COMPARISON OF INFILTRATION BASIN PERFORMANCE FOR DESIGN AND HISTORICAL RAINFALL EVENTS

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ABSTRACT

Infiltration basins are one of the key elements from a suite of Low Impact Urban Design Devices which treat and dispose of urban stormwater runoff. The design runoff volume that is disposed of by infiltration varies from the minimum First Flush (FF) or Water Quality (WQ) Volume through to the total runoff volume from the design event. In this paper, recorded rainfall data are used to quantify the relationship between infiltration basin volume and the performance of the infiltration basin in terms of, volume of runoff treated, time spent by stormwater in the infiltration basin and the statistical significance of overflow events. The volume of the infiltration basin was varied to match the numerous volumes required for various design events.

The difference in basin performance in response to historical as opposed to design rainfall events is assessed and discussed. Statistical analyses performed on historical rainfall records were used to identify the Average Recurrence Interval (ARI) of events that were equivalent to their design ARI event counterpart. Both equivalent rainfall events were run through a purpose-built model to highlight differences in infiltration basin performance.

KEYWORDS

Infiltration basin, rainfall, stormwater design, Low Impact Urban Design

1 INTRODUCTION

Stormwater treatment systems are typically designed to achieve a level of service in response to a particular event without necessarily being assessed on how the system will respond to different events. More in-depth analysis of performance in response to a range of rainfall events can be time-consuming and is generally considered unnecessary, particularly for design events of short duration and/or low Average Recurrence Interval (ARI).

In this paper the performance of an infiltration basin, designed using Christchurch City Council (CCC) methodologies, is tested when subjected to a broad range of rainfall events, provided here by a time series of historical rainfall data. The analysis is split into two parts, namely:

1. Analysis of the recorded rainfall using MATLAB to split the data into discrete events that could be compared to design rainfall events of similar ARI;

2. Sizing of stormwater infiltration basins using CCC methods, followed by an analysis of infiltration basin performance when subjected to an historical 50-year record of rainfall.

To perform this analysis, the runoff response to rainfall on a fully impervious site of one hectare in area was simulated. The assumption of a fully impervious site allows for the losses to be minimised so that these do not impact on the analysis. This simplifies the analysis and removes potential effects that loss model selection could have on end outcomes. A fully impervious site is reasonably representative of a commercial/industrial site.

All runoff from the one hectare impervious area was routed through an infiltration basin, the size of which was determined by the event/guidelines used in sizing. Figure 1 shows the conceptual model of the rainfall to infiltration basin process.

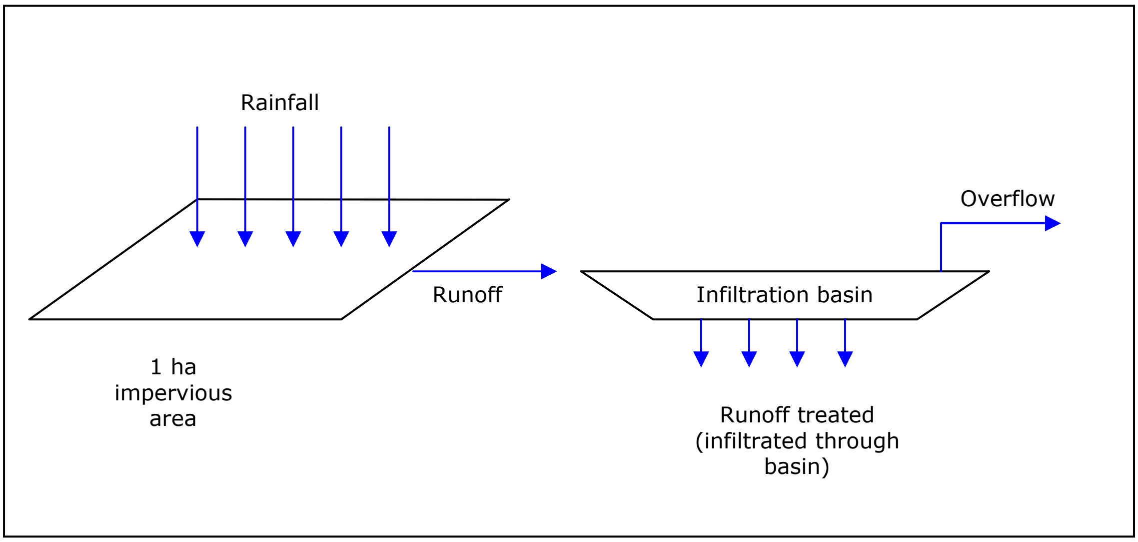

Figure 1: Conceptual model of the rainfall to infiltration basin process

2 CURRENT INFILTRATION BASIN DESIGN PRACTICES

2.1 CHRISTCHURCH CITY COUNCIL INFILTRATION BASIN DESIGN

The current approach to sizing an infiltration basin within the Christchurch City area involves construction of a design rainfall hyetograph to estimate the runoff from the contributing catchment. The hyetograph is generated from rainfall intensities prepared for CCC by NIWA (NIWA, 2009). Figure 2 shows a dimensionless rainfall hyetograph generated using the CCC design approach. Runoff from the contributing catchment in response to this design rainfall is then used in sizing the infiltration basin.

As can be seen from Figure 2, the design hyetograph has a triangular profile. The peak intensity is double the average intensity over the event. The peak intensity is located at 0.7*(the event duration).

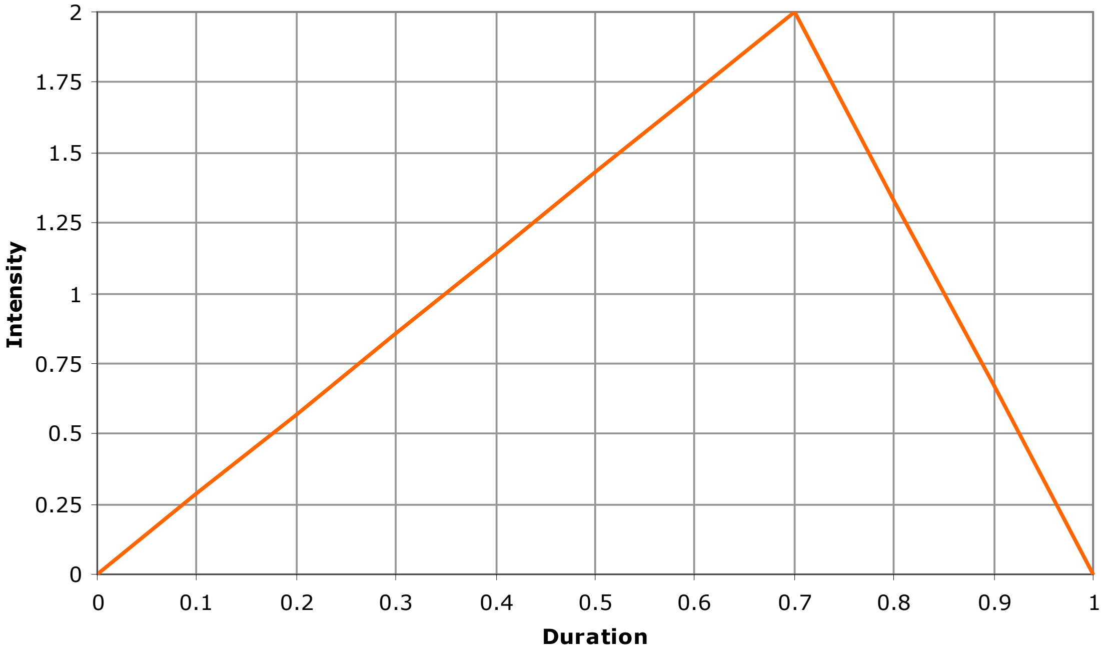

Figure 2: Dimensionless CCC rainfall hyetograph profile (CCC, 2003)

To design an infiltration basin, PDP typically identify the critical rainfall event or rainfall event to be treated/attenuated and create a rainfall hyetograph with the profile shown in Figure 2. Rainfall is converted to runoff (by an appropriate technique) and routed through the infiltration basin model. The size of the infiltration basin is increased/decreased to obtain the minimum volume that is capable of treating the chosen rainfall event.

2.2 FIRST FLUSH DESIGN APPROACH

CCC's Waterways, Wetlands and Drainage Guide (WWDG) (CCC, 2003) recommends that the first flush depth captured should not be less than 15 mm and ideally a first flush depth of 25 mm should be captured. The first flush volume is calculated by taking the first flush rainfall depth (usually 25 mm) and multiplying it by the impervious area within the contributing catchment.

3 MODELLING

3.1 ORIGIN OF STUDY

As part of work conducted for the Selwyn District Council (SDC), Pattle Delamore Partners Limited (PDP) carried out modelling to advise on the performance of infiltration basins in the Selwyn district. Given the availability of long term rainfall records from Christchurch Airport and the Christchurch Botanical Gardens, a model was developed for SDC to evaluate the performance of a hypothetical infiltration basin. SDC's aim was to be able to advise developers on the sizing of stormwater treatment devices for future developments.

The results presented in this paper are a continuance and expansion of the work undertaken for SDC.

3.2 MATLAB SOFTWARE

MATLAB can be described as "a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation."[1] The simplified model setup and the level of customisation that is available with MATLAB, both in terms of passing inputs and obtaining outputs, made it well suited to the task.

3.3 MODEL SETUP

The model was set up to estimate runoff, infiltration basin volume, disposal volume (by infiltration) and overflow at each time step. Hourly rainfall data were obtained for the MATLAB model, which uses hourly time steps to evaluate the infiltration basin characteristics. By assuming an entirely impervious surface, all rainfall becomes runoff; the model essentially conducts a volume calculation at each time step, taking into account the previous volume of water in the infiltration basin, runoff and volume infiltrated. This is shown in Equation 1 below.

$$\text{Volume in Basin}(t) = \text{Volume in Basin}(t-1) + \text{Runoff}(t) - \text{volume infiltrated }(t)$$

Equation 1

Where t = hour

The volume infiltrated and the volume in the infiltration basin are calculated using equations developed within the MATLAB code. The MATLAB code allows these equations to be modified as required to test different parameters such as infiltration basin depth and infiltration rate.

While the above represents an arguably unrealistic situation, the analyses revealed results at one extreme of those likely to be encountered in a real situation. This enables rapid assessment of order-of-magnitude basin performance for initial sizing calculations. At a detailed design stage more in-depth analyses would clearly be required.

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[1] Obtained from http://www.mathworks.com/products/matlab/description1.html on the 4/3/2011

4 MODELLING PARAMETERS

4.1 RAINFALL

This study used two sets of rainfall data. The first dataset was from a rainfall recorder located at Christchurch Botanical Gardens in the central city. The second data set was from a rain gauge located at the Christchurch International Airport on the western outskirts of the city. Both rain gauges are tipping buckets and are accurate to 0.2 mm of rainfall.

The Airport and Botanical rainfall datasets begin on 1 April 1960 and 1 January 1962 respectively, and both run through to 1 January 2011. This provides approximately 430,000 readings for each of the sites.

4.2 INFILTRATION BASIN DESIGN

For this study a standard infiltration basin design was used. This design is commonly adopted by PDP in the conceptual sizing and design of infiltration basins for industrial and residential developments. It is assumed for the modelling that the infiltration basin has:

- a square surface area with side slopes 4:1 (H:V);
- an infiltration rate of 20 mm/hr through its base and sides; and
- a maximum water depth of 1 m.
- First flush/water quality design depth of 25 mm unless otherwise stated

Using this standard design, the infiltration basin's treatment performance over the historical data range was assessed for a number of different infiltration basin volumes. This allowed comparison with intended performance based on the design event methodology.

The assumption of infiltration through the sides of the basin implies that the infiltration basin is located in well draining natural strata. If under drainage is required then it would be better to assume infiltration through the base of the infiltration basin only.

5 PERFORMANCE OF INFILTRATION BASINS

5.1 HISTORICAL RAINFALL VERSUS SYNTHETIC RAINFALL

Historical rainfall events were matched to their synthetic counterparts. Historical events were defined by finding equivalent rainfall depths over the same duration and ARI. Matlab code was written that summed the rainfall for every consecutive 24 hour period within the 50 year dataset and extracted those that had a depth that was equal to (or within a tolerance of 5%) the synthetic rainfall depth in the NIWA (2009) tables. The tolerance was set at 5% to ensure that some historical events were found as it is very unlikely to get a rainfall depth exactly equal to the values found in the NIWA (2009) tables. A number of historical events were identified for the 5, 10 and 20 year Average Recurrence Interval (ARI).

With each historical event extracted, a synthetically generated counterpart was then constructed using the CCC method. A number of storms were analysed to see how the infiltration basin would have performed in a typical historical event or its synthetically generated counterpart. Figure 3 and Figure 4 show a typical 5 year 24 hour historical and synthetic rainfall event.

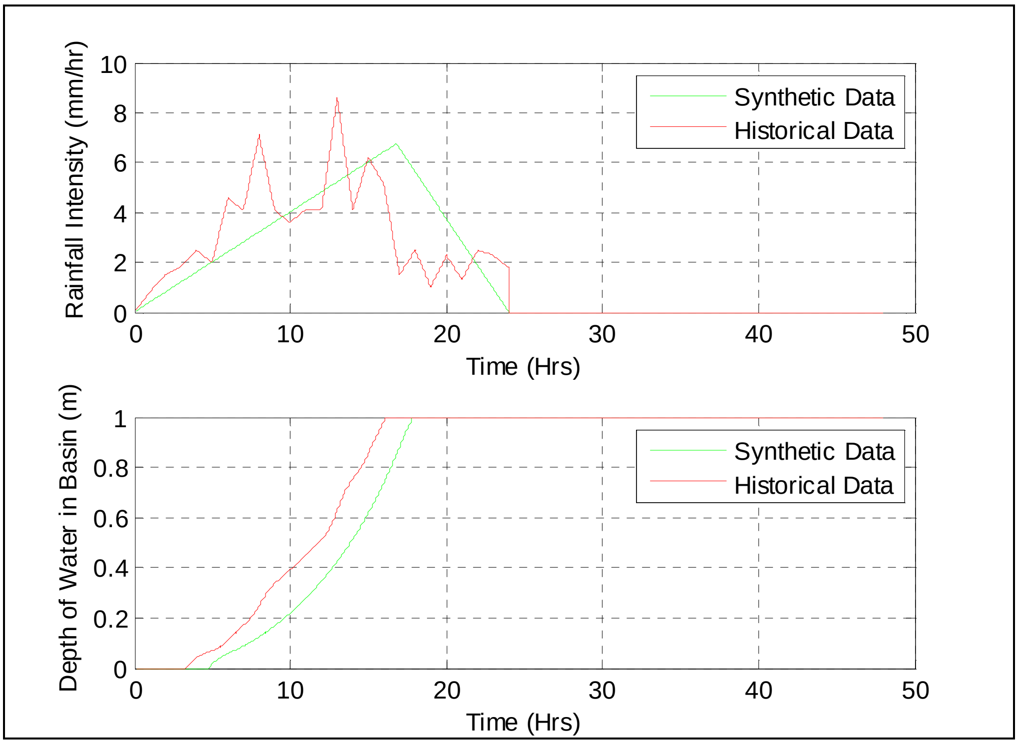

Figure 3: Rainfall intensity and infiltration basin water depth for an historical rainfall event and its synthetically generated counterpart.

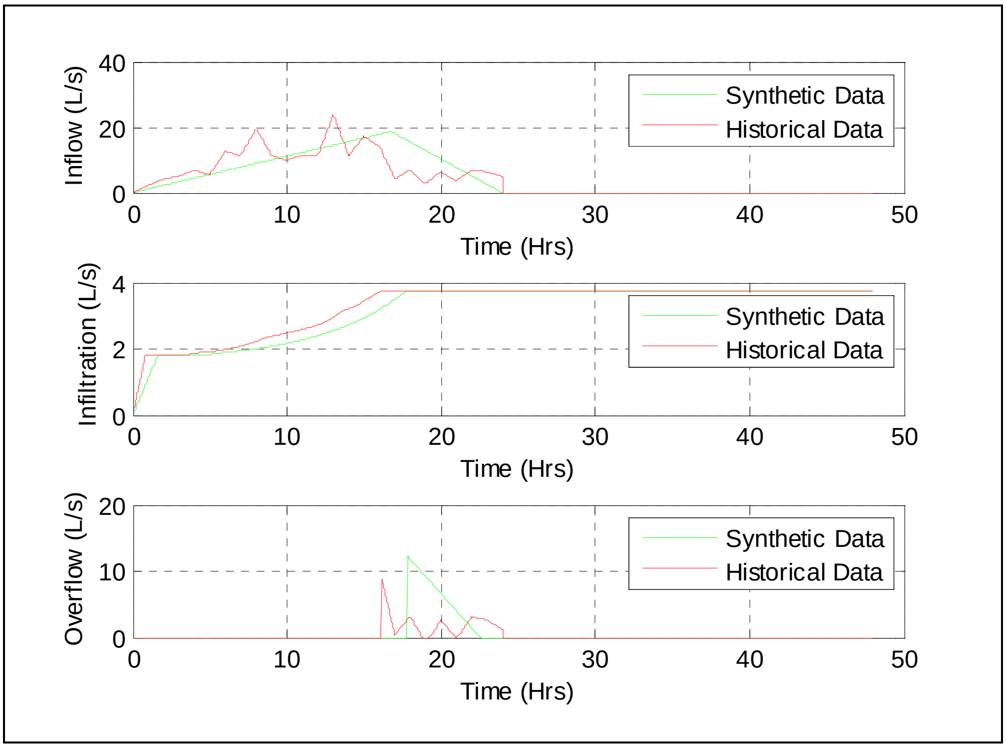

Figure 4: Basin inflow, infiltration and overflow into infiltration basin for an historical rainfall event and its synthetically generated counterpart.

By analysing the identified historical rainfall events it was generally found that although the historical events identified from the rainfall dataset generally peaked earlier in comparison to their synthetic equivalent, it made little difference to the treatment performance of the basin. It was also observed that the infiltration basin tended to have a similar infiltration profile for both the historical event and the synthetic event. As a result the infiltration profiles for the historical and synthetic events were similar. Similarly, the water depth profile within the basin was also smoothed out which resulted in similar water depth profiles within the basin. These effects can be observed in Figure 3 and Figure 4.

In conclusion, infiltration basin performance does not greatly differ for an historical event when compared to a synthetic event.

5.2 CHRISTCHURCH CITY COUNCIL DESIGN

As noted above, CCC generally requires the capture of the first flush, estimated as the runoff from the first 25 mm of rainfall. Ignoring any losses, a fully impervious one hectare site will therefore require a first flush basin with a volume of 250 m^3.

Figure 5 shows the required infiltration basin volumes for different rainfall events, designed using the process outlined in Section 2.1. Figure 5 shows a trend whereby, for all return periods, the maximum infiltration basin volume is required for a design duration of 24 hours. This is referred to as the critical event duration. As discussed later, the critical event duration is related to the design infiltration rate of the basin, 20 mm/hr in this case.

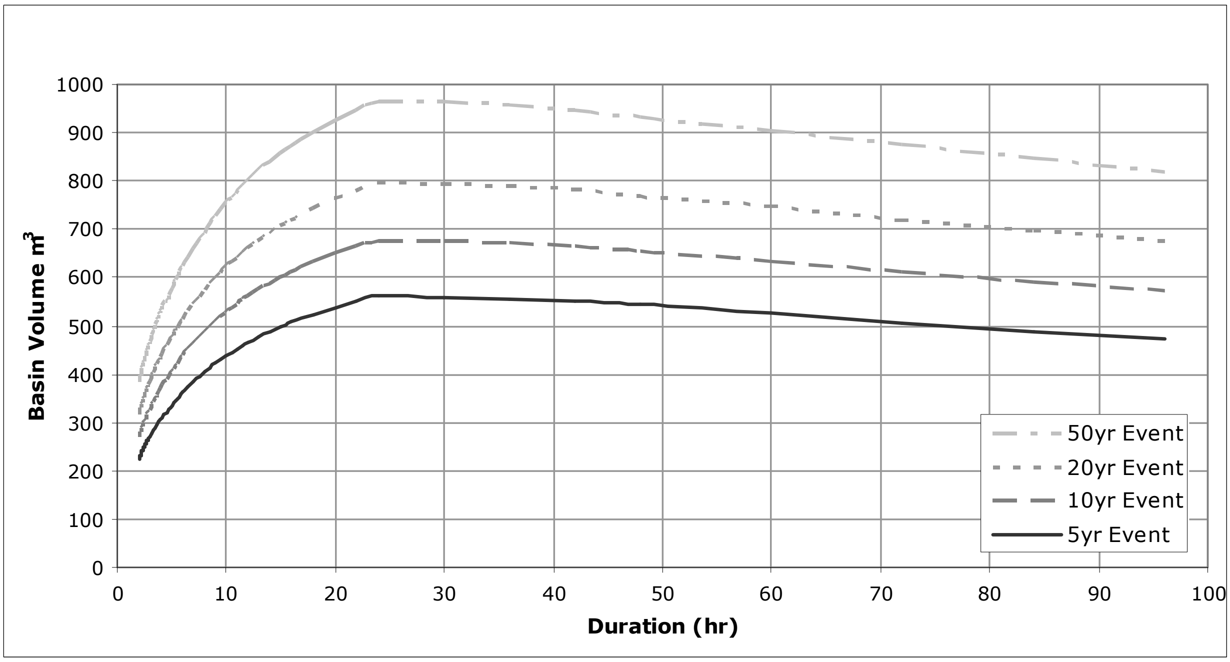

Figure 5: Infiltration basin volume required for total capture and treatment various design rainfall events (CCC hyetograph)

5.3 PERCENT OF HISTORICAL STORMWATER RUNOFF TREATED

Whilst a basin may be sized to treat a specific design event, this does not provide information on what percentage of all rainfall runoff will be treated. In this section, the results from analysing a historical rainfall record is discussed. This analysis is used to demonstrate that sizing a basin for a particular sized storm event does not accurately reflect the total amount of stormwater runoff that is treated via an infiltration basin.

Figure 6a shows what percentage of runoff would have been treated over the historical dataset for different infiltration basin volumes. Infiltration volumes are calculated using the methodology outlined in Section 2.2. As the volume of the infiltration basin increased, a greater percentage of stormwater runoff was treated. Treatment (treated water) refers to water that passes through the infiltration media, water that is not treated refers to water that overflows from the infiltration basin (as seen in Figure 1).

The data sets from Christchurch Airport and the Botanic Gardens were both analysed. Figure 6a shows that there was not a significant difference between the results for both datasets. Therefore, only results for the Botanical dataset are displayed from this point on. These results are based on an infiltration rate of 20 mm/hr through the infiltration basin.

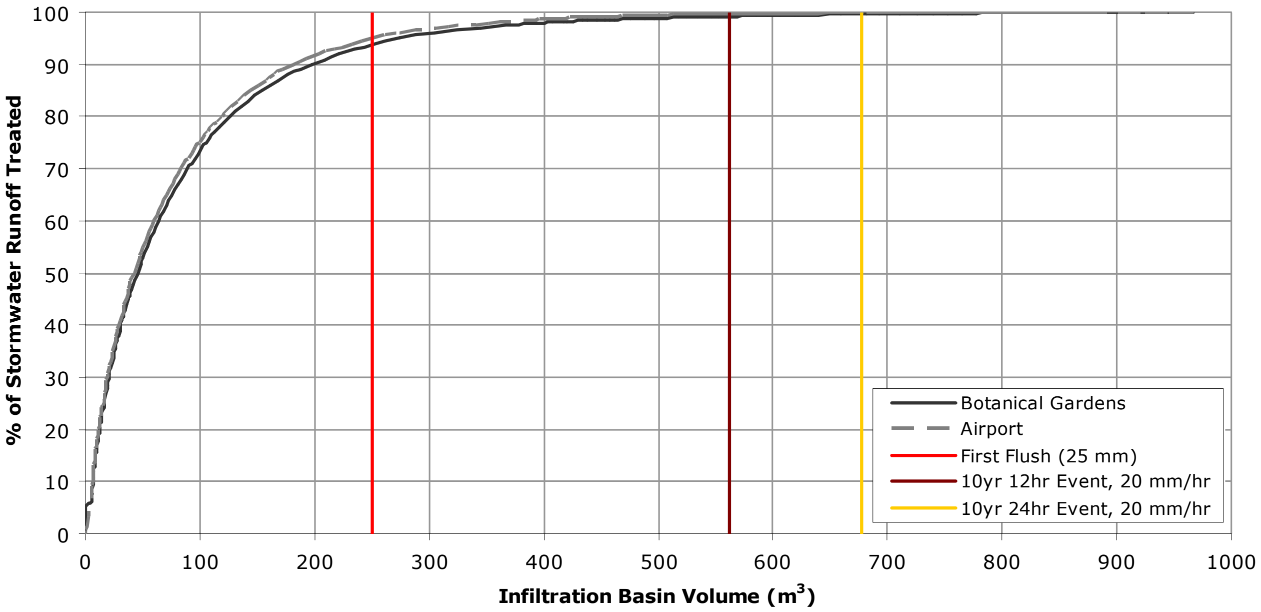

Figure 6a: Percent of runoff for entire historical dataset for various infiltration basin volumes

Figure 6b shows the percentage of runoff treated for infiltration basins of various volumes and infiltration rates. The greater the infiltration rate, the higher the percentage of runoff treated for the same volume. Note the y-axis scale has been exaggerated to better view the slight differences resulting from different infiltration rates.

As shown in Figure 6b, an infiltration basin sized for a first flush of 25 mm, infiltration rate of 20 mm/hr, would have been sufficient to capture and treat approximately 94% of all historical rainfall. Infiltration basins sized for total event detention for the 10 year 12 hour or 10 year 24 hour events would have treated over 99% of all runoff over the period of record.

Figure 6a and Figure 6b show that there are minimal gains to be made once 80% of all stormwater runoff was treated. To capture and treat 80% of all stormwater runoff would have required an infiltration basin volume of approximately 125 m^3 (infiltration rate of 20 mm/hr). Above this, diminishing returns set in and doubling the basin size to 250 m^3 (first flush capture) would have yielded the capture of a further 14% of stormwater runoff. Doubling the size again to 500 m^3 would have yielded the capture of a further 5% of stormwater runoff.

Assuming that an infiltration basin is sized to capture the first flush, it would be fair to assume performance of disposal of 95% of all stormwater runoff (via infiltration media) and removal of the majority of contaminants. Therefore excess stormwater could be disposed of via more rapid and less land-consuming methods such as soakage chambers or via disposal to surface water.

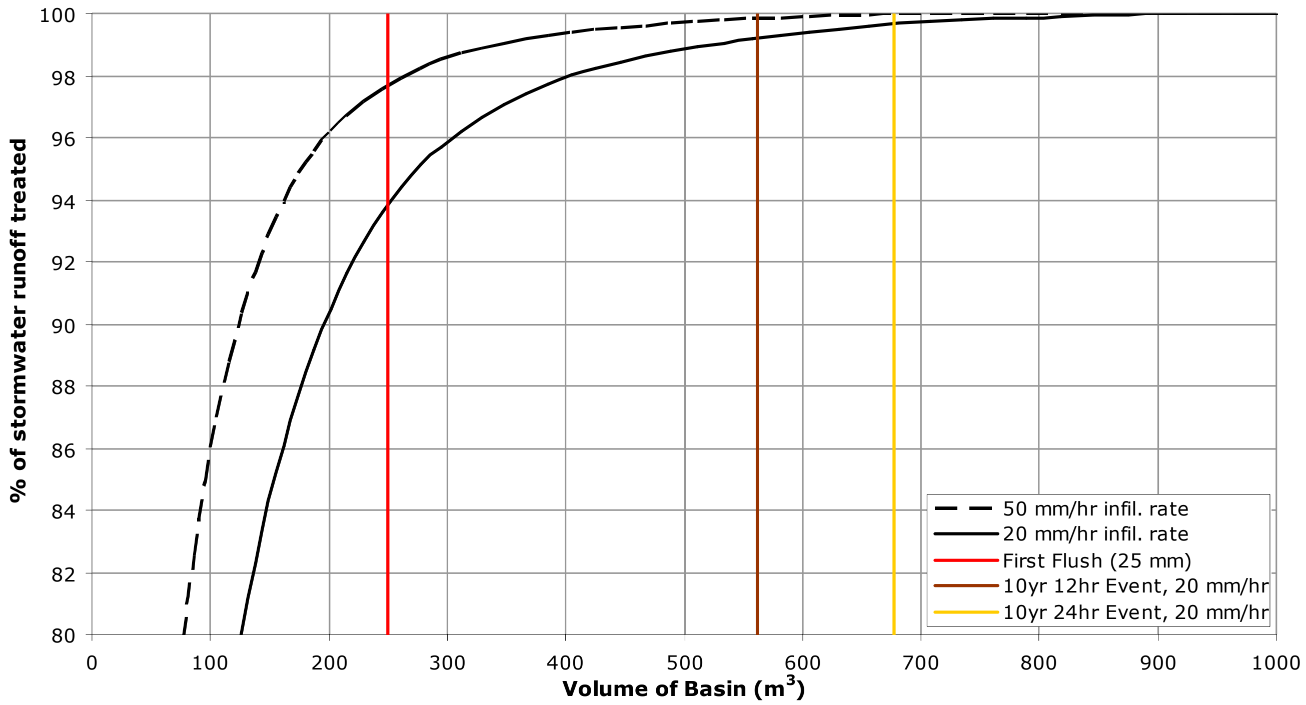

Figure 6b: Percent of runoff for entire historical botanical dataset for various infiltration basin volumes and infiltration rates

Whilst this assessment was for a fully impervious site, some conclusions can be drawn for sites with a greater proportion of pervious area. The opposite end of the spectrum – a fully pervious site (not something that stormwater structures are generally designed for, but illustrates the point well), would have no first flush basin volume (as the CCC first flush volume is calculated based on the impervious area in the catchment), however it would still receive some stormwater from the first 25 mm of rainfall as not all rainfall would infiltrate through the pervious area. As the volume of the first flush basin would be zero, the percent of stormwater runoff treated would also be zero. Therefore, the percent of stormwater treated by the first flush for a one hectare impervious subdivision is the upper bound limit, and as the perviousness of a catchment increases, the first flush basin volume would decrease as would the percent of stormwater treated.

Unfortunately, no further comment can be made on the relationship as modelling a mix of pervious and impervious areas was outside the scope of this paper due to increased complexities. However, as an example, previous work (Brough A. & Brunton R., 2010) for SDC showed that for a catchment with an impervious area of 56% a basin sized for the 25 mm first flush (water quality) depth treated 94% of all rainfall. There are however, a few points of difference between CCC and SDC design. One being that SDC includes the stormwater contribution from pervious areas when calculating the first flush volume.

More difficult to predict is how the event designed infiltration basins will perform for catchments that have a mix of both pervious and impervious areas. Since an event designed basin should account for runoff from both the pervious and impervious parts of the site, there may not be a significant difference between the results shown here for a fully impervious catchment and a catchment that has both impervious and pervious areas.

5.4 TIME THAT STORMWATER RUNOFF IS IN AN INFILTRATION BASIN

The length of time that stormwater spends in a basin can be important. In some climates, a basin that has stormwater in it for prolonged periods can potentially become a breeding ground for mosquitoes. Often basins have dual uses. Whilst their primary use is for the treatment, capture and disposal of stormwater, they can also be used for recreational purposes. Prolonged inundation of some vegetation can cause it to die-off, which reduces the potential opportunities of using the basin for recreational purposes. Furthermore, ponding water for an extended period of time after rainfall could potentially become a health and safety hazard.

For any particular rainfall pattern, the duration over which water will remain in a basin is predominantly dependent on the infiltration rate and depth of the basin. Figure 7 shows the percent of time that there was water within the infiltration basin versus the volume of the infiltration basin. For the remaining time the infiltration basin was effectively empty and was a grassed depression (potentially available for recreation).

Figure 7 shows that larger infiltration basins would have been empty for a greater portion of time. An infiltration basin designed for the 10 year 24 hour event would have been empty 95% of the time for a conservative infiltration rate of 20 mm/hr. For an infiltration rate of closer to 50 mm/hr the infiltration basin would have been empty for 98% of the time, whilst a first flush infiltration basin would have been empty 84% to 93% of the time for an infiltration rate between 20 mm/hr and 50 mm/hr. An infiltration basin that is empty for a greater proportion of time has the potential to be used for recreational purposes on a more frequent basis. Further, it also reduces the likelihood of antecedent wet conditions at the start of an event, this is discussed later.

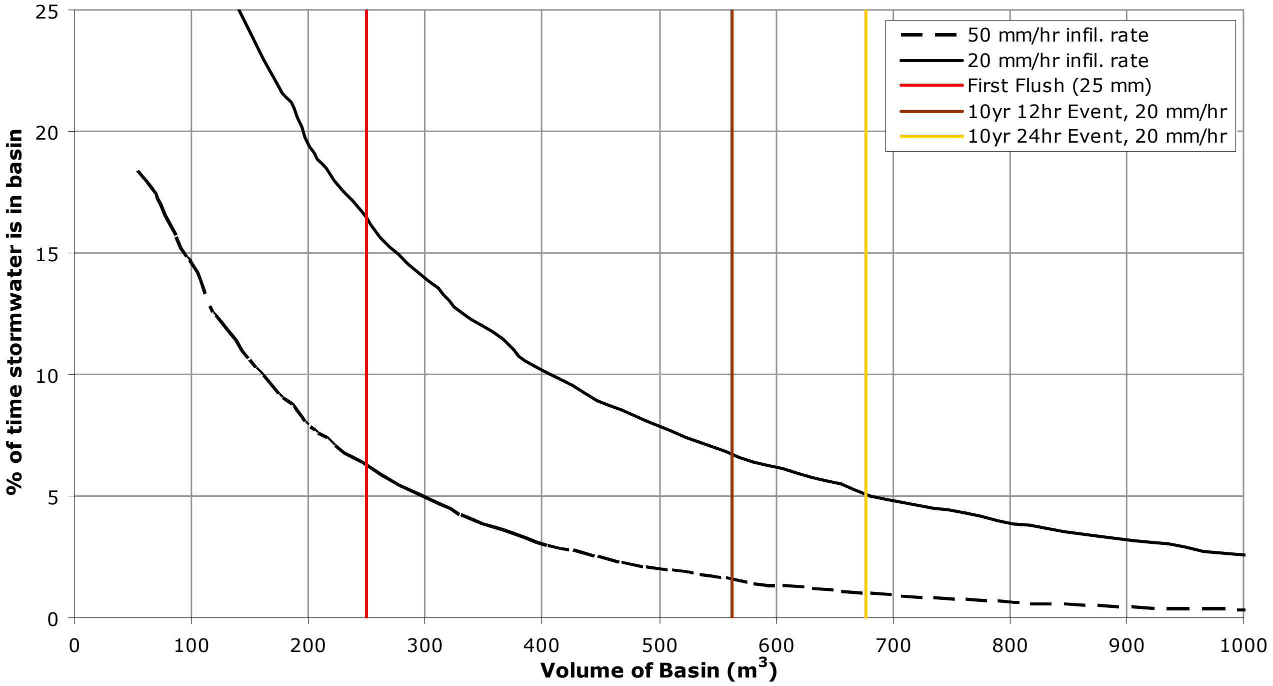

Figure 7: Percent of time, over the historical dataset, that there is standing water in the infiltration basin for various basin volumes and infiltration rates

CCC's WWDG (2003) states that inundation shall not exceed 24 hours for a detention basin located within a park or reserve and should be designed for a 20% AEP (approx. 5 year ARI event). This document also requires that for a detention basin (not in a park or reserve) 24 hours detention should be achieved with full release over 48 hours. Figure 8 shows the number of times when the infiltration basin contains water for a consecutive period of time. For example, an infiltration basin sized using the CCC method for a 10 year 24 hour event with an infiltration rate of 20 mm/hr is, on average, annually inundated once for a period of 48 hours more. Inundation refers to any time when there is water in the infiltration basin, it does not only refer to time when the infiltration basin is full. With the exception of infiltration basins designed with an infiltration rate of 10 mm/hr, a duration of 48 hours is rarely exceeded.

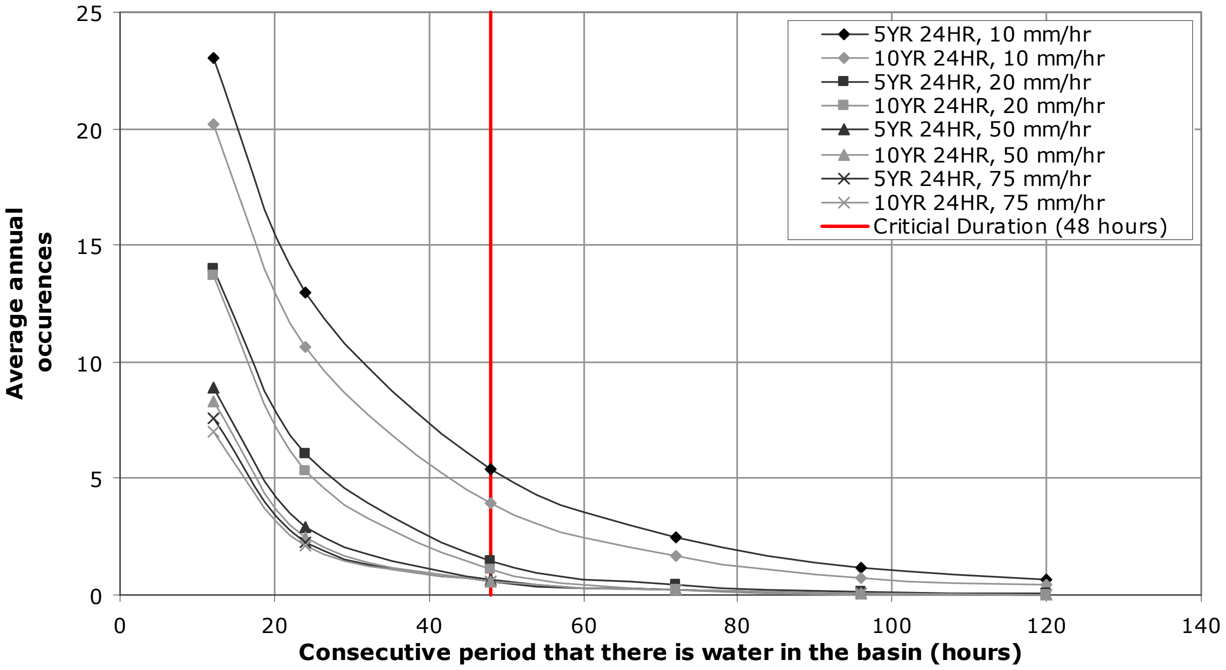

Figure 8: Average annual occurrences that water is in an infiltration basin for consecutive period of hours for an infiltration basin sized for a 10yr 5hr event

5.5 STATISTICAL SIGNIFICANCE OF OVERFLOW FREQUENCY

Statistically, an infiltration basin designed for the critical ten year event would be expected to overflow, on average, five times over a period of 50 years. However, it is statistically unlikely that exactly five 10-year events will have occurred within the 50 year botanical rainfall dataset. Table 1 and Figure 9 show the statistically expected performance of an infiltration basin compared to the actual performance.

Figure 9 shows the probability of the number of overflow events in 50 years. Table 1 shows the number of rainfall events that exceed the relative design event and the number of overflow events, all for an event of 24 hours (critical event duration).

Table 1 shows that a basin designed for the 24 hour duration, under these modelling assumptions, performs similarly to how it is statistically expected. Statistically a basin designed for a five year event of critical duration is most likely to overflow 10 times over a 50 year period. Table 1 shows that an infiltration basin designed for the 24 hour 5 year event would have overflowed as a result of 11 events in the past 50 years, the probability of this (Figure 9) is approximately 0.13. The same process applied to the other events also gives a reasonable relative probability. Basins designed for the 10, 20 and 50 year events of critical duration would have overflowed 7, 3 and 0 times respectively. The probability of this is 0.11, 0.22 and 0.36 respectively (Figure 9). This allows the conclusion that the CCC design process seems to be fairly robust and accurately reflects expectations.

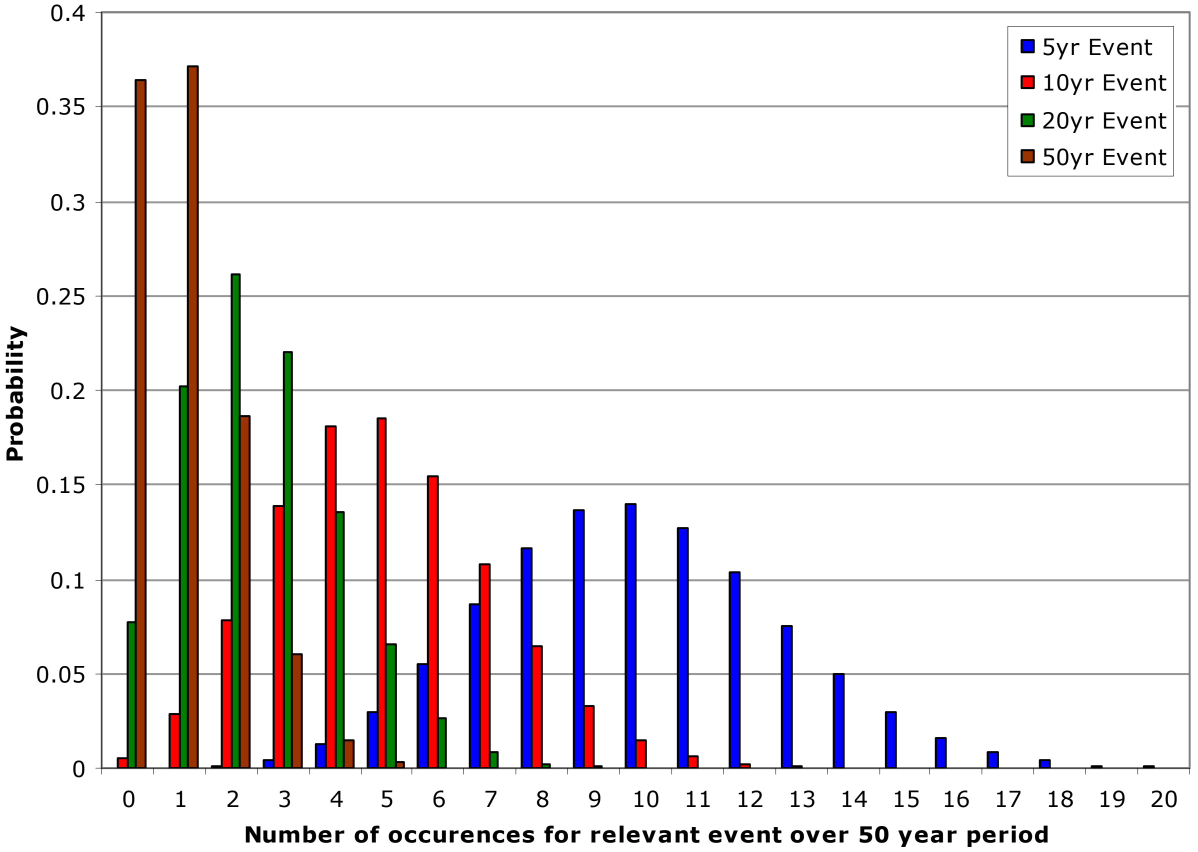

Figure 9: The probability of the number of occurrences for the respective events. (i.e. the probability that a 5 yr event will occur ten times over 50 years is 0.14)

Ideally, the number of overflow events should be compared to the number of rainfall events. If there are (within the 50 year dataset) 12 rainfall events of critical duration that exceed an ARI of ten then an infiltration basin designed for the critical duration event with an ARI of ten should overflow 12 times.

Table 1: Number of overflow event from infiltration basins and number of rainfall events exceeded, all for an event duration of 24 hours

	ARI			
	5	10	20	50
Number of times that a rainfall event is exceeded in 50 year dataset	7	5	3	0
Number of times that basin designed for event overflows in 50 year period	11	7	3	0

Table 1 shows that there are three exceedances in the 50 year dataset for the 20 year 24 hour event. An infiltration basin designed for such an event would have overflowed three times in the past 50 years and therefore it performs exactly as expected in this regard. The same conclusion can be drawn for the 24 hour, 50 year event.

However, Table 1 shows that for the smaller events (5 and 10 year) the infiltration basin overflows more often than expected. Closer inspection of the rainfall events that resulted in basin overflow showed that of the 11 overflow events, seven of these were as a result of exceedances of the 24 hour 5 year rainfall depth and are therefore to be expected. The remaining four events all had a total 24 hour rainfall depth that was less than the respective 5 year 24 hour rainfall depth. However, prior to the start of two 24 hour events, there was a considerable depth of water in the basin (> 100 mm) from previous events. The other two infiltration basin overflows was caused by very intense rainfall over a short period of time (in one case, 8 – 10 mm/hr for four consecutive hours).

This shows that whilst an infiltration basin can be designed for a specific event, due to precedent rainfall and potentially high rainfall intensities, it is possible that the infiltration basin will overflow during events that it was expected to capture and treat. Typically, it appears from this set of data that an infiltration basin for the more frequent events (5 year and 10 year) would overflow 50% more often than expected. The same statement cannot be confirmed or rejected for the less frequent events (20 year and 50 year) as the dataset is of an insufficient period to test this statement.

Whilst an infiltration basin may overflow 50% more often than was expected, this is fairly insignificant in terms of total stormwater treated. An infiltration basin designed for the 5 year 24 hour event will have a design volume of 560 m^3 (Figure 5) and would have treated over 99% of all rainfall. The 11 overflow events presented in Table 1 amount to an untreated total stormwater volume of less than 1%.

The basin designed for a 24 hour 20 year event performed as expected for a few reasons, there were less events to test it compared to the 10 year and 5 year events and, it was a bigger basin so it was able to "absorb" the higher rainfall intensities. Finally, the larger basins had less (or no) standing water (Figure 7) in them at the beginning of events due to their ability to quickly infiltrate large volumes of water.

Potentially, a catchment with some pervious areas will perform worse (the basin will overflow more frequently) than what is presented here. If a design does not account for, or anticipate antecedent conditions, runoff factors for pervious areas, which are relatively dependent on "wetness" may be underestimated and the runoff generated will be greater than was expected/calculated.

5.6 SENSITIVITY ANALYSIS

The sensitivity analysis involved varying a range of parameters to see how these parameters affected the performance of the basin. To perform a sensitivity analysis of various parameters it is important to understand the equation that governs the basin volume. Depth, slope and length of the basin all directly affect the volume of the basin. A basin can be considered as a square based frustum, the volume of which can be calculated by

$$V = D(L - SD)^2 + \frac{1}{3}S^2D^3$$

Where:	V is,	Volume of the basin	(m^3);
	D is,	Depth of the basin	(m);
	L is,	Length at top of the basin	(m);
	S is,	Slope of the basin side batters	(H:V);

Given the above equation it can be seen that varying depth, length and slope of the basin results in a change in basin volume. However these parameters cannot influence the volume required to treat the design event. Therefore, there is little point investigating the sensitivity of the model to these parameters as the basin's performance with a varying basin volume has already been modelled.

The volume of the basin is also affected by the infiltration rate as this effectively governs the outflow from the basin. The infiltration rate can influence the volume required to treat the design event. The infiltration rate is calculated by taking the wetted surface area, multiplying it by the infiltration rate (mm/hr). The relationship between the volume of the basin and the infiltration rate is directly proportional. A higher outflow via infiltration) will result in a smaller basin volume being required, and vice versa. Figure 10 shows how the infiltration basin volume required to treat various events (all with an ARI of 10) decreases as the infiltration rate increases.

The infiltration rate is an important component of the design of infiltration basins and as stated above, influences the size and volume of the infiltration basin. Other factors that determine the size and volume of an infiltration basin such as the intensity and duration of a design event cannot be controlled by the engineer/designer. Figure 10 shows that a change in infiltration rate from 10 mm/hr to 75 mm/hr will for many events halve the basin volume required. Therefore, adequate pre-design infiltration testing to determine natural infiltration rates both of soils and the underlying gravels, in conjunction with careful construction of infiltration media, may potentially yield significant savings both in terms of area and volume required for stormwater treatment.

Figure 10 also shows that, as the infiltration rate increases, the critical storm duration decreases. For an infiltration rate of 20 mm/hr, the critical storm duration is around 24 hours, while for an infiltration rate of 75 mm/hr, the critical storm duration is around 15 hours.

The critical duration of an event, and therefore the required basin volume, is determined by three factors, the length and the intensity of the event, and the infiltration rate of the basin. The length of an event and its intensity are linked; longer duration events of the same return period have a lower average rainfall intensity. As the infiltration rate increases, it can treat higher intensity rainfall in this model, instantaneously. Whilst the duration of the event is such that the rainfall intensity is less than the infiltration rate, basin storage is not required. To utilise storage, the intensity must increase and therefore the duration of the event must decrease. This gives the relationship shown in Figure 10, whereby, as the infiltration rate increases, the duration of the critical event decreases.

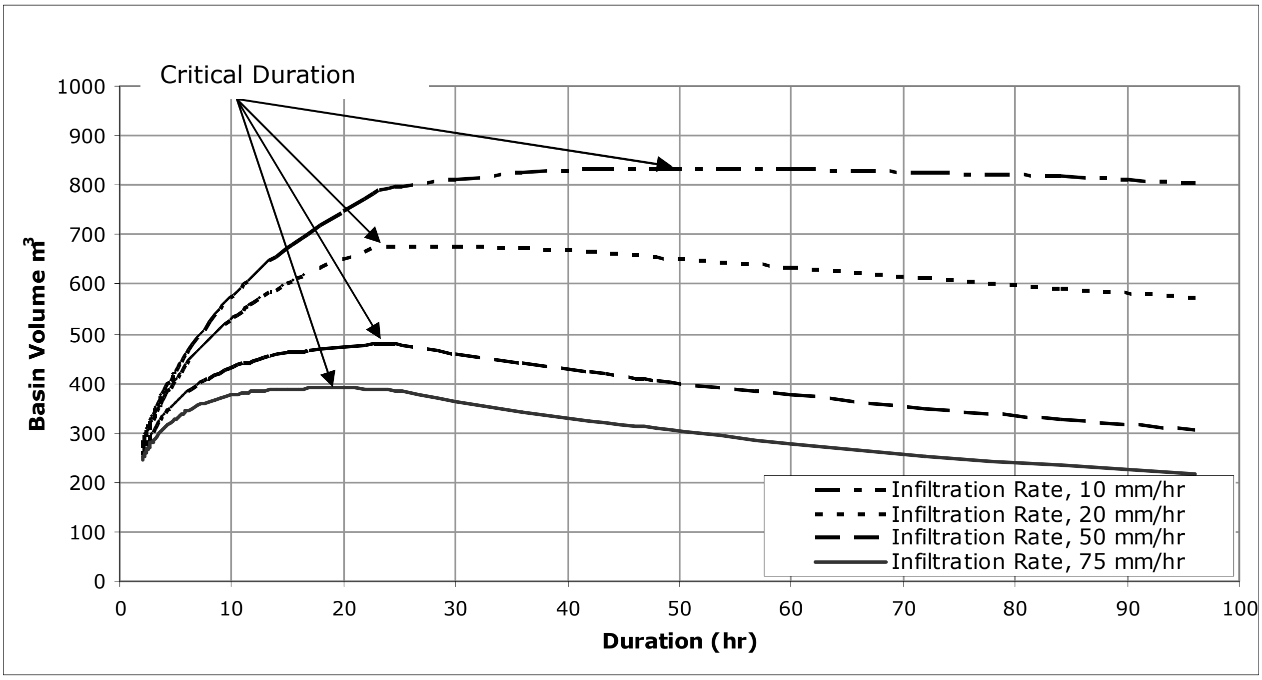

Figure 10: Various basin sizes required to treat all runoff from rainfall events of differing durations, all durations are for the one in ten year event.

6 CONCLUSION

This paper was written to identify the how an infiltration basin performs during synthetic and historical events. Further, the performance of hypothetical basins designed for various events, were assessed using a 50 year rainfall dataset. The assessment included, percent of stormwater treated over a 50 year period, time stormwater spends in an infiltration basin, how the infiltration basin performs from a statistical point of view and the effect of infiltration rates on basin design.

There was generally little difference in terms of basin performance between a synthetic and historical rainfall event. Although the historical events identified from the rainfall dataset generally peaked earlier in comparison to their synthetic equivalent, this made little difference to the performance of the basin. The infiltration basin typically buffered (flattened out) the event so that the infiltration and basin depth profiles were similar between the two synthetic and historical rainfall profiles despite the differences in the peaks.

It was found that an infiltration basin sized using CCC guidelines for first flush would treat 94% of all stormwater runoff given an infiltration rate of 20 mm/h and fully impervious site surface. It was also found that an infiltration basin designed to capture the first flush would be empty for at least 80% of the time. Event designed basins, such as the 5 year 24 hour were calculated to have a larger volume and therefore were able to treat more stormwater whilst remaining empty for a greater period of time.

Infiltration basins designed using the CCC's guidelines generally performed as expected in that they overflowed if an event exceeding the design event occurred. However, the infiltration basins were found to still overflow as a result of an event that was below the design event. Overflow of an infiltration basin may occur 50% more often than is expected and can be attributed to two factors, very high rainfall intensities over a short period of time, or stormwater from a previous rainfall event in the basin at the start of the 24 hour period.

Adequate site investigation and careful design of infiltration media can help identify the expected infiltration rate for the designed basin. Therefore, a potentially less conservative number (for infiltration rate) may be used for design which consequently will reduce the area required for stormwater treatment. Further, the infiltration rate plays an important part in determining what the critical duration of an event is.

Given the availability of long term rainfall records this model could be adapted to provide a more comprehensive analysis for specific locations outside of the Christchurch City area. There is also scope available to include a rainfall-runoff component into the model as well as incorporating other discharge devices into the model such as rapid soakage chambers.

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