network with a view to maximising the outcomes of any works undertaken.

This Drainage Asset Management Plan (DAMP) will capture information about asset condition, and allow Council to move forward with regard to some of its key challenges affecting the drainage network, such as salinity, climate change and planning for the future. It will also provide a strategy and action plan to optimise stormwater drainage maintenance and capital works programs into the future.

1.2 DAMP Objectives and Scope

The key objectives of the DAMP are:

- Gain a better understanding of the current condition of Council's drainage pipes, and how that may change in the future.
- Enhance Council's ability to cost-effectively manage its drainage assets via more informed decision making.
- Develop a plan to respond effectively to problems with the drainage network and in a way that is compatible with Council's resources and funding.

The scope of this DAMP is to:

- Complete an asset condition rating and deterioration profile of Council's stormwater drainage pipes. (Manholes/pits, pumping stations, rising mains and other elements of the drainage network are not included).
- Interpret the results and report on the findings of the deterioration profile.
- Prepare an implementation plan for the next five years, identifying priority actions and, where appropriate, high level, indicative cost estimates.
- Identify a general approach and issues to address for the drainage system relating to maintenance, replacement, growth, capacity/flooding, hotspots, future investigations, etc.

1.3 DAMP Outcomes

This outcomes of this project will improve Council's understanding of the current condition of its drainage assets and provide a better appreciation of how that may change in the future. The DAMP will also identify actions and indicative costs for Council to operate and maintain the drainage system, particularly in relation to the stormwater pipes, and will assist Council when developing programs and budgets.

The outcomes will also allow Council to update and improve its accounting of its Asset Management System, which can be used to support financial reports and be justifiable to the auditor general. This entails forming an accurate indication of the condition and useful life of the existing underground stormwater drains.

Key outputs include:

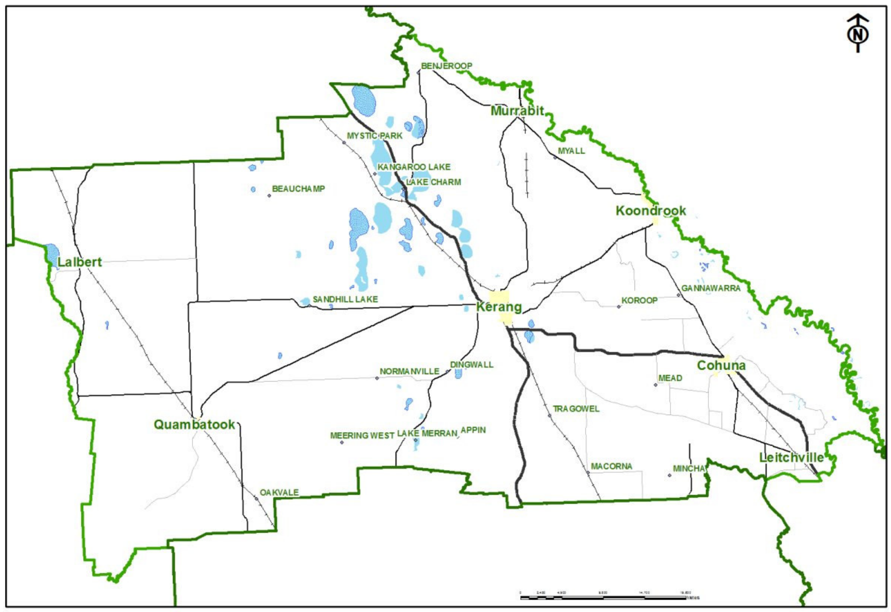
- Drainage asset condition rating of sample of drainage pipes
- Deterioration profile of network based on the asset condition rating
- Implementation Plan

1.4 Understanding of the system

1.4.1 *Existing environment*

The Gannawarra Shire is located in the Loddon Murray region of Victoria approximately 250 km north of Melbourne. It is situated adjacent to the Victoria-New South Wales state border with the Murray River running along the north-eastern boundary. The Gannawarra Shire covers an area of 3,746 square kilometres and includes the towns of Cohuna, Koondrook, Kerang, Lalbert, Leitchville, Murrabit and Quambatook. Refer to Figure 1-1. The area is serviced by an irrigation network that supports diverse agricultural and food industries. The total length of Council's stormwater system is 56.5 km, including channels and underground drainage assets.

Figure 1-1 - Map of Gannawarra Shire



Kerang has salinity issues, a high groundwater table and expansive, clayey soils. These soils are known to dramatically swell and shrink. Similar circumstances exist in Cohuna, although the extent and severity of soil and groundwater issues is lower than Kerang. Koondrook is known to have an underground stream. Quambatook has sandy soils and so a high groundwater table and expansive soil types are not a concern in this area.

1.4.2 *Future growth and development*

The population trend in Gannawarra Shire shows a small decline in population, however this will have negligible effect on the drainage network. There are pockets of new development and expansion of the stormwater network that will generate additional stormwater runoff in their respective the catchments.

Figure 1-2 to Figure 1-4 show the indicative areas (highlighted in pink) where future development is expected in the Shire leading to increased stormwater runoff in the drainage system. Most of these areas are serviced by, or close to, the existing drainage network.

Figure 1-2 - Future development in Kerang

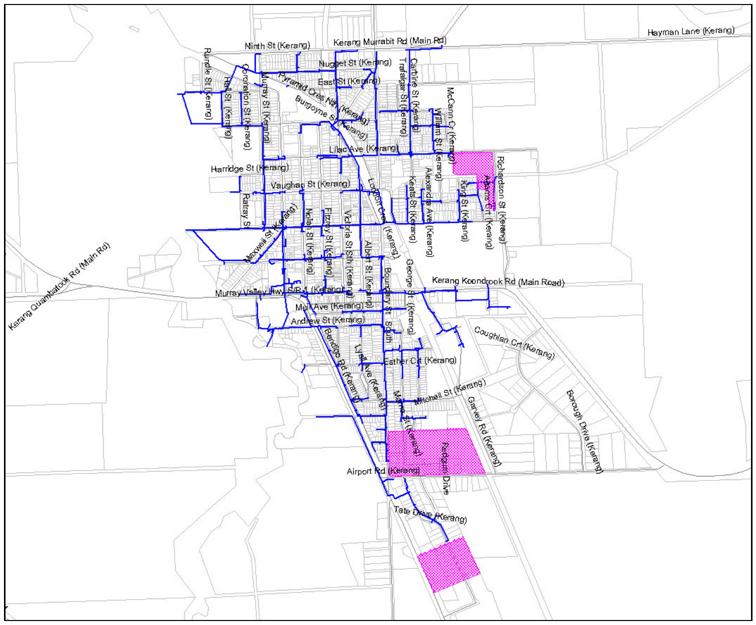


Figure 1-3 - Future development in Cohuna

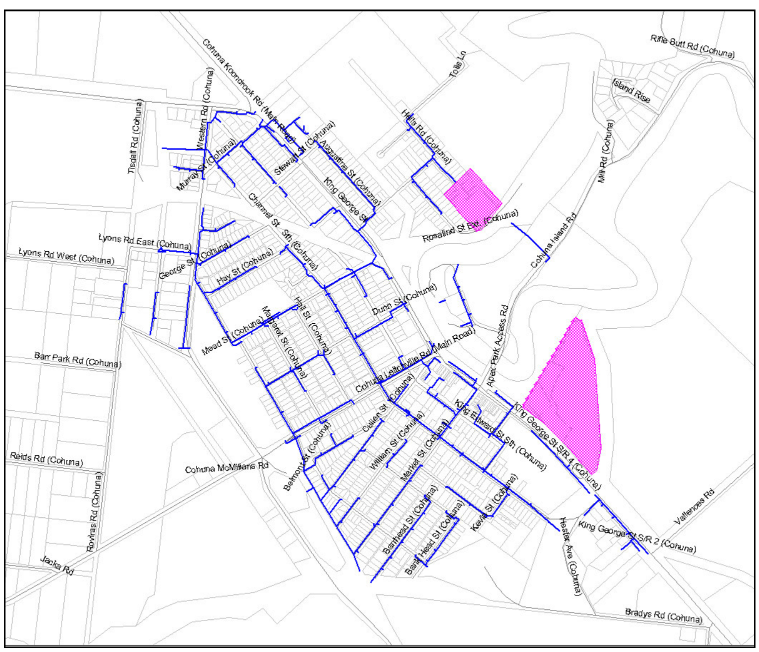
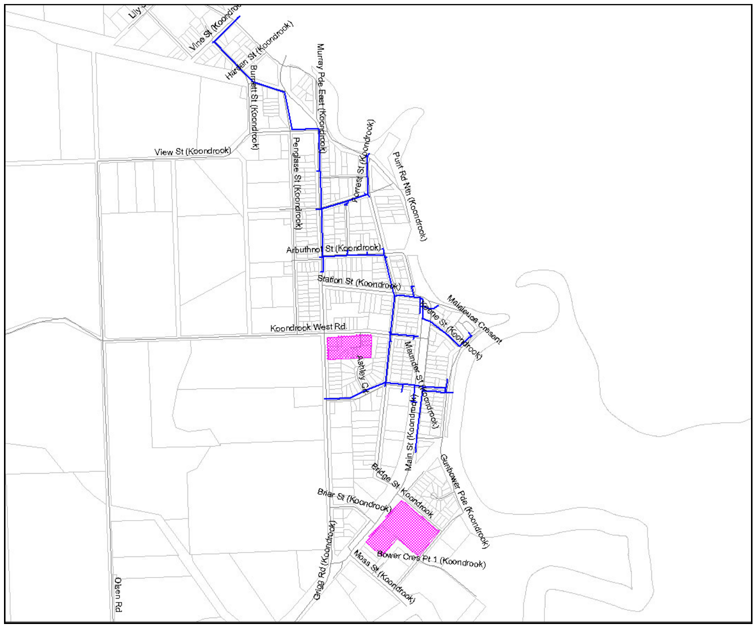


Figure 1-4 - Future development in Koondrook



1.4.3 *Drainage 'hot spots'*

Council has identified a number of locations where there are historical drainage problems, referred to here as 'hot spots'. The problems reported are localised flooding and pooling water from the drainage system. The specific cause(s) of the problems have not been identified but can be broadly categorised as an:

- operational issue (partial or full pipe blockage due to roots, sediment build up, debris, etc); and/or
- hydraulic issue (insufficient hydraulic capacity of pipes, high downstream surcharge levels or pit inlet capacity).

The known hot spots in Kerang and Koondrook identified by Council are shown in Figure 1-5 and Figure 1-6 respectively and are hatched red. The drainage system in Quambatook has also been identified by Council as a general hot spot. Further discussion about how the hot spot areas can be addressed is contained in Section 4.3.5.

Figure 1-5 - Kerang drainage 'hot spots'

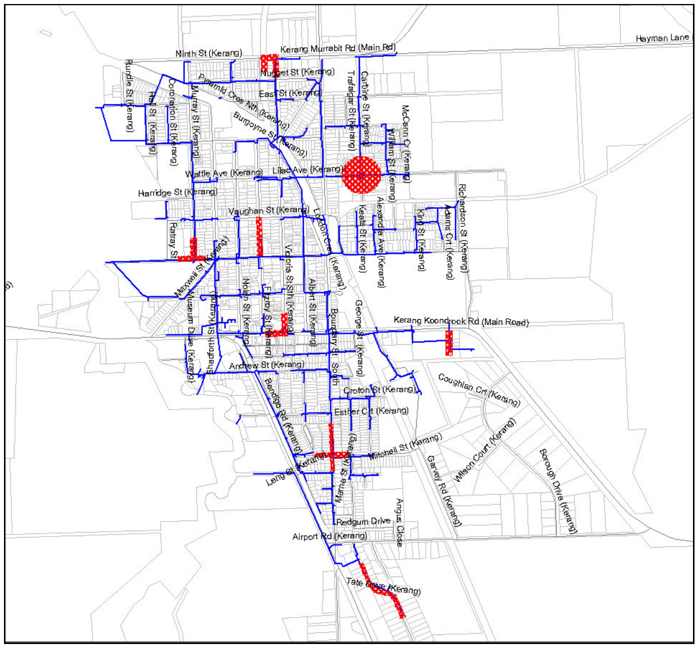
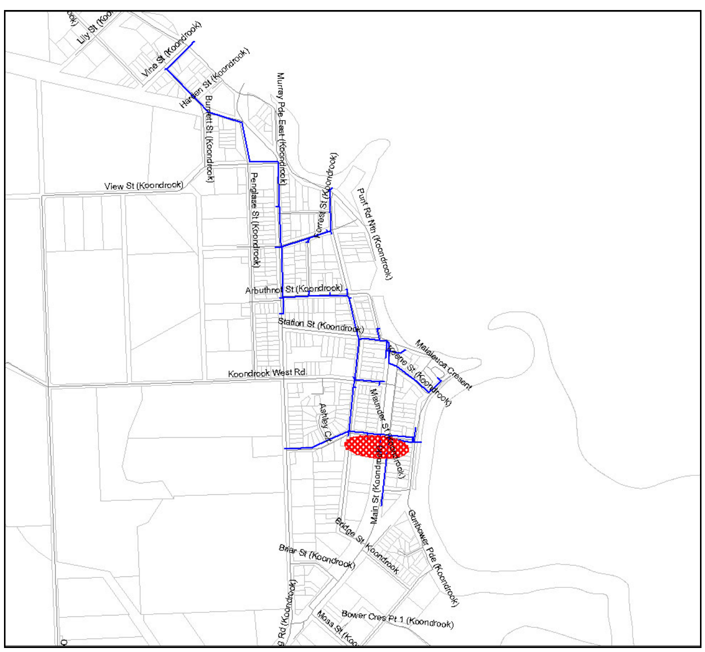


Figure 1-6 - Koondrook drainage 'hot spots'



1.5 Impacts of Climate Change

Projections of Victoria's future climate indicate an increase in temperature, decrease in total annual rainfall and an increase in potential evapotranspiration due to climate change[1]. The potential effects of climate change can directly and indirectly impact the performance and state of a drainage system in a number of different ways, namely:

- More extreme rainfall events and increased rainfall intensity leading to reduced serviceability of drains and increased risk of flooding.
- Increased soil movement contributing to increased pipe displacement and cracking, and ultimately shorter asset life.

It is important that Council plans responses to the potential impacts of climate change. Planning ahead can lead to cost-effective adaptation.

[1] See: www.climatechangeinaustralia.com.au

2 Asset Condition Assessment

2.1 *Methodology*

This section outlines the methodology used to complete the asset condition assessment, deterioration profile modelling and compilation of the DAMP. The methodology provided a sound basis for extrapolation of the condition data and the justification for selecting drain assets to be CCTV surveyed.

The work required to complete the asset condition assessment and deterioration profile was divided into five key tasks, as follows.

1. Review of available information
2. Selection of CCTV Surveys for Review
3. Review of CCTV survey
4. Strategy Development
5. Action Plan

2.1.1 *Review of Available Information*

All available information that may be relevant to the project was compiled and reviewed. Council's drainage asset database was reviewed and categorised to generate a preliminary list of drain type categories based on material, dimensions, joint types or other agreed relevant criteria. Next the locations of available existing CCTV survey was determined and the amount of CCTV survey available for each proposed category was established.

2.1.2 *Selection of CCTV Surveys for Review*

Identification of CCTV Surveys

The purpose of this task was to identify CCTV surveys that were representative of Council's drainage network and were suitable for detailed condition assessment. If the year of construction is not known with surety there can be no reliability in the resulting data for creating a deterioration profile.

Council's existing CCTV surveys were completed in a reactive response to particular drainage problems. As they were not representative of the general condition of the drainage network they were not used in the asset condition assessment and deterioration profile.

Based on Halcrow's previous experience in undertaking Drainage Condition Assessment projects and supporting reference material, a minimum quantity of 5% of survey data is desirable from which to extrapolate. A list of assets for CCTV survey was produced, based on location and deterioration factors to ensure a representative sample was used for each category. Additional CCTV surveys were required to provide an appropriate data set for condition rating of Council's drain assets. This list was passed onto the CCTV surveyor (Pipe Solutions) who was engaged to undertake the CCTV surveying.

CCTV Surveys

Halcrow's preferred sub consultant, Pipe Solutions, completed the CCTV survey. Where required, some drains were cleaned using high pressure water to clear the pipe of roots, sediment and debris. The CCTV survey output was on portable disc drive storage viewed through Wincan viewer and accompanied by a written and photographic report in PDF format.

2.1.3 *Review of CCTV survey*

Development of Rating Methodology

The structural condition of the drain assets can be estimated through use of condition ratings assigned by an engineer. Using the 0 to 10 conditions per

Table 2-1 below, a rating was assigned for each drain during viewing of the CCTV footage. The rating was assigned for the percentage of drain that it affected, as a single rating would not be a fair representation for the whole of the drain where multiple ratings were apparent.

Table 2-1 - Asset Condition Ratings and Descriptions for CCTV Footage

Condition Rating	Physical Description
0-2	No visible deterioration
3-4	Some superficial deterioration
5-6	Presence of consistent defects
7-8	Significant structural deterioration
9-10	Imminent structural failure

Review and Rating of CCTV

Halcrow reviewed the CCTV surveys to determine a structural condition rating for each segment of pipe. Within our analysis, it is important that the year in which the CCTV survey was undertaken is used together with the year of construction to calculate the age of the drain when its condition was assessed. In this case, all the CCTV was current and undertaken in 2010.

The rating derived will be grouped with age of drain asset and length of drain asset which are relevant parameters in creation of a deterioration profile.

2.1.4 *Phase 5 – Strategy Development*

Development of Deterioration Profile

There are several options available for the derivation of a deterioration profile. For this project, regression modelling was the favoured approach.

The regression deterioration profile is created by grouping condition rated pipes into age ranges which could be 5 or 10 years. The condition rating is linearly averaged using length to create a table of 'age range' and 'average condition rating'. The (Age, Condition Rating) pairs of data are then plotted and a regression analysis used to create a best fit profile. The regression equation can be used to estimate the remaining life for all of Council's pipe assets providing their age is known or can be estimated.

Using this approach a deterioration profile graph was produced based on rating the sample of drains that were surveyed by CCTV.

Determine Asset Lives

The deterioration profile developed in the previous task was extrapolated across Council's drainage database to determine an estimated asset life and structural condition for each asset, that has a construction date. It is acknowledged, that not all assets within Council's drainage database contain a known construction date.

2.1.5 *Implemenation Plan*

The purpose of this task is to document the project methodology, results and conclusions of the deterioration profiling of Gannawarra's drainage assets and prepare the Drainage Asset Management Plan (i.e. this report).

The report examines options for maintenance, renewal and operational expenditure based on the current network, future requirements and climate change scenarios. Within the Drainage Asset Management Plan, Halcrow will account for two critical challenges Council currently face, salinity and climate change and their impact on the drainage network.

The Drainage Asset Management Plan also includes methodology, discussion of assignment of remaining life versus condition, discussion of deterioration models, profile plots, qualifications where appropriate and recommendations for future management of the report.

2.2 Data Review

This section summarises the review of Gannawarra Shire Council's existing drainage database, which was contained within their GIS system. This information provided the basis for the drainage asset condition assessment. The drainage condition assessment relies on a number of parameters, including the identification number, length, location and construction date of each asset.

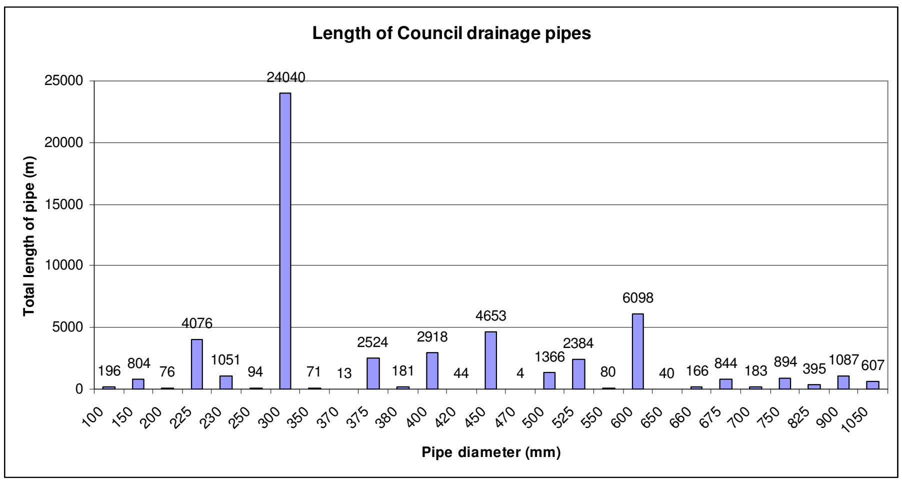
A summary of other background and supporting information is also provided in this section.

2.2.1 *Existing drainage system and database*

Gannawarra Shire Council is responsible for the management and maintenance of drains within the shire, with the exception of declared main roads, which are looked after by VicRoads. Council's drainage network consists of approximately 55km of underground drainage assets ranging between 100mm to 1050mm diameter. Council's GIS database contained information on each of these assets including the location, upstream and downstream pit numbers, the length of the asset and the pipe material. The majority of Council's drainage assets are concrete pipes, which in some places are up to 8m deep, to account for the predominantly flat topography of the region. In some areas of the Shire, salinity, high ground water table and reactive soil conditions create an aggressive environment for buried concrete pipes.

A breakdown of pipe size and total length for Councils stormwater pipe assets is provided in Figure 2-1 below.

Figure 2-1 - Breakdown of Council drainage assets by size and length



Note: data only shown for pipe assets ≥ 100mm diameter and culverts, and does not include channels. Assets with unknowm diameters and lengths are not included

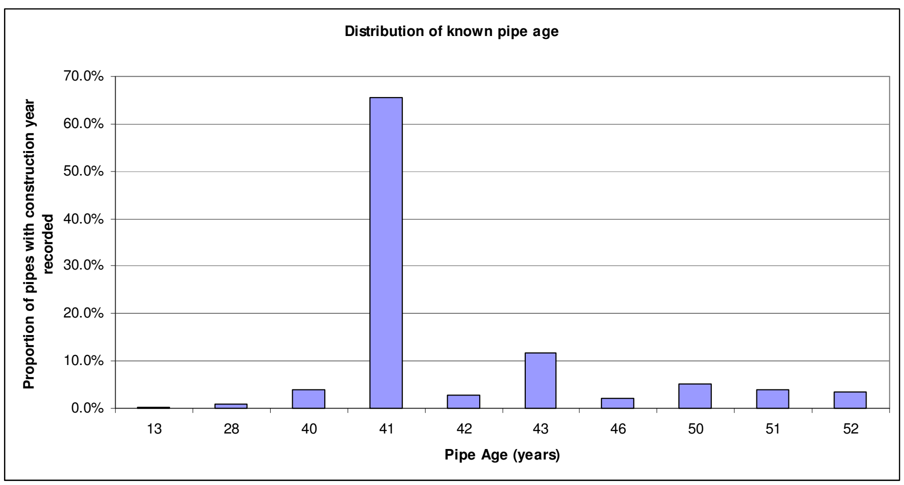
The drainage system in Kerang operates as a dry dam arrangement whereby all stormwater outfalls from the township must be pumped out due to levee banks that protect the town from flooding. Parts of the network contain deep drains also. The deep drains (and sewers) have a tendency to lower the groundwater table due to infiltration into the pipes.

Koondrook is somewhat similar to Kerang except that the stormwater outfalls are controlled by the level of the Murray River. The stormwater system is gravity-driven and can discharge to the river when the river water levels are sufficiently low. However, the stormwater must be pumped out when the river level is high.

To establish the representative set of data for Quickview and subsequent CCTV survey and analysis, this pipe size data was used. In addition, a sample of sizes was selected across the entire municipality.

The review of the drainage database revealed that the construction year was not recorded in the GIS for about 47% of the drains. Of the remaining 53% of drains with a recorded construction year, the variation in age was between 13 and 52 years. Figure 2-2 shows the frequency of age of each pipeline. It also indicates that the majority of pipes are within the 40 to 50 year age bracket, with a significant proportion (66%) that are 41 years old. The construction dates of each drain are critical as they are the only assets from which the required condition versus age profile of the Council's drains can be derived.

Figure 2-2 - Distribution of pipes by age where construction year is known



2.2.2 *A Representative Sample*

From the drains with construction dates, a representative sample was selected for survey. All of these drains were then cleaned and then CCTV surveyed for analysis. The drains selected for CCTV survey were according to size, location and age, to achieve a representative sample across all three categories. The total length of pipes selected for the sample was 3.29 kilometres.

Each drain in the representative sample was sent to Pipe Solutions for action who achieved a total of 2.64 kilometres of CCTV survey, including abandoned and repeat surveys. A small number of surveys were abandoned due to blockage or high water level. Some of the blocked pipes were able to be cleaned and the survey repeated. Not including the repeat surveys, a total of 2.49 kilometres of pipeline was reviewed for the asset condition rating, representing 4.4% of Council's drainage network. The drains which were CCTV surveyed are shown in Figure 2-3 to Figure 2-6 below and are highlighted in green.

Figure 2-3 - CCTV survey of stormwater assets in Kerang

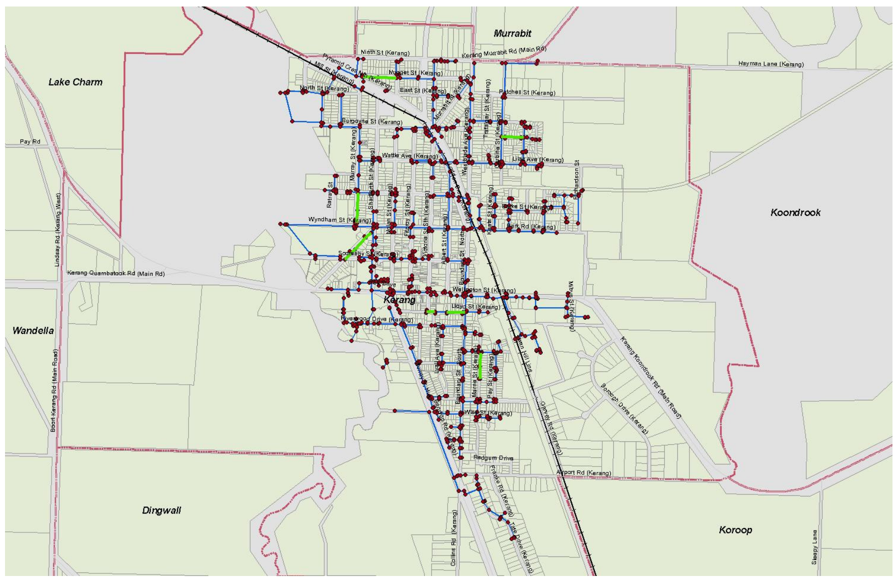


Figure 2-4 - CCTV survey of stormwater assets in Cohuna

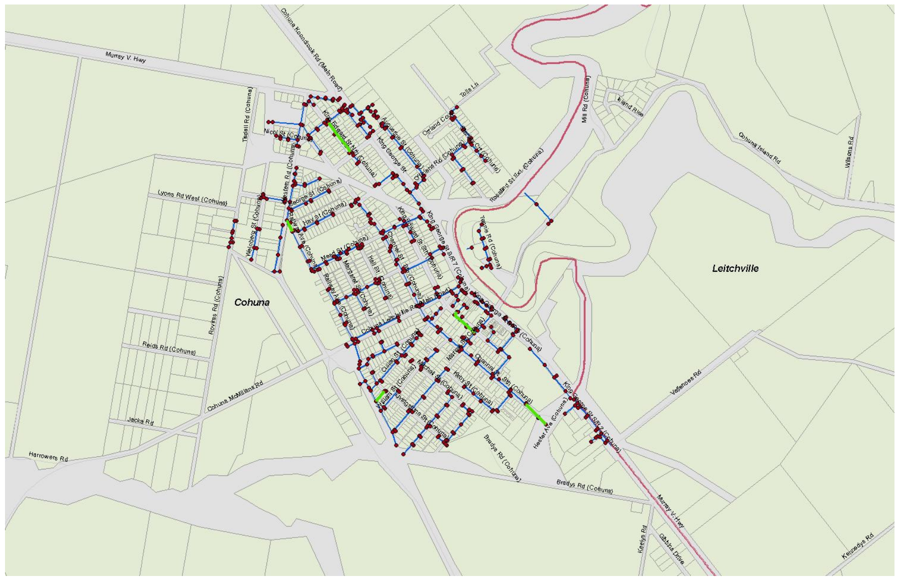


Figure 2-5 - CCTV survey of stormwater assets in Koondrook

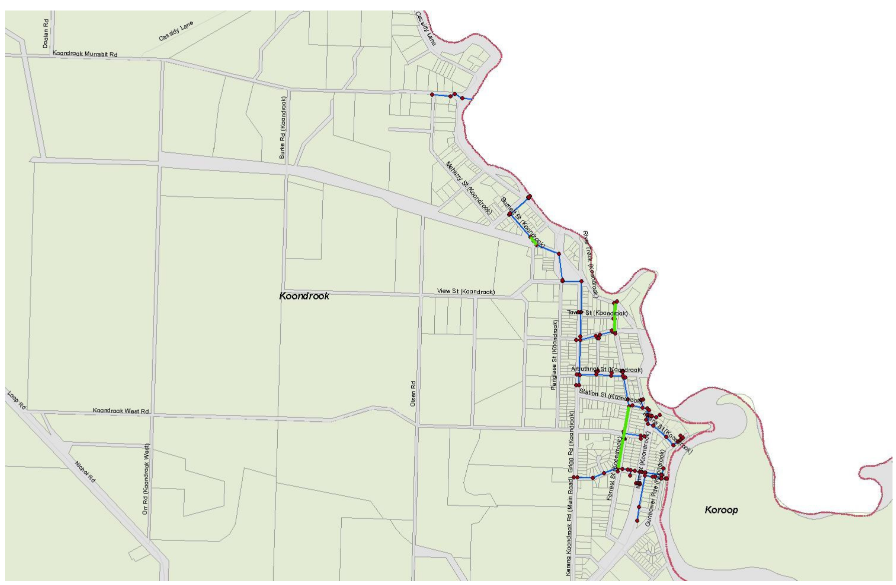
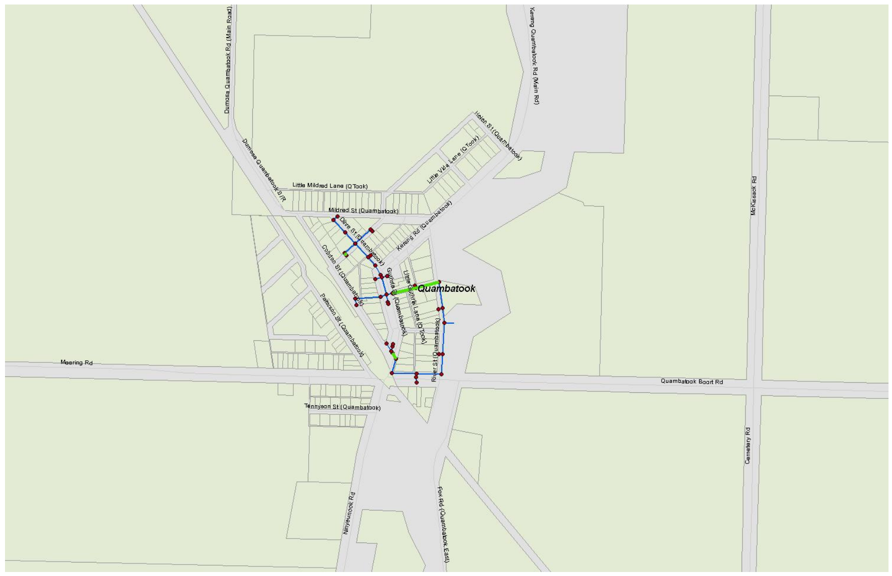


Figure 2-6 - CCTV survey of stormwater assets in Quambatook



2.3 *CCTV Review and Analysis*

This section outlines the process of the CCTV survey review and provides an assessment of the existing condition of Council's drainage assets. The condition assessment of Council's underground drainage assets utilised information from the Council's GIS system and the CCTV surveys to assign a condition rating, which was used to model and determine a deterioration profile for the asset group.

2.3.1 *Condition Evaluation Procedure*

A total of 41 drains (out of 1626 drains in Council's drainage database) were reviewed and assigned a condition rating. The total length of the drains reviewed was approximately 2.49 km, which represented approximately 4.4% of the entire Council network. All of the assessed pipes were made of concrete and ranged between 28 and 52 years old.

The structural condition of the drainage assets was estimated through the use of condition ratings. Using the 1 to 10 condition ratings, as per Table 2-2, a rating was assigned for each drainage asset listed in the representative sample from the review of the CCTV footage. The rating was assigned for the percentage of the drain that it affected, as a single rating would not be a fair representation for the whole of each asset.

The defects associated with the CCTV survey used the current industry standard Sewer Inspection Reporting Code (SIRC). Table 2-2 includes peak and mean structural rating values from the Australian Conduit Condition Evaluation Manual (ACCEM), these are consistent with the 0 to 10 ratings implemented in this project.

Table 2-2 - Ratings and Descriptions for CCTV footage

Condition Rating	Physical Description	Peak Structural Defect Rating	Mean Structural Defect Rating
0-2	No visible deterioration	<10	<0.3
3-4	Some superficial deterioration	10-39	0.3-1.5
5-6	Presence of consistent defects	39-79	1.5-3
7-8	Significant structural deterioration	79-164	3-5
9-10	Imminent structural failure	>164	>5

2.3.2 *Structural Condition Assessment*

The serviceability of a drainage asset is rated on obstructions and other defects that affect hydraulic performance, not structural performance of a pipe, irrespective of age. Blockages were not rated as they are serviceability defects. However the cause of the blockage was assessed and if found to be caused by a structural defect, the structural defect was included in the assessment. For example, tree roots generally enter the drains through joints or significant cracks, and create structural defects such as joint displacement or widening cracks, and therefore the structural condition assessment includes root intrusions to the extent they structurally affect the drain.

Notwithstanding the above, heavy root penetration and/or sedimentation was observed in a number of the drains reviewed to the extent that blockage and significant reduction in hydraulic capacity is likely.

Structural defects within the reviewed pipes were common, however the significance of these defects varied. The general nature of observed defects assets were noted as:

- cracking (small to large extent and width);

- spalling/broken concrete and holes in the pipe;
- joint displacement;
- heavy scouring;
- exposed reinforcement; and
- broken areas around poor connections.

A number of structural failures (rating 9 or 10) were found in some sections of drainage pipe due to major circumferential cracking or large, defective repairs. The circumferential cracking is likely caused by pipe movement due to movement of the soil or pipe bedding, or differential movement between the pipe and pit in close proximity to the pit. The need for large repairs on the drains is not known for certain, however damage during installation or subsequent excavation works could be the cause. Replacement of the damaged pipe segments would have been more appropriate given the size and nature of the repair. Table 2-3 below lists where the assessed structural failures were observed.

Table 2-3 - Observed structural failures in drains

Pipe ID	Diameter & approx length affected	Location	Description
0148-0177	300 mm dia. 2.5 m	71 Marne St, Kerang (residential area)	360 degree, wide, circumferential cracking
0404-0263	225 mm dia. 2.5 m	48 Carbine St, Kerang (residential area)	360 degree, wide, circumferential cracking
0696-0798	300 mm dia. 2.5 m	59A Maxwell St, Kerang (residential area and sports reserve)	360 degree, wide, circumferential cracking
1047-1046	300 mm dia. 5.0 m	5 Salisbury St, Quambatook (residential)	360 degree, wide, circumferential cracking
1206-1205	300 mm dia. 2.5 m	31 King Edward Street, South Cohuna (commercial/retail centre)	360 degree, wide, circumferential cracking
NL002	300 mm dia 7.0 m	27 King Edward Street, South Cohuna (commercial/retail centre)	Large, defective pipe repairs

Examples of typical structural defects with their assigned condition rating are presented in Figure 2-7 to Figure 2-17.

Figure 2-7 - Good pipe condition. Condition rating 1 to 2 (Pipe 0798-0800).

Figure 2-9 - Minor spalling concrete at joint. Condition rating 3 to 4 (Pipe 1478-1475).

Figure 2-8 - Minor joint displacement. Condition rating 3 to 4 (Pipe 0263-0407).

Figure 2-10 - Close view of spalling defect in Figure 2-9.

Figure 2-11 - Circumferential crack from 3 to 9 o'clock Condition rating 5-6 (Pipe 0800-0801).

Figure 2-12 - Greater joint displacement, spalling concrete and cracking. Condition rating 7-8 (Pipe 1183-1620).

Figure 2-13 - Exposed circumferential and longitudinal reinforcement. Alos note sediment build-up. Conditions rating 7 to 8 (Pipe 1456-1437).

Figure 2-14 - Large, defective structural repair. Condition rating 9-10 (Pipe NL002).

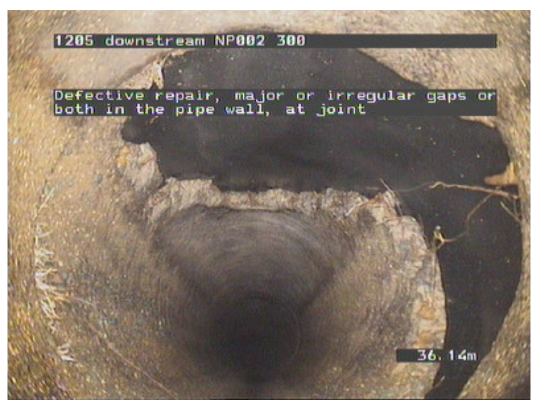


Figure 2-15 - Complete circumferential cracking. Condition rating 9-10 (Pipe 0148-0177).

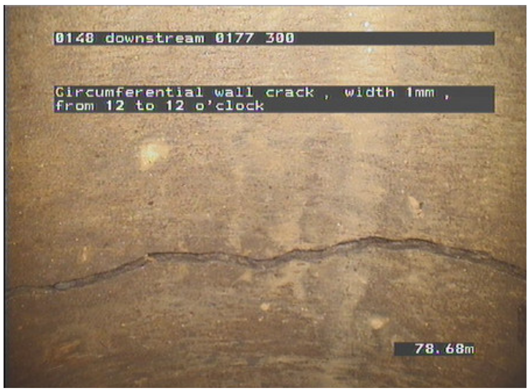


Figure 2-17 - Example of sedimentation and (in background root penetration).

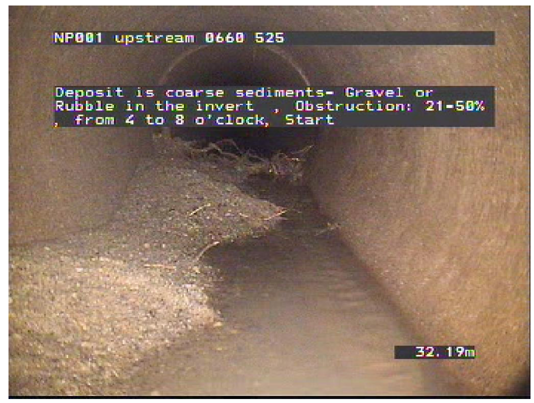
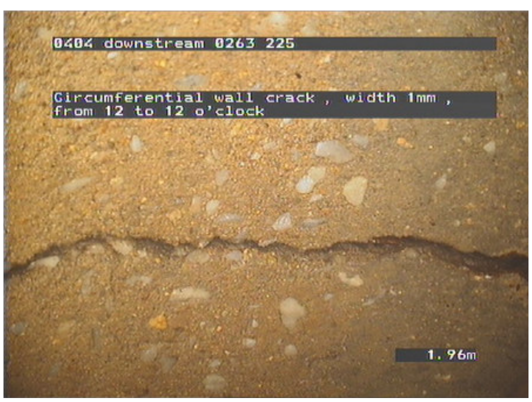


Figure 2-16 - Complete circumferential cracking. Condition rating 9-10 (Pipe 0404-0263)



A brief analysis of the relationship between condition rating of the data sample and the location of the pipe indicates that the vast majority (>90%) of pipes that were reviewed for each town were between condition rating 1 and 6. The remaining proportion of pipes were rated between 7 and 10. It is difficult to draw meaningful conclusions as the sample size across each town is relatively small, however in general, most pipes within each town are in good to reasonable condition and do not show significant and serious structural deterioration. Table 2-4 summarises this data more clearly.

Table 2-4 - Coarse breakdown of drain rating by town

Town	% of drain with rating 1-6	% of drain with rating 7-10	Total length of pipe assessed (m)
Cohuna	90.6	9.4	620.65
Kerang	93.6	6.4	1089.90
Koondrook	98.5	1.5	583.89
Quambatook	97.5	2.5	195.88
Total			**2490.29**

3 Generation and Review of Deterioration Profile

This section presents the deterioration profile for Council's underground drainage assets. The profile was developed based on the structural condition assessment from the CCTV surveys.

3.1 *Condition Rating versus Age*

To establish the expected life of Council's drain assets it was necessary to plot the average condition ratings against the age of the pipe, at the time of its CCTV survey. Assigning multiple condition ratings to each drain, meant these pipe ratings were treated as individual segments. The condition of each pipe was analysed according to age, and grouped in five year timeframes. A ten year time frame is another way of grouping the data however was not selected in this case due to the limited variation in pipe age (between 28 and 52 years old). Table 3-1 shows the collated data in terms of the length of pipes for each age and corresponding condition rating.

Table 3-1 - Condition vs Age of the Representative Sample

	Condition Rating					
Age	**1-2**	**3-4**	**5-6**	**7-8**	**9-10**	**5 year average**
5 to 25	No Data					
30	87.525	34.130	29.427	9.980	8.989	3.369
35						
40	69.658	116.116	5.246	0.000	4.860	2.991
45	851.355	629.291	290.828	91.029	10.148	3.128
50	13.904	8.690	6.952	5.214	0.000	3.700
55	69.419	83.128	43.710	20.694	0.000	3.645
60 to 80	No Data					

Note: No data available for blank cells.

The analysis shows that the majority of the Council's drains are in good condition regardless of age. However, there are sections in most drain ages that have some form of structural defect, which affects the overall condition rating of the drain.

To develop the deterioration profile, the average condition rating based on length versus age, was graphed. Each point was then analysed to determine it validity and impact on a trend line.

3.2 Deterioration Profile

3.2.1 *Creation of the deterioration profile*

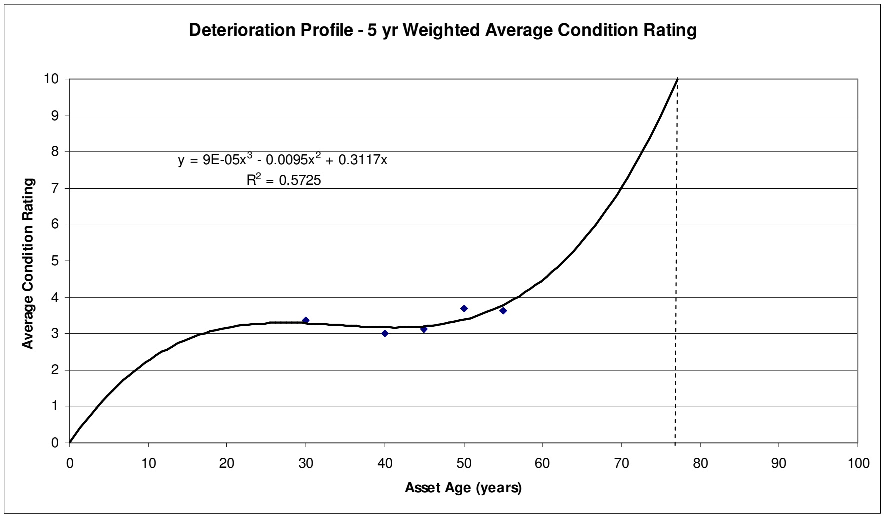
The deterioration profile shows the statistical performance trend of the stormwater drains. This can be used to estimate the predicted life and deterioration of a stormwater drainage asset. The profile can be in many different forms i.e. linear, exponential, polynomial or logarithmic. The AASB116 valuation standard uses a linear approach to determine the depreciated value and the expected life of a drainage asset.

The deterioration profile is based on Council's historical data. A deterministic model was used to develop the deterioration profile, providing the average pipe's structural condition rating over time. The deterministic modelling uses statistical regressions fitted to the reviewed data to predict the average pipe condition at a specific time and the drain's structural condition over time. In order to determine the best statistical regression for the data set, the linear, exponential and polynomial regressions were determined and then compared against the expected results and the R^2 values for each.[2]

A profile has been developed based on five year timeframe groupings. This profile shows a third order polynomial regression is the best fit. Refer to Figure 3-1.

[2] R^2: A statistical measure of the degree to which data points and the regressions are related. The nearer to 1.0 the R^2 is, the more closely the regression fits the data set. R^2 cannot exceed 1.0.

Figure 3-1 - Drainage Deterioration Profile for Gannawarra Shire Council (based on 5 year groupings)



The results show that a third order polynomial was the best fit to the data. This is due to the relatively small variation in pipe age and the comparatively high structural condition rating of the younger pipes. Some pipes in the 25 to 30 year showed significant structural deterioration.

These concrete pipes could in theory last for hundreds of years, however once structural defects, due to whatever reason, reach a moderate level they often experience accelerated failure and are no longer serviceable. For example, an average pipe will have an average condition rating of 6 after approximately 105 years, however will generally experience rapid deterioration after this time, to reach the end of its life at an average of 125 years.

3.2.2 *Modification to the deterioration profile*

The initial deterioration profile indicates that a drain will reach condition rating 10 and will be in need of replacement, after approximately 77 years on average. That is, the average asset life is 77 years. Of course, some pipes could fail sooner or later than that depending on a range of specific conditions (environment, installation, fabrication, loading, catchment, etc.).

Gannwarra Shire Council has a relatively small pipe drainage asset base (in comparison to the intensely developed, metropolitan Councils). The deterioration profile is based on review of a small sample of these drainage assets, and so in this case a small number of results that deviate from the expected norm, tend to have a big impact on the outcome. Upon review, the relatively poor asset condition for five drains from the sample set, aged only 28 years, were deemed to be "outlier" results that were disproportionately skewing the deterioration profile resulting in an shorter than expected average asset life. These results were not considered to be representative of Council's drainage assets.

Rather than remove these five selected drains from the review sample (and risk making the sample size smaller), the condition rating was modified (i.e. improved). This corrected the profile curve that raised the average asset life to approximately 94 years. Refer to Figure 3-2. This was approach was taken based on Halcrow's knowledge and experience of drainage condition assessment and drainage asset management. In other similar studies completed, the average service life of a pipe asset (across all sizes and material types) was found to range from about 125 to 180 years. Pipe manufacturers often claim a 100 design life for their products.

It should be noted that on average 50% of the assets will have failed prior to 94 years old.

Figure 3-2 - Revised Drainage Deterioration Profile for Gannawarra Shire Council (based on 5 year groupings)

The revised profile curve is more consistent with expectations and makes a balanced allowance for reduced asset life due to aggressive environmental conditions (i.e. salinity and high groundwater table, and expansive soils.).

3.2.3 *Effect of environment on pipe condition and deterioration profile*

The following comments are made to better understand the local conditions and environment in Gannwarra Shire and the potential effects this can have on the condition of concrete pipes, and consequently the derived deterioration profile

- Expansive soils, such as in Kerang tend to shrink and develop wide cracks as they dry out during the warmer, drier summer months. The soil will swell and return to normal as it wets up. This movement in the soil structure can induce loads on buried pipes, potentially leading to displaced joints and/or cracks in the pipe. The pipe is also more susceptible to root penetration and ingress of surrounding soil where open joints and cracks appear.
- Root penetration can cause significant blockage and impede flow due to the roots themselves and also the sediment and debris which they trap. Over time, roots may also widen cracks and joints as they grow.
- Pipes with exposed reinforcement are at risk of accelerated deterioration as corrosion of the reinforcement can lead to spalling of the surrounding concrete. They also have reduced structural integrity as the transfer of stresses to the steel likely to be insufficient or ineffective given that the reinforcement is corroded and therefore weakened and/or does not have sufficient cover.
- Pipes that are regularly exposed to saline groundwater and a high groundwater experience a more aggressive environment leading to accelerated deterioration of the concrete and reinforcement.
- Pipes with flat gradients are more prone to sedimentation and build up of debris which will reduce hydraulic capacity and increase the risk of flooding. Ponding water and infiltration of saline groundwater can also lead to accelerated deterioration of the pipe.

In light of the above, it is anticipated that the average asset life of a pipe in Gannawarra Shire is lower than average due to a range of environmental and installation conditions. Kerang, in particular would appear to have harsher conditions than elsewhere. This is significant as Kerang is the largest town in the Shire and has the most drains.

3.3 Climate Change

Climate change is expected to cause increased soil movement contributing to increased pipe displacement and cracking. The severity of displaced joints and cracked pipes may vary, though the frequency of their occurrence is likely to increase. The rate of deterioration is likely to increase, placing extra pressure on the structural condition of drainage assets, causing the assets to fail prior to the estimated end of life shown in the deterioration profile in Figure 3-2.

An increase in rainfall intensities could result in greater extent and risk of flooding to properties currently within or close to land subject to inundation from the stormwater system.

Planning ahead for the potential impacts of climate change on the drainage system includes gaining a better appreciation of the current condition of drainage pipes, the remaining life, and how that may change. This helps to make informed and cost-effective decisions related to drainage asset management.

3.4 Estimated End of Life

The deterioration profile based on the revised five year age grouping was used to estimate at what age, an average drain would reach a condition rating of 10, thereby providing the estimated life of a drain in Gannawarra Shire. However, it is noted, that the end useful life of the asset may occur earlier and intervention strategies should be occurring at condition rating 7 or earlier.

The estimated life was 94 years (

Table 3-2 or graphically in Figure 3-2) based on the equation of the deterioration profile curve:

$$y = 2.7X10^{-5}x^3 - 0.0031x^2 + 0.158x$$

Table 3-2 - Estimated Stage Life of the Council's drainage assets

Stage (Condition rating)	Average age of drain at given Stage
1	7
2	18
3	38
4	58
5	69
6	76
7	82
8	87
9	91
10	94

For each pipe with a construction date in the drainage pipe database, an estimated "end of life" can be calculated assuming replacement is required 94 years after it was constructed. To accurately further apply this across the rest of the drainage network, future work is required to either estimate the drainage dates for different locations, or gather date data from construction plans.

3.5 Qualifications on the Deterioration Profile

The deterioration profile produced for Council's underground drainage assets shows the structural condition of an average drain at any particular time, while the entire pipe inventory for the particular category will range from condition 1 to condition 10. For example, the drain profile at an age of 70 years, has an average structural condition of 5, however some sections of drain may still have a structural condition of 1, whilst others may have already failed.

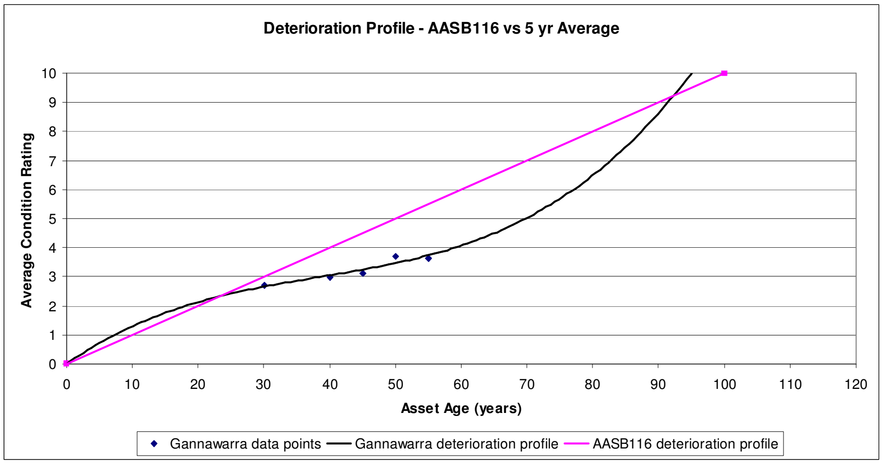
Deterministic modelling cannot predict when a specific pipe will be in a specific state at a specific time. Stochastic modelling, such as the Markov model is the preferred tool for prediction of future asset condition. The Markov model also removes the inherent problem of averaging the condition rating for a specific drain age, as it ensures that a drain can only be in one condition state at a time and not numerically midway through a condition rating.

Averaging the condition rating without the use of a weighting was employed in the generation of the profile in this project. Assigning mid range condition weightings (i.e. 1.5, 2.5, 3.5, etc) was considered too speculative as the appropriate weighting is itself a function of the drain's age. As a result there may be a degree of conservatism in the older age data points used in generating the deterioration profile.

It is probable that some of Council's drains have been replaced due to their poor structural condition in the past. These drains would form an important component of any asset database used for generating specific condition profiles. Incorporating records of drain replacement would improve the general dataset and help avoid under-representing the drains in condition rating 7 to 10. However, it should be noted that the small amount of CCTV data reviewed and the generally good condition of the drains does indicate that it is unlikely that this issue could be significantly affecting the deterioration profile generated.

It should also be noted that the structural condition of a stormwater drain does not necessarily deteriorate gradually. Gradual deterioration is more likely to occur in regards to serviceability of stormwater pipe, due to the progressive build up of debris, sediment and root intrusions. The structural condition is most likely to deteriorate through an event, such as a heavy vehicle load, earthquake or subsidence. As shown by Figure 3-3, the deterioration model derived to meet the AASB116 requirements is significantly different to the deterioration model estimated by the use of statistical regression. This highlights the need to derive infrastructure deterioration models from observed performance.

Figure 3-3 - Comparison between AASB116 deterioration and the Regression Curve



4 Implementation Plan

This section of the report provides discussion about actions, risks and expenditure in relation to Council's management of its drainage assets. The outcome is a proposed implementation plan that draws on learnings from the previous deterioration profile exercise and highlights the additional actions and indicative costs that will assist Council to plan and budget for future drainage maintenance activities for the next five years. All costs are expressed in nominal dollars (2010).

4.1 Existing Operating and Capital Expenditure

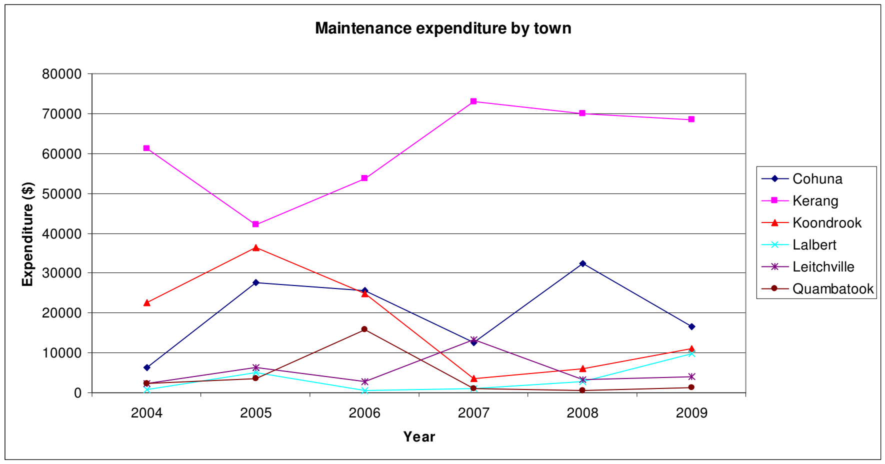
With limited resources and funding available, Council's drainage system priorities are typically focused on avoiding significant deterioration of service levels, responding to known problems and customer complaints, and addressing stormwater flooding.

4.1.1 Operating expenditure

Details of Council's drainage related operating and maintenance expenditure were provided to Halcrow. The data was analysed based on year, town and account. Refer to Figure 4-1 and Figure 4-2.

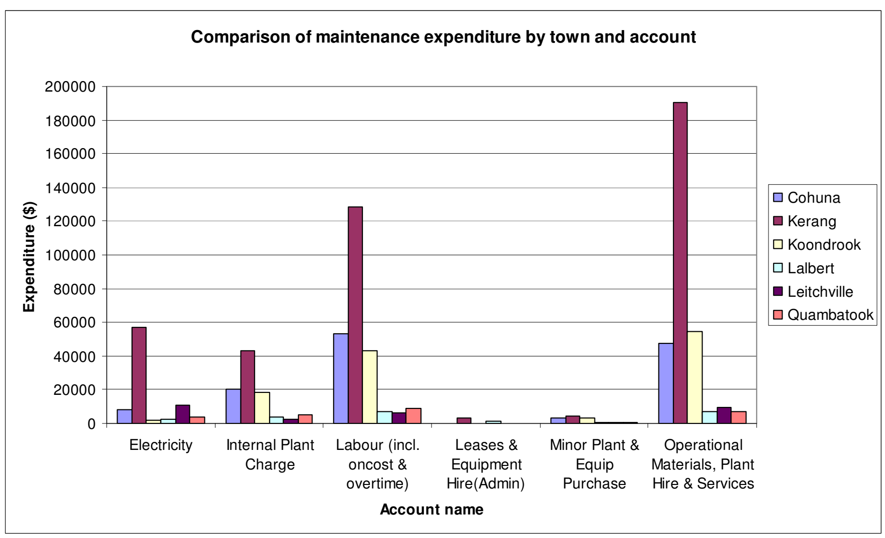
In summary, the figures show that operating and maintenance expenditure is highest in Kerang, followed by Cohuna, Koondrook, Leitchville, Quambatook and Lalbert. Accounts that were common to all or most of the townships were summed and assessed. The labour, labour oncost and labour overtime account were grouped together, and so were operational materials, operational plant hire and operational services. The analysis shows that operational, labour and internal plant charges were the three largest accounts, in decreasing order, and that Kerang, Cohuna and Koondrook were the towns with highest expenditure in these three accounts and in total.

Figure 4-1 - Council drainage operating and maintenance expenditure (2004-2009



Note: Graph above shown for full years of 2004 to 2009 only.

Figure 4-2 - Breakdown of operating and maintenance expenditure by town and account



Note: Graph above includes expenditure for 2010 and 2011.

4.1.2 *Capital expenditure*

Council's currently planned capital works are listed below. The key driver for these projects is to address flooding problems through pumping station upgrade works to increase capacity. The driver for Haymens Lane Pump Upgrade project is essentially renewal (new for old replacement), although Council is using this opportunity to increase the discharge capacity also.

- Carbine Street Pump & Pipe Upgrade (2010/11).
- Tate Drive pump duplication (2010/11).
- Koondrook Vine Street Second Pump Upgrade (2011/12).
- Tate Drive & Mitchell Street outfall (2012+).
- Haymens Lane Pump Upgrade (2012+).

It is expected that completion of these planned works will help reduce the frequency and severity of flooding, particularly nuisance flooding from minor storm events. Future capital works should be guided by findings from flooding/drainage studies that identify a need for augmentation of the system.

4.2 *Consideration of Asset Risks*

An asset risk management approach is based on assessing the likelihood and consequence of drainage assets failing. The aim of a risk assessment approach is to identify areas where the risk of failure is greatest. The developed deterioration profiles are used to determine asset risk, and allow a targeted approach to asset maintenance, renewals and rehabilitation. An example of a risk management matrix used in a risk assessment is shown in Figure 4-3.

Figure 4-3 - Risk matrix

		Consequence				
		1	2	3	4	5
Likelihood	5	Moderate	Moderate	High	Significant	Significant
	4	Low	Moderate	Moderate	High	Significant
	3	Low	Low	Moderate	Moderate	High
	2	Low	Low	Low	Moderate	Moderate
	1	Low	Low	Low	Low	Moderate

Application of a risk-based approach to Gannawarra Shire Council's drainage assets and the outcomes of the asset condition assessment and deterioration profile, highlights the following:

1. The review of CCTV survey and deterioration profile found drains of varying age and structural condition. Those pipes that are older or in very poor condition are generally more likely to fail and should be monitored more regularly, commensurate with their age and condition, and a decision made about when intervention or asset replacement is needed.
2. The review of CCTV survey found a number of failed pipe segments due to significant cracking (i.e. 360 degree circumferential cracking). There is serious risk of further separation of the pipe, major soil ingress, root penetration and blockage, and possibly catastrophic collapse. This has a high priority.
3. Drains that are subject to expansive soils, salinity or high groundwater table (or other forms of aggressive environment) which are consequently more prone to soil movement and accelerated deterioration should have a higher priority for CCTV monitoring than other drains.
4. Regular occurrence of sedimentation and root infiltration was observed in many drains in the CCTV survey sample. Flat pipe grades and displaced joints are contributing factors. Council will need to do more flushing and cleaning of drains in reactive and proactive maintenance. Initial priority should be guided by known trouble areas, surface indicators (e.g. vegetation above drain line) and manhole lift-and-look inspections.
5. The pumping stations in Kerang (in particular) and Koondrook are essential for managing stormwater outflows from the townships. The reliable and effective operation of these pumping stations is critical to preventing flooding and therefore maintaining the pumping stations holds a very high priority.
6. Focus investment on drainage hotspots to address flooding issues.
7. Drainage expenditure and investment should be focussed on (in order): Kerang, Cohuna and Koondrook. Historically, Council's operation and maintenance expenditure is the greatest in these towns which reflects that they have the largest drainage network and indicates that have required the most attention. Asset monitoring, maintenance and replacement should be prioritised based on risk, as discussed above.

Further discussion of these points and development of the implementation plan is provided in the following sections.

4.3 Components of the implementation plan

4.3.1 *Data gathering*

To improve understanding of the drainage network and estimated end of asset life, the drainage asset database needs to be updated with construction date information. Data gaps can be filled in by best estimation of construction date or derivation from construction plans or other data sources. Those drains which are likely to fail within the next 10 years based on age should be identified for regular monitoring through future CCTV survey.

Development of a hot spot register or database is also essential in improving understanding of the network and facilitating knowledge sharing. Further discussion about the hot spot register and drainage investigations is contained in Section 4.3.5.

An allowance of $10,000 has been made in the implementation plan for external resources to assist with undertaking and/or reviewing this task. It is acknowledged that Council may undertake this task completely with internal resources, in which case there would be no additional cost.

4.3.2 *Planning for Climate Change*

Future augmentation works on the drainage system such as replacement, upgrade or extension for future growth, should consider use of collared pipes and the effect of change in rainfall intensities due to climate change. The use of collared pipes, with a socket and spigot connection, will be more resistant to joint displacement due to soil movement. Changes to rainfall intensities will affect the calculated design flow and may change pipe sizing. This can be taken into account during planning and early design phase of projects.

4.3.3 *Replacement of drainage pipes*

The oldest recorded drain in the asset database was constructed in 1958, 52 years ago. Using an average asset life of 94 years (refer to Section 3.4), the forecast replacement of drains is not predicted to begin for another 40 years. Given this situation, a general program of pipe renewals is not proposed here. However, review of the CCTV survey sample identified a number of particular drains that had failed. Refer to Table 2-3 - Observed structural failures in drains, from earlier in this report. It is recommended that the failed sections of these drain be replaced.

In total, the replacement will involve 22 m of pipe, 19.5 m of which is 300 mm diameter pipe and 2.5 m of 225 mm diameter pipe. Higher priority should be given to the drains in King Edward Street, Cohuna (9.5 m of 300 mm pipe) which are located in the commercial/retails areas in the town centre. The drains in Kerang and then Quambatook, which are in residential areas, would take next priority.

The estimated pipe replacement cost is $445/m for drains 1-2 m deep in the roadway. Given the short lengths and different locations, site mobilisation costs would be additional to this rate and are assumed to be $5,000 per site. Total cost of pipe repair/replacement is estimated to be $25,000.

Should Council choose not to replace the pipes or postpone the works, then it is recommended that CCTV survey of the specific failed pipes be undertaken regularly (say every 2 years) to monitor their condition and check for changes.

4.3.4 *Changes to maintenance procedures*

Many of Council's drains suffer from sedimentation and root penetration. The flat gradients and soil conditions contribute to this problem. It is estimated that approximately 20% of drains in the CCTV survey review require cleaning due to sedimentation and root penetration. Taking this as a representative sample of the drainage network, then 20% of the total drainage network is also likely to need cleaning. It would be practical to complete the drain cleaning gradually over time rather than attempt to do it all at once. Any drain cleaning should be recorded and linked to the GIS database for future reference and to avoid unnecessary duplication of work.

It is proposed that at least 3% of the network, or about 1700 m of drain, is cleaned each year for the next 5 years. Cleaning these drainage assets maximises available hydraulic capacity within the drainage network, and will reduce the likelihood of flooding during small rain events. This should, therefore, also decrease the incidence of community complaints regarding localised flooding and blocked drains where there are operational issues. At an estimated rate of $6/m, this equates to around $10,000 per year for drain cleaning.

No specific changes or works are proposed for the stormwater pumping stations. It would appear that Council has an appreciation of the high priority to maintain/upgrade these assets given the proposed capital works projects. Future augmentation or maintenance of the stormwater pumping stations should have regard for any relevant drainage studies or hot spot investigations that may have been completed.

4.3.5 *Strategies for identified hot spots*

To resolve drainage trouble hot spots, essentially two key pieces of information must be known: (i) where they are, and (ii) what is causing the problem.

A drainage problem register is a valuable tool for tracking and reporting on hotspots and helps with problem investigation and resolution. It should (at least) include the following features:

- Record of location, date and time of reported drainage incident(s) and who reported it.
- Record of relevant circumstances known at the time, e.g. rainfall, construction work, photos, severity and duration of problem, etc.
- Register is linked to Council's GIS database. This improves data capture and knowledge sharing within Council, and also builds an understanding of the spatial relationships associated with the problems in the network.
- Register is linked to Council's maintenance systems so that a record of maintenance actions or repairs are noted for each hot spot.

With respect to identifying the cause of the problem and investigating solution options, a general approach would involve

- Undertake preliminary investigations such as: review of stormwater system design and function, review of hotspot register, CCTV survey, manhole lift and look inspection, topographic survey.
- Hydrological assessment/modelling of catchment to predict volume of runoff generated and peak flows for existing and future development scenarios.
- Hydraulic assessment/modelling of drainage network to analyse capacity and performance of the drainage network under existing and future development scenarios, followed by assessment of augmentation options to resolve the problems. This assessment could be extended to incorporate flood mapping.
- Preparation of conceptual, preliminary and/or detailed design documentation as required where hydraulic issues are present and warrant augmentation works.
- This may lead to potential solution options such as: pipe cleaning (one-off or regularly as preventative maintenance), upgrade pipe capacity, pipe replacement (if failed structurally), pipe rehabilitation (i.e. lining), pump station capacity upgrade/rehabilitation, provision of storage facilities

(detention basin), diversion of network, or stormwater harvesting and re-use.

- Economic analysis of options (e.g. via cost-benefit analysis, whole-of-life cost, net present value) can also be included, particularly for major or strategic projects. This adds value to the engineering analysis and business case to help Council make a more informed decision.

Kerang is a high priority area. It is noted that hydraulic modelling, analysis, identification of system deficiencies and proposal of drainage system improvement works have been completed for Kerang. Refer to Kerang Township Drainage Study – Final Report (Montgomery Watson, November 2000). Whilst Halcrow has not undertaken a detailed, independent review of this Drainage Study, it is reasonable to assume that implementation of the proposed actions would alleviate some areas of flooding due to hydraulic issues. The planned capital works involving pump station upgrades (see Section 4.1.2 of this report) appears to have similarities with the improvement works proposed in the Kerang Drainage Study.

A review and update of the Kerang Drainage Study and hydraulic model would help identify the likely cause of flooding problems in the hot spot locations. Where flooding is due to operational issues (rather than hydraulic), the problem can be addressed through targeted drain cleaning and/or CCTV survey.

The estimated cost to review the Kerang Drainage Study, or to conduct a hot spot investigation is $50,000, subject to confirmation of scope of work.

4.3.6 *Future review and update of DAMP*

At the end of this five year program, Council should seek to update the Drainage Asset Management Plan at the end of this five year program early in 2016. This would involve undertaking CCTV survey of a further 5% of the network with condition assessment, followed by an update of the deterioration profile, actions and priorities and a forecast of levels of additional expenditure expected within the following period. The estimated cost for this is $60,000, subject to confirmation of scope of works.

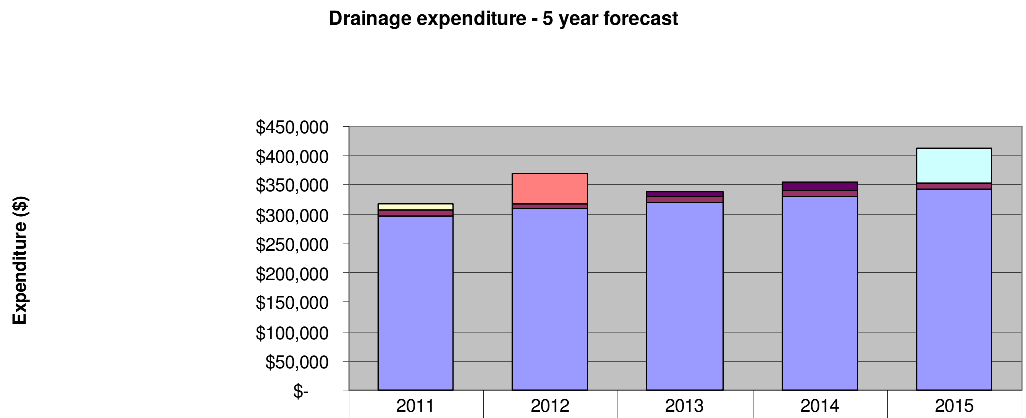
Council may choose to review and update the DAMP earlier if a significant event or change in circumstances warrants doing this.

4.4 Implementation Plan and forecast expenditure

A proposed implementation plan has been developed based on learnings from the previous deterioration profile exercise and which highlights the additional actions and indicative costs that will assist Council to plan and budget for future drainage maintenance activities for the next five years. An estimate has been made for Council's ongoing general operation and maintenance annual expenditure for drainage based on the 2009 expenditure of $278,381 plus an increase of 3.5% per year. (The average annual increase in expenditure from 2006 to 2009 is 3.5%). The additional actions and costs as described above have been added to this annual expenditure to produce the total estimated annual operating expenditure for drainage. Please note that all costs are expressed in nominal dollars. Estimated costs over the total five year program are shown in Figure 4-4 and

Table 4-1 below.

Figure 4-4 - Graph of five year drainage expenditure forecast



	2011	2012	2013	2014	2015
Kerang hot spot study (OPTIONAL)		$50,000			
Pipe repair/replacement			$10,000	$15,000	
Update of DAMP (OPTIONAL)					$60,000
Construction date update & hot spot register (OPTIONAL)	$10,000				
Drain cleaning	$10,000	$10,000	$10,000	$10,000	$10,000
General Opex	$298,209	$308,646	$319,449	$330,630	$342,202

Table 4-1 - Five Year Implementation Program

Year	Action	Costs	Optional Costs
2011/12	Drain cleaning and maintenance	$10,000	
	Construction dates update & develop hot spot register. (Optional)		$10,000
	General annual expenditure	$298,200	
	Total	**$308,200**	**$10,000**
2012/13	Drain cleaning and maintenance	$10,000	
	Hot spot investigation in Kerang (review and update Drainage Study) (Optional)		$50,000
	General annual expenditure	$308,600	
	Total	**$318,600**	**$50,000**
2013/14	Drain cleaning and maintenance	$10,000	
	Pipe replacement in Cohuna	$10,000	
	General annual expenditure	$319,500	
	Total	**$339,500**	**$-**
2014/15	Drain cleaning and maintenance	$10,000	
	Pipe replacement in Kerang and Quambatook	$15,000	
	General annual expenditure	$330,600	
	Total	**$355,600**	**$-**
2015/16	Drain cleaning and maintenance	$10,000	
	Update of DAMP: including CCTV survey, deterioration profile and review of actions/priorities. (Optional).		$60,000
	General annual expenditure	$342,200	
	Total	**$352,200**	**$60,000**

Note: These costs are estimates only. General annual expenditure extrapolated from 2009 figure.

5 Conclusions and Recommendations

5.1 *Conclusions*

5.1.1 *Condition assessment and deterioration profile*

A representative sample of Councils drains were selected for CCTV survey for the purposes of asset condition assessment. A total of 2.49 kilometres of pipeline was reviewed, representing 4.4% of Council's drainage network. All of the assessed pipes were made of concrete and ranged between 28 and 52 years old. The structural condition of the drain assets reviewed was estimated through the use of condition ratings. The observed structural defects in the drains varied in nature and significance.

The condition rating of a drain can change along its length. So whilst the vast majority of the length of drains reviewed showed good structural condition, defects typically affected some sections of the drain. A number of structural failures were found in some sections of drainage pipe due to major circumferential cracking or large, defective repairs. The circumferential cracking is likely caused by pipe movement due to movement of the soil or pipe bedding, or differential movement between the pipe and pit in close proximity to the pit. These pipes should be replaced in the near future.

A deterioration profile was created by plotting average condition ratings against the age of pipe using results from the condition assessment of the representative sample. The condition of each pipe was analysed according to age, and grouped in five year timeframes. The initial deterioration profile indicated that a drain will reach condition rating 10 and will be in need of replacement, after approximately 77 years on average. The results appeared to be disproportionally skewed and so modifications were made to the profile curve resulting in an average asset life of 94 years. It is noted that on average 50% of assets will fail prior to 94 years old.

The average asset life of a pipe in Gannawarra Shire is lower than the typical average due to a range of environmental and installation conditions, including high groundwater table, salinity, expansive soils, flat pipe gradients. Kerang, in particular would appear to have harsher conditions than elsewhere in the Shire.

Climate change is expected to cause increased soil movement contributing to increased pipe displacement and cracking. The severity of displaced joints and cracked pipes may vary, though the frequency of their occurrence is likely to increase. The rate of deterioration is likely to increase, placing extra pressure on the structural condition of drainage assets, causing the assets to fail prior to the estimated end of life shown in the deterioration profile.

Planning ahead for the potential impacts of climate change on the drainage system includes gaining a better appreciation of the current condition of drainage pipes, the remaining life, and how that may change. This helps to make informed and cost-effective decisions related to drainage asset management. Future drainage works and upgrade should consider the use of collared pipes and the effect of change in rainfall intensities due to climate change.

5.1.2 Implementation plan

This Drainage Asset Management Plan is intended to provide Gannawarra Shire Council with a better appreciation of the current condition of its drainage pipes, and how that may change in the future.

The five year implementation plan identifies priority actions and high level, indicative cost estimates that will guide Council in management of problems with the drainage network and in a way that is compatible with Council's resources and funding.

Application of a risk-based approach to Gannawarra Shire Council's drainage assets and the outcomes of the asset condition assessment and deterioration profile, highlights the following:

1. Those pipes that are older or in very poor condition are generally more likely to fail and should be monitored more regularly, commensurate with their age and condition, and a decision made about when intervention or asset replacement is needed.
2. High priority should be given to those drains found to have failed pipe segments due to significant cracking
3. Drains that are subject to an aggressive environment are more prone to soil movement and accelerated deterioration, and consequently have a higher priority for CCTV monitoring than other drains.
4. Council will need to do more flushing and cleaning of drains in reactive and proactive maintenance. Initial priority should be guided by known trouble areas, surface indicators (e.g. vegetation above drain line) and manhole lift-and-look inspections.

5. The pumping stations in Kerang (in particular) and Koondrook are essential for managing stormwater outflows from the townships. The reliable and effective operation of these pumping stations is critical to preventing flooding and therefore maintaining the pumping stations holds a very high priority.
6. Focus investment on drainage hotspots to address flooding issues.
7. Drainage expenditure and investment should be focussed on (in order): Kerang, Cohuna and Koondrook. Historically, Council's operation and maintenance expenditure is the greatest in these towns. Asset monitoring, maintenance and replacement should be prioritised based on risk.

5.2 Recommendations

In addition to Gannawarra Shire Council's routine annual operating and maintenance activities, it is recommended that additional actions are implemented over the next five years from 2011/12 to 2015/16 as shown in the following table.

Year	Action	Costs	Optional Costs
2011/12	Drain cleaning and maintenance	$10,000	
	Construction dates update & develop hot spot register. (Optional)		$10,000
	General annual expenditure	$298,200	
	Total	**$308,200**	**$10,000**
2012/13	Drain cleaning and maintenance	$10,000	
	Hot spot investigation in Kerang (review and update Drainage Study) (Optional)		$50,000
	General annual expenditure	$308,600	
	Total	**$318,600**	**$50,000**
2013/14	Drain cleaning and maintenance	$10,000	
	Pipe replacement in Cohuna	$10,000	
	General annual expenditure	$319,500	
	Total	**$339,500**	**$-**
2014/15	Drain cleaning and maintenance	$10,000	
	Pipe replacement in Kerang and Quambatook	$15,000	
	General annual expenditure	$330,600	
	Total	**$355,600**	**$-**
2015/16	Drain cleaning and maintenance	$10,000	
	Update of DAMP: including CCTV survey, deterioration profile and review of actions/priorities. (Optional).		$60,000
	General annual expenditure	$342,200	
	Total	**$352,200**	**$60,000**

Note: *These costs are estimates only. General annual expenditure extrapolated from 2009 figure.*

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