Design of Stormwater Treatment and Retention Systems in the Little Stringybark Creek Catchment

CIV4210 - Final Report

Prepared by Rhys Eddy

Project supervisor Dr Tim Fletcher

i. Executive Summary

It is well known that the urbanisation of catchments has a negative impact on the physical, chemical and biological processes that exist in natural streams. These effects have been labelled the urban stream syndrome and can be observed in urban streams around the world.

Catchment management authorities have acknowledged the issue of urban stream degradation and are working to mitigate further damage and restore streams back to a more natural condition. However, most of the existing restoration methods only focus on the riparian zone with works usually including revegetation and replacement of natural obstructions. The value of these methods to the long term health of urban streams is disputed, leaving the catchment authorities with few options.

Research into the fundamental degrading processes has highlighted the relationship between stream condition and the proportion of effective impervious area in a catchment. It is proposed that reducing the effective area of imperviousness in a catchment will result in an improvement in stream health over time, by returning to a more natural hydrological regime. It is hoped that this can be achieved by breaking the direct connection through the use of water sensitive urban design (WSUD) structures such as infiltration systems. The Little Stringybark Creek Project is a pilot project testing this hypothesis on the semi-degraded Little Stringybark Creek in Mount Evelyn.

This project aimed to design stormwater infiltration systems to be retrofitted into the existing streetscape to reduce the frequency of runoff from the roads to just 15 days per year, the approximate frequency in a natural catchment. A standard design was produced, from which four individual systems, located on Newton Ave and Heath Ave, have been detailed.

Using a new infiltration model by Walsh et al. the performance of each of the systems has been modelled to assess the potential reductions in runoff frequency. This model uses a continuous rainfall simulation run at an hourly time step and showed that the two key factors in determining performance were storage size and vegetation.

When selecting the final dimensions of each system, listed in the table below, particular attention was paid to the reduction in runoff frequency but also to the potential cost of construction. Three of the systems designed met and exceeded the target frequency, while a significant reduction was made by system 3. The extra frequency reductions achieved will offset runoff from other sub-catchments which may be difficult to disconnect.

System	Catchment m^2	Length m	Width m	Depth m	Pond Length m	Runoff Freq days
1	178	9.0	1.0	1.2	9.0	6
2	178	11.5	1.2	1.0	8.0	1
3	347	9.8	1.0	1.4	9.8	25
4	162	7.0	1.4	1.0	7.0	3

This project has successfully produced designs for four infiltration systems that meet the required targets for runoff reduction. It has also highlighted the difficulties experienced when retrofitting WSUD into existing urban areas, the major hurdle being the difficulty in finding space free from surface obstructions and underground services. The design process also identified limitations in the infiltration model used in the industry standard MUSIC software package.

ii. Table of Contents

1 Introduction 1

1.1 Urban Streams 1

1.2 Catchment Hydrology 1

1.3 Improving Stream Health 2

1.4 The Little Stringybark Creek Project 3

1.5 Project Objectives 4

2 Infiltration System Design 5

2.1 Design Objectives 5

2.2 Site Details 5

2.3 Infiltration Systems 6

2.3.1 Location 6

2.3.2 Structure and Layout 7

2.3.3 Hydraulic Conductivity 8

2.3.4 Storage Size 8

2.3.5 Filtration and Storage Media 8

2.3.6 Planting 9

3 Infiltration Modelling 10

3.1 Model Types 10

3.2 Computer Models 11

3.3 Model Inputs 12

4 Proposed Designs 13

4.1 Standard Design 13

4.1.1 Inlet and Extended Storage 13

4.1.2 Storage 13

4.1.3 Vegetation 14

4.2 Infiltration System 1 14

4.2.1 Location 14

4.2.2 Model Results 14

4.2.3 Design Dimensions 14

4.3 Infiltration System 2 14

4.3.1 Location 14

4.3.2 Model Results 15
4.3.3 Design Dimensions 15
4.4 Infiltration System 3 15
4.4.1 Location 15
4.4.2 Model Results 15
4.4.3 Design Dimensions 16
4.5 Catchment 4 16
4.5.1 Location 16
4.5.2 Model Results 16
4.5.3 Design Dimensions 16
4.6 Design Summary 17
5 Contribution 18
6 Acknowledgments 18
7 References 19
8 Appendices 21
Appendix 1: Model Results
Appendix 2: Design Drawings
Appendix 3: Service Location Plans

1 Introduction

1.1 Urban Streams

Creeks, streams and rivers are all examples of the natural drainage network. These waterways are the receiving waters (collection point) for water that falls in their catchment areas as rain, hail or snow. They convey water from the catchment to the ocean via a series of connections with other waterways, often travelling long distances.

The characteristics of these waterways are determined by the way land is used in the catchments that feed them. Changes in the catchment may affect the physical, chemical and biological processes (Booth & Jackson, 1997, Konrad, Booth, & Burges, 2005, McBride & Booth, 2005) that occur in waterways. While there are many different types of waterways, streams are often most affected because they have small catchments, and changes in catchment land use often alter a large proportion of this catchment (Walsh, Leonard, Ladson, & Fletcher, 2004).

The urbanisation of catchments, driven by the growth of urban centres and the need for productive land, is one of the largest changes that can occur. Urban catchments are characterised by a large proportion of impervious area, efficient drainage networks and reduced vegetation. These characteristics degrade the health of the stream and, as time passes, it becomes increasingly difficult to restore the natural condition of the stream.

This project focuses on the effects of urbanisation on small urban streams and new methods being developed to restore degraded streams back to a natural condition.

1.2 Catchment Hydrology

To appreciate the need for stream restoration it is important to understand the hydrological changes that occur when catchments are urbanised. Most of these changes disturb the natural methods of water delivery to the stream by altering the proportions of overland, subsurface and groundwater flows.

In a natural catchment precipitation either permeates into the soil or evaporates into the atmosphere. The water in the soil may be taken up and used by the vegetation, before being released through transpiration. The combination of these two processes is known as evapotranspiration and much of the precipitation is removed in this way. The remaining water in the soil percolates down to the stream as subsurface flow, or enters the deeper groundwater. The seepage of this water into the stream provides a base flow that keeps the stream flowing during dry weather. In a natural catchment the only time overland flow is generated is when the soil becomes saturated during a large rainfall event, or after several consecutive events.

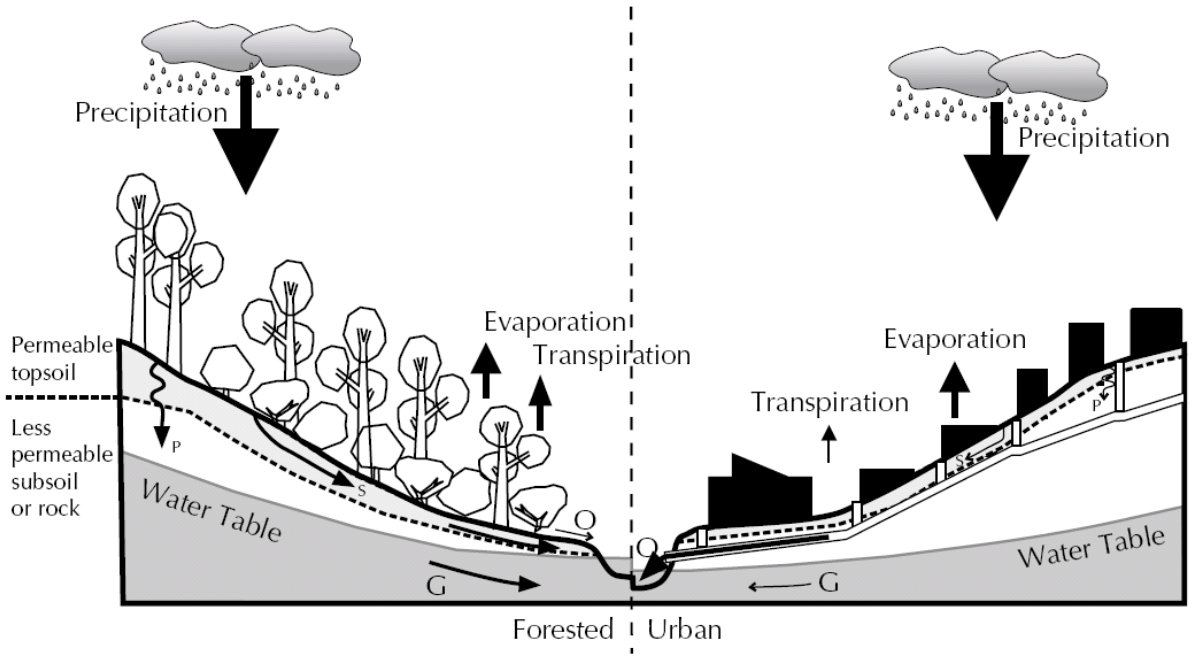


Figure 1 – Water pathways from precipitation to the stream. The relative size of the arrows represents the magnitude of the flow (Walsh, Leonard, Ladson, & Fletcher, 2004).

In an urbanised catchment much of the water is transported to the receiving waters as overland flow due to increased impervious area, which prevents rainfall infiltrating into the soil and groundwater. Instead this water is directed into drainage pipes and is quickly transported to the stream. Base flows are reduced and the stream may stop flowing in dry weather. Losses from transpiration are also reduced due to the reduction in vegetation cover (Walsh, Leonard, Ladson, & Fletcher, 2004).

The high hydraulic efficiency of an urban drainage network means that peak flows entering the receiving waters during and after a storm are much higher, but last a shorter period of time than in a natural catchment. These flash flows scour the banks of the stream, reduces biotic diversity and increases water temperature (Walsh et al., 2005). Water draining from urban catchments also picks up increased levels of pollutants, including litter, nitrogen, phosphorus and heavy metals which damage the stream and downstream waterways (for example, Port Phillip Bay).

1.3 Improving Stream Health

Current methods for urban stream improvement focus only on the stream and its immediate surrounds. Common methods include replacing natural obstructions, replanting native vegetation, and constructing wetlands to improve water quality (Ladson, Walsh, & Fletcher, 2006, p. 24). The effectiveness of these approaches has been brought in to question (Larson, Booth, & Morley, 2001) and has left management authorities searching for new solutions.

Hobbs & Norton (1996) suggested that a key step in the development of ecological restoration solutions is to identify the processes that cause degradation. Studies into the causes of urban stream degradation (Beach, 2002) had linked high total imperviousness (TI) to poor stream condition, suggesting that the

high levels of TI is the cause of the increased flows that degrade urban streams. Yet, statistics showed that at lower levels of TI there was an amount of variation in stream condition, where for similar levels of TI the stream conditions at different sites varied from good to poor (Ladson, Walsh, & Fletcher, 2006).

It was suggested by Walsh et al. (2005) that the quality of the connection between the impervious area and the stream could explain this variation. They found that catchments that have a higher proportion of impervious areas that are directly connected to the stream by a drainage system showed increased levels of stream degradation. Conversely, catchments that had poorly connected areas of imperviousness had a lower level of stream degradation.

Walsh et al. hypothesized that stream health could be improved by reducing the proportion of effective impervious (EI) area in the catchment. They also proposed that the reduction in EI could be achieved whilst maintaining a similar proportion of TI (to avoid major changes in the catchment) by providing points of disconnection between the impervious areas and the stream. The disconnection of impervious areas reduces the hydraulic efficiency of the drainage networks, and attenuates the flow of stormwater into the stream.

The suggested target is the reduction of runoff frequency from the catchment to a level comparable with that of the natural, pre-developed catchment level. The proposed approach for achieving this disconnection is to install a number of WSUD elements into the drainage network, be it existing or new, that redirect the frequent small rainfall events away from the stream and into buffer areas. For the larger rainfall events, the system would allow runoff to be drained conventionally using the existing drainage network.

1.4 The Little Stringybark Creek Project

The Little Stringybark Creek project is a world first large-scale trial and demonstration being undertaken by The University of Melbourne and Monash University with the cooperation of Melbourne Water, Yarra Valley Water and the Yarra Ranges Shire Council. The small, urban catchment of Little Stringybark Creek has been selected to be retrofitted with water sensitive systems in order to assess the ability of the stream to be restored by reducing the effective impervious area of the catchment. This creek was selected due to its semi-degraded condition (meaning that it is still in a condition where restoration is possible, rather than degraded to the point where any interventions are unlikely to produce a result), which is typical of many peri-urban streams, and small catchment size (making it feasible to retrofit nearly the entire catchment, in order to elicit a response).

The project is broken into two areas; works at the allotment level to be constructed by the property owners, and streetscape works to be constructed by the council.

At the allotment level, retention and diversion systems such as rainwater tanks, rain gardens and first flush devices will be installed to reduce the frequency of rainfall runoff entering the drainage network. These works are being funded by an innovative auction process that provides money for systems that will have the largest environmental benefit to the stream.

The streetscape works are to be designed by private consultants on behalf of the council. These systems will divert and retain flows from public land such as roads, parks and other reserves. It is the design of four of these systems that this report details.

1.5 Project Objectives

This primary objective of this project is the design of stormwater treatment and retention systems for the streetscape in the Little Stringybark Creek catchment, as part of the catchment-trial. These systems should be able to infiltrate runoff from the roads into the soil such that the total number of days of runoff is reduced to the target level.

The project will also explore the ability of existing urban catchments to be retrofitted with infiltration systems in the streetscape. Detailing the size, materials and geometry of an infiltration system that will meet the required targets can be done with current knowledge and tools, the challenge lies in designing system that fit into the existing streetscape.

It is also an opportunity to be part of a greater project that is at the forefront of the water industry in developing new ways of environmental management and restoration. The theories that underpin the practices being used in the project are untested in the real world and the outcomes may determine future stream and catchment management policy.

2 Infiltration System Design

2.1 Design Objectives

The objective of the designs is to infiltrate stormwater to reduce the total number of days of runoff from street catchments to the natural, pre-developed number of around 15 days per year. This figure represents the number of days that the rainfall exceeds 15mm in an average year, a rainfall depth that would typically (depending on antecedent conditions) have caused runoff to occur in the natural catchment.

The designed systems must also fit into the existing streetscape environment, and systems that are excessively large, expensive, impracticable to construct or maintain will be deemed unsuitable. In these instances it will be favourable to make a concession on the number of days of runoff and redesign the system.

2.2 Site Details

The site is located at Mount Evelyn, approximately 37 km east of Melbourne. The area has a population of 9100 people and is typical of outer suburban residential areas in Melbourne. The population density in the area covered by this report is approximately 1400 people/km^2 compared to 2500 people/km^2 for inner Melbourne (Australian Bureau of Statistics, 2006). Most properties are privately owned and consist of separate houses. Figure 2 shows the boundaries of the Little Stringybark Creek catchment which is the focus of this project.

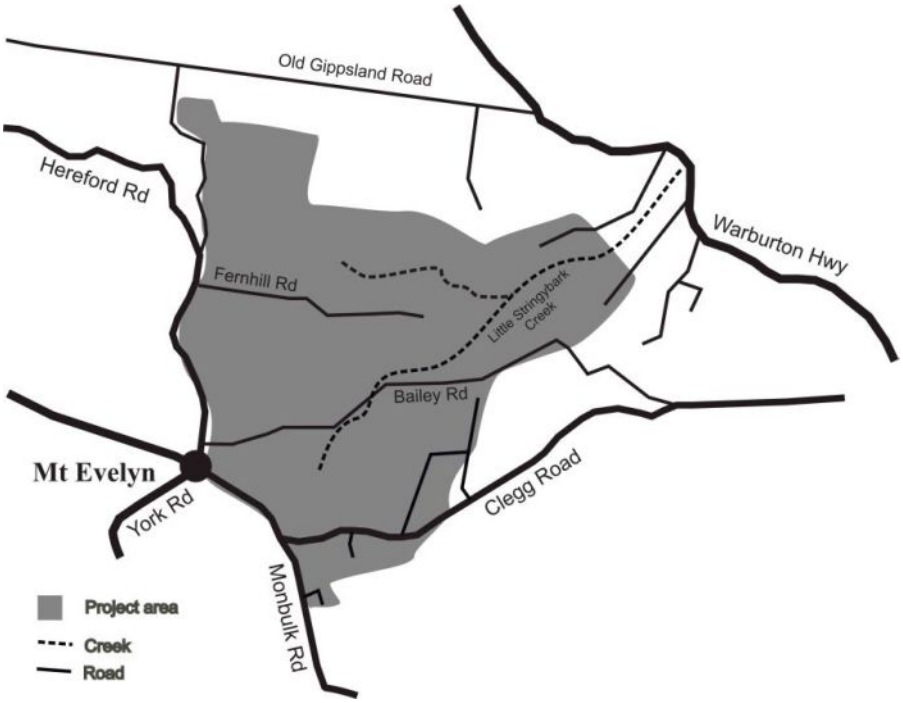


Figure 2 - Map of project area (Little Stringyback Project Team, 2008)

The terrain in the area is mildly hilly and the site has a gentle grade, sloping down from Hereford Road to the east. The geology of the area consists of heavy clay soils, such as the Melbourne formation

(Coffey Geosciences Pty Ltd, 2005). Soil conductivity tests conducted by Coffey Pty Ltd found that the approximate hydraulic conductivity rate was 0.1 mm/hr.

The road reserves in the area are 16m wide, a standard size for a residential development, however the road is fairly narrow at 5.5m to the back of kerb. In addition footpaths are only located on one side of the road, and thus in some areas the verge is very wide. These large, grassed verges are sparsely vegetated with trees and small shrubs.

The area is fully serviced by mains water, gas, sewerage, electricity and Telstra. Most services are located underground in the road reserve or in easements where required. Electricity is provided by a mix of overhead and underground cables. As part of the design process a MOCS request was made to locate the services and the plans received from the relevant authorities can be found in Appendix 3.

2.3 Infiltration Systems

Infiltration systems collect, store and then infiltrate stormwater runoff into the soil. There are several key factors to be considered in the design and each of these is discussed in detail below.

2.3.1 Location

The decision where to locate an infiltration must take into account the catchment area, the surface grade, and the proximity to any structures.

The size of the catchment area will affect the size of the inflow and therefore affect the required storage volume. It is therefore best to locate infiltration systems such that the catchment area is reduced to a size that can be accommodated by the available area for infiltration.

Infiltration systems must not be located on steep grades, as it is possible that under certain conditions water infiltrated into the soil may reappear at the surface further down the slope (Melbourne Water, 2005), particularly where a shallow layer of soil is underlain by rock. Engineers Australia (2006) recommends that at least 3 meters of soil depth should be available for the length of the slope to minimise the potential for this to occur.

Furthermore, infiltration systems must be kept away from buildings, footings and other structures. The interaction of water can cause swelling, particularly in reactive soils (Engineers Australia, 2006), that can affect structural stability. Heavy clays, such as the soil in the study area, require a separation of not less than five meters, while in sandy soils a separation as little as one meter may be acceptable (Engineers Australia, 2006). To reduce the required separation, partial lining of the system will prevent water seepage in the direction of the structures.

2.3.2 Structure and Layout

A typical infiltration system will consist of an inlet zone, sedimentation and filtration area, storage area and an overflow outlet. A typical road side infiltration system that receives water from a break in the kerb can be seen in Figure 3. Many different designs exist and it is the role of the designer to select the most appropriate for the site conditions.

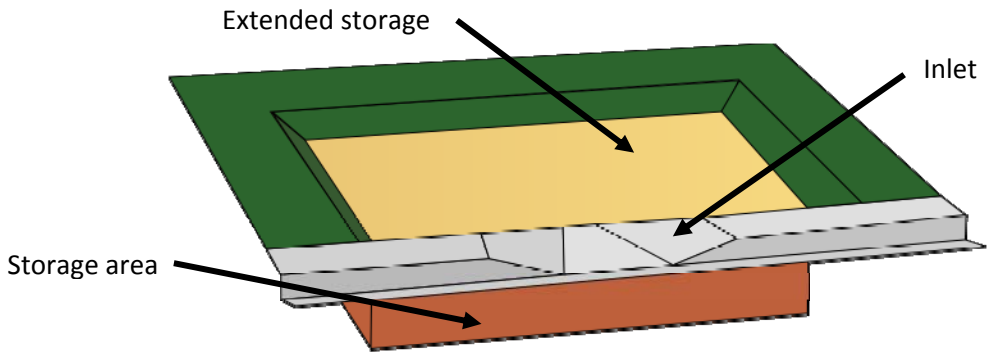


Figure 3 – Typical layout of a road side infiltration system

The inlet zone is designed to collect the water from the catchment and direct it into the storage area. A common method of redirecting flow from a road catchment is a break in the kerb, as shown in Figure 3 that catches and redirects water as it flows down the kerb. This method is commonly used in retrofitted systems where the existing kerb is modified to suit.

The sedimentation and filtration area is an important factor in the ongoing performance as it removes sediment and other fine particulate pollutants that may build up and obstruct the storage. This area is generally a shallow area of ponding that also provides extended storage during peak inflow. The area may be planted, to provide additional treatment and prevent soil media from washing away, and is usually underlain by a geotextile or layers of size graduated media (i.e. from loamy sand, through fine sand, course, sand and fine gravel, overlying the scoria storage zone) to prevent the fine particles entering the storage area.

The storage area is a vital component of any infiltration system. Storage is required to attenuate the peaky inflow hydrograph into the flatter infiltration outflow hydrograph. The storage area is usually excavated and filled with a material of high porosity and hydraulic conductivity (e.g. scoria drainage gravel) to maximise the storage capacity within the available space. Some systems have a partially lined storage area to prevent infiltration in a particular direction.

An overflow discharge point must be provided for periods when the storage becomes full and the inflow exceeds the rate of discharge into the surrounding soil. This could be in the form of a high level outlet from an inlet pit or, with careful control of levels, backflow from the inlet. Overflow must be conveyed to the drainage network to prevent flooding.

2.3.3 Hydraulic Conductivity

Hydraulic conductivity is a property of soils and rock that describes the rate at which water can pass through the pores in the material structure. In an infiltration system it represents the rate at which water leaves the system and moves into the surrounding soil. It is recommended that infiltration systems are most suited to locations where the soil has a hydraulic conductivity exceeding 36mm/hr (Melbourne Water, 2005, p. 215). Soils that have a lower permeability may require storages to be exceedingly large to meet infiltration targets due to the larger difference between the rate of inflow and outflow. Typical soil conductivity rates are shown below in Table 1.

Table 1 - Typical soil hydraulic conductivity rates (Source: Engineers Australia, 2006, p.11-4)

Soil Type	Saturated Hydraulic Conductivity mm/hr
Sand	180
Sandy clay	36-180
Weathered or fractured rock	3.6-36
Medium clay	3.6-36
Heavy clay	0.036-3.6

Falling head tests in the Little Stringybark Creek catchment have shown a typical infiltration rate of just 0.1 mm/hr, putting the soils well into the heavy clay category, a soil generally accepted to be unsuitable for infiltration systems.

Hydraulic conductivity is also to be considered in the design and selection of media for the inlet and sedimentation area. The media used in this area should be able to convey the peak flows for the design storm into the storage area, and usually highly permeable sand or gravel is used.

2.3.4 Storage Size

Selecting an appropriate storage size is a key factor in the performance of an infiltration system. The storage volume must be sized such that it can hold enough stormwater without overflowing during the design storm. While this can be easily calculated for a single storm event, when a continuous rainfall model is used it is likely that the store will not always be empty at the time the next storm event begins. It is therefore important that the storage volume is large enough to store water from successive events. The storage volume is also influenced by the infiltration rate, and in soils with high hydraulic conductivity, the store may only need to handle a one or two consecutive events, while in soils of low hydraulic conductivity the storage must be able to store multiple events occurring in succession.

2.3.5 Filtration and Storage Media

The selection of an appropriate storage media for the systems is another factor in maximising the performance of an infiltration system. In order to maximise the storage capacity of the system while minimising the size, a highly porous storage media is preferred. Traditional media, including sand, loamy sand and gravel, are capable of holding a relatively large amount water in the pores between the soil particles.

Scoria, a volcanic aggregate, is particularly suitable as a storage media. Scoria has a vesicular structure which increases the void space in the rock and therefore the water storage volume. It is generally accepted that scoria has a porosity of approximately 60%; however, this figure varies depending on the source and volcanic formation process. Scoria has been applied in many engineered structures as a road base and as a lightweight concrete aggregate. There are a number of scoria quarries in Victoria and the cost is comparable to traditional 20mm screenings, at around $\$60/m^3$.

Where the system is to be planted, then it is appropriate to use a loamy-sand filter media above the storage media. With a hydraulic conductivity of around 100-300 mm/hr, this media will support plants, and also act to prevent influent sediment from being transported directly into the scoria storage zone. A typical filter media profile is shown in Figure 4.

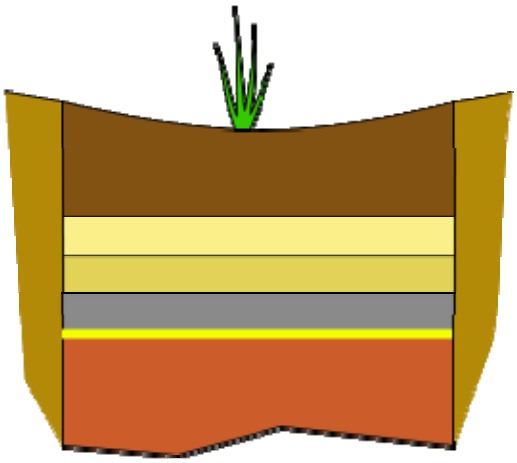


Figure 4 - Typical filter layer profile of (from top) top soil, fine sand, coarse sand, gravel, open weave shade cloth and scoria

2.3.6 Planting

Adding vegetation by planting the ponding area adds an additional method of removing water from the infiltration system through evapotranspiration, and may account for losses of up to 35% of the mean annual flow (Hatt, Fletcher, & Deletic, in press). Deep rooted plants, such as sedges (e.g. *Carex appressa*), have been found to be very effective at removing pollutants in stormwater (Read, Wevill, Fletcher, & Deletic, 2007) and are particularly suited to this application.

3 Infiltration Modelling

Infiltration models are used to assist the design process by predicting the performance of an infiltration system for a given set of design inputs. For this project a model is required that will allow the calculation of the number of days of overflow from the system.

3.1 Model Types

There are two types of infiltration models, one- and two-dimensional, and each of these can be simulated for a single design storm or using a continuous rainfall method.

One and two dimensional systems differ in the direction that they assume water flows out of the storage area into the surrounding soil. In a one dimensional infiltration model the flow path is vertical, and water is assumed to only leave the base of the infiltration system. In a two dimensional model, water is assumed to flow vertically and horizontally through the sides of the infiltration system. Figure 5 illustrates this flow of water from the two types of infiltration model.

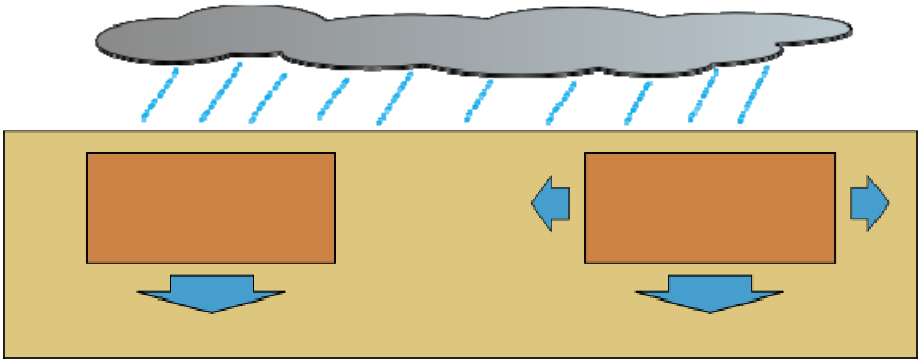


Figure 5 a) The seepage flow path in a 1-D infiltration model and b) the flow path in a 2-D infiltration model

The two dimensional model is more complex as it must take into consideration the height of the water in the storage and the additional flow from the corners of the system. While more complex, a two dimensional increases the possible area of infiltration and usually results in a higher outflow rate. A 2D model is particularly suited to systems that are long and narrow in dimension, as they have small base area and a large amount of side area. A 1D model is less complex and suitable for modelling shallow, square systems and systems that are lined.

Both of the models can be simulated in two different ways, using a single design storm event, or using a continuous rainfall method. The design storm method considers only the largest rainfall event that occurs within a defined period, known as the average recurrence interval (ARI). Typically municipal minor drainage is designed to handle a design storm with a 5 year ARI. The size of the infiltration system is determined by the difference between the inflow and outflow volumes for this design storm.

In a continuous rainfall simulation the effect of all the rainfall from a historical period is modelled. These models look at the effects of storms in the long term and are therefore suited to predicting annual loads. Continuous simulations can run calculations at different intervals, or time steps, and the shorter

the interval the more accurate the results. The trade-off for accuracy is time, complex two dimensional models running at a six minute time step can take some time to run.

3.2 Computer Models

The most common software tool for modelling the performance of infiltration systems is the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) package (Cooperative Research Center for Catchment Hydrology, 2005). This is a conceptual design application that is widely used in the water industry and it was initially selected to be used as the primary modelling tool for this project.

However, limitations were soon found in the model that made it less suited for use in this project. MUSIC uses a one dimensional infiltration model and it was found to underestimate the performance of the narrow infiltration systems used in this project. With limitations on storage size and the low soil hydraulic conductivity, a two dimensional model that could more accurately model the infiltration performance by accounting for flow from both the base and sides was needed.

Such a model was being developed by Walsh et al. (Environmental Benefit Calculator Technical Notes, 2008) for the residential works side of the Little Stringybark Project to model the performance of rain gardens, a type of infiltration system being used to treat stormwater from roof runoff. The Walsh et al. model has several advantages over MUSIC, including two dimensional infiltration modelling and a more flexible scripting interface. The model also uses the latest biofiltration research to come out of the Facility for Advancing Water Biofiltration (FAWB; see www.monash.edu.au/fawb), published in Bratières et al. (in press).

To quantify the differences between the different models, a simple infiltration system typical of those designed for this project was analysed. The storage area of this comparison system was 10m long, 1m wide and 1.4m deep and received water from a 180m^2 catchment. No extended detention area or lining was used (except when using the Walsh et al. model in 1D mode). The results, in Table 2 below, show that the MUSIC infiltration model is comparable to the 1D Walsh et al. model. The 2D Walsh et al. model is a clear improvement over the 1D models as expected. However, the largest reduction of runoff frequency is achieved when vegetation is used.

Table 2 - Modelling results of the same infiltration system using different models and parameters

Model	Parameters	Runoff Frequency, days
MUSIC	6 minute time step	101
MUSIC	Hourly time step	97
Walsh et al.	1D	111
Walsh et al.	1D vegetated	3
Walsh et al.	2D	76
Walsh et al.	2D vegetated	2

A limitation of the Walsh et al. model is that it is run at an hourly time step. The catchments in this project are very small and the time of concentration (the length of time for all the water to reach the

outlet) is in the order of minutes and rainfall simulations should be run at a comparable time step. A six minute time step would have been better suited to modelling the system in this project and may have provided a more accurate prediction of performance.

In addition, the model is not a true two dimensional model as it does not model the full area available for infiltration, in particular it does not model flow from the corners of the storage. To make up for this limitation the model was calibrated against another, more complex model by Browne (2008). In calibrating the Walsh model it was found that it was underestimating the performance and was adjusted such that the results were in line with the Browne model.

3.3 Model Inputs

Any simulation model requires inputs that accurately represent those values expected in reality. If the inputs are not a true representation then the output from the model will be meaningless as an indication of performance. The Walsh et al. infiltration model requires the follow inputs:

- Rainfall data recorded at one hour intervals;
- Evapotranspiration data;
- Hydraulic conductivity of the surrounding soil and the storage media;
- Porosity of the storage media;
- Infiltration system dimensions including depth of ponding
- Catchment area

The rainfall data used in this project is from the Croydon area and was collected from 1/4/1965 to 31/3/1966 which represents a period of average rainfall. The hydraulic conductivity used was 0.1mm/hr and scoria with a porosity of 0.6 was selected for the storage media. The area of the catchment and dimensions of the infiltration systems were unique to each catchment and are summarised later in the report.

4 Proposed Designs

4.1 Standard Design

A standard design layout was produced that could be used in the four proposed locations. While the systems are similar in design, each location is unique and requires the layout to be adapted to suit. Therefore, each system has an individual set of dimensions that best meet the design objectives.

The general details of the design are listed below, and then the unique features of each system are described further. Detailed drawings specifying the location, layout and dimensions of the infiltration systems are provided in Appendix 2.

4.1.1 Inlet and Extended Storage

The inlet to the infiltration systems consists of a break in the existing kerb, similar to entry to the existing side entry pits (SEP). A clear opening width of 600mm will direct flow from the kerb channel into the extended storage area.

The extended storage area consists of a swale drain type of storage area that has a constant level invert. The curved sides of this area will be vegetated with grass, so that it merges into the existing verge, and the base will be planted with sedges to improve the performance of the system. The size of this area is limited by the slope of the verge, as even a gentle grade may require a steep batter to maintain the constant invert level, creating a trip hazard for pedestrians. Therefore, the length of the extended storage area may be less than that of the storage area below.

The invert level of the extended storage is to be 100mm below the kerb invert level at the inlet. This gives a small amount of storage at times when the storage is full or when the inflow exceeds the infiltration capacity of the filter media. When the extended storage is full, the water level will be at the same level as the kerb and thus it will backflow into the downstream SEP.

4.1.2 Storage

The storage area consists simply of a trench backfilled with scoria. The dimensions of this area are unique to each system designed, and are determined by the available area. The dimensions of the storage may be larger than the extended storage depending on the conditions.

The transition from the scoria storage media to the vegetated top soil consists of 50mm layers of graduated particle sizes rather than a geotextile that could clog over time. The final transition from a crushed rock aggregate to the scoria is separated by a shade cloth material to ensure that the upper layers do not enter the storage area. The open weave of the shade cloth, which has a pore size larger than a geotexile, should not cause blockages over time. The layer profile is detailed further in drawing SBC-004 in Appendix 2.

The storage area on all of the infiltration systems is lined on the road side to prevent seepage into the base courses that could cause damage. Additional lining is required on the top of the storage area where the storage extends beyond the length of the extended storage to prevent the backfill material from entering the scoria and clogging the pore spaces.

4.1.3 Vegetation

To improve the performance of the infiltration systems they will be planted with sedges such as *Carex appressa* and *Carex fascicularis* which are native Australian species that naturally occur in riparian zones.

4.2 Infiltration System 1

4.2.1 Location

The first infiltration system is located on the north side of Newton Ave at the intersection with Muir Smith Pl and Kemp Ave. This location was selected for its flat terrain and area available on the surface. This system has a catchment of 178m^2. Services which are located near this system include Telstra, overhead and underground electricity, drainage water and gas. This system is located between a Φ500mm drainage pipe and a water main.

4.2.2 Model Results

Due to the restrictions on the available area for this system the dimensions have been constrained to a maximum length of 9m and 1m width. Modelling a system of this size with storage depths ranging from 1m to 2.4m showed (Table 3) that, when planted, the system will meet the runoff frequency target. The complete set of dimensions modelled with results can be found in Appendix 1.

Table 3 – Model results for infiltration system 1, length 9m, width 1m

Depth (X), m	Runoff Frequency, days	
	Vegetated	Non-vegetated
1	9	101
1.2	6	97
1.4	4	92
1.6	4	90
1.8	2	86
2.0	1	82
2.2	1	80
2.4	1	78

4.2.3 Design Dimensions

The selected size of the storage area is 9m long, 1m wide and 1.2m deep, with a ponding area that extends the length of the storage area, resulting in approximately 6 days of runoff. This exceeds the targets and actually reduces the runoff frequency below the natural level. This is acceptable as it offsets the runoff from other areas where it is not possible to reduce the runoff frequency.

4.3 Infiltration System 2

4.3.1 Location

System 2 is located on the south side of Newton Ave on the corner of Kemp Ave and has a catchment of 178m^2. This location is fairly flat and is bounded by the road and the footpath, leaving approximately

1.8m of width for the infiltration system. Below ground the only services are sewer and gas, however the sewer alignment crosses the proposed system location.

4.3.2 Model Results

The catchment size of system 2 is very similar to that of the first system but there is more space available, so a different range of dimensions were modelled. The results showed that the larger systems were capable of retaining all runoff and never overflowed when vegetated. While it was acceptable to reduce the frequency below the target of 15 days (to offset other sub-catchments), the size of the system could be optimised to reduce the construction costs. Therefore, systems that resulted in just one or two days of runoff were of most interest, and some of these are listed below in Table 4.

Table 4 – Sample of dimensions modelled for infiltration system 2 that resulted in 1 or 2 days of runoff

Length, (L) m	Width, (W) m	Depth, (D) m	Runoff Freq, days	Storage Volume, m^2
9.0	1.4	1.0	1	12.6
9.5	1.0	1.6	2	15.2
9.5	1.2	1.2	1	13.7
10.0	1.0	1.4	2	14.0
10.0	1.0	1.6	1	16.0
10.5	1.0	1.4	1	14.7
10.5	1.2	1.0	1	12.6
11.5	1.0	1.2	1	13.8

4.3.3 Design Dimensions

Dimensions of 11.5m x 1.2m x 1m were selected for this system, resulting in approximately one day of runoff. While a system length of 10.5m was modelled, an extra meter of length has been added to accommodate the sewer crossing. This size was selected over other sizes that produced similar results because it minimised the depth and the volume of materials required for construction, thus keeping the costs down.

4.4 Infiltration System 3

4.4.1 Location

This system is located on Heath Avenue and has a catchment of approximately 347m^2. The system lies in a broad verge with plenty of area available on the surface. The underground services in the area are sewer, water (both of which are near the title boundary) and drainage. The drainage line is a small Φ100mm house drain and provides the only obstacle.

4.4.2 Model Results

This system has the largest catchment area of the four systems designed, and this is reflected in the runoff frequency performance. The largest system possible is 9.8m in length and 1m in width and all the depths tested resulted in some runoff (Table 5). However, the vegetated systems still result in a

reasonable reduction in runoff frequency, particularly when compared with the non-vegetated systems of the same dimensions.

Table 5 – Runoff model results for infiltration system 3 with length 9.8m and width 1m

Depth (D), m	Runoff Frequency, days	
	Vegetated	Non-vegetated
1	28	101
1.2	27	97
1.4	25	92
1.6	24	90
1.8	24	86
2.0	23	82
2.2	20	80

4.4.3 Design Dimensions

The selected size of the storage area is 9.8m long, 1m wide and 1.4m deep, with a ponding area that extends the length of the storage area, resulting in approximately 25 days of runoff. This system does not meet the design objectives; however the increased runoff frequency from this system is offset against the extra reductions achieved in the other systems. While further reductions in runoff frequency could be achieved, it was decided to maintain a minimum depth of excavation.

4.5 Catchment 4

4.5.1 Location

The last system designed in this project is also located in Heath Avenue, adjacent to system 3. This system has a catchment of 162m^2 to the north. The location is almost the same as system 3, with few services and a large open surface area. A 300mm drainage pipe and a large tree are the only obstructions in the area of this system.

4.5.2 Model Results

Once again this size of this system is limited, in this case by the 300mm drainage pipe and a residential driveway. The maximum dimensions are about 7m x 1.5m, however, this location has the smallest catchment which is reflected in the modelling results, with large runoff reductions being made with systems as small as 5.5m x 1m x 1m. A complete list of dimensions trialled and results can be found in appendix 1.

4.5.3 Design Dimensions

The dimensions selected for this system are 7m length, 1.4m width and 1m of depth, resulting in runoff on about 3 days per year. While there were a variety of dimensions that met the target, it was decided to go for the largest reductions to offset other catchments. These dimensions give a very large reduction in runoff frequency but also have minimal material requirements, with a storage volume of just 9.8m^3 compared with other dimensions that required up to 15.8m^3 to achieve the same result.

4.6 Design Summary

The final design dimensions are summarised below in Table 6. These dimensions represent the required size of the storage area of each system as shown in the detailed drawings in appendix 2.

Table 6 - Infiltration system design dimensions

System	Catchment m^2	Length (L) m	Width (W) m	Depth (D) m	Pond Length (X) m	Runoff Freq days
1	178	9.0	1.0	1.2	9.0	6
2	178	11.5	1.2	1.0	8.0	1
3	347	9.8	1.0	1.4	9.8	25
4	162	7.0	1.4	1.0	7.0	3

5 Contribution

This project has produced designs that, when constructed, will contribute to the continuing search for improved stream restoration methods in urban catchments. In combination with the associated projects at the allotment level, the infiltration systems will reduce the effective area of imperviousness in the catchment of Little Stringybark Creek, and potentially make a measurable improvement in the health of the stream.

The results from the design processes showed that the two key features of infiltration systems in this catchment are the size of the storage area and the vegetation of the extended storage. With such a poor infiltration rate in the local soils, the storage area needed to be large enough to hold runoff from consecutive rainfall events. Vegetation proved to help keep this size down by providing another method of removing water from the system. By combining these two factors the systems designed in this project have reduced the frequency of runoff to just 8.8 days on average. This project has been successful in meeting and exceeding the set targets, which will offset runoff from other sub-catchments.

This project has also highlighted the difficulties faced by engineers when retrofitting infiltration systems into existing urban catchments. Sloped surfaces, underground services and narrow verges are some of the features of existing urban streetscapes that decrease the likelihood of finding suitable locations.

Further difficulty was encountered in this project due to the low availability of information. Locating existing services proved to be difficult using the available information, such asset maps, which are usually vague and lacking the required detail. For this project copies of the original subdivision plans were available, however, these are not as detailed as plans produced by modern consultants and it was apparent that additional works had been undertaken since, for which plans were not provided or available. The final location and size of the systems designed may vary from those quoted in this project because of latent conditions that can only be proved on site during construction.

Another issue highlighted by this project is the limitation of the one dimensional MUSIC infiltration model. While the tool is widely used in industry, it was found to be unsuitable for this project because it predicted lower infiltration rates than more complex two dimensional models. If an engineer is to detail the most cost effective infiltration solution they need to be able to model its performance as accurately as possible. It is likely that this model could be updated in future versions of the software.

6 Acknowledgments

I would like to thank the Little Stringybark Creek Project team, Tim Fletcher, Chris Walsh, Darren Bos and Sharyn RossRakesh for their time and assistance in designing the infiltration systems.

7 References

Australian Bureau of Statistics. (2006). *Mount Evelyn (State Suburb), Population Density.* Retrieved May 12, 2008

Beach, D. (2002). *Coastal Sprawl: the Effect of Urban Design on Aquatic Ecosystems in the United States.* Retrieved May 18, 2008, from http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Protecting_ocean_life/env_pew_oceans_sprawl.pdf

Booth, D. B., & Jackson, C. R. (1997). Urbanization of Aquatic Systems - Degradation Thresholds, Stormwater Detention and the Limits of Mitigation. *Journal of the American Water Resources Association , 33* (5), 1077-1090.

Bratières, K., Fletcher, T. D., Deletic, A., & Zinger, Y. (in press). Nutrient and Sediment Removal by Stormwater Biofilters; a Large Scale Design Optimisation. *Water Research* .

Browne, D. (2008). *Modelling the Performance of Stormwater Infiltration Systems.*

Coffey Geosciences Pty Ltd. (2005). *Infiltration Testing for Proposed Drainage System, Mt Evelyn, Victoria.* Not Published.

Cooperative Research Center for Catchment Hydrology. (2005). Model for Urban Stormwater Improvement Conceptualisation (version 3.01). Melbourne, Australia: Cooperative Research Center for Catchment Hydrology.

Engineers Australia. (2006). *Australian Runoff Quality : A Guide to Water Sensitive Urban Design.* Crows Nest, NSW: Engineers Media.

Hatt, B. E., Fletcher, T. D., & Deletic, A. (in press). Hydrologic and Pollutant Removal Performance of Biofiltration Systems at the Field Scale. *Journal of Hydrology* .

Hobbs, R. J., & Norton, D. A. (1996). Towards a Conceptual Framework for Restoration Ecology. *Restoration Ecology , 4* (2), 93-110.

Konrad, C. P., Booth, D. B., & Burges, S. J. (2005). Effects of Urban Development in the Purget Lowland, Washington, on Interannual Streamflow Patterns: Consequences for Channel Form and Streambed Disturbance. *Water Resources Research , 41* (7), 7009-7009.

Ladson, A. R., Walsh, C. J., & Fletcher, T. D. (2006). Improving Stream Health in Urban Areas by Reducing Runoff Frequency from Impervious Surfaces. *Australian Journal of Water Resources , 10* (1), 23-33.

Larson, M. G., Booth, D. B., & Morley, S. A. (2001). Effectiveness of Large Woody Debris in Stream Rehabilitation Projects in Urban Basins. *Ecological Engineering , 18* (2), 211–226.

Little Stringyback Project Team. (2008, April 2). *Map of Project Area*. Retrieved May 14, 2008, from Little Stringybark Creek Project: http://www.urbanstreams.unimelb.edu.au/map.htm

McBride, M., & Booth, D. B. (2005). Urban Impacts on Physical Stream Condition: Effects of Spacial Scale, Connectivity and Longitudinal Trends. *Journal of the American Water Resources Association , 41* (3), 565-580.

Melbourne Water. (2005). *WSUD Engineering Procedures: Stormwater* (Vol. 1). Melbourne, Victoria, Australia: CSIRO Publishing.

Read, J., Wevill, T., Fletcher, T. D., & Deletic, A. (2007). Variation Among Plant Species in Pollutant Removal from Stormwater in Biofiltration Systems. *Water Research , 42* (4-5), 893-902.

Walsh, C. J., & Fletcher, T. D. (2008, May 21). *Environmental Benefit Calculator Technical Notes*. Retrieved May 22, 2008, from Little Stringybark Creek: http://www.urbanstreams.unimelb.edu.au/EBcalctech.html

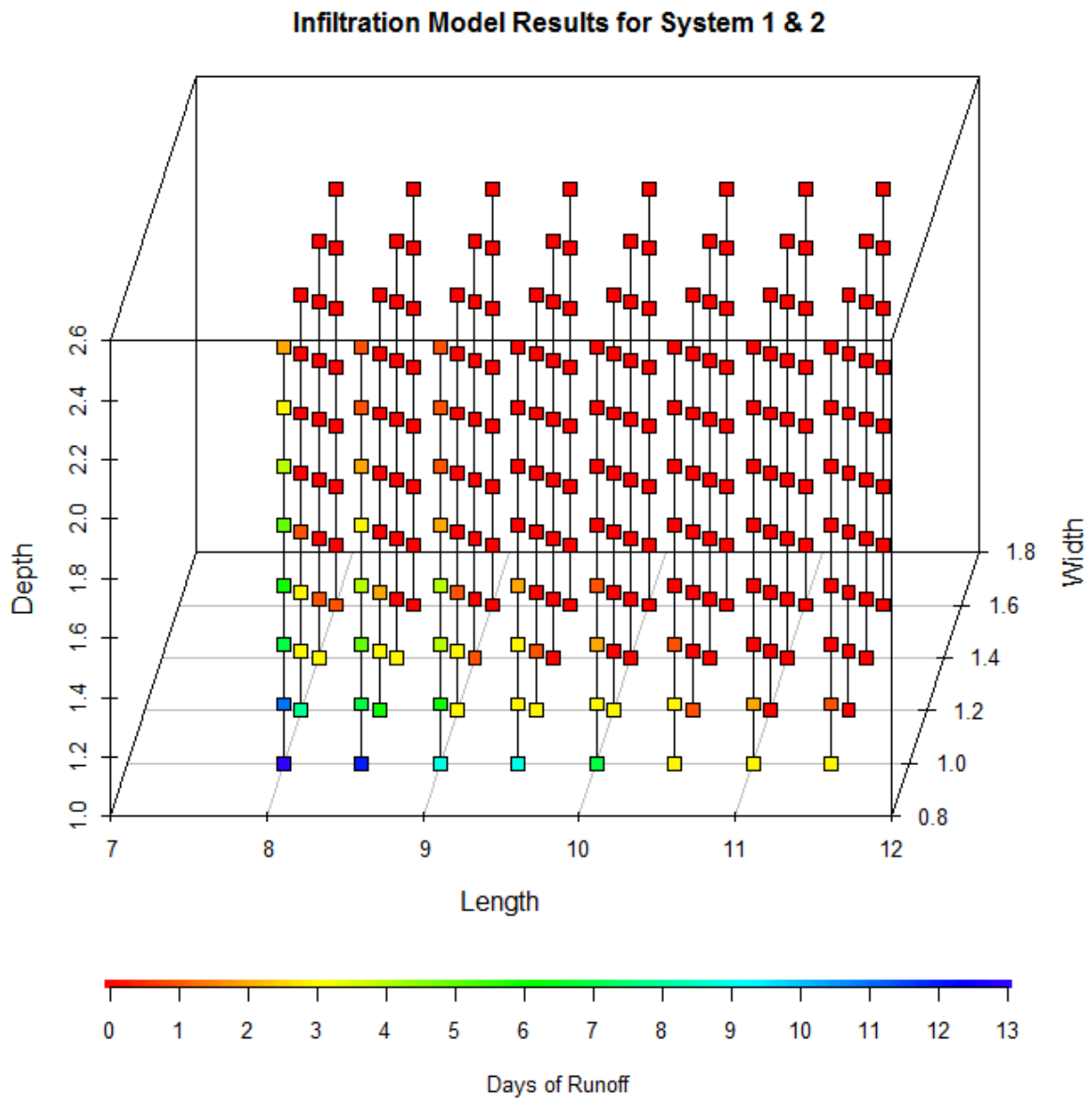
Walsh, C. J., Fletcher, T. D., & Ladson, A. R. (2005). Stream Restoration in Urban Catchments Through Redesigning Stormwater Systems: Looking to the Catchment to Save the Stream. *Journal of the North American Benthological Society , 24* (3), 690-705.

Walsh, C. J., Leonard, A. W., Ladson, A. R., & Fletcher, T. D. (2004). *Urban Stormwater and the Ecology of Streams.* Canberra: CRCFE.

Walsh, C. J., Roy, A. H., Feminella, J. W., Cottingham, P. D., Groffman, P. M., & Morgan II, R. P. (2005). The Urban Stream Syndrome: Current Knowledge and the Search for a Cure. *Journal of the North American Benthological Society , 24* (3), 706-723.

8 Appendices

Appendix 1: Model Results

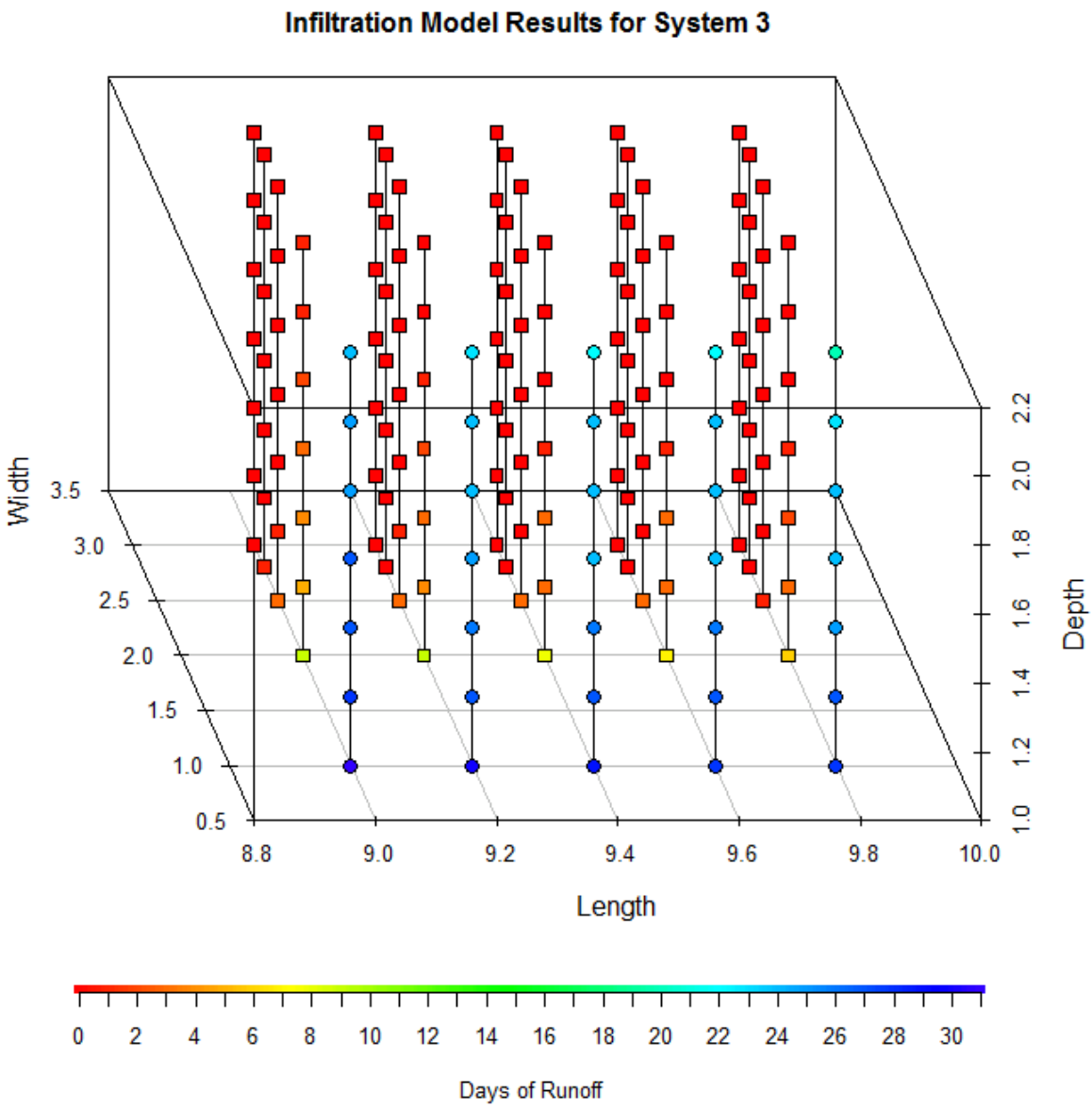

Infiltration Model Results for System 1 & 2
Depth
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
Length
7
8
9
10
11
12
Width
0.8
1.0
1.2
1.4
1.6
1.8
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Days of Runoff

Infiltration System 1 & 2

Model Results

Catchment: 178m2

Length	Width	Depth	Runoff
8	1	1	13
8	1	1.2	11
8	1	1.4	7
8	1	1.6	6
8	1	1.8	5
8	1	2	4
8	1	2.2	3
8	1	2.4	2
8	1.2	1	8
8	1.2	1.2	3
8	1.2	1.4	3
8	1.2	1.6	1
8	1.2	1.8	0
8	1.2	2	0
8	1.2	2.2	0
8	1.2	2.4	0
8	1.4	1	3
8	1.4	1.2	1
8	1.4	1.4	0
8	1.4	1.6	0
8	1.4	1.8	0
8	1.4	2	0
8	1.4	2.2	0
8	1.4	2.4	0
8	1.6	1	1
8	1.6	1.2	0
8	1.6	1.4	0
8	1.6	1.6	0
8	1.6	1.8	0
8	1.6	2	0
8	1.6	2.2	0
8	1.6	2.4	0
8.5	1	1	12
8.5	1	1.2	7
8.5	1	1.4	5
8.5	1	1.6	4
8.5	1	1.8	3
8.5	1	2	2
8.5	1	2.2	1
8.5	1	2.4	1
8.5	1.2	1	6
8.5	1.2	1.2	3
8.5	1.2	1.4	2
8.5	1.2	1.6	0
8.5	1.2	1.8	0
8.5	1.2	2	0
8.5	1.2	2.2	0
8.5	1.2	2.4	0
8.5	1.4	1	3
8.5	1.4	1.2	0
8.5	1.4	1.4	0
8.5	1.4	1.6	0
8.5	1.4	1.8	0
8.5	1.4	2	0
8.5	1.4	2.2	0
8.5	1.4	2.4	0
8.5	1.6	1	0
8.5	1.6	1.2	0
8.5	1.6	1.4	0
8.5	1.6	1.6	0
8.5	1.6	1.8	0
8.5	1.6	2	0
8.5	1.6	2.2	0
8.5	1.6	2.4	0
9	1	1	9
9	1	1.2	6
9	1	1.4	4
9	1	1.6	4
9	1	1.8	2
9	1	2	1
9	1	2.2	1
9	1	2.4	1
9	1.2	1	3
9	1.2	1.2	3
9	1.2	1.4	1
9	1.2	1.6	0
9	1.2	1.8	0
9	1.2	2	0
9	1.2	2.2	0
9	1.2	2.4	0
9	1.4	1	1
9	1.4	1.2	0
9	1.4	1.4	0
9	1.4	1.6	0
9	1.4	1.8	0
9	1.4	2	0
9	1.4	2.2	0
9	1.4	2.4	0
9	1.6	1	0
9	1.6	1.2	0
9	1.6	1.4	0
9	1.6	1.6	0
9	1.6	1.8	0
9	1.6	2	0
9	1.6	2.2	0
9	1.6	2.4	0
9.5	1	1	9
9.5	1	1.2	3
9.5	1	1.4	3
9.5	1	1.6	2
9.5	1	1.8	0
9.5	1	2	0
9.5	1	2.2	0
9.5	1	2.4	0
9.5	1.2	1	3
9.5	1.2	1.2	1
9.5	1.2	1.4	0
9.5	1.2	1.6	0
9.5	1.2	1.8	0
9.5	1.2	2	0
9.5	1.2	2.2	0
9.5	1.2	2.4	0
9.5	1.4	1	0
9.5	1.4	1.2	0
9.5	1.4	1.4	0
9.5	1.4	1.6	0
9.5	1.4	1.8	0
9.5	1.4	2	0
9.5	1.4	2.2	0
9.5	1.4	2.4	0
9.5	1.6	1	0
9.5	1.6	1.2	0
9.5	1.6	1.4	0
9.5	1.6	1.6	0
9.5	1.6	1.8	0
9.5	1.6	2	0
9.5	1.6	2.2	0
9.5	1.6	2.4	0
10	1	1	7
10	1	1.2	3
10	1	1.4	2
10	1	1.6	1
10	1	1.8	0
10	1	2	0
10	1	2.2	0
10	1	2.4	0
10	1.2	1	3
10	1.2	1.2	0
10	1.2	1.4	0
10	1.2	1.6	0
10	1.2	1.8	0
10	1.2	2	0
10	1.2	2.2	0
10	1.2	2.4	0
10	1.4	1	0
10	1.4	1.2	0
10	1.4	1.4	0
10	1.4	1.6	0
10	1.4	1.8	0
10	1.4	2	0
10	1.4	2.2	0
10	1.4	2.4	0
10	1.6	1	0
10	1.6	1.2	0
10	1.6	1.4	0
10	1.6	1.6	0
10	1.6	1.8	0
10	1.6	2	0
10	1.6	2.2	0
10	1.6	2.4	0
10.5	1	1	3
10.5	1	1.2	3
10.5	1	1.4	1
10.5	1	1.6	0
10.5	1	1.8	0
10.5	1	2	0
10.5	1	2.2	0
10.5	1	2.4	0
10.5	1.2	1	1
10.5	1.2	1.2	0
10.5	1.2	1.4	0
10.5	1.2	1.6	0
10.5	1.2	1.8	0
10.5	1.2	2	0
10.5	1.2	2.2	0
10.5	1.2	2.4	0
10.5	1.4	1	0
10.5	1.4	1.2	0
10.5	1.4	1.4	0
10.5	1.4	1.6	0
10.5	1.4	1.8	0
10.5	1.4	2	0
10.5	1.4	2.2	0
10.5	1.4	2.4	0
10.5	1.6	1	0
10.5	1.6	1.2	0
10.5	1.6	1.4	0
10.5	1.6	1.6	0
10.5	1.6	1.8	0
10.5	1.6	2	0
10.5	1.6	2.2	0
10.5	1.6	2.4	0
11	1	1	3
11	1	1.2	2
11	1	1.4	0
11	1	1.6	0
11	1	1.8	0
11	1	2	0
11	1	2.2	0
11	1	2.4	0
11	1.2	1	0
11	1.2	1.2	0
11	1.2	1.4	0
11	1.2	1.6	0
11	1.2	1.8	0
11	1.2	2	0
11	1.2	2.2	0
11	1.2	2.4	0
11	1.4	1	0
11	1.4	1.2	0
11	1.4	1.4	0
11	1.4	1.6	0
11	1.4	1.8	0
11	1.4	2	0
11	1.4	2.2	0
11	1.4	2.4	0
11	1.6	1	0
11	1.6	1.2	0
11	1.6	1.4	0
11	1.6	1.6	0
11	1.6	1.8	0
11	1.6	2	0
11	1.6	2.2	0
11	1.6	2.4	0
11.5	1	1	3
11.5	1	1.2	1
11.5	1	1.4	0
11.5	1	1.6	0
11.5	1	1.8	0
11.5	1	2	0
11.5	1	2.2	0
11.5	1	2.4	0
11.5	1.2	1	0
11.5	1.2	1.2	0
11.5	1.2	1.4	0
11.5	1.2	1.6	0
11.5	1.2	1.8	0
11.5	1.2	2	0
11.5	1.2	2.2	0
11.5	1.2	2.4	0
11.5	1.4	1	0
11.5	1.4	1.2	0
11.5	1.4	1.4	0
11.5	1.4	1.6	0
11.5	1.4	1.8	0
11.5	1.4	2	0
11.5	1.4	2.2	0
11.5	1.4	2.4	0
11.5	1.6	1	0
11.5	1.6	1.2	0
11.5	1.6	1.4	0
11.5	1.6	1.6	0
11.5	1.6	1.8	0
11.5	1.6	2	0
11.5	1.6	2.2	0
11.5	1.6	2.4	0


Infiltration Model Results for System 3
Width
3.5
3.0
2.5
2.0
1.5
1.0
0.5
8.8
9.0
9.2
9.4
9.6
9.8
10.0
Length
Depth
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Days of Runoff

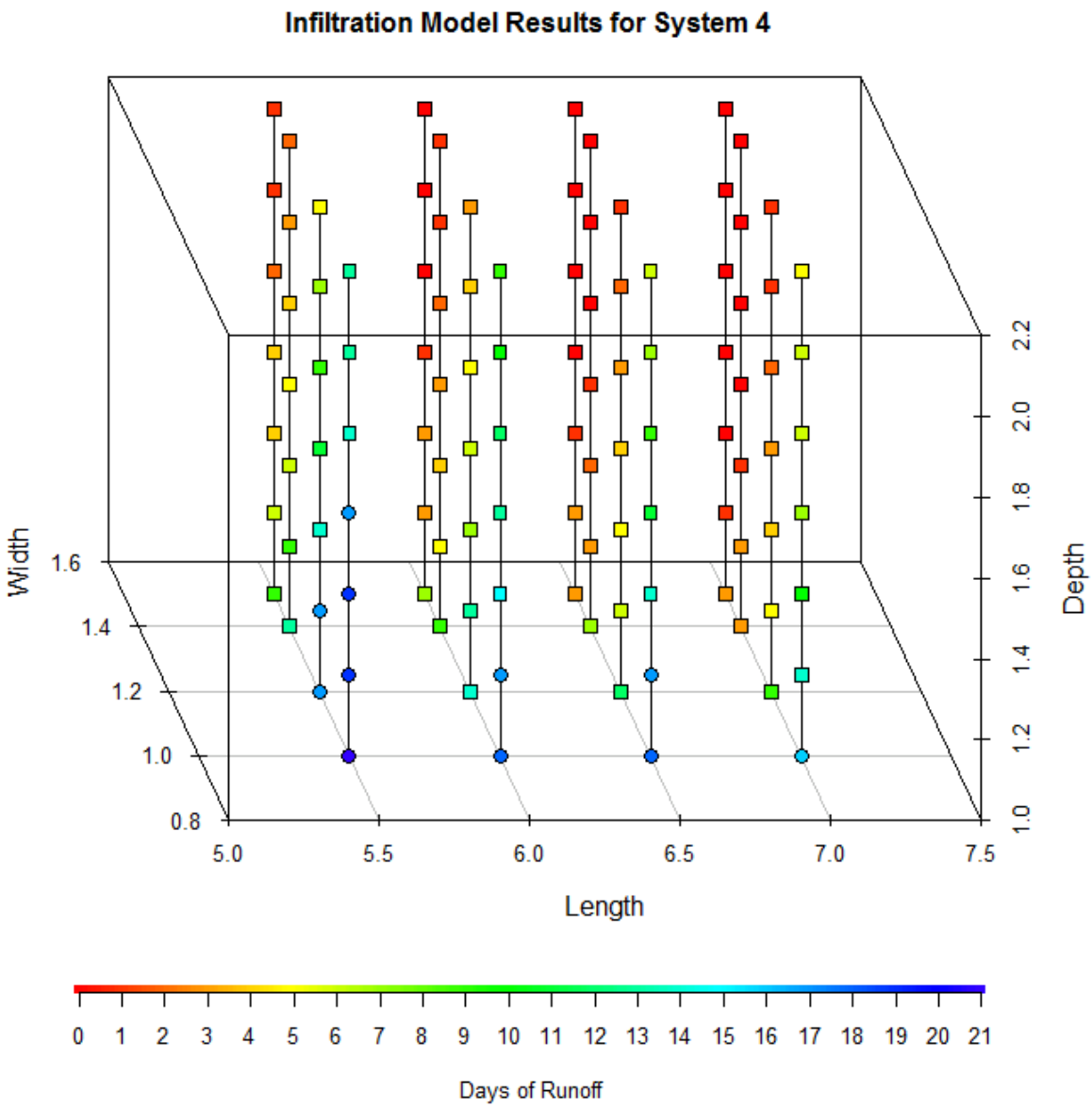
Infiltration System 3

Model Results

Catchment: 347m2

Length	Width	Depth	Runoff
9	1	1	31
9	1	1.2	28
9	1	1.4	27
9	1	1.6	27
9	1	1.8	25
9	1	2	25
9	1	2.2	24
9	2	1	9
9	2	1.2	5
9	2	1.4	4
9	2	1.6	3
9	2	1.8	2
9	2	2	1
9	2	2.2	1
9	2.5	1	3
9	2.5	1.2	1
9	2.5	1.4	0
9	2.5	1.6	0
9	2.5	1.8	0
9	2.5	2	0
9	2.5	2.2	0
9	2.8	1	1
9	2.8	1.2	0
9	2.8	1.4	0
9	2.8	1.6	0
9	2.8	1.8	0
9	2.8	2	0
9	2.8	2.2	0
9	3	1	0
9	3	1.2	0
9	3	1.4	0
9	3	1.6	0
9	3	1.8	0
9	3	2	0
9	3	2.2	0
9.2	1	1	30
9.2	1	1.2	27
9.2	1	1.4	26
9.2	1	1.6	25
9.2	1	1.8	24
9.2	1	2	24
9.2	1	2.2	23
9.2	2	1	9
9.2	2	1.2	4
9.2	2	1.4	3
9.2	2	1.6	2
9.2	2	1.8	1
9.2	2	2	0
9.2	2	2.2	0
9.2	2.5	1	3
9.2	2.5	1.2	1
9.2	2.5	1.4	0
9.2	2.5	1.6	0
9.2	2.5	1.8	0
9.2	2.5	2	0
9.2	2.5	2.2	0
9.2	2.8	1	0
9.2	2.8	1.2	0
9.2	2.8	1.4	0
9.2	2.8	1.6	0
9.2	2.8	1.8	0
9.2	2.8	2	0
9.2	2.8	2.2	0
9.2	3	1	0
9.2	3	1.2	0
9.2	3	1.4	0
9.2	3	1.6	0
9.2	3	1.8	0
9.2	3	2	0
9.2	3	2.2	0
9.4	1	1	29
9.4	1	1.2	27
9.4	1	1.4	26
9.4	1	1.6	24
9.4	1	1.8	24
9.4	1	2	24
9.4	1	2.2	22
9.4	2	1	8
9.4	2	1.2	3
9.4	2	1.4	3
9.4	2	1.6	1
9.4	2	1.8	0
9.4	2	2	0
9.4	2	2.2	0
9.4	2.5	1	3
9.4	2.5	1.2	0
9.4	2.5	1.4	0
9.4	2.5	1.6	0
9.4	2.5	1.8	0
9.4	2.5	2	0
9.4	2.5	2.2	0
9.4	2.8	1	0
9.4	2.8	1.2	0
9.4	2.8	1.4	0
9.4	2.8	1.6	0
9.4	2.8	1.8	0
9.4	2.8	2	0
9.4	2.8	2.2	0
9.4	3	1	0
9.4	3	1.2	0
9.4	3	1.4	0
9.4	3	1.6	0
9.4	3	1.8	0
9.4	3	2	0
9.4	3	2.2	0

Length	Width	Depth	Runoff
9.6	1	1	28
9.6	1	1.2	27
9.6	1	1.4	26
9.6	1	1.6	24
9.6	1	1.8	24
9.6	1	2	24
9.6	1	2.2	22
9.6	2	1	7
9.6	2	1.2	3
9.6	2	1.4	3
9.6	2	1.6	1
9.6	2	1.8	0
9.6	2	2	0
9.6	2	2.2	0
9.6	2.5	1	3
9.6	2.5	1.2	0
9.6	2.5	1.4	0
9.6	2.5	1.6	0
9.6	2.5	1.8	0
9.6	2.5	2	0
9.6	2.5	2.2	0
9.6	2.8	1	0
9.6	2.8	1.2	0
9.6	2.8	1.4	0
9.6	2.8	1.6	0
9.6	2.8	1.8	0
9.6	2.8	2	0
9.6	2.8	2.2	0
9.6	3	1	0
9.6	3	1.2	0
9.6	3	1.4	0
9.6	3	1.6	0
9.6	3	1.8	0
9.6	3	2	0
9.6	3	2.2	0
9.8	1	1	28
9.8	1	1.2	27
9.8	1	1.4	25
9.8	1	1.6	24
9.8	1	1.8	24
9.8	1	2	23
9.8	1	2.2	20
9.8	2	1	6
9.8	2	1.2	3
9.8	2	1.4	2
9.8	2	1.6	1
9.8	2	1.8	0
9.8	2	2	0
9.8	2	2.2	0
9.8	2.5	1	1
9.8	2.5	1.2	0
9.8	2.5	1.4	0
9.8	2.5	1.6	0
9.8	2.5	1.8	0
9.8	2.5	2	0
9.8	2.5	2.2	0
9.8	2.8	1	0
9.8	2.8	1.2	0
9.8	2.8	1.4	0
9.8	2.8	1.6	0
9.8	2.8	1.8	0
9.8	2.8	2	0
9.8	2.8	2.2	0
9.8	3	1	0
9.8	3	1.2	0
9.8	3	1.4	0
9.8	3	1.6	0
9.8	3	1.8	0
9.8	3	2	0
9.8	3	2.2	0


Infiltration Model Results for System 4
Width
1.6
1.4
1.2
1.0
0.8
5.0
5.5
6.0
6.5
7.0
7.5
Length
Depth
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Days of Runoff

Infiltration System 4

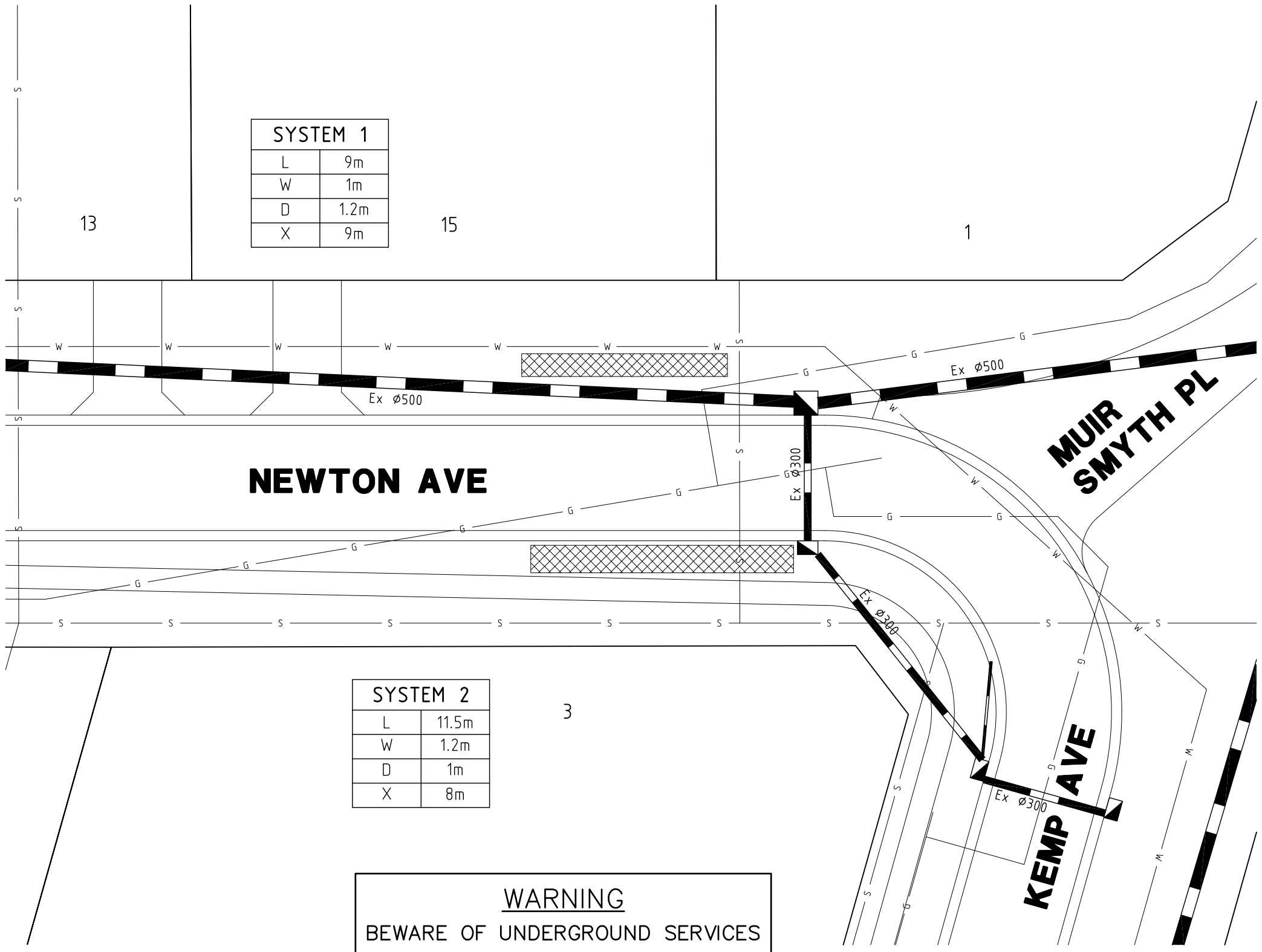
Model Results

Catchment: 162m2

Length	Width	Depth	Runoff
5.5	1	1	21
5.5	1	1.2	19
5.5	1	1.4	19
5.5	1	1.6	17
5.5	1	1.8	14
5.5	1	2	13
5.5	1	2.2	13
5.5	1.2	1	17
5.5	1.2	1.2	17
5.5	1.2	1.4	14
5.5	1.2	1.6	11
5.5	1.2	1.8	9
5.5	1.2	2	7
5.5	1.2	2.2	5
5.5	1.4	1	13
5.5	1.4	1.2	9
5.5	1.4	1.4	6
5.5	1.4	1.6	5
5.5	1.4	1.8	4
5.5	1.4	2	3
5.5	1.4	2.2	2
5.5	1.5	1	9
5.5	1.5	1.2	6
5.5	1.5	1.4	4
5.5	1.5	1.6	4
5.5	1.5	1.8	2
5.5	1.5	2	1
5.5	1.5	2.2	1
6	1	1	18
6	1	1.2	17
6	1	1.4	15
6	1	1.6	13
6	1	1.8	12
6	1	2	10
6	1	2.2	9
6	1.2	1	14
6	1.2	1.2	13
6	1.2	1.4	7
6	1.2	1.6	6
6	1.2	1.8	5
6	1.2	2	4
6	1.2	2.2	3
6	1.4	1	9
6	1.4	1.2	5
6	1.4	1.4	4
6	1.4	1.6	3
6	1.4	1.8	2
6	1.4	2	1
6	1.4	2.2	1
6	1.5	1	7
6	1.5	1.2	3
6	1.5	1.4	3
6	1.5	1.6	1
6	1.5	1.8	0
6	1.5	2	0
6	1.5	2.2	0

Length	Width	Depth	Runoff
6.5	1	1	18
6.5	1	1.2	17
6.5	1	1.4	14
6.5	1	1.6	11
6.5	1	1.8	9
6.5	1	2	7
6.5	1	2.2	6
6.5	1.2	1	12
6.5	1.2	1.2	6
6.5	1.2	1.4	5
6.5	1.2	1.6	4
6.5	1.2	1.8	3
6.5	1.2	2	2
6.5	1.2	2.2	1
6.5	1.4	1	7
6.5	1.4	1.2	3
6.5	1.4	1.4	2
6.5	1.4	1.6	1
6.5	1.4	1.8	0
6.5	1.4	2	0
6.5	1.4	2.2	0
6.5	1.5	1	3
6.5	1.5	1.2	3
6.5	1.5	1.4	1
6.5	1.5	1.6	0
6.5	1.5	1.8	0
6.5	1.5	2	0
6.5	1.5	2.2	0
7	1	1	16
7	1	1.2	14
7	1	1.4	10
7	1	1.6	7
7	1	1.8	6
7	1	2	6
7	1	2.2	5
7	1.2	1	9
7	1.2	1.2	5
7	1.2	1.4	4
7	1.2	1.6	3
7	1.2	1.8	2
7	1.2	2	1
7	1.2	2.2	1
7	1.4	1	3
7	1.4	1.2	3
7	1.4	1.4	1
7	1.4	1.6	0
7	1.4	1.8	0
7	1.4	2	0
7	1.4	2.2	0
7	1.5	1	3
7	1.5	1.2	1
7	1.5	1.4	0
7	1.5	1.6	0
7	1.5	1.8	0
7	1.5	2	0
7	1.5	2.2	0

Appendix 2: Design Drawings



SYSTEM 1	
L	9m
W	1m
D	1.2m
X	9m

SYSTEM 2	
L	11.5m
W	1.2m
D	1m
X	8m

WARNING

BEWARE OF UNDERGROUND SERVICES

THE LOCATION OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT LOCATION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

0 2 5 10 15 20

SCALE 1:200

INFILTRATION SYSTEM

MELBOURNE ONE CALL SYSTEM DIAL 1100 DIAL BEFORE YOU DIG

LEGEND	
—S— Ex SEWER	Ex DRAINAGE
—W— Ex WATER	Ex DRAINAGE PIT
—G— Ex GAS	
—T— Ex TELSTRA	
—E— Ex ELECTRICITY	

NORTH

YARRA RANGES SHIRE COUNCIL
LITTLE STRINGYBARK CREEK PROJECT

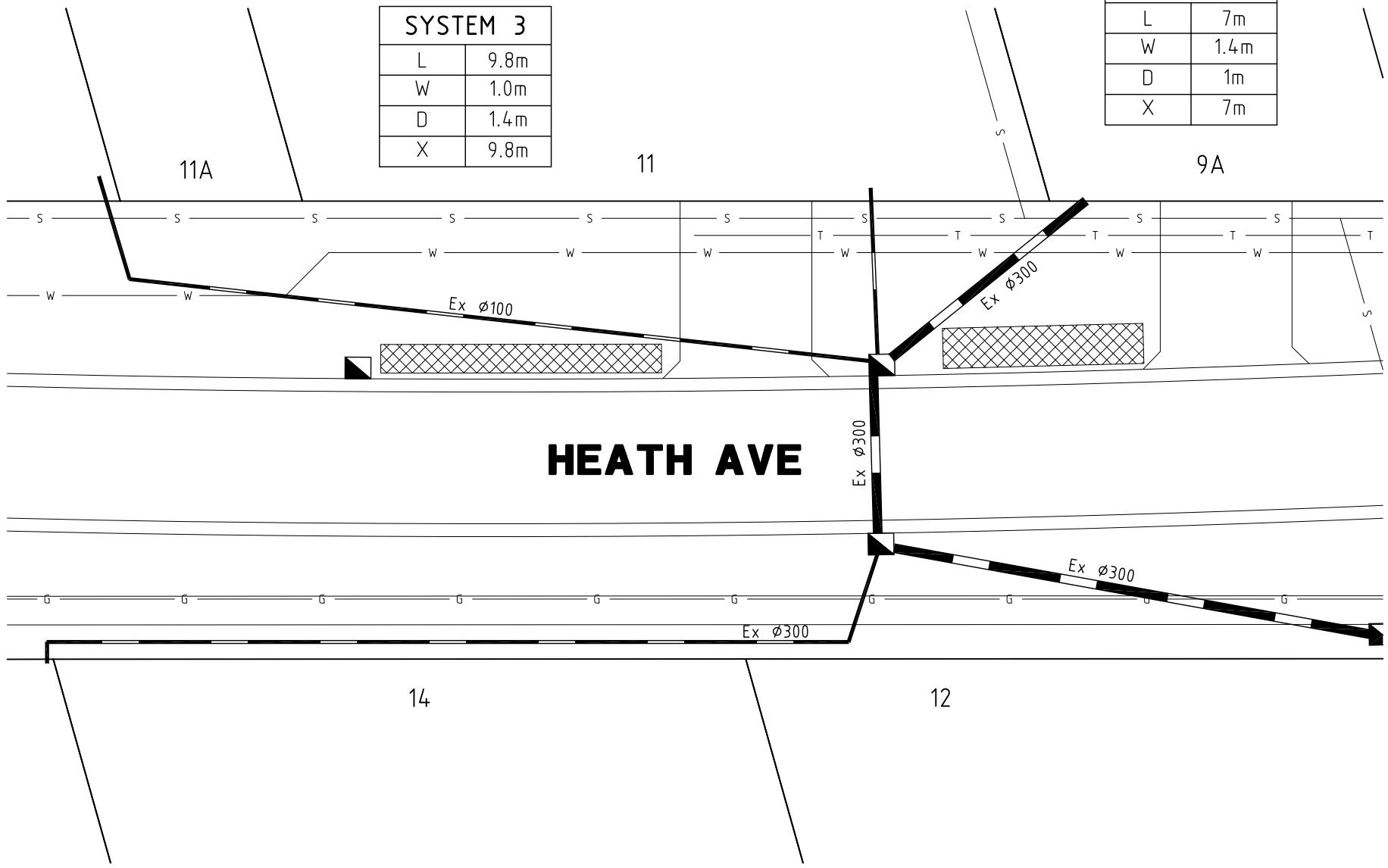
LAYOUT PLAN 1

DRAWN: RE	DATE: 25/5/2008
DESIGNED: RE	SCALE: 1:200@A3
CHECKED: -	DRAWING: SBC-001-A

SYSTEM 3	
L	9.8m
W	1.0m
D	1.4m
X	9.8m

SYSTEM 4	
L	7m
W	1.4m
D	1m
X	7m

INFILTRATION SYSTEM



0 2 5 10 15 20

SCALE 1:200

MELBOURNE ONE CALL SYSTEM
DIAL 1100
DIAL BEFORE YOU DIG

WARNING

BEWARE OF UNDERGROUND SERVICES

THE LOCATION OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT LOCATION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

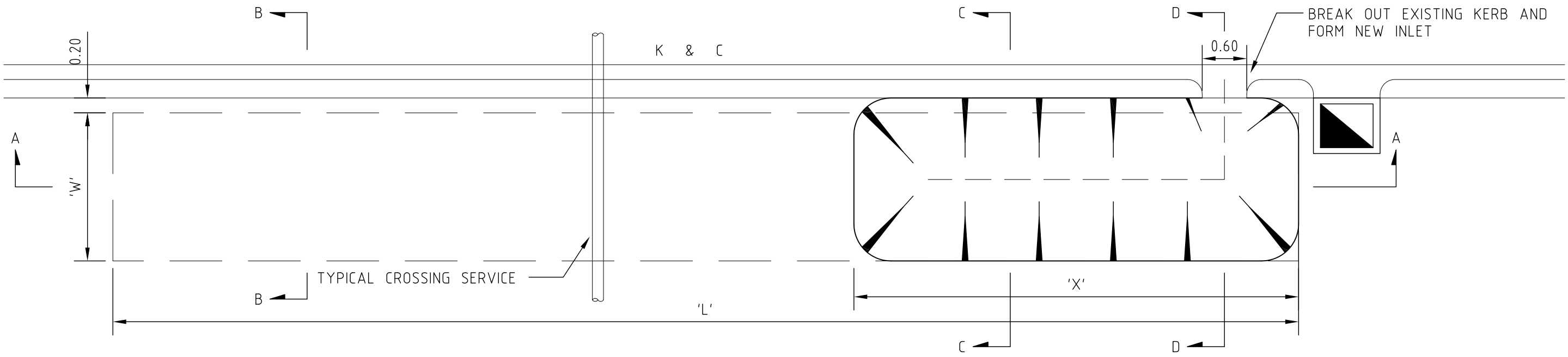
LEGEND	
—S— Ex SEWER	Ex DRAINAGE
—W— Ex WATER	Ex DRAINAGE PIT
—G— Ex GAS	
—T— Ex TELSTRA	
—E— Ex ELECTRICITY	

NORTH

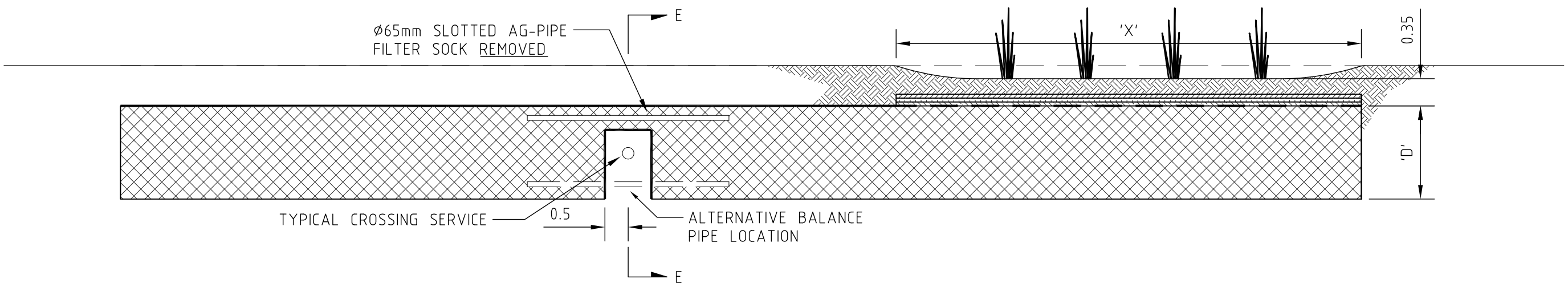
YARRA RANGES SHIRE COUNCIL
LITTLE STRINGYBARK CREEK PROJECT

LAYOUT PLAN 2

DRAWN: RE	DATE: 25/5/2008
DESIGNED: RE	SCALE: 1:200@A3
CHECKED: -	DRAWING: SBC-002-A



PLAN



SECTION A-A

LEGEND			NORTH			
— — EXISTING SURFACE	PVC LINER			**YARRA RANGES SHIRE COUNCIL**	DRAWN RE	DATE 25/5/2008
——— FINISHED SURFACE	— — SHADE CLOTH			**LITTLE STRINGYBARK CREEK PROJECT**	DESIGNED RE	SCALE N.T.S.
				INFILTRATION SYSTEM DETAIL PLAN AND LONGITUDINAL SECTION	CHECKED -	DRAWING SBC-003-A

NOTES

GENERAL

1. INFILTRATION SYSTEMS ARE TO BE PROTECTED FROM STORMWATER FLOWS UNTIL CONSTRUCTION AND SITE CLEANUP IS COMPLETE USING A GRAVEL SAUSAGE FILTER OR SIMILAR

INLET

2. NEW INLET IS TO FORMED SIMILAR TO EXISTING S.E.P. INLETS

PONDING AREA

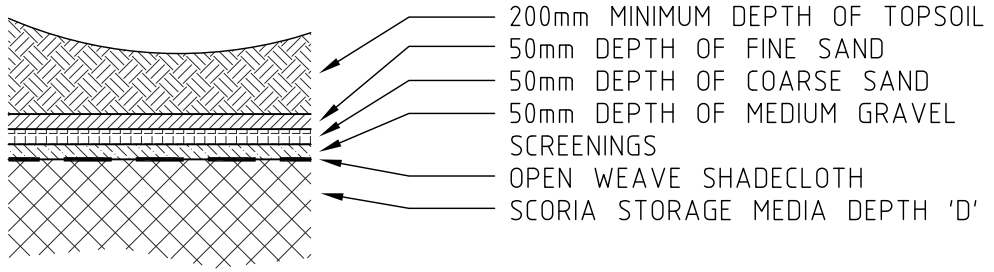
3. THE INVERT LEVEL OF THE PONDING AREA IS TO BE A CONSTANT 100mm BELOW THE INVERT LEVEL OF THE KERB AT THE INLET
4. THE PONDING AREA IS TO BE VEGITATED WITH SEDGES SUCH AS CAREX APPRESSA

STORAGE AREA

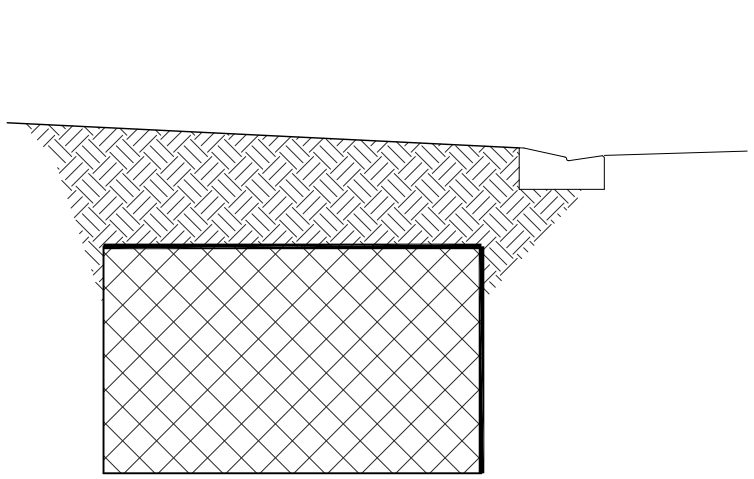
5. STORAGE AREAS ARE TO BE LINED WITH AN APPROPRIATE PVC LINING WHERE SPECIFIED IN THE DRAWINGS

CROSSING SERVICES

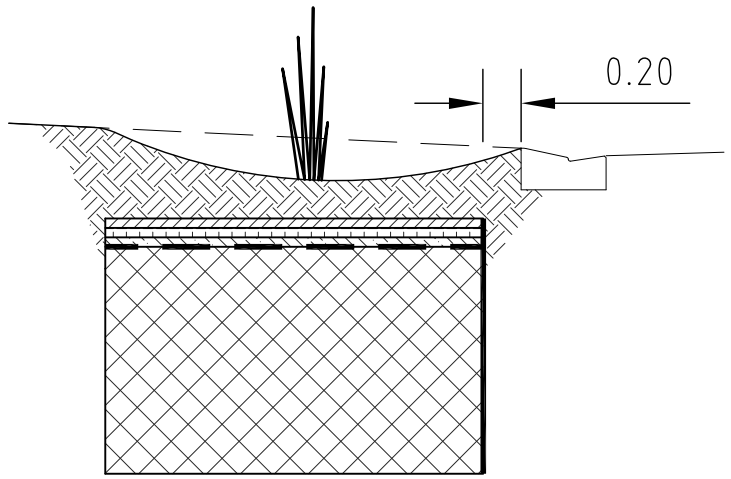
6. THE LOCATION OF ALL SERVICES MUST BE PROVEN ON SITE
7. SEWER & WATER TO BE ACCOMODATED AS DRAWN
8. ALL AG-PIPE MUST HAVE THE FILTER SOCK REMOVED PRIOR TO INSTALLATION



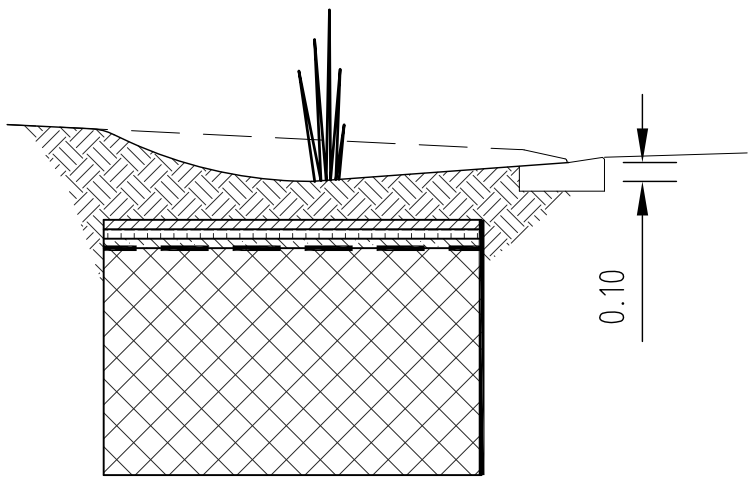
FILTER SOIL PROFILE



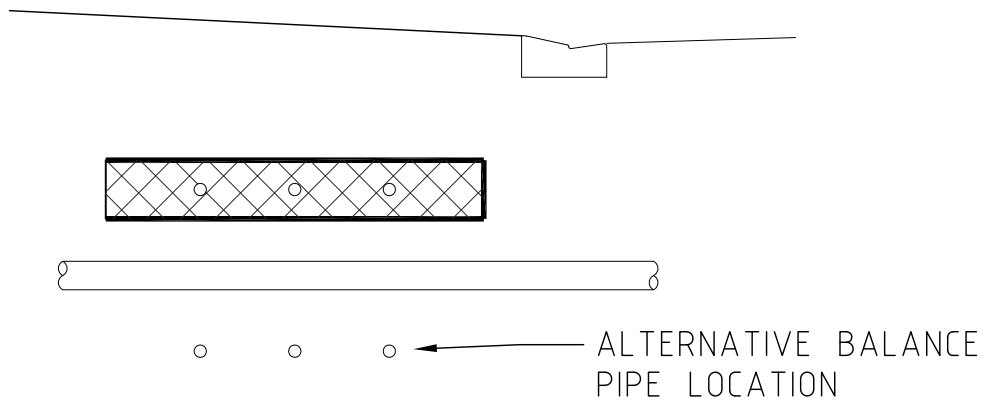
SECTION B-B



SECTION C-C



SECTION D-D



SECTION E-E

LEGEND			NORTH	YARRA RANGES SHIRE COUNCIL LITTLE STRINGYBARK CREEK PROJECT	DRAWN: RE	DATE: 25/5/2008
— — EXISTING SURFACE	——— PVC LINER				DESIGNED: RE	SCALE: N.T.S.
——— FINISHED SURFACE	— — SHADE CLOTH			INFILTRATION SYSTEM DETAIL NOTES AND CROSS SECTIONS	CHECKED: -	DRAWING: SBC-004-A

Appendix 3: Service Location Plans

Yarra Valley Water
Water Plan

Dial Before You Dig Sequence No.

13502888

Address	NEWTON AVENUE MT EVELYN 3796
Melway Ref.	118B10
Date	31/03/2008

0 25 30
metres

Yarra Valley Water

www.dialbeforeyoudig.com.au DIAL1100 BEFORE YOU DIG

Existing Title	Chlorination Point	Scour, Pump	Hydrant Above Ground Council
Proposed Title	Flow Meter	Manhole	Hydrant Above Ground - YVW
Abandoned Water Main	Dialysis Patient	Reducer/Taper	Hydrant Above – YVW/Council
Existing Water Main	Electrolysis	Change of Pipe	Valve Controlled Hydrant
Offset Water Main	Mains not Connected	Strainer	Hydrant Below Ground Council
Depth of Water Main	Large Main Record Set	Trunk Service	Hydrant Below Ground - YVW
Conduit in Main	Blank End	Particle Dispersion	Hydrant Below – YVW/Council

Yarra Valley Water Water Plan

Dial Before You Dig Sequence No.

13502888

Address	NEWTON AVENUE MT EVELYN 3796
Melway Ref.	118C10
Date	31/03/2008

0 25 30
metres

Yarra Valley Water

www.dialbeforeyoudig.com.au DIAL 1100 BEFORE YOU DIG

Existing Title	Chlorination Point	Scour, Pump	Hydrant Above Ground Council
Proposed Title	Flow Meter	Manhole	Hydrant Above Ground - YVW
Abandoned Water Main	Dialysis Patient	Reducer/Taper	Hydrant Above – YVW/Council
Existing Water Main	Electrolysis	Change of Pipe	Valve Controlled Hydrant
Offset Water Main	Mains not Connected	Strainer	Hydrant Below Ground Council
Depth of Water Main	Large Main Record Set	Trunk Service	Hydrant Below Ground - YVW
Conduit in Main	Blank End	Particle Dispersion	Hydrant Below – YVW/Council

Yarra Valley Water

Sewer Plan

Dial Before You Dig Sequence No.

13502888

Address	NEWTON AVENUE MT EVELYN 3796
Melway Ref.	118B10
Date	31/03/2008

0 25 30
metres

Yarra Valley Water

www.dialbeforeyoudig.com.au DIAL1100 BEFORE YOU DIG

Existing Title		Circular Access Point		Inspection Shaft	
Proposed Title		Junction		End of Pipe	
Existing Sewer		Gas Check Manhole		Maintenance Shaft	
Abandoned Sewer		Square Manhole		Long Branch Reducer	
Offset Distance		Rectangle Manhole		Pump Station	
Change of Grade		Chambered Manhole		Ventilation	

Yarra Valley Water

Sewer Plan

Dial Before You Dig Sequence No.

13502888

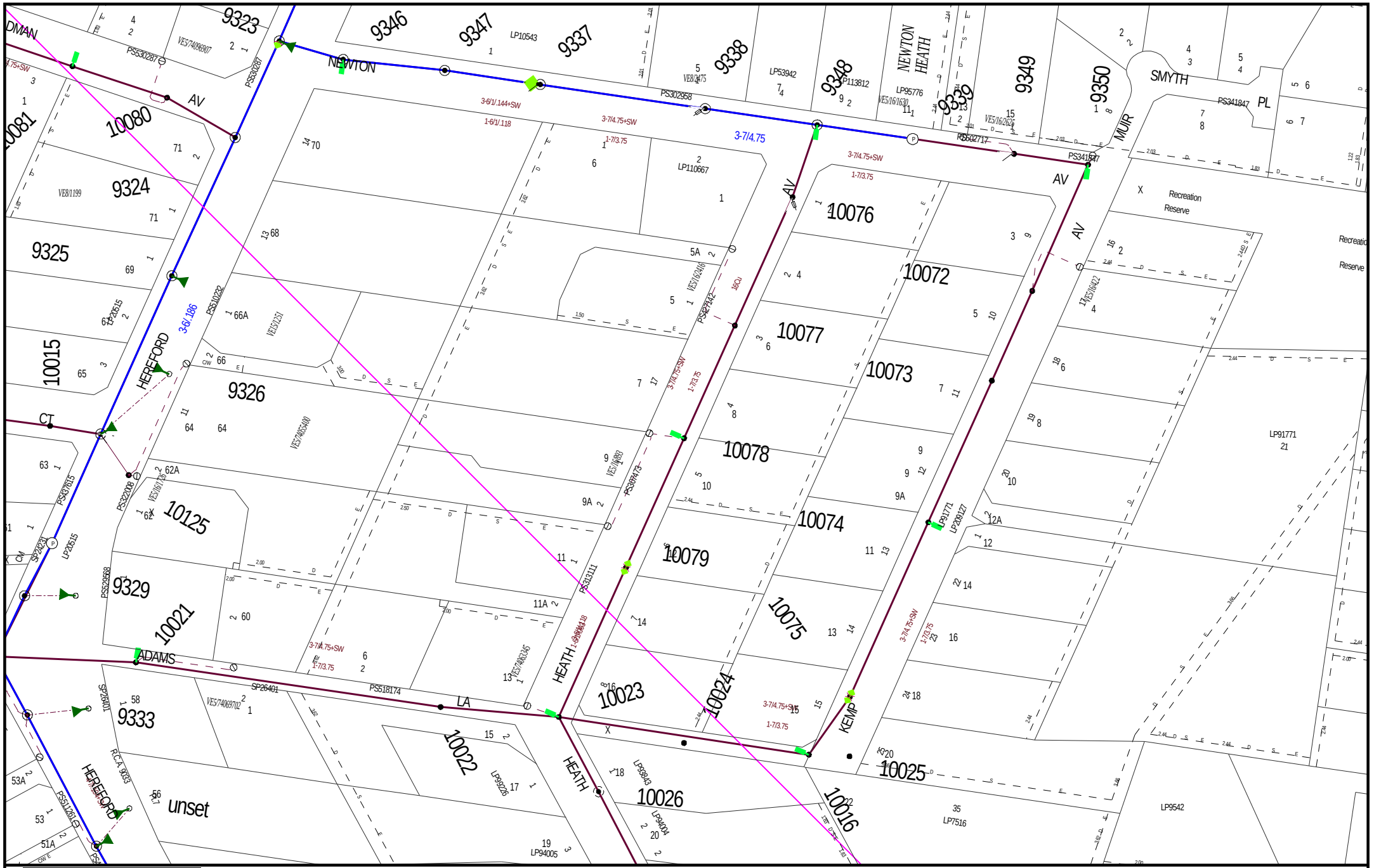
Address	NEWTON AVENUE MT EVELYN 3796
Melway Ref.	118C10
Date	31/03/2008

0 25 30
metres

Yarra Valley Water

www.dialbeforeyoudig.com.au DIAL1100 BEFORE YOU DIG

Existing Title		Circular Access Point		Inspection Shaft	
Proposed Title		Junction		End of Pipe	
Existing Sewer		Gas Check Manhole		Maintenance Shaft	
Abandoned Sewer		Square Manhole		Long Branch Reducer	
Offset Distance		Rectangle Manhole		Pump Station	
Change of Grade		Chambered Manhole		Ventilation	



www.dialbeforeyoudig.com.au

DIAL 1100 BEFORE YOU DIG

0 72 m

Print Date: 31/03/2008

SP AusNet
A member of Singapore Power Group

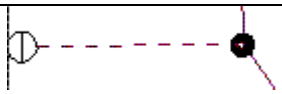
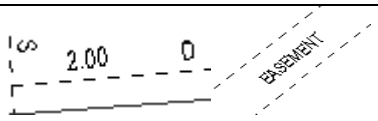
N NW NE W E SW SE S

Melway 118 B10
Vic Roads 79 H6
ESMAP 682 H11
Yarra 2,500/25.14

AMG Extents:

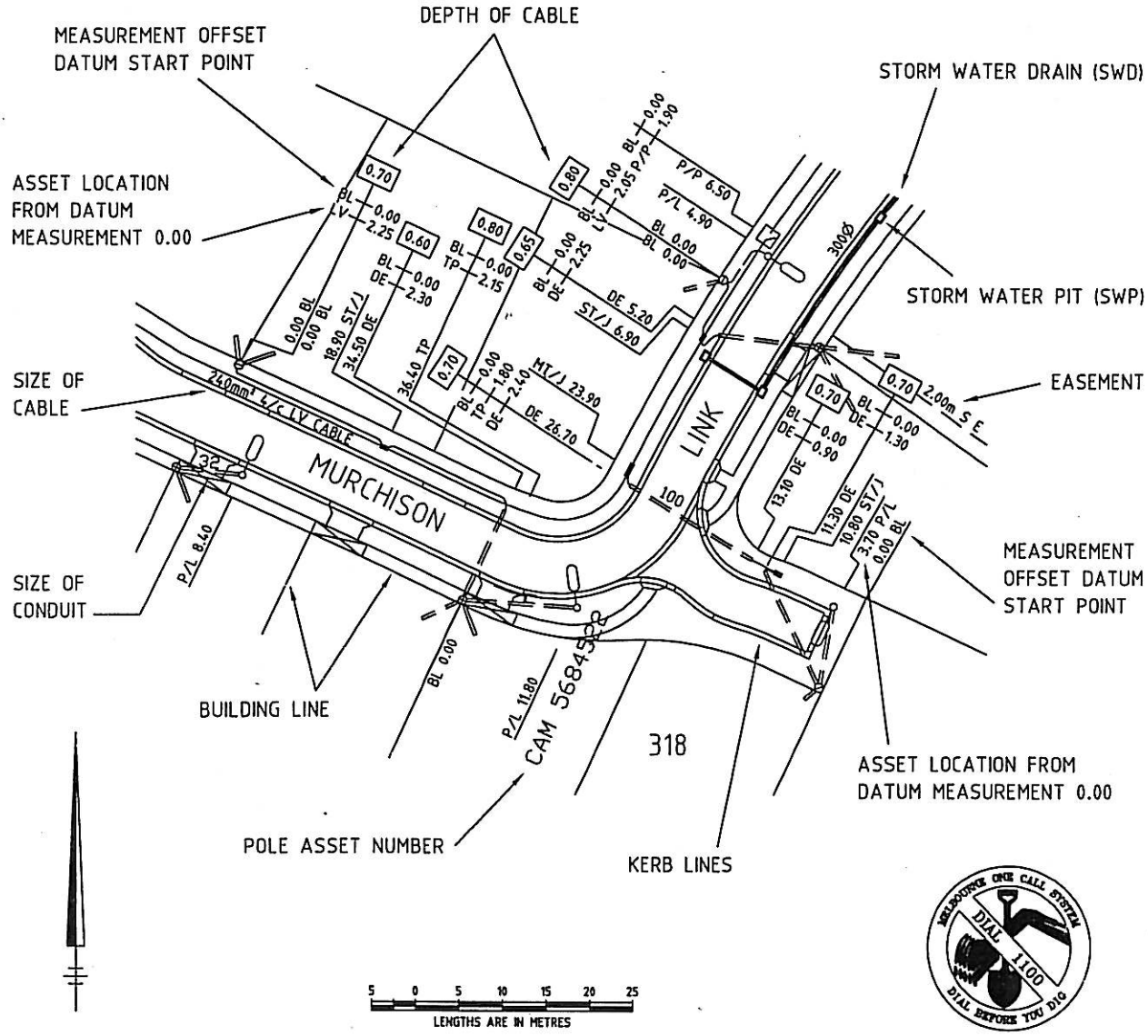
SW:	357228 E	5817239 N
NE:	357649 E	5817510 N

AMFM LEGEND

SYMBOL	NAME
	HV/LV Pole
	22kV HV Pole, 66kV Pole
	LV Pole
	LV Overhead Line
	HV and LV Overhead Line HV Earthing Overhead Line
	Substation Pole, Kiosk Substation, Indoor Substation, Ground Type Substation
	Open Point in Overhead Line, Isolating Device
	Underground Cable
	Underground Street Lighting
	Street Lights
	Pit
	Pole to Pit
17525 unset	An example of a Pole Number A Pole that is Unset has no number
PS520714	An example of a Plan of Subdivision Number
MARKET MAROONDAH	An example of a Substation Name
	Easements

An AM/FM plot is an overall plan of the area you specified in your Dial Before You Dig enquiry that shows the **approximate** location of our overhead and underground assets. North point, scale and street directory references are provided at the bottom of the page.
This plan is to be used as a guide only.

INTERPRETING UNDERGROUND CABLE DRAWINGS



LEGEND

- UNDERGROUND CABLE
- PUBLIC LIGHTING CABLE
- STRAIGHT JOINT (S/J)
- LV MAINS TEE JOINT (MT/J)
- LV SERVICE TEE JOINT (ST/J)
- INSULATED END
- SEALED END
- U/G CABLE CUT END
- CABLE CONDUIT (125 = 125mm Dia.)
- STEEL COLUMN & PUBLIC LIGHT
- CABLE HEAD POLE:-
- SERVICE PIT
- PARALLELING PILLAR
- LOT NUMBER
- SUBTRANSMISSION POLE
- HV/LV POLE
- HV POLE
- LV POLE
- SINGLE POLE SUBSTATION
- HV CABLE TERMINATION
- LV CABLE TERMINATION

(E)	EXISTING
(N)	NEW
FUT	FUTURE
P/L	PUBLIC LIGHTING
TP	TANGENT POINT
DE	DUCT END
BL	BUILDING LINE
BOK	BACK OF KERB

SP AusNet™
A member of Singapore Power Group

AUTOCAD A4

A4