University of Southern Queensland

Faculty of Health, Engineering & Sciences

Infill Development Impact on the Capacity of Regional Drainage Networks

A dissertation submitted by

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Abstract

The scope of the dissertation is to identify the hydraulic capacity of the stormwater drainage pipes and if they can accommodate ongoing infill development in two sample catchments in the Bass Coast local government area of Victoria. The research project identifies existing inadequacies of stormwater assets and conversely the areas of the drainage network with additional hydraulic capacity. A hydraulic model has been created in PCSWMM software to examine the capacity of Bass Coast Shire Council's drainage pipes. One model for each study area has been created based on the existing level of development. A second model has then been created assuming the catchment areas are infill developed to their maximum potential. The increase in impervious surfaces results in a higher volume of runoff, increased flow rates and thus greater pressure on the existing drainage network.

This study can assist Council engineers to make more informed decisions around drainage requirements for future infill developments in regional towns. The project has classified individual pipes into a class of drainage network capacity for two sample study areas in Cowes and Inverloch. The resultant capacity classes for the Cowes study area are:

- Critical = 26 %
- Near capacity = 30 %
- Sufficient capacity = 44 %

The capacity classes for the Inverloch study area are:

- Critical = 7 %
- Near capacity = 16 %
- Sufficient capacity = 77 %

The 'critical' class is the pipes that are already surcharging under the existing level of development; the 'near capacity' class are the pipes that will surcharge if the catchment is developed to the full potential. These results show that while the Inverloch study area is reasonably well equipped for future infill development, the Cowes study area requires onsite detention or pipe upsizing to accommodate the growth.

Despite the results of under-capacity pipes, most of the surcharging is found to be contained within the stormwater pits and thus flooding is minimal. All infill development in Bass Coast is currently required to manage the increase in stormwater runoff via onsite detention systems. This study has found that a 'one size fits all' approach to stormwater management is overly conservative for infill development and some areas may not require flow restriction. A risk assessment should be undertaken however before Council allows infill development to proceed without either onsite detention or upsizing of the pipes in the existing drainage network.

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Abbreviations and Acronyms

AEP – Annual Exceedance Probability

AHD – Australian Height Datum

ARI – Average Recurrence Interval

AR&R – Australian Rainfall and Runoff Guidelines

BOM – Bureau of Meteorology

BCSC – Bass Coast Shire Council

CHI – Computational Hydraulics International

CSIRO – Commonwealth Scientific and Industrial Research Organisation

EPA – Environmental Protection Agency

GRZ – General Residential Zone

GIS – Geographic Information System

IFD – Intensity-Frequency-Duration

LGIDA – Local Government Infrastructure Design Association

LSIO – Land Subject to Inundation Overlay

IDM – Infrastructure Design Manual

PCSWMM – Personalised Computer Stormwater Management Model

PSD – Permissible site discharge

PVC – Polyvinyl Chloride

RCP – Reinforced Concrete Pipe

TSS – Total Suspended Solids

VPO – Vegetation Protection Overlay

WSUD – Water Sensitive Urban Design

1.0 Introduction

1.1 Background – Bass Coast Shire

Bass Coast Shire Council (BCSC) is a local government municipality in south-east Victoria. The Shire is primarily administered out of its head office in Wonthaggi, located approximately 140 kilometres or 1.5 hours south-east of the Melbourne CBD. The Shire boundary is outlined in red in Figure 1.1. The most notable towns in the Shire includes Cowes, San Remo, Wonthaggi, Inverloch and Cape Paterson.

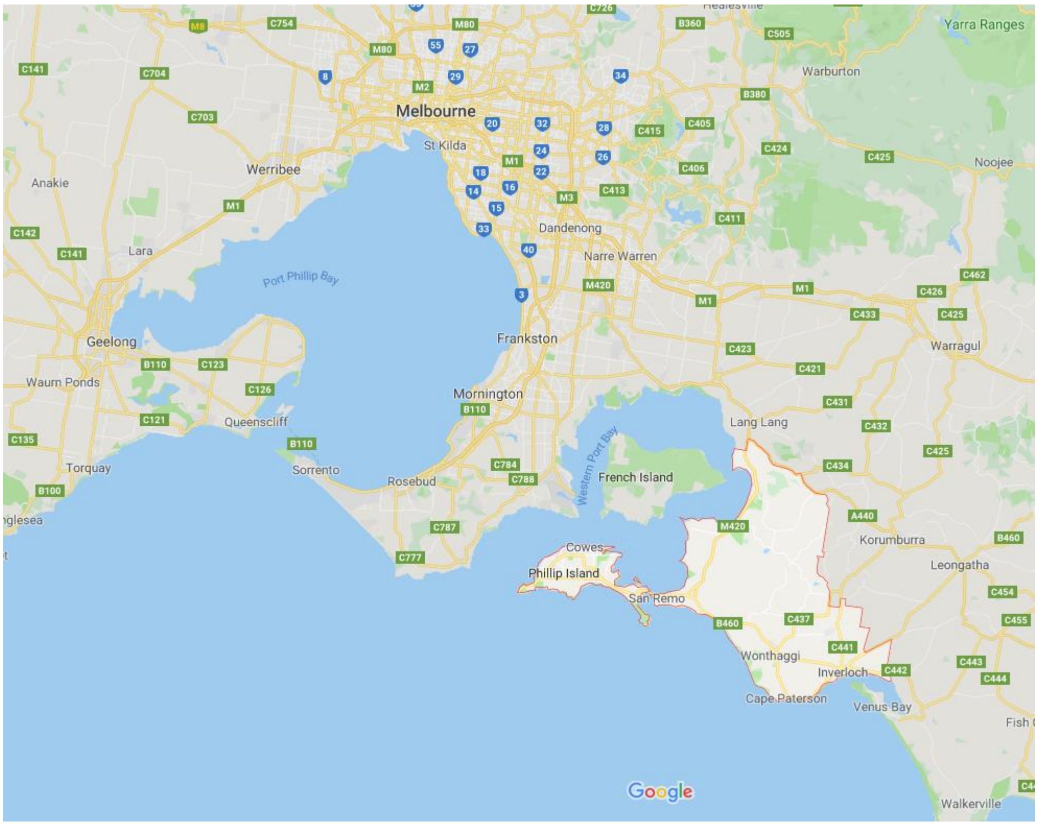

Figure 1.1: Map of Bass Coast Shire – bordered in red (Google Maps 2019)

The Shire is one of the fasting growing regions in Victoria (BCSC, 2019). Much of the development to accommodate this growth is occurring within existing town limits by way of small subdivisions and multi-dwelling developments. This type of development is often termed 'infill development'. Infill development places pressure on existing infrastructure and services, such as the drainage network. The purpose of this research project is to examine the impact infill development is having on drainage infrastructure in regional areas, such as Bass Coast.

The Bass Coast Shire includes the popular holiday destination of Phillip Island. Phillip Island is home to many natural and man-made attractions, such as the Penguin Parade and The Australian Motorcycle Grand Prix. The region is also known for the coastal lifestyle, surf beaches and proximity to Melbourne. These things make the island very attractive to tourists, holiday-makers, retirees and families. It also makes the region very attractive to developers, proven by the increasing scale of development in Bass Coast.

1.1.1 Flooding in Bass Coast

Wonthaggi receives a relatively high average annual rainfall of 938 millimetres (Bureau of Meteorology 2019). The flat topography of the coastal regions in this area experience many flooding issues in wetter times due to a combination of both the topography and the high rainfall. Winter is typically much wetter than summer in Bass Coast, however intense storms can occur a any time of year. Figure 1.2 shows the flooding as a result of an intense storm in May 2019.

Figure 1.2: Flooding at Wonthaggi Surf Life Saving Club (Paterson 2019a)

1.1.2 Riverine Flooding & Coastal Inundation

The two most notable river systems in the Bass Coast Shire include the Powlett River and the Bass River. Neither river system runs through a major town and therefore the risk of riverine flooding in Bass Coast is of little consequence to the community. Coastal inundation is of much greater concern for Bass Coast residents, particularly on Phillip Island. The town Silverleaves is predominantly below 3.0 metres Australian Height Datum (AHD) which is of significant concern for coastal inundation. Some residential blocks in Silverleaves are situated below 2.0 metres AHD. BCSC has a flooding overlay map in the Planning Scheme known as the Land Subject to Inundation Overlay (LSIO). This is used to inform decision making for those low-lying areas prone to riverine flooding and coastal inundation. The LSIO is the extent of flooding expected for a 1% AEP flood event.

1.1.3 Localised Flooding

The prevalence of localised flooding is of much greater concern for the Bass Coast community. The winter months are typically much wetter for the region (Bureau of Meteorology 2019) and this is usually when the towns in Bass Coast experience localised flooding problems. Figure 1.3 shows the localised flooding issues experienced in Cape Paterson due to a sever hailstorm in May 2019. The seaside town in Bass Coast, Cape Paterson, did not have adequate drainage infrastructure to convey the storm. This resulted in inundation experienced at several properties in Cape Paterson, including the Wonthaggi Surf life Saving Club as seen in Figure 1.2.

BCSC employ onsite detention systems in an effort to prevent localised flooding. These detention systems are a means of restricting flows from new developments to pre-development levels. Onsite detention systems are described in more detail in the literature review.

Figure 1.3: Localised flooding at Cape Paterson (Paterson 2019b)

1.1.4 Regional Town vs City environment

There are many differences between the urban environment in Australia's regional towns to the capital cities. Much of the literature surrounding the study of stormwater and runoff is based in our largest population centres. This is evident from the literature review in Chapter 2. Although the built-up areas in a small town such as Wonthaggi are generally classified as 'urban', the environment in this small town is vastly different to the urban environment of a city such as Melbourne. The density of the city's urban areas is much greater to that in a small town with a relatively humble population of around five thousand people. It is a reasonable assumption that the engineers in Melbourne designed the infrastructure in the city for a relatively dense level of development. One of the assumptions that lead to this research was that drainage networks in the city are more likely to be designed for a denser development level compared to the regional country towns in Victoria.

1.2 The Research Problem

The capacity of the existing drainage network in the older areas of the townships in Bass Coast is largely unknown. There are several locations throughout the shire where localised flooding issues are common. There is often no record of the design computations for the drainage assets in these areas. It is believed that the hydraulic capacity of the drains in these areas will not be designed for the intensity of development which is permissible under current planning legislation. The pipes were likely designed for the large 'lifestyle' blocks typical of country towns. Small houses, large blocks with a big backyard. Historically, this was the norm in small country towns.

However, in modern times, things have changed. Geoff Sawyer has been an engineer in the region for 42 years. He says there has been a shift towards urban consolidation (2019 pers. comm., 11 April). Larger houses are being built on smaller blocks. The older 'lifestyle' blocks are also being subdivided into the minimum allowable size. In Bass Coast, multi-dwelling developments are also common where there is a small courtyard with no backyard or lawn. In these cases, the ratio of impervious to pervious surfaces has increased significantly which also increases rainfall runoff. It is unlikely the drainage pipes in these old streets will be designed to cope with such a high level of runoff. This is the design problem for which this research is based.

1.3 Research Aims and Objectives

The scope of this research is to identify the hydraulic capacity of the drainage pipes in two sample catchments. The research project endeavours to identify existing inadequacies of stormwater assets and conversely the areas of the drainage network with additional hydraulic capacity. This will assist Council officers to make more informed decisions around drainage requirements for future developments. The aim of the project is to separate individual pipes into a class of drainage network capacity to incorporate into BCSCs GIS database. The following levels of capacity are proposed:

- Critical
- Near capacity
- Sufficient capacity

The outcome of the research is to incorporate the drainage capacity classes into the Council's GIS software, and ultimately the local Planning Scheme. This information is intended to be freely available to both Council and developers, to ensure drainage of future infill development is well managed. The intention is to help Council engineers ensure stormwater assets are upgraded appropriately to service the increasingly dense urban environment. If this cannot be accommodated, identify where other controls can be implemented to ensure flooding will not occur from new development.

The following list is a summary of the objectives/outcomes of this research:

- Identification of both existing and future capacity issues in BCSC drainage infrastructure.
- Mapping of critical, near-capacity and sufficient capacity stormwater infrastructure.
- Propose options to BCSC to manage increased stormwater runoff from future infill development.

2.0 Literature Review

2.1 Introduction

This chapter will review literature relating to the study of hydraulic capacity in urban drainage networks.

2.2 Australian Rainfall and Runoff Guidelines

The Australian Rainfall and Runoff Guidelines (AR&R) were updated in 2016. This was the first significant revision since 1987. Subtitled 'A Guide to Flood Estimation', the guidelines are intended to be used by engineers, politicians and others to aid drainage design and the estimation of flood events throughout Australia. Previously, the 1987 version had been influential in policy decision and projects in Australia (Ball et al. 2016). The guidelines developed by Ball et al. are a nationally accepted reference for projects, including:

- infrastructure such as roads, rail, airports, bridges, dams, stormwater and sewer systems;
- town planning;
- mining;
- developing flood management plans for urban and rural communities;
- flood warnings and flood emergency management;
- operation of regulated river systems; and
- prediction of extreme flood levels.

Book 9 of AR&R (2016) is titled 'Runoff in Urban Areas'. The information in this book is valuable for studying effects of rainfall events specific to urban environments. This dissertation will employ AR&R (2016) and the recommended practices relevant to town planning.

One of the key updates to AR&R 2016 is the new intensity-frequency-duration (IFD) rainfall data, freely available from the BOM website. The updated IFD data has a varied effect depending on your study area. In many regions, the updated data results in more intense rainfall events. This is largely the case for Wonthaggi. Table 3.1 shows the updated IFD data in 2016 compared with the old 1987 IFD data. The minor drainage systems (pits and pipes) for residential areas in Victoria are now designed for 20% AEP storm events (LGIDA 2019, p. 104). In the past, the minor drainage systems were designed for the 5 year ARI storm event. It is worth noting that the 20% AEP does not correspond perfectly to the 5 year ARI. Rather it corresponds to the 4.48 ARI (BOM 2016). Table 2.1 therefore compares the rainfall intensities for each storm event, which is applicable to the design of the hydraulic capacity in minor drainage systems.

Table 2-1: Comparison between 1987 and 2016 IFD data for Wonthaggi (BOM 2016)

	Rainfall intensity (mm/h)	
Duration (mins)	**1987 IFD data (5 Year ARI)**	**2016 IFD data (20% AEP)**
5 mins	81.0	85.9
6 mins	75.5	79.7
10 mins	60.6	63.1
20 mins	42.6	44.0
30 mins	33.9	34.9
1 hour	22.4	22.8
2 hours	14.6	14.6
3 hours	11.4	11.1
6 hours	7.41	6.98
12 hours	4.81	4.35
24 hours	3.09	2.71
48 hours	1.92	1.67
72 hours	1.42	1.25

What is evident from Table 2.1 is that the shorter rainfall events are more intense for the 2016 IFD data. This is applicable for rainfall events up to 2 hours in duration for a 20% AEP storm event.

For this research project, all hydraulic modelling is conducted using the updated 2016 IFD data. Given the 1987 data predicted less intense rainfall events, it is anticipated that this will influence the results of the study.

2.3 Infrastructure Design Manual for Victoria

The Infrastructure Design Manual (IDM) is a technical guide developed by several regional Councils in Victoria. These Councils have banded together to form the Local Government Infrastructure Design Association (LGIDA) who own and maintain the IDM. The aim of the document is to work towards consistent requirements and standards for the design and construction of infrastructure (LGIDA 2019).

The IDM states that the design of drainage systems should follow the minor/major storm approach as outlined in AR&R 2016. That being, the minor drainage system should have sufficient hydraulic capacity to convey the runoff from a 20% AEP rainfall event whereas the major drainage system should have sufficient hydraulic capacity to convey a 1% AEP rainfall event. The minor drainage system includes the underground infrastructure such as the pits and pipes, while the major drainage system comprises the overland surcharge routes such as roads and channels.

According to the IDM, the minor drainage system should be designed with a hydraulic capacity in accordance with Table 2.2.

Table 2-2: Minor drainage system design parameters (LGIDA 2019, p. 104)

Location of Drainage System	Design Storm
Urban residential areas	20% AEP
Commercial centres of 10 shops or less	10% AEP
Industrial areas or where surcharge would seriously affect private property	10% AEP
Drainage through private industrial property	5% AEP
Commercial Areas	5% AEP

As can be seen from Table 2.2, the IDM requires infrastructure in commercial and industrial precincts to be designed for larger storm events. No justification for this is provided in the IDM.

The intention is for the minor drainage system to be designed to convey the flows in the pits, pipes and kerb and channel. This represented diagrammatically in Figure 2.1.

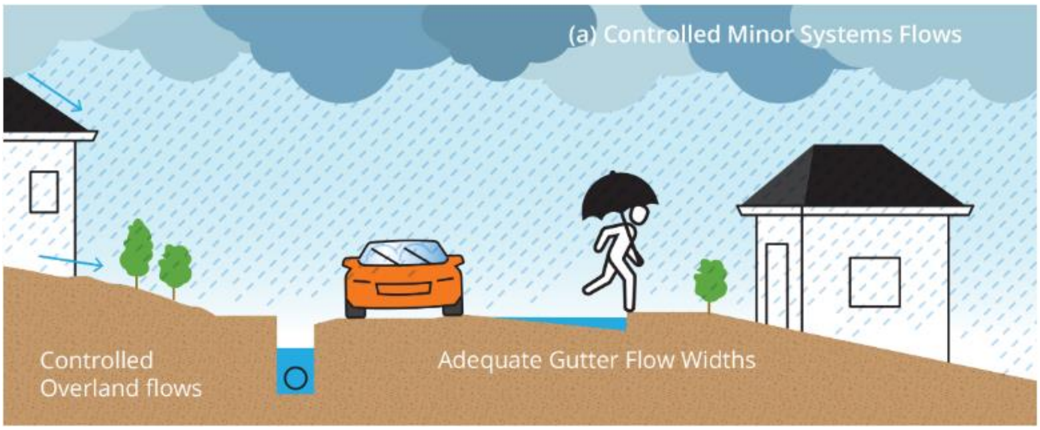

Figure 2.1: Minor conveyance network concept (AR&R 2016)

Figure 2.1 shows the pits and pipes flowing full, as well as the kerb and channel, without disrupting traffic flow within the carriageway. Conversely, the major drainage system is intended to convey the flows above ground in accordance with Figure 2.2.

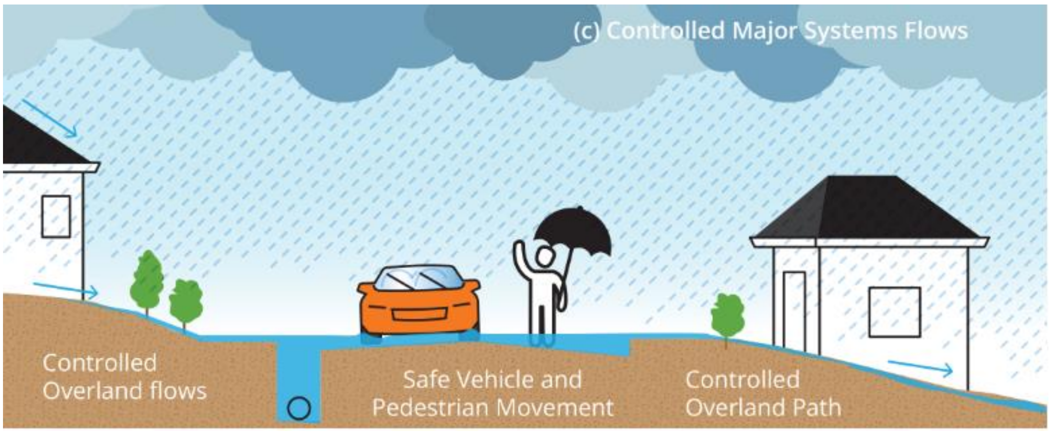

Figure 2.2: Major conveyance network concept (AR&R 2016)

Figure 2.2 shows the pits and pipes are full and surcharging out to the road. The water is conveyed overland with minimal depth and velocity which should ensure safe vehicle and pedestrian movement. Good design will ensure overland flow paths are available to divert water around dwellings to avoid inundation.

2.4 The Effects of Infill Development

Regarding infill development, the effects on the hydraulic capacity is not as well documented as the effects on stormwater quality. Paule-Mercado et al. (2018) studied the effects of land use and land cover on urban drainage. Their paper however focussed on the effects on stormwater quality for cities in South Korea. Personal Computer Stormwater Management Model (PCSWMM) software was used by Paule-Mercado et al. (2018) to study the effects of urbanisation on runoff in terms of pollutant concentration. The study areas for the paper were newly subdivided residential land. These were greenfield sites where the existing use consisted of agricultural, natural forest or grassland. Figure 2.3 is an accurate representation of the type of urbanisation at the centre of that study.

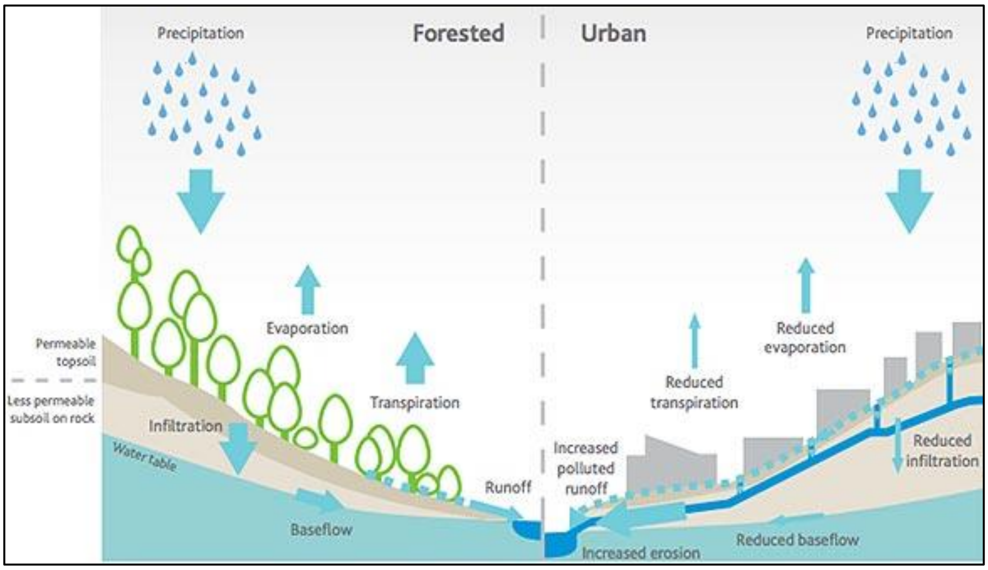

Figure 2.3: Difference between the natural and urban environment (Melbourne Water 2017)

Unsurprisingly, the results showed a negative consequence on the urban runoff with higher pollutant loadings such as total suspended solids (TSS). The paper certainly recognised the need for stormwater quality treatment in urban environments. What Paule-Mercado et al. (2018) did not address was infill development and the implications on the hydraulic capacity of the city's network assets.

Jacob and Lopez (2009) set about to compare the difference between infill development and urban sprawl regarding stormwater quality and runoff volumes. They discovered that infill development is an effective way of catering for population growth. Their results showed that the nutrient loadings and total runoff per hectare where greater for the denser development however were lower per capita. Jacob and Lopez (2009) concluded:

> 'Because higher density is associated with vibrant urban life, building a better city may be the best BMP to mitigate the water quality damage that will accompany the massive urban growth expected for the next several decades.'

Although this quote is referring to urban growth in America, it is of equal relevance to the Australian population. BCSC is heading towards a denser future due to the definition of town boundaries for every urban centre in the Shire. The Council Plan (BCSC 2017) states that following are among their 'areas of highest priority':

- the maintenance of town boundaries
- to protect native vegetation and rural land

The Council Plan is backed up by the Community Plan 'Towards 2030' which lists minimising subdivision of precious rural land as an objective. These priorities suggest that infill development is encouraged by BCSC and reaffirms the need for research around the capacity of existing assets.

Total phosphorous, total nitrogen and total suspended solids were all found in higher concentrations (Jacob & Lopez 2009) which raises questions about suitable treatment methods and the space provision for these in dense urban environments. The research also suggests that the total runoff decreases markedly with density. Although, this makes no guarantees that existing drainage assets will be able to cope with the increased runoff. It must be noted that this dissertation does not intend to study the effects of infill development on stormwater quality which is certainly a limitation of the research.

What Jacob and Lopez (2009) did not study was if the existing drainage networks could cope with additional infill development and the associated increase in impervious surfaces. Another key difference from this dissertation is that Jacob and Lopez (2009) conducted their research in American cities. Their 'per capita' findings regarding infill development were likely to include high-rise apartments that is not found in regional towns. Thus, a much greater population could be accommodated for with a relatively similar level of impervious surfaces. A multi-dwelling development in Bass Coast Shire may house 5-10 people whereas the multi-dwelling developments in the cities can potentially house hundreds. The results of the aforementioned study are therefore less applicable to regional areas.

One of the major advantages of new development on greenfield sites is the space and capacity to design new infrastructure to today's standards. This includes sufficient hydraulic capacity in the pipes and appropriate treatment infrastructure. The unknown with infill development is the capacity of the existing network. There are ways of mitigating the effects of more runoff, such as green infrastructure and onsite detention systems. These are discussed in more detail in Sections 2.5 and 2.6 respectively.

2.5 Green Infrastructure & WSUD

Water Sensitive Urban Design (WSUD) is an approach to planning and designing urban areas make use of stormwater and reduce the harm it causes to our waterways (Melbourne Water 2017). Green infrastructure can be defined as water management paraphernalia that protects, restores, or mimics the natural water cycle (EPA 2018). Essentially, WSUD is a stormwater best practice ideology which makes use of green infrastructure. Examples of green infrastructure commonly used for water management includes (but not limited to):

- Rain gardens,
- Planter boxes,
- Bioswales and wetlands,
- Permeable pavements,
- Green roofs, and
- Street trees.

Eckart, McPhee and Bolisetti (2018) discovered green infrastructure in the form of low impact development controls were useful in reducing the peak runoff flows from urban catchments. Their study was conducted in the densely populated city of Windsor, Canada.

Berland et al. (2017) studied the many benefits of trees as a green infrastructure measure in urban design. The paper explains the reduced stormwater runoff from canopy interception loss, transpiration, improved infiltration and possible benefits with regard to deeper percolation along root channels and water table management. According to the United States EPA (2018), many cities have set tree canopy goals to restore some of the benefits of trees that were lost when the areas were developed. The urban tree canopy can reduce and slow stormwater runoff by intercepting precipitation in their leaves and branches. Figure 2.4 illustrates a dense canopy in the Melbourne suburb of Toorak. It is evident from this photograph that a high level of interception loss would occur in a rainfall event.

Figure 2.4: Leafy street in Toorak (Realestate.com.au n.d.)

BCSC has recognised the importance to incorporate trees into new subdivisions by including a standard permit condition for advanced street trees to be planted every 10-12 metres in residential areas. It is unlikely that these will have much of an effect on stormwater runoff in the short term, however the benefits will be there for future generations.

From the available literature, it is evident that green infrastructure has an important role to play in water management. There is doubt however that certain green infrastructure such as rain gardens are entirely suitable for the urban residential developments in regional towns. BCSC has found rain gardens to be a substantial maintenance burden. Build-up of silt and particulates in these systems require regular cleaning to ensure their effective operation. BCSC engineers are not confident that residents maintain their rain gardens to an appropriate standard to ensure their effective operation. Infiltration methods are also unsuitable in many environments close to the coastline at Bass Coast. There are numerous developments on the foreshore of coastal settlements, in Bass Coast Shire, where the ground level is at or below 2.0 m AHD. The groundwater for these settlements is that close to the surface that any infiltration methods are ineffective.

2.6 Onsite Detention Systems

Onsite detention systems have been developed as a method of retarding peak flows during a rainfall event. The use of onsite detention as a means of restricting flows is common for new developments. The objective is to ensure that runoff from new development sites will not exceed the capacity of the existing drainage system (LGIDA 2019). A quote from the IDM describes why we need onsite detention systems:

> 'To ensure that the capacity of existing drainage infrastructure is not exceeded as a result of developments that increase the volumes and peak rates of stormwater runoff beyond the capacities for which the infrastructure was originally designed.'

They do this by limiting the flow rate off the development site to a flow rate equal to what was running off the site prior to the development. Put more simply, they limit the post-development flow to the pre-development flow.

Onsite detention systems should ensure that existing minor drainage networks continue to meet current needs and expectations as more intensive development takes place (LGIDA 2019). The sizing of detention systems should therefore be for a 20% AEP storm event.

To achieve the flow restriction, large detention capacities are required with the outflow restricted by a small orifice. According to Laurie Gervasi of BCSC (2019, pers. comm., 9 April), one of the major concerns with these designs is orifice blockages. It does not take much silt and leaf litter to block small orifices, especially in pits. BCSC request developers provide an overflow in orifice pits and tanks to ensure the properties will effectively drain in the case of orifice blockages. Once the orifice is blocked and the flow bypasses to the overflow, the detention system becomes ineffective. It is therefore essential that detention systems are maintained to ensure they are operating as intended by the designer.

According to BCSCs engineers, it is difficult to enforce maintenance responsibility with privately owned detention systems. Clause 19.3.5.2 of the IDM suggests that Councils in Victoria may enter a Section 173 Agreement under the Planning and Environment Act 1987. The agreement is registered on the land title and places a restriction on that land. Typically, the agreement will state that the owner of the land will maintain and not modify the onsite detention system in accordance with the approved plans. The agreement will usually provide for Council inspection of the onsite detention system. Resourcing the Council inspection is not always possible. BCSC do not currently have the resources available to enforce the maintenance of private detention systems. BCSC has also been criticised for not having enough resources to maintain their own drainage assets, let alone maintaining private assets.

This research endeavours to locate the areas of the drainage networks where the hydraulic capacity is 'critical'. This will enable Council officers to enter Section 173 agreements with developers in these areas to ensure localised flooding does not increase for a 20% AEP storm event.

2.7 The Regional Town Dynamic

Understandably, the majority of research in this field has been conducted in large city environments. One assumption is that these large centres are much better resourced than regional areas such as Bass Coast. This can be attributed to the population per hectare. A larger rate base contributes to a greater pool of resources for local governments. The permanent population for the Bass Coast Shire is only 32,000 (Department of Jobs, Precincts and Regions 2019).

BCSC engineers are aware of many gaps in the drainage network which contribute to localised flooding issues. In other words, there are urban areas which are not serviced by underground drainage. The apparent lack of resources at the disposal of engineers means the issues remain unaddressed indefinitely. This is an issue that is assumed to be less prevalent in the city environments and may explain the lack of literature regarding the hydraulic capacity of drainage networks in regional towns.

2.8 Bass Coast Planning Scheme

The Bass Coast Planning Scheme is a document of reference for Council's town planners and engineers. Clause 22.01 of the Planning Scheme is the Stormwater Management Policy. The Policy recognises stormwater drainage as a concern in urban areas where there is inadequate street drainage infrastructure (BCSC 2019).

The following objectives of the Stormwater Management Policy are listed in Clause 22.01-2 of the Bass Coast Planning Scheme (BCSC 2019, p. 256):

1. To incorporate stormwater management considerations in the decision making for the use and development of land.
2. To maintain and enhance stormwater quality introduced to the drainage and waterway environment of the Shire.
3. To address priority stormwater threats facing the urban and non-urban areas of the Shire as documented in the Bass Coast Stormwater Management Plan (2003).
4. To promote and improve the contribution the drainage system makes in upholding and where possible improving the values of the waterways across the Shire.
5. To maintain stormwater flows and discharges at a maximum of the pre-development flow level.
6. To maximise the effectiveness of stormwater infrastructure in protecting the waters of Bass Coast Shire.
7. To manage flooding and drainage so as to minimise risks to the community and the environment.

The relevance of the third objective is questionable given that the Bass Coast Stormwater Management Plan (2003) is no longer available to the public on the Council's website. All other objectives are to be achieved via the preparation of a stormwater management plan. A stormwater management plan should be submitted for any subdivision or development proposal (BCSC 2019). This dissertation focusses heavily on objectives 5, 6 and 7 by way of researching the hydraulic capacity of the network and subsequently the protection of the waterways and community in Bass Coast.

The Planning Scheme guides developers to comply with the book Urban Stormwater Best Practice Environmental Management Guidelines. This book was developed by the CSIRO (1999) for the Victoria Stormwater Committee. The stormwater quality objectives for all new development in Victoria are listed in Table 2.3.

Table 2-3: Stormwater Quality Targets (CSIRO 1999, p. 15)

Suspended Solids	80 per cent retention of the typical urban annual load
Total Phosphorus	45 per cent retention of the typical urban annual load
Total Nitrogen	45 per cent retention of the typical urban annual load
Litter	70 per cent retention of typical urban annual load
Flows	maintain discharges for the 1.5 year ARI at pre-development levels

This dissertation does not intend to delve into designing stormwater treatment train systems, however, these stormwater quality objectives must be considered when designing stormwater systems. Thus, some allowance must be made for the incorporation of stormwater quality treatment in design solutions.

3.0 Resources

3.1 BCSC GIS Data

This research would not be possible without the GIS data for the Bass Coast Shire. All required GIS information has been supplied from BCSC for the purposes of this research. BCSC use software known as Intramaps, which is a user friendly spatial data portal. The BCSC data in Intramaps enabled the hydraulic model to be constructed relatively quickly and efficiently.

The following is a summary of the GIS data used to complete the project:

- Drainage pipes including diameter, material and length.
- Drainage pits including type, surface level (to AHD) and depth.
- Contour data for defining catchments and subcatchments.
- Cadastre for defining lot sizes and subdivision potential.
- Land zone maps.
- Aerial imagery for defining impervious areas.

Any discrepancies in the data (or missing data) have been confirmed via field visits where possible. Vehicles, survey and measuring equipment has been supplied by BCSC for the purposes of conducting this research. The field visits were made during business hours.

3.2 Hardware & Software

The hydraulic model for each study area is drawn and run in the software package PCSWMM, developed by the company Computational Hydraulics International (CHI). This was achieved using an educational license obtained through USQ. The software was installed on a personal computer (PC). All modelling and reporting was conducted on the PC.

All the GIS data as outlined in Section 3.1 was manually entered into PCSWMM. Additional information required to run the model includes the rainfall data for each study area. This data is freely available on the BOM website. The 2016 AR&R IFD rainfall data is downloaded from the BOM website, and the temporal patterns downloaded from the AR&R data hub website. Together, this information is sufficient to create a storm and run the simulations.

Other necessary software to complete the project includes the Autocad software by Autodesk. This is used for drafting. Illustrations have been used to aid presentation of the results by portraying visual interpretations of the study area. An educational license from Autodesk was used for this project.

Microsoft Office was used for reporting. A copy of Microsoft Office was used, including Word, Excel and PowerPoint, for all necessary reporting and presentations needed to complete the BENH degree. Word has been used to prepare the report and complete the final dissertation. Excel has been used to complete the Project Plan Gantt chart which is attached in Appendix B.

4.0 Study Areas

4.1 Cowes

Cowes is located on the northern side of Phillip Island as seen in Figure 1.1 and is the largest township on the island. Most visitors to Phillip Island will visit Cowes as it is the main commercial centre on Phillip Island. There is mix of permanent residences and holiday homes in this town, with a permanent population of approximately 5,000 people (Australian Bureau of Statistics 2016). The Cowes study area is highlighted in red in Figure 4.1.

Figure 4.1: Cowes study area outlined by red polygon (BCSC 2018)

The aerial photo seen in Figure 4.1 shows the main street of Cowes, Thompson Avenue, in the centre of the figure. Thompson Avenue runs north-south and leads all traffic to the large jetty on the foreshore, which is known locally as the 'jetty triangle'. The chosen study area is not far from the town centre, shown highlighted by a red border in Figure 4.1.

To first identify the complexity of the task, a relatively small catchment has been identified in Cowes. The catchment boundary is shown more clearly in Figure 4.2. The total catchment area has been measured on Intramaps as approximately 4.55 hectares. Due to the study area's proximity to the beach and the main commercial hub of Phillip Island, the real estate here is in high demand. The entire catchment is in a GRZ. There are also many large properties in the catchment with land areas well over 300 m² and suitable for subdivision or multi-dwelling developments. The land is therefore considered to have a high potential for infill development. This study area has been selected as it has the potential for further subdivision and multi-dwelling developments while also containing ageing drainage infrastructure which is not likely to be designed for a dense level of development. There are also several pre-existing developments which have constructed onsite detention systems, which has been Council's drainage response to infill development to date.

Figure 4.2: Cowes study area – definition of catchment boundary (BCSC 2018)

The catchment boundary of this study area has been determined off the 0.5 metre contour data supplied by BCSC. The outfall is situated at the top of Eva Lane in Figure 4.2, in the foreshore reserve adjacent to the beach. The outfall pokes through the sand dunes and runs out to the beach. A photo collected during a site inspection is shown in Figure 4.3. The flow path from this outfall to the beach is shown in Figure 4.4. As can be seen, erosion issues are prevalent through the sand dune ecosystem and this is an important consideration in drainage design. Management of the outfall erosion on the beach is particularly important for this site as the beach is a popular tourist destination.

Figure 4.3: Cowes study area outfall (Whitby 2019a)

Figure 4.4: Flow path for Cowes study area outfall (Whitby 2019b)

It is worth noting that the properties fronting the beach shown in Figure 4.2 are not part of the catchment, as they all drain towards the beach and away from the Council drains in Beach Street. However, the downpipes from these properties are connected to the kerb on Beach Street and therefore the roof areas are included in this analysis.

Below are the catchment properties for the Cowes study area, which have been measured off Intramaps.

Catchment Properties (as calculated in Appendix D):

- Asphalt road pavement, concrete footpaths, driveways and paved areas = 8,533 m^2
- Roof areas = 12,357 m^2
- The total impervious area has been measured as 20,890 m^2 ≈ 2.09 ha

- The total catchment area has been measured to be 45,510 m^2 ≈ 4.55 ha
- Soil infiltration = Very high, predominantly sand 46 – 432 mm/hr as per percolation test results from a nearby development. (Obtained from BCSC).

Therefore, the level of existing development in the Cowes study area is approximated at 46 % impervious area. Based on these measurements, the scope for infill development is evident.

The drainage assets in the Cowes study area have also been identified, based on the GIS data supplied by BCSC. These assets are listed below.

Drainage assets:

- 23 Council drainage pipes with a combined total length of 713 m
- 17 side entry pits
- 6 junction pits
- 1 outlet/end wall

The data listed above has been computed for the total catchment area. To conduct the modelling, the data is separated into each specific subcatchment for each individual pipe as shown in Appendix D. This will allow us to classify each individual pipe into a capacity class.

4.2 Inverloch

Inverloch is popular a holiday destination, located at the mouth of Anderson Inlet. The town is located on the eastern side of the Bass Coast Shire as shown in Figure 1.1. The relatively calm water of the estuary is popular with families for activities such as boating, fishing, sailing, jet skis and more. 47.6 % of residential dwellings were unoccupied on Census day in 2016 (South Gippsland Sentinel-Times 2017), demonstrating how seasonal the population is. The town has a permanent population of approximately 5,500 (Australian Bureau of Statistics 2016), making it the second largest population centre in Bass Coast behind Wonthaggi.

Much like Cowes, property in Inverloch is highly valuable. The coastal nature and proximity to Melbourne makes the town attractive to developers. There is scope for much more infill development in Inverloch and this makes it a suitable town to include as a study area for this research project. The catchment will be identified following the completion of the modelling for the Cowes study area. There is the potential in this town to choose a much larger catchment area as there are limited outfalls to Anderson Inlet.

The study area for Inverloch is shown in Figure 4.5. As can be seen, there are many large lots with a high percentage of pervious area as of December 2018, when the aerial photograph was taken.

Figure 4.5: Inverloch study area outlined by red polygon (BCSC 2018)

Below are the catchment properties for the Inverloch study area, which have been measured off Intramaps.

Catchment Properties (as calculated in Appendix E):

- Asphalt road pavement, concrete footpaths, driveways and paved areas = 29,605 m²
- Roof areas = 31,971 m²
- The total impervious area has been measured as 61,576 m² ≈ 61.6 ha
- The total catchment area has been measured to be 159,731 m² ≈ 16.0 ha
- Soil infiltration = Medium-High for predominantly sandy loam 36-180 mm/hr approximate value adopted from City of Gold Coast (2007).

Therefore, the level of existing development in the Inverloch study area is approximated at 39 % impervious area. Based on these measurements, the scope for infill development is greater for this area.

The drainage assets in the Inverloch study area have also been identified, based on the GIS data supplied by BCSC. These assets are listed below.

Drainage assets:

- 105 Council drainage pipes with a combined total length of 3,262 m
- 105 side entry and junction pits
- 1 outlet/end wall

The data listed above has been computed for the total catchment area within the Inverloch study area. To conduct the modelling, the data is separated into each specific subcatchment for each individual pipe as shown in Appendix E. This will allow us to classify each individual pipe into a capacity class.

5.0 Methodology

A brief outline of the methodology employed for this research project is summarised in Section 5.1 below. The techniques are then elaborated in the subsequent sections, 5.2-5.4.

5.1 Outline of Methodology

The methodology for this project is based on the approach adopted by Eckart, McPhee and Bolisetti (2018). This study also employs PCSWMM software to create the hydraulic model. Two study areas have been identified and divided into many unique subcatchments. The subcatchment properties were determined through GIS data, satellite imagery, and site inspection. The network of links and nodes were drawn in the model based on drainage asset maps obtained from BCSC.

Once the study areas are defined, the catchment boundary for each pipe is identified using the BCSC contour data on Intramaps. 0.5 metre contour intervals are displayed in Intramaps. The current level of development for each study area is then determined to simulate the existing conditions and model the flow in each pipe. The existing level of development has been estimated as accurately as possible. This is done by measuring all the impervious surfaces seen on the aerial imagery in the BCSC Intramaps. The aerial imagery is from December 2018, so it is reasonably up to date. The Intramaps measuring tool is used to measure all roofs, road surfaces and driveways in each subcatchment. These surfaces would normally be assigned a runoff coefficient of 1.0 for roofs and 0.95 for paved surfaces in accordance with Table 5.2 of this report to compute a flow using the Rational Method. All other area would be assumed as landscaped pervious surfaces and assigned a runoff coefficient of 0.25 in accordance with Table 5.2. The IDM suggests the Rational Method to be used for flow estimation in small catchments. However, to simplify the task of modelling ten different temporal patterns in accordance with AR&R 2016, we will instead employ the PCSWMM software. As we are using PCSWMM which does not use the Rational Method, we do not need to estimate these runoff coefficents. PCSWMM instead requires the user to input the percentage of impervious areas for each subcatchment as well as infiltration data for the pervious areas.

The pipe network is drawn in PCSWMM, with the appropriate data entered for each pipe for the existing level of development. The rainfall data for a 20% AEP rainfall event for each study area will be downloaded from the BOM website and uploaded to the PCSWMM model. We then run the model to determine the flow in each pipe.

The results for the existing level of development is then recorded. The results for each pipe are analysed, with each pipe assigned a hydraulic capacity class. These classes are summarised below:

- Critical:
  This class is intended for those areas where the existing level of development is already too great for the existing stormwater infrastructure to cope with. The pipes will be flowing full and the overflow paths will have large flows.

- Near Capacity:
  This class is for areas where stormwater assets are flowing between 70 % capacity and full flow. There is room for additional flows in the pipe however only limited room.

- Sufficient Capacity:
  This class is for areas where there are no flooding problems for the present level of development, and the pipe has additional capacity to cope with additional runoff from more infill development.

Once each pipe in the study area has been assigned a capacity class, we can then model the maximum development level. The runoff coefficient for the maximum development level will be determined based on the land zone, as shown in Table 5.2 of this report. Once both levels of development have been modelled, this will allow us to compare the results and determine what action is required to cater for the future increase in runoff.

5.2 Risk Assessment

Field trips have been conducted to confirm the accuracy of GIS data supplied by BCSC. There are situations in the study areas where GIS data has been assumed in the absence of physical inspection. BCSC have records which states whether the data has been physically measured or assumed. The critical data for this research project is the reduced levels to Australian Height Datum (AHD) and the pipe materials. Field trips will endeavour to record missing data and to clarify any discrepancies present in the data. There are a certain number of assets that cannot be inspected and the assumed data must be used. For example, buried junction pits in private backyards. These pits are normally in Council easements, however it is not uncommon for the land owner to construct a garden shed or landscaping over these assets.

A risk assessment for these field trips has been conducted using the Victorian State Government’s template (2018). This risk assessment is included in Appendix C. The risk assessment shows that all risks associated with the field trips are adequately managed. The highest risk identified was traffic when measuring any side entry pits beside the road carriageway. This is identified as a high-risk activity, however the risk is managed with the use of appropriate signage, flashing lights and a spotter.

The appropriate controls were put in place to lower all risks to acceptable levels.

5.3 Rainfall Data

The temporal patterns relevant for Bass Coast were downloaded from the AR&R data hub. Ball et al. (2016) suggest an ensemble of ten temporal patterns are modelled. Interestingly, it is not recommended to use the temporal pattern which represents the worst case for design. Ball et al. (2016) suggest it may be more practical to design adopting an average which may be more representative of the local conditions. If a single storm is to be selected for design, it is important to ensure the selected temporal pattern represents a mean result for the whole catchment response.

For this project, we have modelled ten randomly selected temporal patterns to accord with AR&R 2016. The same ten temporal patterns have been used for each study area for simplicity.

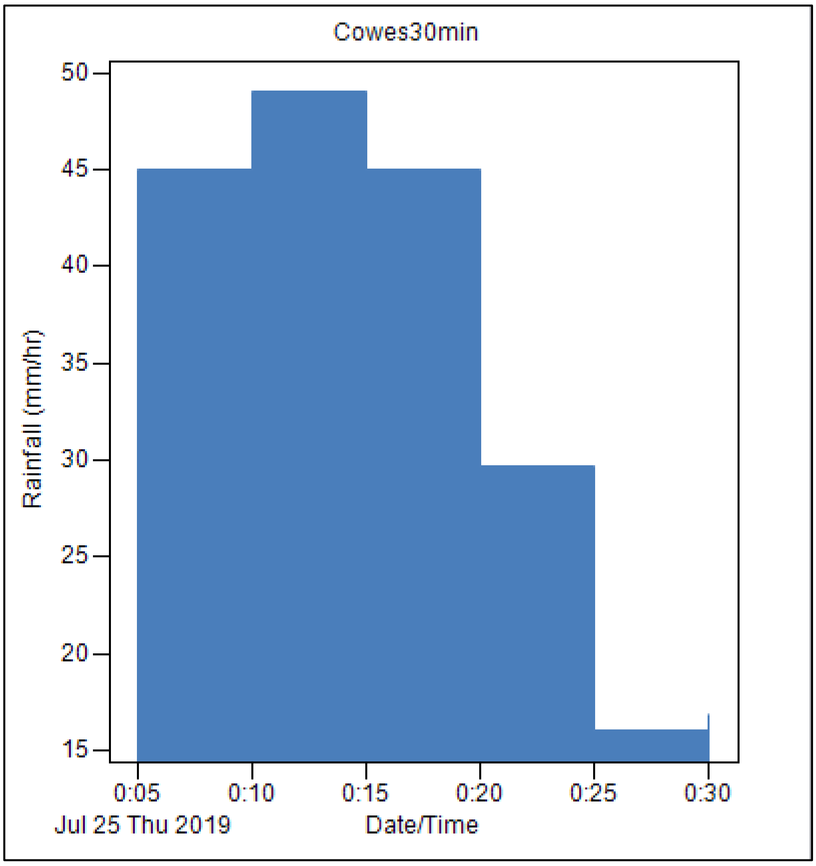

Figure 5.1: Temporal pattern for 30 minute storm

Figure 5.1 represents the shortest storm in duration that was modelled for this project. The shortest time step for the temporal patterns available on the AR&R data hub is 5 minute intervals. This results in a 'blocky' temporal pattern which may not represent the peak intensity as accurately as it may occur in reality. This is a limitation of the available data.

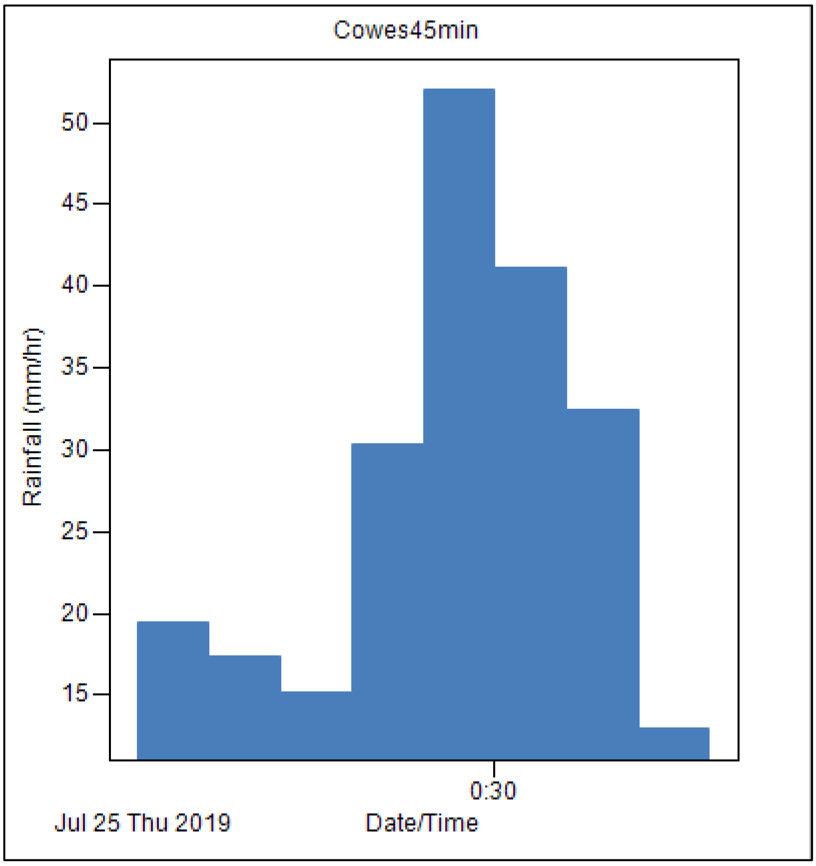

Figure 5.2: Temporal pattern for 45 minute storm

Figure 5.2 represents a temporal pattern of 45 minutes in duration. The intensities have been recorded in 5 minute intervals as per the previous. A more obvious peak intensity is evident in Figure 5.2.

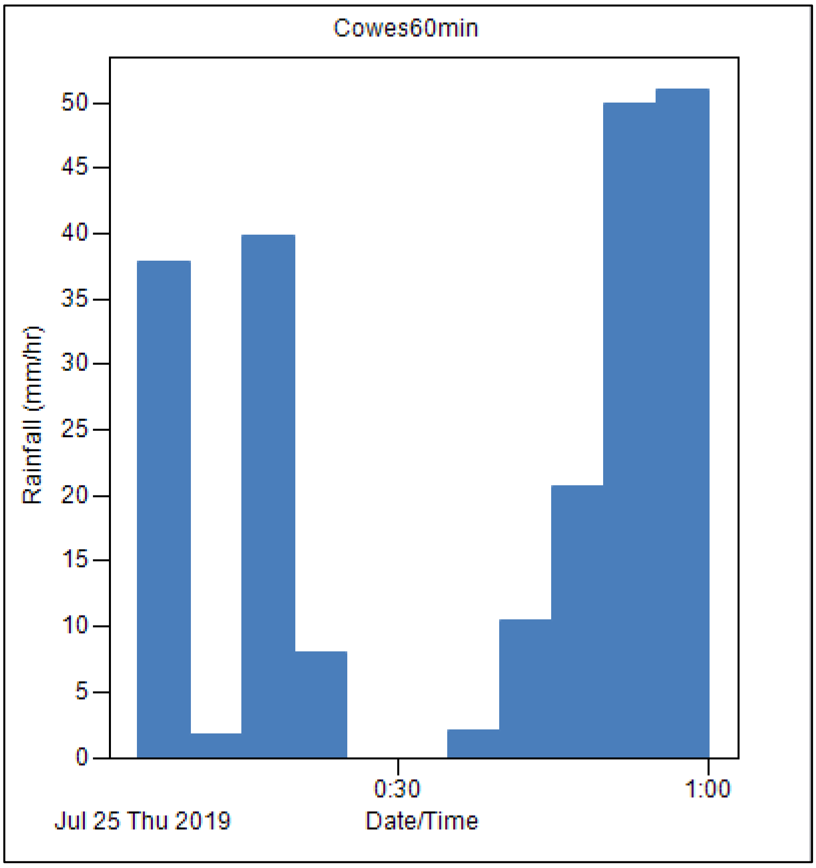

Figure 5.3: Temporal pattern for 60 minute storm

Figure 5.3 graphs the selected temporal pattern with a duration of 60 minutes. The time step is again 5 minute intervals. This pattern is different to the previous as it has two isolated peaks, separated by a lull in the middle of the storm. The second peak occurs at the end of the 60 minute duration, which presumably would result in a larger amount of runoff due to the ground being already saturated by the initial high intensity rainfall at the beginning of the storm.

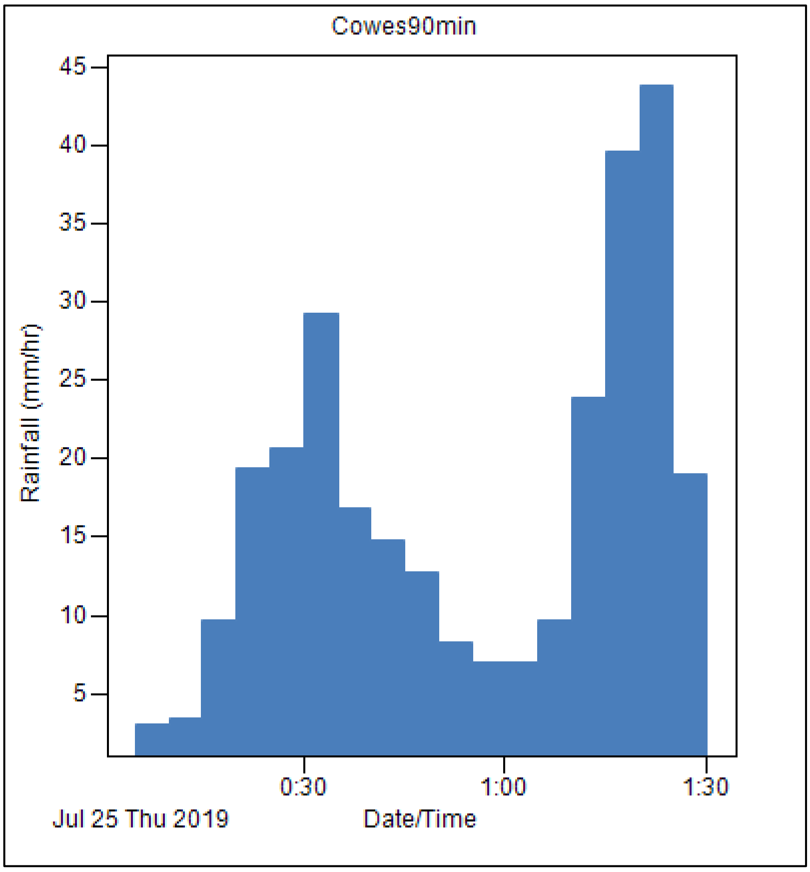

Figure 5.4: Temporal pattern for 90 minute storm

Figure 5.4 represents a similar temporal pattern to the 60 minute storm, only of longer duration with less intense peaks. The time steps are also recorded at 5 minute intervals.

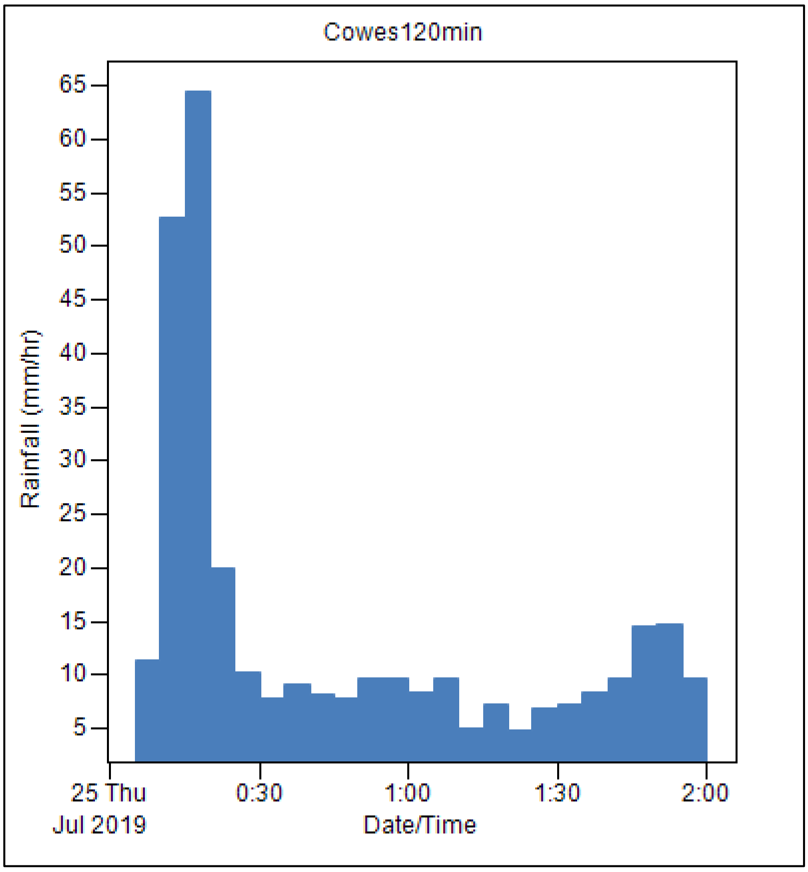

Figure 5.5: Temporal pattern for 120 minute storm

Figure 5.5. represents the first of two different temporal patterns modelled for a 120 minute duration. This storm starts with short burst of very high intensity, followed by a relatively long duration of steady rainfall. 5 minute intervals are again used.

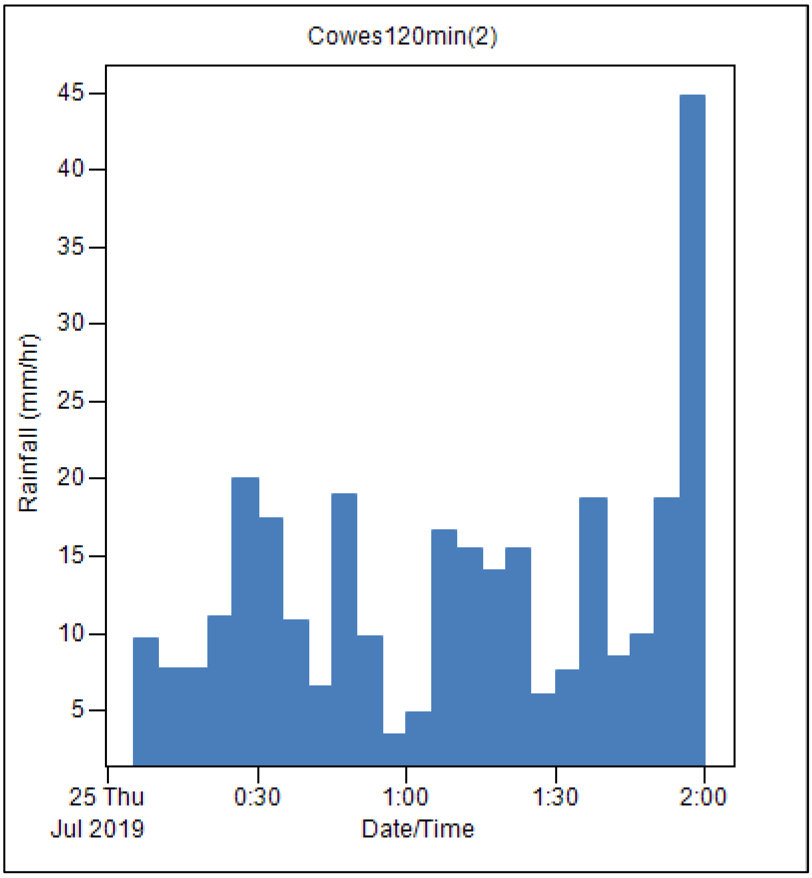

Figure 5.6: Alternative temporal pattern for 120 minute storm

Figure 5.6 is the reverse of Figure 5.5 in the sense that the storm starts with a reasonably steady intensity until an isolated peak, high intensity burst right at the end of the storm's duration. The catchment is likely to be saturated before the peak hits, potentially resulting a very high rate of runoff. Although, the peak is not as intense as the temporal pattern in Figure 5.5.

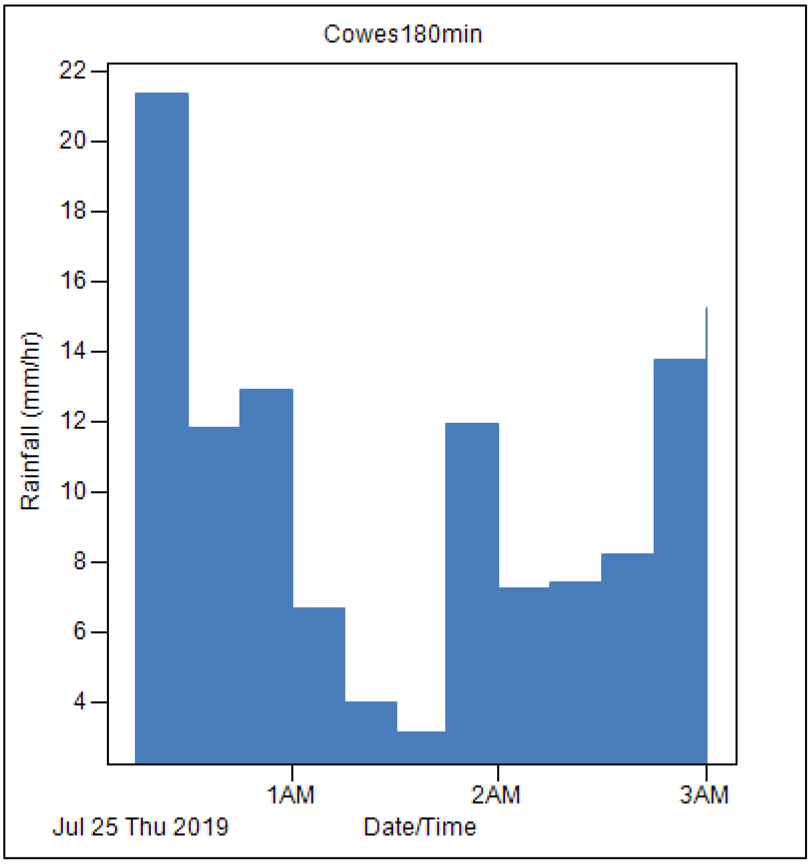

Figure 5.7: Temporal pattern for 180 minute storm

Figure 5.7 represents a 3 hour long storm with a longer time step of 15 minutes. The issue with the larger gap in the recording intervals is that there may be hidden peaks within the 15 minute duration. Therefore, the intensities are more likely to represent average durations which may result in reduced flows which may not represent the realistic peak flow. The highest peak intensity in Figure 5.7 is less than half the corresponding peak in the previous temporal patterns.

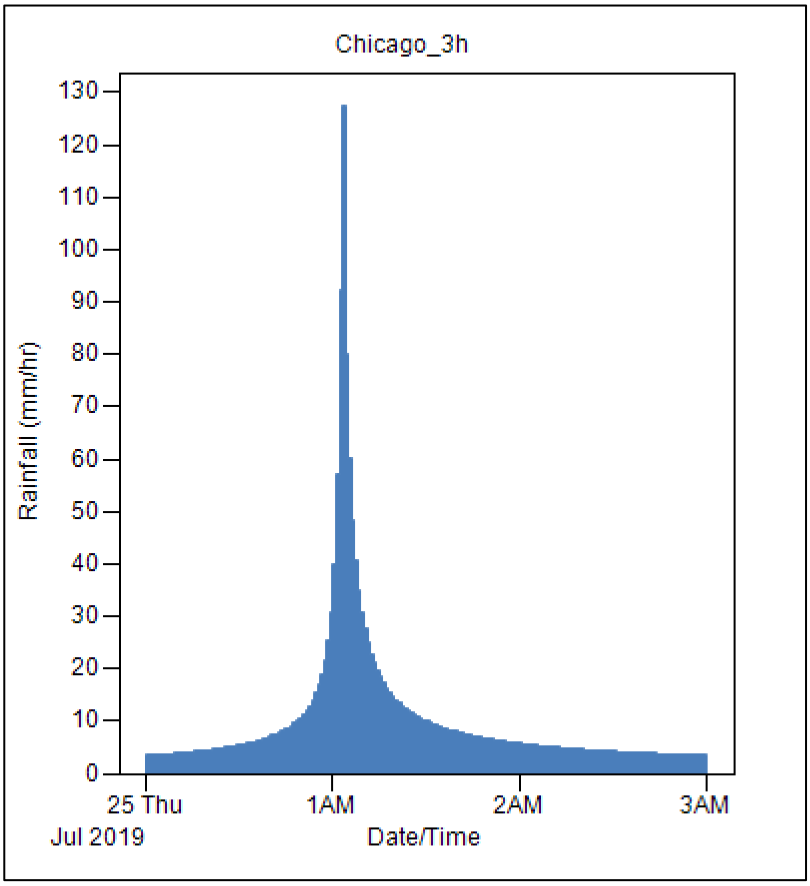

Figure 5.8: Alternative temporal pattern for 180 minute storm

Figure 5.8 is the predefined temporal pattern in PCSWMM that comes with the software. It is labelled 'Chicago_3h'. This storm event is defined via a 1 minute time step. This temporal pattern has also been calibrated for a 20 % AEP using the IFD data for Cowes in Table 5.1. This rainfall event shows an exponential increase in intensity to a peak around the middle of the duration, followed by a sharp exponential decline in intensity. The result is a very high intensity for a very short duration. Although this storm was not part of the temporal pattern suite downloaded from the AR&R data hub like the rest, it was considered valuable for the modelling exercise. The extreme intensity and the much shorter time steps made this storm event unique compared with the other temporal patterns.

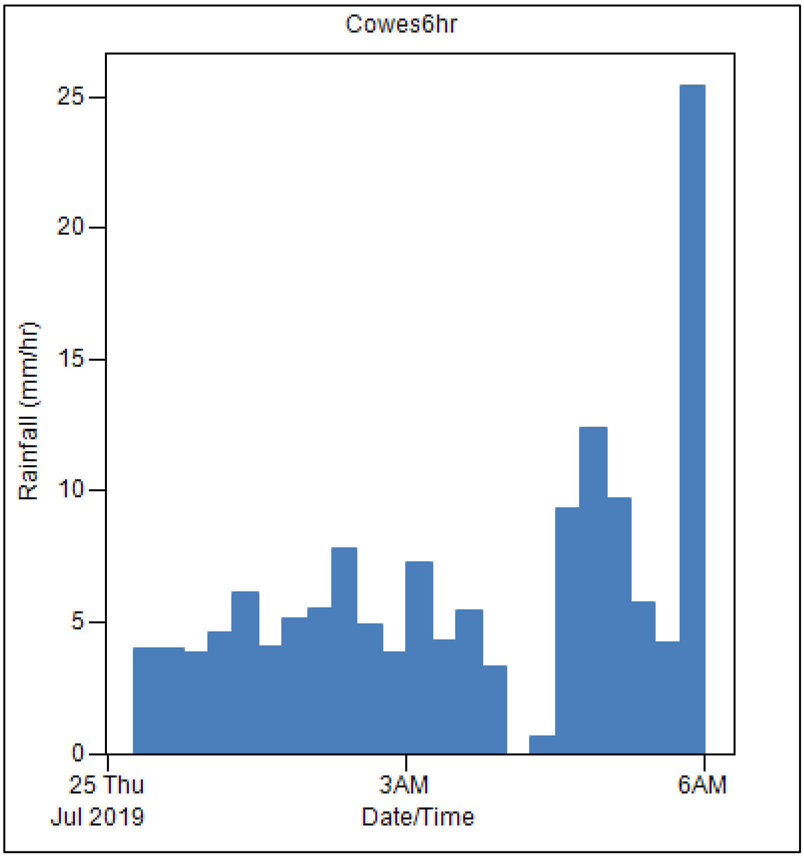

Figure 5.9: Temporal pattern for 6 hour storm

The time step for the 6 hour storm shown in Figure 5.9 is 15 minutes. As with Figure 5.7, the peak intensity may be flattened by the relatively large time steps.

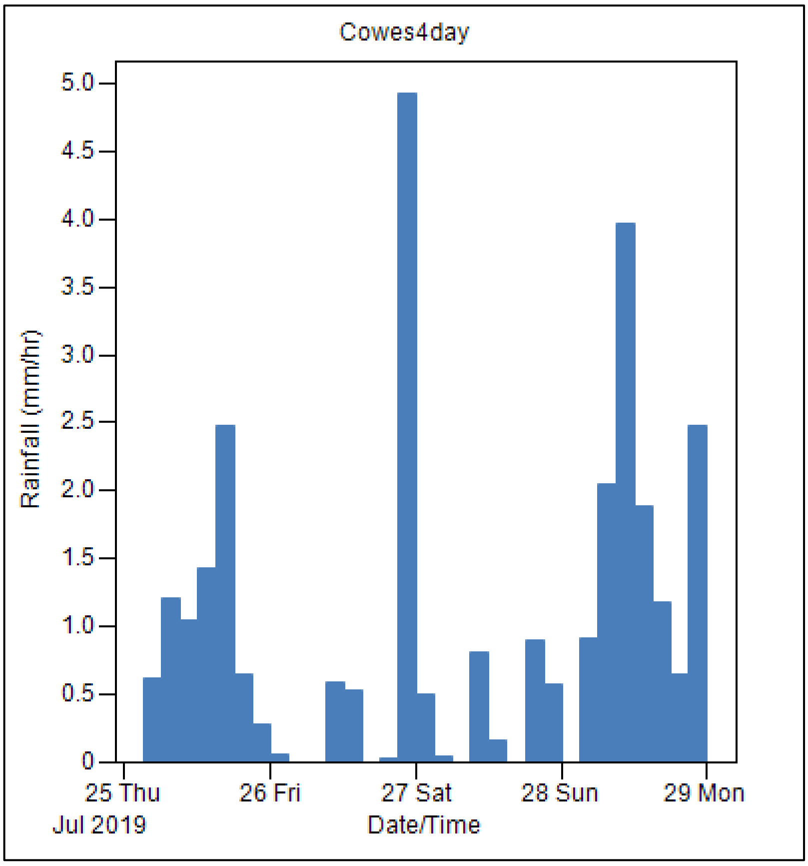

Figure 5.10: Temporal pattern for 4 day storm

The 4 day storm shown in Figure 5.10 has been recorded in 3 hour intervals. This means that any bursts of rain within each three hour period are not defined. This a potential issue as the modelling results using this temporal pattern may not be reflective of the peak flow. This is almost certainly hidden within a 3 hour average intensity period. No other temporal patterns were modelled for these lengthy durations as the results of the flow for the small scale study areas will be quite obviously much lower than that for shorter, more intense storms.

All the above temporal patterns have been calibrated for a 20% AEP for the Cowes location. This calibration is done by ensuring the total rainfall volume is equivalent to the IFD values of a 20% AEP, which are highlighted in blue in Table 5.1.

Table 5-1: Cowes IFD values (BOM 2016)

	Annual Exceedance Probability (AEP)						
Duration in min	63.20%	50%	20%	10%	5%	2%	1%
1	1.54	1.68	2.16	2.49	2.83	3.3	3.68
2	2.68	2.91	3.67	4.2	4.68	5.22	5.63
3	3.58	3.89	4.92	5.65	6.32	7.12	7.73
4	4.33	4.72	5.99	6.88	7.74	8.83	9.67
5	4.97	5.43	6.91	7.96	8.99	10.3	11.4
10	7.3	8	10.3	11.9	13.6	15.9	17.9
15	8.89	9.74	12.5	14.5	16.6	19.6	22
20	10.1	11.1	14.2	16.5	18.8	22.2	24.8
25	11.1	12.2	15.6	18.1	20.6	24.2	27
30	12	13.1	16.8	19.4	22.1	25.8	28.8
45	14	15.3	19.5	22.5	25.5	29.5	32.7
60	15.6	17	21.5	24.8	28	32.2	35.5
90	17.9	19.5	24.6	28.2	31.8	36.3	39.9
120	19.8	21.5	27.1	31	34.7	39.7	43.5
180	22.5	24.5	30.9	35.2	39.5	45.2	49.5
270	25.6	27.9	35.3	40.3	45.2	52	57.3
360	27.9	30.6	38.8	44.4	50.1	58	64.2
540	31.6	34.7	44.5	51.3	58.2	68.2	76.2
720	34.4	37.9	49.1	56.9	65	77	86.6

The IFD data was downloaded from the BOM website to calibrate the temporal patterns to give us a storm intensity representative of the 20 % AEP for Cowes. The IFD data for Inverloch was also downloaded, however given the close proximity between the two study areas, the difference in values were negligible. Therefore, for simplicity, the same IFD data and subsequent temporal patterns have been used for each study area.

5.4 Subcatchment Properties

What is the minimum lot size in Bass Coast? Unfortunately, there is no simple answer to this question. It depends on several planning factors, such as the land zone, planning overlay, neighbourhood character, vegetation constraints, etc. This dissertation does not intend to delve into the profession of town planning therefore we have to make assumptions to develop the model. The following assumptions could be made regarding minimum lot sizes and runoff coefficients:

- Minimum lot size to be 300 m^2 across the board in the residential areas. This is a general rule of thumb for the minimum lot size in a General Residential Zone (GRZ) that can meet the requirements of the planning scheme.

- For this project, industrial and commercial zones were not part of the selected study areas. therefore we do not need to calculate lot sizes. Regardless, for these land zones we would adopt the runoff coefficients in the IDM (LGIDA 2019, p. 105). This value is 0.9 for both land zones.

The rationale behind calculating minimum lot sizes in residential areas is the fact that with smaller lot size comes a larger portion of impervious surfaces. According to the planning staff at BCSC, the average roof area for an old home in Bass Coast would be approximately 200 m^2. So if we have existing lots of say 800 m^2, allowing a 100 m^2 for a driveway and paved areas, we would have 500 m^2 of pervious garden areas. Therefore 62.5 % of the property is garden area with a low coefficient of runoff. Now let us assume this property is developed. With a lot size of 800 m^2, the lot may be subdivided in two, creating two lots of 400 m^2. If a house in constructed on each lot, and each has their own driveway, impervious surfaces may account for 300 m^2 on each lot. So now there is a total of 600 m^2 of impervious area. Thus, the infill development could result in only 25 % of the property being available for garden area.

The existing level of development will be estimated off the BCSC aerial images. The primary task is differentiating the roof areas, paved areas and landscaped areas. The runoff coefficients for each surface are consistent with those in the IDM and are reproduced here in Table 5.2.

Table 5-2: Runoff coefficients for surface type

Surface	Runoff Coefficient
Roof	1.00
Paved	0.95
Landscape / Garden	0.25

In accordance with IDM standards, the runoff coefficients to model the maximum developed conditions should be in accordance with Table 5.3. The coefficient would be applied to the entire area of the catchment. This simplifies the calculations whilst also maintaining a reasonable level of accuracy. These values are conservative and assume the lots are developed to their maximum development potential.

Table 5-3: Runoff coefficients for land zones

Land Zone	Runoff Coefficient
General residential	0.80
Industrial and Commercial	0.90
Open Space Reserves	0.35

Although we will not be using the Rational Method, we can replicate these conditions using PCSWMM by estimating a suitable percent impervious. The following sections of the report will demonstrate how this is done.

5.4.1 Existing Level of Development

To model the existing level of development in PCSWMM, we must calculate the percentage of impervious area from the catchment area. The impervious area for each subcatchment has been manually measured off the aerial imagery on BCSC Intramaps. There is a measuring tool on the GIS interface which allows the user to manually define an area. The use of the measuring tool is demonstrated in Figure 5.11. A blue perimeter has been manually traced around the roof and the tool automatically estimates an area from this. Here a house roof area, at 31 Beach Street in Cowes, has been measured as 143.5 m².

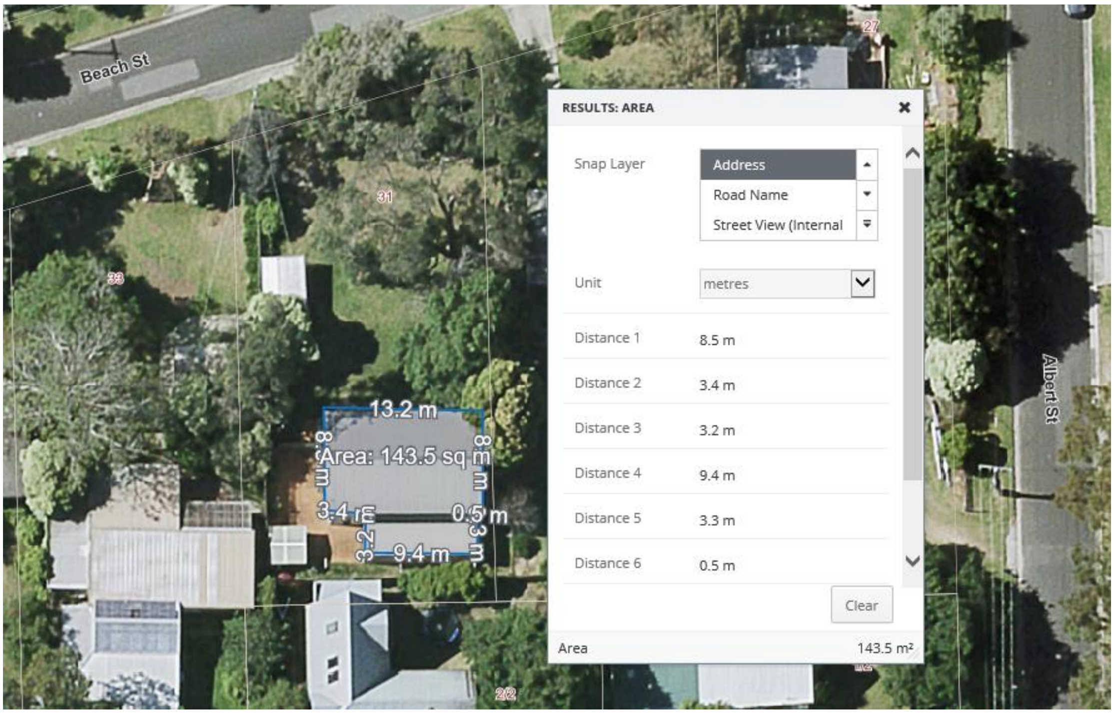

Figure 5.11: Intramaps measuring tool

The measuring tool provides a reasonable level of accuracy that was deemed acceptable for this project. BCSC has land titles on record for new developments. Every land title shows the exact area for each land parcel. A sample of land titles were compared to the area as measured on Intramaps to give an indication on the level of accuracy to be expected from the tool. The results of this comparison are shown in Table 5.4.

Table 5-4: Intramaps measuring tool errors

Land Title Area (m²)	Intramaps Tool Measured Area (m²)	Error
7015	7161	2%
881	889	1%
728	716	-2%
702	698	-1%
628	615	-2%
753	775	3%

It is evident that the tool has a sporadic error up to approximately 3%. Given the reasonably low error, this was considered acceptable for the impervious area estimation. It is also noted that the measuring tool is prone to both over and under estimation. No calibration of the measuring tool was therefore necessary due to the errors being random.

This measuring tool was used for every roof, road, driveway and other impervious surface which was visually evident on the December 2018 aerial photograph. The aerial images from BCSC were much higher resolution to that found on Google Maps or Bing Maps. Although tedious, this was seen as the most accurate way to define the existing percent impervious and ultimately the existing level of development. Once the impervious areas were measured, they were tabulated for each subcatchment and entered into the PCSWMM model. The tabulated areas are included in Appendix D and E for the Cowes and Inverloch study areas respectively.

5.4.2 Maximum Level of Development

To determine the maximum level of development, we must assume that every lot is subdivided to the smallest possible lot. The smaller the lots, the larger the ratio of impervious surfaces. Under current planning legislation in Bass Coast Shire, residential developments must maintain a minimum garden area of 25 %. This means that we must assume 75 % impervious areas for all residential land. To model the maximum level of development then, we modify the subcatchment properties in PCSWMM so that all residential lots are 75 % impervious. Care must be taken though, as not all subcatchments comprise only residential lots. The road reserves are much closer to 50 % pervious surfaces. A good example of this is S14 in the Cowes subcatchment data in Appendix D. This subcatchment includes a lot developed to full potential with 75 % impervious surfaces, however the subcatchment includes a road reserve. The total proportion of impervious surfaces was measured to be 63 %. Therefore, we cannot assume every subcatchment will become 75 % impervious or this will overestimate the flows.

For the Cowes study area, there are two existing subcatchments which are developed to their full potential but contain road reserves as part of their catchment areas. From Appendix D, these have been identified as S08 and S14 measured at 56 % and 63 % impervious respectively. For this study area, for simplicity we will adopt an estimate of 60 % impervious area for subcatchments containing areas of road reserves.

The other determining factor in modelling the maximum level of development is the ratio of roof areas to paved surfaces. Given we are assuming roof areas have no depression storage, i.e. classified as 'zero impervious' in PCSWMM, we must quantify what percentage roof areas will be. Again, this will be variable depending on the development and the amount of road reserve present. For S08 and S14, the roof areas were measured to be 61 % and 57 % of the impervious areas respectively. Therefore, we will assume 60 % of the impervious area to be roof areas or zero depression storage.

To model the maximum level of development, the subcatchment properties will be amended in accordance with the above analysis and then the simulation will be run again to compare the results. The same temporal pattern will be modelled to ensure consistency in the results.

5.4.3 Other subcatchment inputs

The figure below shows the subcatchment input data required to run the PCSWMM model.

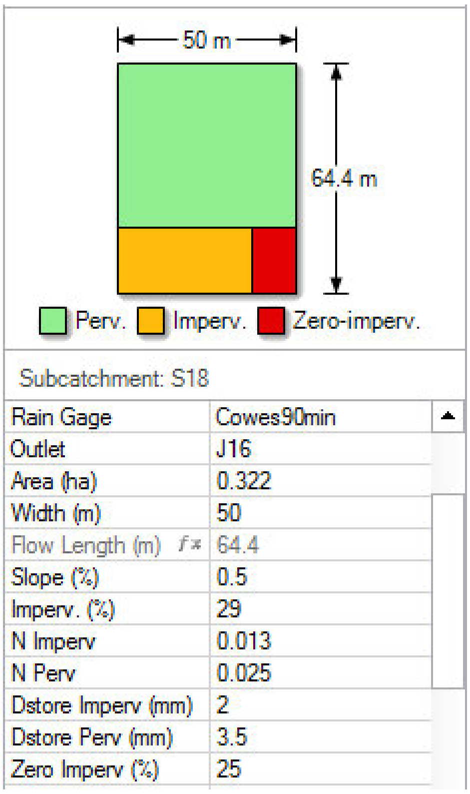

Figure 5.12: Subcatchment inputs

- Depression storage values were assumed from recommended values by Torlapati (2017). This was 2.0 mm for impervious surfaces and 3.5 mm for pervious areas.

- Manning's n values were estimated from the recommended values by Mag (2019). This was n = 0.013 for concrete pipes; n = 0.025 for pervious areas (most pervious areas are well mown grass).
- Slope for each individual subcatchment was calculated based on the contour data at 0.5 m intervals obtained from BCSC.

6.0 Cowes Results

6.1 Existing Criticality

To determine if the existing drainage system for the Cowes study area is adequate, we have run the PCSWMM model for a 20 % AEP storm using 10 different temporal patterns. These temporal patterns are visually portrayed in Figures 5.1 to 5.10. We can then compare the peak flows and select an average storm to be used for the determination of the existing and future criticality of the drainage system. A screenshot of the drainage model that has been created in PCSWMM for the Cowes study area is reproduced in Figure 6.1. The red triangle is the outfall; blue dots are the pits; yellow lines are pipes; green polygons are subcatchments; and red dotted lines show which pit each subcatchment is discharging to. The subcatchment boundaries have been assumed to follow lot boundaries for model simplicity. This assumption is evident in Figures 6.1 and 7.1.

Figure 6.1: PCSWMM model of the Cowes study area

PCSWMM labels the pipes as ‘conduits’. Figure 6.2 compares the peak flow results of three conduits C01, C02 and C03 for all ten temporal patterns that have been used in this study. C01 is the largest pipe with the highest flow as it is the last pipe before the outfall.

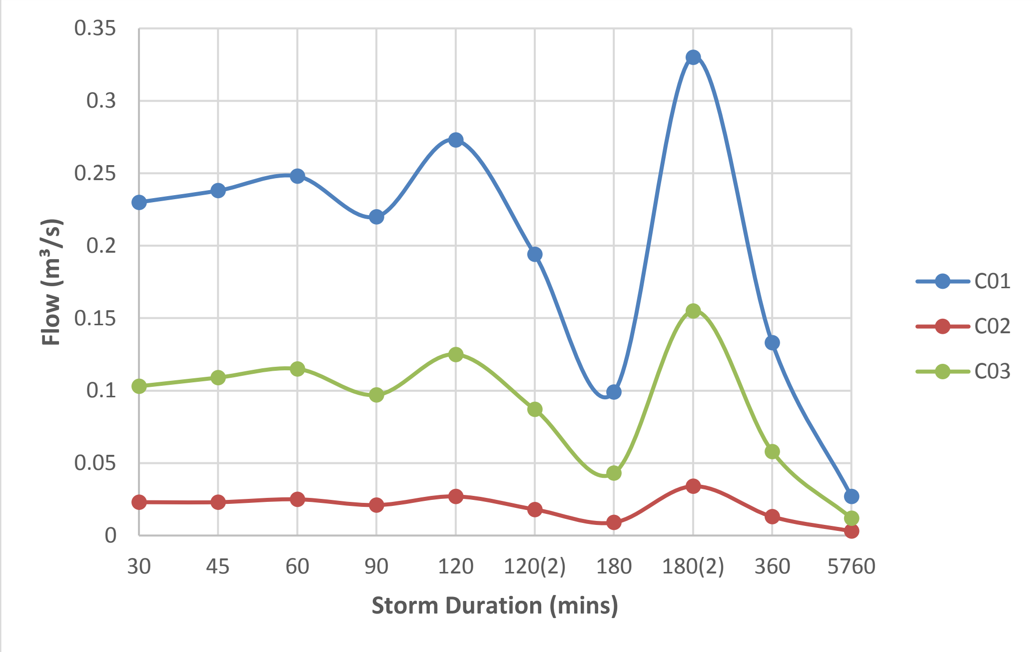

Figure 6.2: Peak flow comparison

As can be seen in Figure 6.2, the peak flows fluctuate wildly for durations greater than 120 minutes. This could be attributed to the large time steps in these temporal patterns. The trend for the longer storms is that the peak flow is reduced. The one exception to this is the 180 minute storm shown in Figure 5.8. This storm has time steps of one minute with a very high peak rainfall intensity, and as a result we can see that the largest flows recorded were from this temporal pattern. Conversely, the temporal patterns adopted from the AR&R data hub (2019) for the longer storm events resulted in relatively low flows.

To align with the suggested modelling practices by Ball et al. in AR&R 2016, we need to adopt the storm in Figure 6.2 which represents the average peak flow. Given the random nature of the storms of duration equal to and greater than 180 minutes, these will be discounted. This eliminates the highest and lowest flow results in Figure 6.2. The average peak flow was calculated and then a table of percent difference was created to determine the temporal pattern which was most representative of the average. This correlated to the 90 minute temporal pattern seen in Figure 5.4. The model has been simulated for the 90 minute storm, with all results from PCSWMM reported in Appendix F

The results obtained from the 90 minute storm found the hydraulic capacity has been exceeded in 7 pipes. Of interest, 6 of these pipes from the branch which runs north-south on the left in Figure 6.1. Note that north is straight up the page in Figure 6.1. It is important to note that at the top of this catchment, there is a subcatchment which is already developed to its maximum potential. S10 in Appendix D is 74 % impervious and is piped directly to the southernmost junction pit. This is piped to a 225 mm pipe which is laid at a relatively flat grade, which is reason for the lack of capacity. This 225 mm diameter pipe is likely to have been installed prior to the development of S10 and has obviously not been designed for the high percentage of impervious surfaces. The gradient of the pipe is very important for hydraulic capacity as explained by

Manning's equation which is further explained in Section 7.3 of this report. The grades of the pipes which are under capacity, shown in Figure 6.3, are shown in Table 6.1.

Table 6-1: Under capacity pipe gradients in Cowes

Pipe	Grade
C18	2.1%
C19	0.7%
C20	0.8%
C21	0.4%
C22	3.1%
C23	0.4%

Half of the pipes which were found to be under capacity are below 1 % grade, which is not desirable. There are two pipes which are below 0.5 % which is very flat and potentially cause for our capacity issues.

The south-westernmost subcatchment, namely S14 in Appendix D, is also developed to full potential. This subcatchment is 63 % impervious and discharges to a 225 mm diameter pipe. Given the pipe is already taking large flows from subcatchments S10 and others, its capacity is well exceeded.

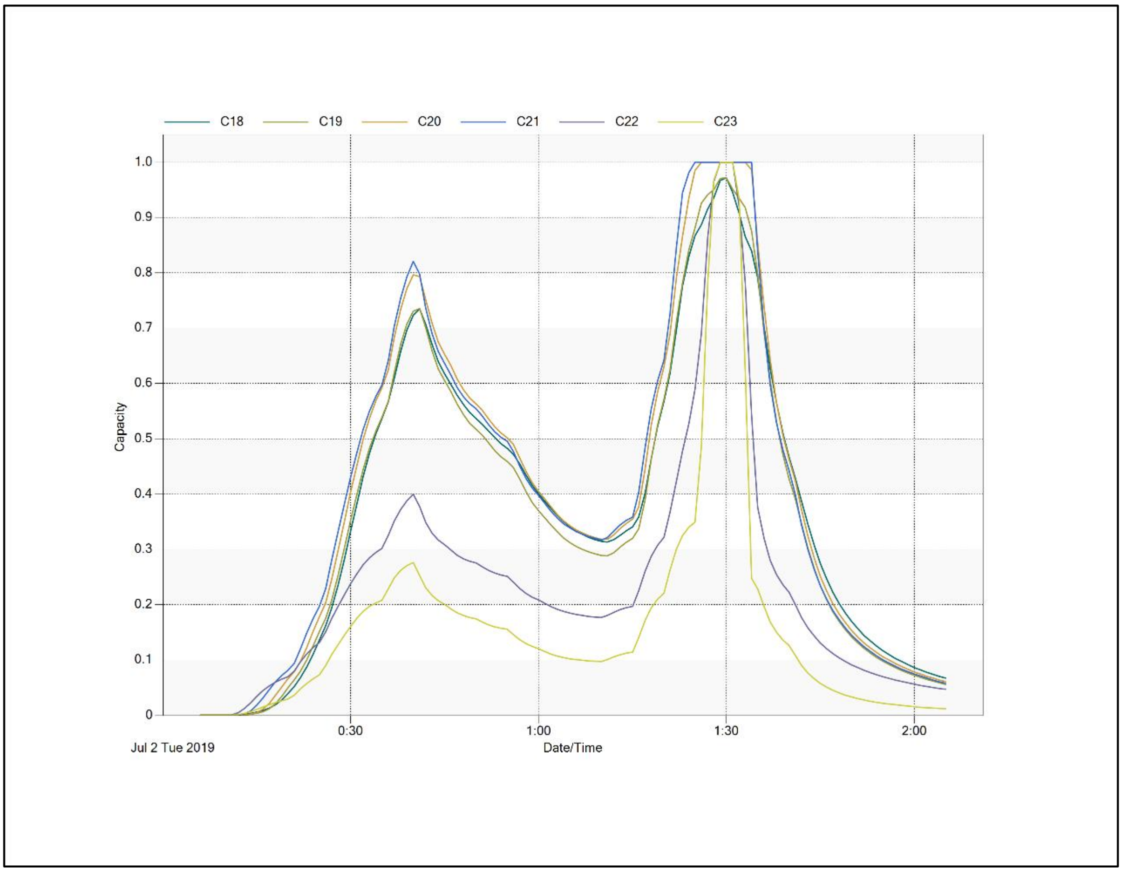

Figure 6.3: Cowes pipe capacity 'critical' chart from PCSWMM

Figure 6.3 shows the pipe capacity results for the pipes classified as critical. The y-axis shows a capacity reading, which is 1.0 for flowing full and exceeded capacity; 0.5 for half full and half empty; 0.1 for 10 % full and 90 % empty, etc. For a 2 hour simulation run in PCSWMM for the 90 minute temporal pattern, we can see that the flow in the pipes closely represents the temporal pattern. There are two obvious peaks in flow which correlate with the peak intensities seen in Figure 5.4. What is evident form Figure 6.3 is that the capacity in the pipes are only exceeded for a relatively short amount of time. When the storm is finished at the 1 hour 30 minutes mark, the flow in each pipe also decreases exponentially.

Although we have several pipes under capacity, there is minimal flooding in this study area for the existing level of development. The results from PCSWMM showed flooding at only one pit in the network. This flooding was for a relatively short period of time with a minor flow. This means that although the pipes are flowing full, they are at sufficient depth that the hydraulic grade lane is still below the surface for most of the network. The water level in the pits is above the obvert of the outlet pipes but in all but one case there is no water overflowing onto the road. This is significant because it means that our drainage network is currently functioning for the 20 % AEP storm event in accordance with Figure 2.1.

These results have been confirmed with BCSC maintenance staff, who say flooding in this area has not been recorded. Allegedly, storm water can sit around in the kerb for days due to the flat grades, however flooding of the road or properties has not been an issue historically.

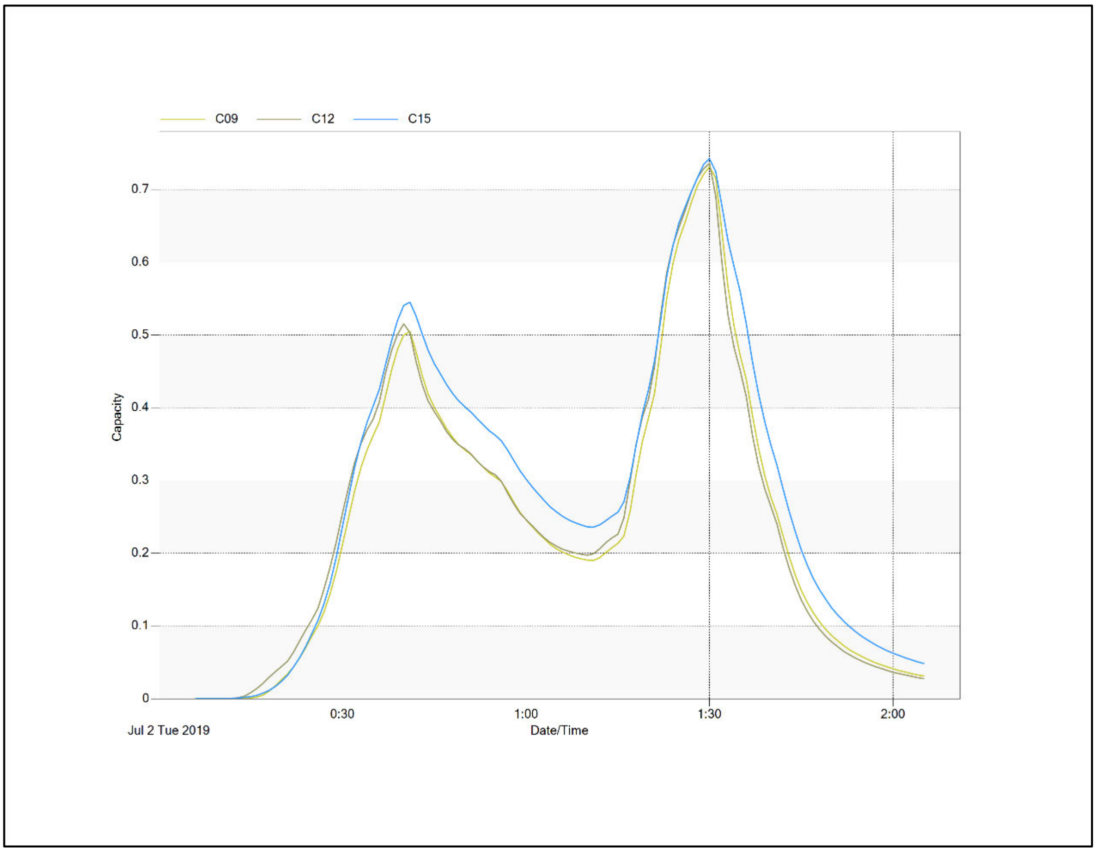

Figure 6.4: Cowes pipe capacity ‘near capacity’ chart from PCSWMM

Figure 6.4 represents the three pipes from the study area that have been classified as being close to capacity exceedance. As can be seen, the peak flow resulted in approximately 75 % hydraulic capacity for each pipe.

All other pipes have greater than 30 % spare capacity and therefore are classified as 'sufficient capacity' for the existing level of development. Based on the initial analysis, the interim pipe capacity classes are listed below:

- Critical = $\frac{6}{23} = 26\ \%$
- Near capacity = $\frac{3}{23} = 13\ \%$
- Sufficient capacity = $\frac{14}{23} = 61\ \%$

It is important to note that although 61 % of the pipes in this study area are deemed 'sufficient capacity' for the existing level of development, this is only an interim assessment. The final capacity classes are determined by modelling the theoretical maximum level of development. This is discussed in Section 6.2 of this report.

6.2 Future Criticality

To determine the future criticality, we have altered the subcatchment properties in accordance with section 5.4.2 of this report. This will simulate the runoff at the theoretical maximum level of development for this catchment. The full results from this model has been reported in Appendix G.

The simulation was run at the theoretical maximum level of development and this resulted in surcharging of 13 out of the total 23 pipes. If we compare this to the existing level of development where only 6 pipes were surcharging, it is evident that more than double that number do not have sufficient hydraulic capacity for future infill development. With these results, we can now confirm the capacity classes for the Cowes study area:

- Critical = $\frac{6}{23} = 26\ \%$
- Near capacity = $\frac{7}{23} = 30\ \%$
- Sufficient capacity = $\frac{10}{23} = 44\ \%$

These results show that although we initially assumed 61 % of the pipes to have sufficient capacity, once we have modelled the full level of development there is actually only 44 % of the pipes with ample capacity for future infill development.

Of the pits, only 3 out of 23 pits experienced flooding. This is potentially acceptable, subject to a risk assessment for the locations that could be flooded.

The infiltration data adopted for our Cowes study area was based on percolation tests obtained from BCSC for a development in the general vicinity. This data is very high at 46 – 432 mm/hr. The soil was confirmed to be mostly sand, as the development is located at the back of a sand dune ecosystem. City of Gold Coast (2007) suggests the saturated hydraulic caonductivity of sand is > 180 mm/hr, so the adopted infiltration data seems high but could be feasible. The results should however be confirmed with appropriate soil samples and subsequent percolation testing in the catchment itself to ensure this study has not overstated the infiltration.

The infiltration data was changed to 3.6 – 36 mm/hr which the City of Gold Coast (2007) recommends for medium clay soils. This was done just to complete an analysis on the effect infiltration data would have on the computed runoff coefficient and subsequent flooding in the catchment. The computed runoff coefficients for each subcatachment, on average, in PCSWMM comparatively was:

- C = 0.58 for 46 – 432 mm/hr (sandy soil as assumed)
- C = 0.61 for 3.6 – 36 mm/hr (medium clay soil)

This resulted in flooding at 5 pits, an additional 2 pits to the previous model. This is a relatively large increase in the prevalence of flooding. We can conclude that infiltration data has a significant impact on the amount of flooding and thus recommend BCSC undertake soil testing to confirm the infiltration rates in different catchments.

6.3 Cowes Results Summary

The results for the Cowes study area show that more than half the pipes in the drainage network do not have sufficient hydraulic capacity to cater for future infill development. This is represented graphically in the figure below.

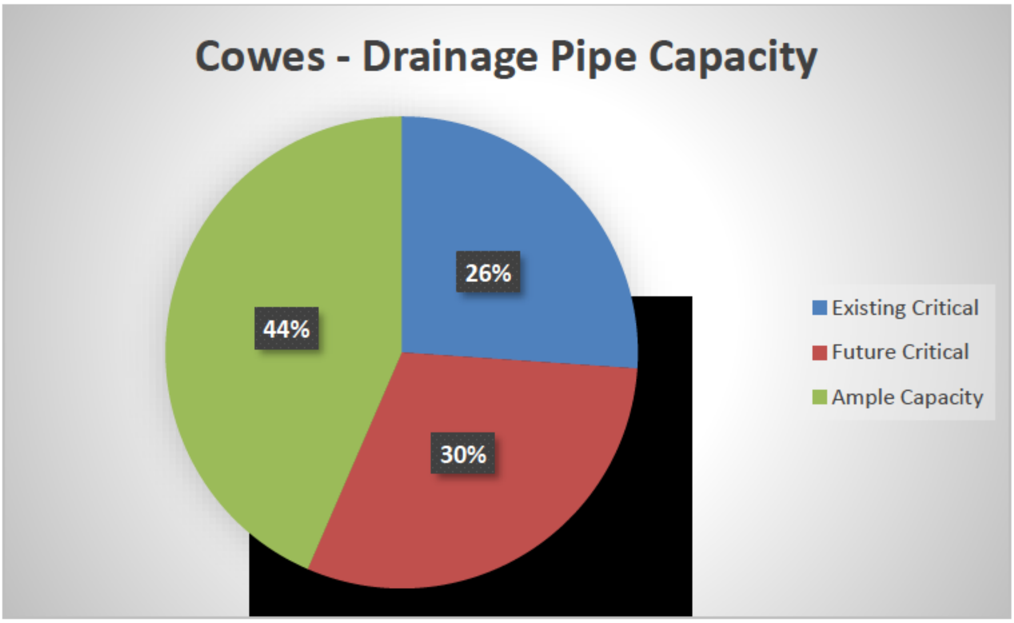

Figure 6.5: Cowes pipe capacity summary

Only 44 % of the pipes in the drainage network in the Cowes study area have adequate hydraulic capacity for future infill development. On face value this may be considered unacceptable. Conversely, when the resultant flooding is taken into consideration it may be more acceptable. Considering only 3 out of 23 pits were flooded, much of the drainage network is considered adequate for infill development.

Our results are therefore conclusive that drainage improvements are required to cater for future development although the risk of no action at this location is low.

6.4 Recommended upgrades

There are two approaches typically used to cater for infill development. Either the drainage network requires upgrading to an increased capacity, or alternatively each development must retard the flow of water off their development site to the capacity of the downstream drainage infrastructure.The approach of upgrading downstream drainage infrastructure is often costly and unfeasible for relatively small scale development which is common in Bass Coast. Onsite detention is often preferred, as this may be cheaper for small development sites.

What has been discovered in this analysis is that a blanket requirement for onsite detention for small catchments may not be necessary. This is a conservative approach to infill development that has been employed by BSCS to protect their assets and ultimately to protect the community from potential flooding. It is however a significant expense for relatively small developments to detain water onsite. This analysis has discovered that the risk to the community for the Cowes study area is low and therefore onsite detention should be reconsidered for some developments in this catchment. It is noted however that the catchment is relatively flat and any flooding may result in stagnant water sitting around for long periods of time. This becomes an amenity issue and is unfavourable for the community.

Onsite detention should continue to be applied in this catchment to avoid flooding however the blanket approach should be reviewed by BCSC. Due to only three instances of flooding found in our results, it is recommended Council also explore pipe upsizing as a solution to infill development in this catchment. It may result in only one or two pipes to be upgraded. This could potentially avoid the need for onsite detention to be enforced.

7.0 Inverloch Results

7.1 Existing Criticality

For the Inverloch study area we have followed the same methodology used in chapter 6. First we have identified the existing level of development and run the PCSWMM model for a 20 % AEP storm using 10 different temporal patterns as shown in Figures 5.1 to 5.10. Again we have compared the peak flows to select an average storm to be used for the determination of the existing and future criticality of the drainage system. This was the 90 minute storm for Cowes however we have analysed all temporal patterns again for Inverloch to see if a different storm would be adopted to represent the average peak flow. The peak flow comparison in Figure 6.2 was replicated for the Inverloch study area and found an almost identical result. The 90 minute storm was again most representative of the average peak flow and therefore was adopted for our Inverloch study area. A screenshot of the drainage model that has been created in PCSWMM for the Inverloch study area is shown in Figure 7.1. The full results of the model simulation is included in Appendix H.

Figure 7.1: PCSWMM model of the Inverloch study area

The results obtained from the 90 minute storm found surcharging in 7 out of 105 pipes in the Inverloch study area. This is only 7 % of the pipes in the catchment. Importantly, flooding was discovered in just 1 pit. These results suggest that the minor drainage network in Inverloch is performing very well for a 20 % AEP rainfall event. The steeper grades in this catchment may also be to thank, as capacity is greater for the same size pipes as in our Cowes study area. The Cowes study area was relatively flat, with the average grade just over 1 % and many pipes below 1 %. In the Inverloch study area, the average grade is much steeper at approximately 5 %.

The results also found 10 pipes to be 'near capacity' at approximately 70 % hydraulic capacity for our design scenario. This is represented graphically in the figure below:

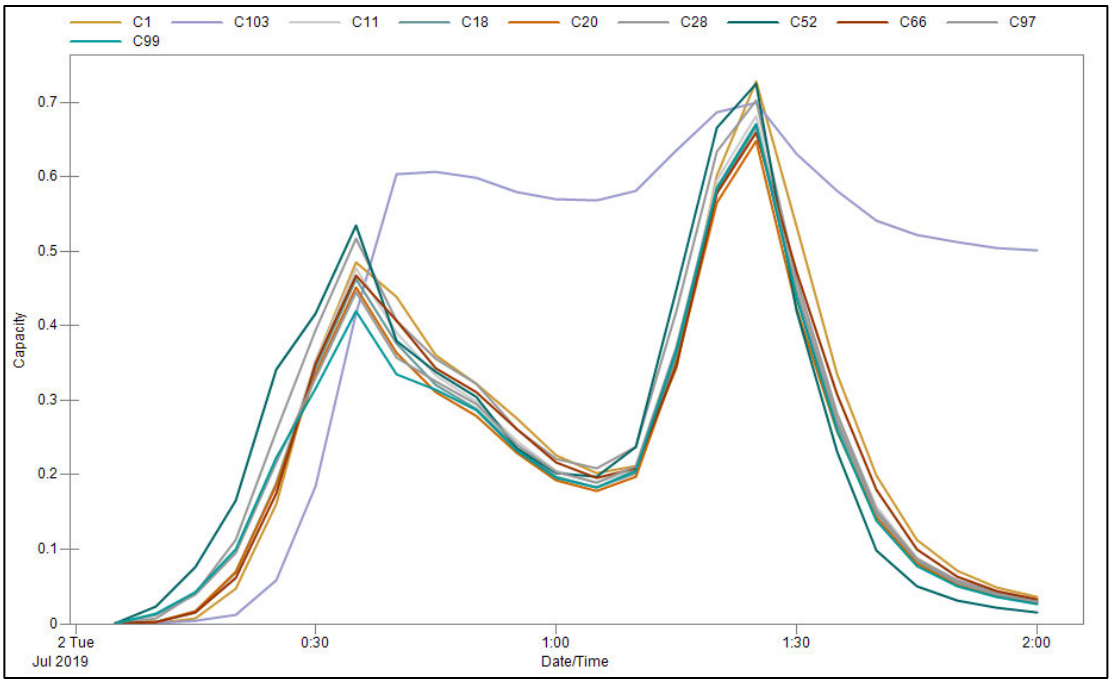

Figure 7.2: Inverloch pipe capacity 'near capacity' chart from PCSWMM

Our interim capacity classes are therefore determined as follows:

- Critical = $\frac{7}{105} = 7\ \%$
- Near capacity = $\frac{10}{105} = 9\ \%$
- Sufficient capacity = $\frac{88}{105} = 84\ \%$

The initial analysis shows the drainage system appears to be functioning relatively well for the existing level of development. The capacity classes will again be revised in the following section where we model the theoretical maximum level of development.

7.2 Future Criticality

Inline with the previous study area, we have again altered the subcatchment properties in accordance with section 5.4.2 of this report. This will simulate the runoff at the theoretical maximum level of development for this catchment. The results from this simulation has been included in Appendix I.

The simulation was run at the theoretical maximum level of development and this resulted in surcharging of 24 out of the total 105 pipes. If we compare this to the existing level of development where only 7 pipes were surcharging, it is evident that more than triple that number do not have sufficient hydraulic capacity for future infill development. This is still considered a low percentage of pipes which do not have capacity for potential infill development. The capacity classes for the Inverloch study area are confirmed below:

- Critical = $\frac{7}{105} = 7\ \%$
- Near capacity = $\frac{17}{105} = 16\ \%$
- Sufficient capacity = $\frac{81}{105} = 77\ \%$

Of the pits, only 3 out of 105 pits experienced flooding. The drainage network has therefore performed considerably well even with the assumed maximum infill development.

Modelling our estimated ‘maximum level of development’, PCSWMM calculated the runoff coefficient to be approximately 0.58. This was for subcatchments with a combination of road reserve and private property. It is important to note that the IDM recommends a runoff coefficient of 0.80 is adopted for residential development in accordance with Table 5.3 of this report.

Based on this research, the IDM runoff coefficients appear to be very conservative. This is to be expected, as the runoff coefficients in the IDM are a standard to be applied across all catchments in regional Victoria. A standard like this to be applied across such a wide variety of area must consider:

- urban areas where a higher percentage of impervious surfaces are found such as town centres;
- more clayey soils where there is significantly less infiltration;
- Modern road reserve widths (narrower than older residential areas);
- Footpaths on both sides of the road (Inverloch typically has a footpath on only one side or none at all)

For Bass Coast, this runoff coefficient of 0.80 for residential areas appears too conservative. For PCSWMM to calculate a runoff coefficient closer to 0.80, the entry data needed to be closer to 75 % impervious with 75 % zero depression storage (roof area) and reduced infiltration data to heavy clay type soils. This is typically not representative of development in Bass Coast. Although, townships such as Wonthaggi and Corinella in the Bass Coast local government area do possess soils with a much higher clay content and thus the runoff coefficient will be higher.

The standard residential streets in Bass Coast have a 16 m wide road reserve of which the road is usually 7.6 m wide from back of kerb to back of kerb. Typically, a 1.5 m wide footpath is provided on just one side of the road and frequently the residential streets have no footpath. This equates to 6.9 m wide grass verge per metre of road if we assume footpath on one side. For, say, a 100 m long road, this equates to a percent impervious in accordance with the following:

- Total Area $= 100 \times 16 = 1600$ m²
- Pervious = $\frac{100 \times 6.9}{1600} = 43$ %
- Impervious = $\frac{100 \times 9.1}{1600} = 57$ %

Let us now assume there are 5 large residential allotments with a 20 m frontage and 50 m deep. This equates to 1,000 m² per lot and a total of 5,000 m². If each lot is developed to it's maximum potential such a multi-dwelling development on every lot and becomes 75 % impervious. Using a weighted average formula, we get the following results:

Total catchment area = $5000 + 1600 = 6600$ m²

Percent impervious = $\left(\frac{5000}{6600} \times 0.75\right) + \left(\frac{1600}{6600} \times 0.57\right) = 71$ %

The results from the theoretical situation above would have you question why a maximum developed percent impervious of 60 % was adopted. This value was measured manually in existing developed residential land parcels in the Cowes study area. The developed areas did not have a footpath in the street and the multi-unit developments had a garden area greater than the minimum 25 %. It is also worth noting that the likelihood of every property in the street developing their blocks with only 25 % land area for a garden is very low. Regional towns typically have larger yards than city counterparts, such is the lifestyle in Bass Coast. The 60 % impervious is therefore considered a more realistic maximum percent impervious for this region.

7.3 Inverloch Results Summary

The results for the Inverloch study area show that over three quarters of the pipes in the drainage network have sufficient hydraulic capacity to cater for future infill development. This is represented graphically in the figure below. The drainage network in this study area is performing very well for our design storm and these results have been confirmed in verbal conversations with BCSC maintenance staff. No flooding has been recorded in the residential streets to date. The exception to these findings is the overtopping of the open drain on Ramsey Boulevard. This is the street which runs east-west along the street. BCSC staff have explained that there are a numerous points where the open drain along Ramsey Boulevard is not well formed and the stormwater flows across the road to the foreshore. This has not been picked up in the model however it is of no consequence to the property owners as stormwater flows make their way through the foreshore and into the ocean.

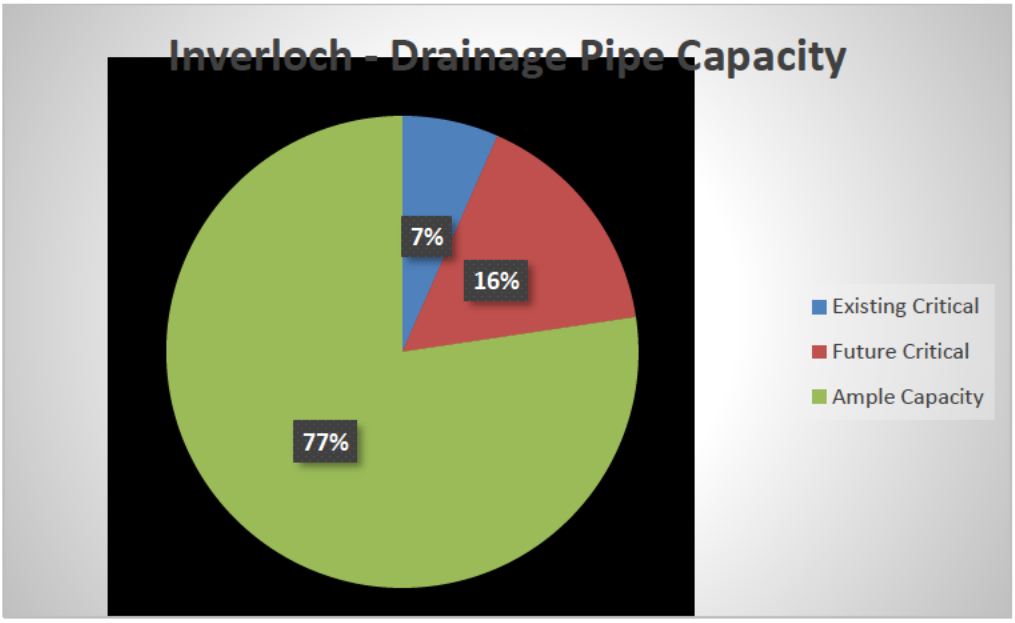

Figure 7.3: Inverloch pipe capacity summary

The results for the pipe capacities in the Inverloch study area are significantly better than that of the Cowes study area. As suggested in Section 7.1, this may be attributed to the steeper grades available in Inverloch and therefore greater flow capacity per pipe size. Manning's equation explains that capacity increase with slope:

$$Q = \frac{AR^{\frac{2}{3}}S^{\frac{1}{2}}}{n}$$

Where Q = flow

A = cross-sectional area of the pipe

R = hydraulic radius

S = slope of the pipe

n = Manning's roughness coefficient

It is also important to note that the assumed soil parameters for Inverloch were different. We assumed a soil with a lower saturated hydraulic conductivity which would result in a greater volume of runoff. It is evident however that more capacity issues were found in the Cowes study area. This strengthens the argument that the pipe slope or gradient has a significant effect on the performance of the drainage network.

7.4 Recommended Upgrades

For the Inverloch study area, it is not recommended to upgrade the network. The analysis has shown that the drainage network is performing adequately to accommodate existing and future infill development with the exception of three pits. The model has discovered that surcharging may occur in approximately 23 % of the pipes, however this is largely contained within the pits and therefore flooding should only an issue in three locations. It is apparent that the blanket approach to onsite detention by BCSC may not be warranted in this situation. The ongoing use of onsite detention systems in this area should be reviewed.

It should be noted that risk assessment must be undertaken before Council could allow infill development to proceed without either onsite detention or pipe upsizing. This study has identified that flooding will occur in two additional locations to the existing situation. Before Council could accept the potential of any additional surcharging, it must be confirmed that there is a safe and adequate overland flow path for the passage of these stormwater flows. This must be confirmed to ensure the Council does not breach the Water Act 1989 (Victoria) in the way of detriment downstream from increased flow. A desktop analysis has suggested the flooding would not directly inconvenience adjoining properties, however this should be confirmed via onsite survey and subsequent modelling.

8.0 Results Summary

8.1 Runoff Coefficients

The runoff coefficient adopted for modelling has a huge effect on the results. For this study, we have manually measured the impervious areas to determine the percent impervious as accurately as possible.

Using a runoff coefficient of 0.80 as recommended by the IDM is a conservative approach for Bass Coast, as it assumes a very small percent pervious of the subcatchment area. Given BCSC Planning Scheme requires a 25 % garden area, the runoff coefficient of 0.80 would assume that no road reserves are part of the subcatchment and it is strictly residential properties with a very high percent impervious. The data required for a 0.80 runoff coefficient was discovered to be approximately:

- 75 % impervious of the total catchment area;
- 75 % of the impervious area with zero depression storage; and
- Medium – heavy clay soils with low saturated hydraulic conductivity < 36 mm/hr.

This percent impervious was not found in previously infill developed properties in the Bass Coast study areas. We have therefore obtained results for a more realistic representation of the development in Bass Coast, which correlated to a runoff coefficient of 0.58. The data used:

- 60 % impervious of the total catchment area;
- 60 % of the impervious area with zero depression storage; and
- Sandy and silty sand soils with high saturated hydraulic conductivity 36 – 180 mm/hr.

8.2 Onsite Detention or Pipe Upgrades

Upsizing the pipes will not always be possible for flat catchments such as Cowes. Cover is often limited where grade is not available, and this complicates matters further. The depth of the outfall also limits the amount of onsite detention that can be provided for surface flows. Furthermore, it may difficult to justify one infill development to replace a Council owned pipe in the road reserve when all other properties may benefit from the upgrade. The cost may also be prohibitive for one developer to cover for small scale developments such as infill. One option would be for Council to take a contribution for upsizing a pipe and adding to the balance when another property in the street is developed later. This is difficult to administer for Council and would result in an ad-hoc approach to drainage upgrades. It is seen as an undesirable way to manage the increased runoff from infill development.

Onsite detention to IDM standards is currently being applied by BCSC for all infill developments. For the Cowes study area, where capacity is more of an issue, it appears logical to require onsite detention for infill developments. However, the approach to burden all infill development with onsite detention does not appear to be suitable for the Inverloch study area. It is therefore recommended that BCSC undertake a review of when to require onsite detention, as a case-by-case analysis may be a more equitable outcome for developers.

Both onsite detention and pipe upsizing have their place and should be applied on a case-by-case basis. It is recommended that BCSC request the consultants who are preparing drainage plans for infill development to propose a solution where hydraulic capacity of the drainage system is known to be problematic. Onsite detention is preferred due to lower administration costs to Council and pipe upsizing should only be considered when existing capacity issues can be resolved.

8.3 Limitations of research

Existing onsite detention systems have been excluded from the study. BCSC does not have a map of the existing onsite detention systems. For us to identify the restricted flow rates off sites with existing detention systems, we would need to search through years of archives to find the hard copy drainage plans. BCSC has not yet made these records available in electronic format, therefore it was not feasible to physically locate these plans and apply the restricted flow rates to our model. This makes it difficult to identify the actual PSD from sites developed in the last two decades. Given there are relatively few of these new development in the study areas with onsite detention systems, the restricted PSD from these sites has not been considered in the research. As previously explained, there is concern that the onsite detention systems are not maintained by property owners, therefore excluding their consideration in the modelling is deemed conservative but acceptable.

Infiltration data should be confirmed via onsite testing. The data used in the PCSWMM models has been assumed based on previous percolation tests for the Cowes study area. The infiltration data for Inverloch was assumed based on the soil type and supporting literature. Infiltration data has also been assumed as uniform across the entire catchment area for each study area. The infiltration rates will vary across the catchment in reality. As shown in the results discussion, the infiltration rates impact the volume of runoff, subsequent flow rates in the pipes and thus our capacity classification.

Several other assumptions or generalisations have been made to allow a hydraulic computer model to be created. Some of these include:

- Slope of each subcatchment is uniform across the length of the catchment.
- Evaporation data has been excluded from the study, as short duration storm events were chosen where evaporation losses would be negligible.
- Depth of impervious and pervious depression storages considered uniform across all catchments.
- Drainage pipes assumed to be in good serviceable condition, all laid at a constant grade from inlet to outlet.
- The entire drainage network is assumed to be free of blockages.

9.0 Conclusion

The hydraulic capacity in older residential areas of our regional towns varies greatly. Some catchments may be able to cope well with an increase in runoff, however others may become strained and require appropriate controls such as onsite detention systems.

Two study areas have been modelled in PCSWMM to classify the hydraulic capacity of the drainage pipes. The resultant capacity classes for the Cowes study area are:

- Critical = 26 %
- Near capacity = 30 %
- Sufficient capacity = 44 %

The capacity classes for the Inverloch study area are:

- Critical = 7 %
- Near capacity = 16 %
- Sufficient capacity = 77 %

The drainage pipes in one study area are performing well in terms of hydraulic capacity and infill development will only have a relatively minor effect on the drainage network. The other study area, which is in Cowes, requires tighter development controls to ensure the drainage network is not overwhelmed.

This research project has identified that onsite detention or pipe upsizing is required in situations where the drainage network is inadequate to cope with infill development. Onsite detention is preferred as it is easier to apply to developments one-by-one. This does not mean that a blanket approach of onsite detention is appropriate to all infill development in regional towns. Onsite detention should be considered on a case-by-case basis in regional towns. The situations it is likely to be required include where:

- The catchment is relatively flat and the existing pipe gradient is under 1 %.
- The saturated hydraulic conductivity of the soil is very low.
- Development is close to town centres, where the percent impervious in residential allotments is closer to the maximum of 75 %.

List of References

Australian Bureau of Statistics 2016, Australian Government, Canberra, viewed 25 May 2019, https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/SSC20653

Australian Rainfall & Runoff 2019, viewed 20 July 2019, https://data.arr-software.org/

Ball, J, Babister, M, Nathan, R, Weeks, W, Weinmann, E, Retallick M & Testoni, I 2016, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia.

BCSC 2017, *Council Plan: Shaping a better Bass Coast*, Bass Coast Shire Council, Wonthaggi, Victoria.

BCSC 2019, *Bass Coast Planning Scheme*, Bass Coast Shire Council, Wonthaggi, Victoria.

Berland, A, Shiflett, SA, Shuster, WD, Garmestani, AS, Goddard, HC, Herrman, DL & Hopton, ME 2017, 'The role of trees in urban stormwater management', Landscape and Urban Planning, vol. 162, pp. 167-177.

Bureau of Meteorology 2016, Australian Government, Docklands, Victoria, viewed 31 March 2019, http://www.bom.gov.au/water/designRainfalls/revised-ifd/

Bureau of Meteorology 2019, Australian Government, Docklands, Victoria, viewed 31 March 2019, http://www.bom.gov.au/climate/averages/tables/cw_086127.shtml

City of Gold Coast 2007, *Water sensitive urban design (WSUD) guidelines*, Gold Coast, viewed 23 September 2019, http://www.goldcoast.qld.gov.au/gcplanningscheme_policies/attachments/policies/policy11/section_13_8_infiltration_measures.pdf

CSIRO 1999, *Urban stormwater: best practice environmental management guidelines*, CSIRO Publishing, Collingwood, Victoria.

Department of Jobs, Precincts and Regions 2019, Victoria State Government, Melbourne, viewed 15 April 2019, https://regionalliving.vic.gov.au/explore-regional-victoria/gippsland/bass-coast

Eckart, K, McPhee, Z & Bolisetti, T 2018, 'Multiobjective optimization of low impact development stormwater controls', Journal of Hydrology, vol. 562, pp. 564-576.

EPA 2018, United States EPA, Washington DC, viewed 21 April 2019, https://www.epa.gov/green-infrastructure/what-green-infrastructure

Jacob, JS & Lopez, R 2009, 'Is denser greener? An evaluation of higher density development as an urban stormwater-quality best management practice 1', Journal of the American Water Resources Association, vol. 45, no. 3, pp. 687-701.

Leafy street in Toorak n.d., Realestate.com.au, Australia, viewed 21 April 2019, https://www.realestate.com.au/neighbourhoods/toorak-3142-vic

Local Government Infrastructure Design Association 2019, *Infrastructure Design Manual*, ver 5.20, Local Government Infrastructure Design Association, Victoria.

Map of Bass Coast Shire 2019, Google Maps, Australia, viewed 10 September 2019, https://www.google.com/maps/place/Bass+Coast,+VIC/@-38.4755488,145.1317191,9.5z/data=!4m5!3m4!1s0x6ad5f64c9b2c4bb3:0x5bf69bd44ce02667!8m2!3d-38.5087582!4d145.5358152

Melbourne Water 2017, Victoria State Government, Melbourne, viewed 21 April 2019, https://www.melbournewater.com.au/planning-and-building/stormwater-management/introduction-wsud

Mag, V & Mag, M 2019, *Drainage system design*, Stormy Water Solutions, Melbourne.

Paterson, J 2019a, *Flooding at Wonthaggi Surf Life Saving Club*, unpublished photo.

Paterson, J 2019b, *Localised flooding at Cape Paterson*, unpublished photo.

Paule-Mercado, MCA, Salim, I, Lee, BY, Memon, S, Sajjad, RU, Sukhbaatar, C & Lee CH 2018, 'Monitoring and quantification of stormwater runoff from mixed land use and land cover catchment in response to land development', *Ecological Indicators*, vol. 93, pp. 1112-1125.

South Gippsland Sentinel-Times 2017, 'What's so special about South Dudley?', July 25, viewed 26 May 2019, https://sgst.com.au/2017/07/whats-special-south-dudley/

Torlapati, J 2017, *Hydrology Worksheet 1*, Rowan University, Glassboro, New Jersey.

Victoria State Government 2018, *Risk Assessment Template*, Department of Education and Training, Victoria State Government, Melbourne, viewed 18 May 2019, https://www.education.vic.gov.au/hrweb/safetyhw/Pages/ohsriskmgt.aspx

Whitby, M 2019a, *Cowes study area outfall*, unpublished photo.

Whitby, M 2019b, *Flow path for Cowes study area outfall*, unpublished photo.

Appendix A: Project Specification

ENG4111/4112 Research Project

Project Specification

For:	Mathew Whitby
Title:	Infill development impact on the capacity of regional drainage networks
Major:	Civil Engineering
Supervisor:	Rezaul Chowdhury
Sponsorship:	Bass Coast Shire Council
Enrolment:	ENG4111 – EXT S1, 2019
	ENG4112 – EXT S2, 2019
Project Aim:	To investigate the capacity of drainage networks within regional towns and the impact of increasingly dense infill development.

Program: Version 1, 19 March 2019

1. Research the existing literature relating to managing drainage capacities for infill development.

2. Review current planning legislation and existing development controls.

3. Identify drainage networks to be investigated.

4. Collect all required drainage data.

5. Determine existing level of development and the maximum level of development permissible under existing planning legislation.

6. Calculate the hydraulic capacity of the drainage networks using hydraulic modelling software for both levels of development (existing and maximum).

7. Identify areas of the drainage network with existing and potential future capacity issues.

8. Propose prioritised upgrade options for the local Council.

If time and resources permit:

9. Develop a drainage strategy for the ongoing management of infill development.

Appendix B: Project Plan Gantt Chart

		Semester 1																	Recess			Semester 2													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17				1	2	3	4	5	6	7	8	9	10	11	12	13	14
#	Task			March				April			|		May				June					July		|		August				September				October	
1	Project Allocation/Initiation	■	■																																
2	Research literature and planning laws			■	■	■	■	■	■	■	■																								
3	Gathering existing network data							■	■	■	■	■	■																						
4	Determining level of development													■	■	■	■	■	■																
5	Impervious area estimation															■	■	■	■																
6	Modelling existing development															■	■	■	■	■															
7	Recording model results																	■	■	■					■	■	■								
8	Determining full development																			■	■	■	■	■	■	■									
9	Modelling full development																					■	■	■	■	■	■								
10	Reviewing results/capacities																								■	■	■	■	■						
11	Prepare project presentation																													■					
12	PP2 Project Conference																														■				
13	Drafting Dissertation					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
14	Finalise Report/ Dissertation																															■	■	■	■
15	Submit Dissertation																																		■

Appendix C: Risk Assessment – Field Trips

VICTORIA State Government | Education and Training

Human Resources

Risk Assessment Template

This template is to be used with reference to the *OHS Risk Management Procedure*. For support in conducting a Risk Assessment contact the OHS Advisory Service on 1300 074 715 or email safety@edumail.vic.gov.au.

1. Background Information			
School/Workplace:	Bass Coast Shire Council	**Date:**	18 May 2019
Title of Assessment:	Field trips for collection of stormwater asset data (e.g. measuring pit depths and pipe diameters)	**Name of person conducting assessment:**	Mathew Whitby

2. Risk Assessment

	Identify and list Hazards	List Current Risk Controls	Risk Rating	List Additional Controls *(if any - where current controls are not adequately managing the level of risk)*
1	Sun exposure	- Long sleeve clothing and hat to be worn - Sunscreen	Low	- Not required
2	Slips, trips and falls	- Sturdy, steel-capped hiking boots to be worn	Medium	- Not required
3	Snakes and spiders	- Long pants and enclosed footwear to be worn - Gloves to be worn when lifting pit lids	Low	- First aid kit to be added to work vehicles
4	Traffic	- Hi-vis clothing to be worn - Flashing lights on vehicle - Traffic management plan (e.g. signs and cones to be used if required)	High	- Spotter to be used for any work on or near the road carriageway
5	Heavy lifting (e.g. stormwater pit lids)	- 2-man lift employed for > 20 kg	Medium	- Not required

Last updated: 22 June 2018

Risk Assessment Template

1. **Consequence** - Evaluate the consequences of a risk occurring according to the ratings in the top row

Descriptor	Level	Definition
Insignificant	1	No injury
Minor	2	Injury/ ill health requiring first aid
Moderate	3	Injury/ill health requiring medical attention
Major	4	Injury/ill health requiring hospital admission
Severe	5	Fatality

2. **Likelihood** - Evaluate the **likelihood** of an incident occurring according to the ratings in the left hand column

Descriptor	Level	Definition
Rare	1	May occur somewhere, sometime ("once in a life time / once in a hundred years")
Unlikely	2	May occur somewhere within the Department over an extended period of time
Possible	3	May occur several times across the Department or a region over a period of time
Likely	4	May be anticipated multiple times over a period of time May occur once every few repetitions of the activity or event
Almost Certain	5	Prone to occur regularly It is anticipated for each repetition of the activity of event

3. **Risk Matrix** – Using the matrix calculate the level of **risk** by finding the intersection between the likelihood and the consequences

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Severe
Almost Certain	Medium	High	Extreme	Extreme	Extreme
Likely	Medium	Medium	High	Extreme	Extreme
Possible	Low	Medium	Medium	High	Extreme
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

4. **Risk Level/Rating and Actions**

Descriptor	Definition
Extreme:	Notify **Workplace Manager and/or Management OHS Nominee** immediately. Corrective actions should be taken immediately. Cease associated activity.
High:	Notify **Workplace Manager and/or Management OHS Nominee** immediately. Corrective actions should be taken within 48 hours of notification.
Medium:	Notify **Nominated employee, HSR / OHS Committee**. Nominated employee, OHS Representative / OHS Committee is to follow up that corrective action is taken within 7 days.
Low	Notify **Nominated employee, HSR / OHS Committee**. Nominated employee, HSR / OHS Committee is to follow up that corrective action is taken within a reasonable time.

Risk Assessment Template

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Appendix D: Cowes existing subcatchment data

Subcatchment #	Area (m²)	Roof areas (m²)	Paved (m²)	Total Imperv. Areas (m²)	Imperv	Perv	Zero Imperv (roofs)
S1	680	0	315	315	46%	54%	0%
S2	1500	189	675	864	58%	42%	22%
S3	5870	1151	1368	2519	43%	57%	46%
S4	665	0	280	280	42%	58%	0%
S5	1000	300	450	750	75%	25%	40%
S6	3550	525	475	1000	28%	72%	53%
S7	3160	720	450	1170	37%	63%	62%
S8	2050	700	445	1145	56%	44%	61%
S9	730	0	360	360	49%	51%	0%
S10	1800	1000	325	1325	74%	26%	75%
S11	6105	1135	555	1690	28%	72%	67%
S12	1000	320	260	580	58%	42%	55%
S13	2900	670	335	1005	35%	65%	67%
S14	2560	915	695	1610	63%	37%	57%
S15	860	330	100	430	50%	50%	77%
S16	1545	280	290	570	37%	63%	49%
S17	180	0	100	100	56%	44%	0%
S18	3220	642	300	942	29%	71%	68%
S19	2005	580	155	735	37%	63%	79%
S20	3210	1980	600	2580	80%	20%	77%
S21	920	920	0	920	100%	0%	100%
Total	45510	12357	8533	20890	Average 46%	Average 54%	Average 59%

Appendix E: Inverloch existing subcatchment data

Subcatchment	Area (m^2)	Roof areas	Paved	Total Imperv. Areas	Imperv	Perv	Zero Imperv (roofs)
S1	676	676	0	676	100%	0%	100%
S2	7120	1565	1075	2640	37%	63%	59%
S3	9260	0	465	465	5%	95%	0%
S4	1450	0	815	815	56%	44%	0%
S5	2160	465	0	465	22%	78%	100%
S6	490	490	0	490	100%	0%	100%
S7	3640	1015	95	1110	30%	70%	91%
S8	490	0	170	170	35%	65%	0%
S9	1565	0	155	155	10%	90%	0%
S10	2030	435	400	835	41%	59%	52%
S11	1235	0	0	0	0%	100%	0%
S12	700	230	225	455	65%	35%	51%
S13	3465	835	900	1735	50%	50%	48%
S14	180	0	135	135	75%	25%	0%
S15	600	0	200	200	33%	67%	0%
S16	800	185	195	380	48%	53%	49%
S17	3845	925	420	1345	35%	65%	69%
S18	375	0	170	170	45%	55%	0%
S19	860	0	370	370	43%	57%	0%
S20	2945	595	350	945	32%	68%	63%
S21	1520	175	400	575	38%	62%	30%
S22	1245	240	455	695	56%	44%	35%
S23	185	0	125	125	68%	32%	0%
S24	3500	660	730	1390	40%	60%	47%
S25	130	0	65	65	50%	50%	0%
S26	855	0	380	380	44%	56%	0%
S27	6975	1470	1325	2795	40%	60%	53%
S28	1020	0	630	630	62%	38%	0%
S29	1290	0	755	755	59%	41%	0%
S30	155	0	120	120	77%	23%	0%
S31	2240	460	765	1225	55%	45%	38%
S32	4590	1500	670	2170	47%	53%	69%
S33	1260	700	150	850	67%	33%	82%
S34	475	0	230	230	48%	52%	0%
S35	300	0	100	100	33%	67%	0%
S36	2190	765	700	1465	67%	33%	52%
S37	2315	720	375	1095	47%	53%	66%
S38	1340	270	215	485	36%	64%	56%

S39	1300	425	155	580	45%	55%	73%
S40	1360	350	155	505	37%	63%	69%
S41	2435	225	345	570	23%	77%	39%
S42	1065	320	80	400	38%	62%	80%
S43	1030	0	440	440	43%	57%	0%
S44	2350	410	395	805	34%	66%	51%
S45	1400	670	285	955	68%	32%	70%
S46	2545	870	320	1190	47%	53%	73%
S47	3360	305	700	1005	30%	70%	30%
S48	665	200	0	200	30%	70%	100%
S49	740	240	0	240	32%	68%	100%
S50	175	0	105	105	60%	40%	0%
S51	600	0	275	275	46%	54%	0%
S52	1100	360	265	625	57%	43%	58%
S53	1315	190	200	390	30%	70%	49%
S54	1380	460	75	535	39%	61%	86%
S55	4440	745	860	1605	36%	64%	46%
S56	1150	0	585	585	51%	49%	0%
S57	155	0	110	110	71%	29%	0%
S58	3235	715	520	1235	38%	62%	58%
S59	615	330	95	425	69%	31%	78%
S60	3135	635	815	1450	46%	54%	44%
S61	5225	555	490	1045	20%	80%	53%
S62	1020	295	160	455	45%	55%	65%
S63	705	250	125	375	53%	47%	67%
S64	1405	270	90	360	26%	74%	75%
S65	1830	730	300	1030	56%	44%	71%
S66	235	0	130	130	55%	45%	0%
S67	2940	805	515	1320	45%	55%	61%
S68	2075	615	500	1115	54%	46%	55%
S69	2810	0	0	0	0%	100%	0%
S70	3915	360	410	770	20%	80%	47%
S71	1230	75	120	195	16%	84%	38%
S72	1270	280	100	380	30%	70%	74%
S73	650	300	65	365	56%	44%	82%
S74	1080	485	130	615	57%	43%	79%
S75	1340	255	100	355	26%	74%	72%
S76	980	215	230	445	45%	55%	48%
S77	195	0	130	130	67%	33%	0%
S78	540	0	375	375	69%	31%	0%
S79	1935	735	500	1235	64%	36%	60%
S80	150	0	105	105	70%	30%	0%
S81	680	0	340	340	50%	50%	0%
S82	870	285	170	455	52%	48%	63%
S83	3500	740	290	1030	29%	71%	72%

S84	1510	460	110	570	38%	62%	81%
S85	725	175	210	385	53%	47%	45%
S86	2550	160	1525	1685	66%	34%	9%
S87	1965	690	225	915	47%	53%	75%
S88	1525	570	225	795	52%	48%	72%
S89	720	330	115	445	62%	38%	74%
S90	630	210	90	300	48%	52%	70%
S91	1610	300	100	400	25%	75%	75%
S92	315	0	185	185	59%	41%	0%
S93	190	0	85	85	45%	55%	0%
S94	185	0	105	105	57%	43%	0%
S95	205	0	145	145	71%	29%	0%
Total	159731	31971	29605	61576	Average 39%	Average 61%	Average 52%

Appendix F: Cowes existing PCSWMM results

EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.012)

4.53 ha catchment at Beach Road, Cowes

WARNING 01: wet weather time step reduced to recording interval for Rain Gage Chicago_3h

****
Element Count
****

Number of rain gages 10
Number of subcatchments ... 21
Number of nodes 24
Number of links 23
Number of pollutants 0
Number of land uses 0

****
Raingage Summary
****

Name	Data Source	Data Type	Recording Interval
Chicago_3h	Chicago_3h	INTENSITY	1 min.
Cowes120min	Cowes120min	INTENSITY	5 min.
Cowes120min(2)	Cowes120min(2)	INTENSITY	5 min.
Cowes180min	Cowes180min	INTENSITY	15 min.
Cowes30min	Cowes30min	INTENSITY	5 min.
Cowes45min	Cowes45min	INTENSITY	5 min.
Cowes4day	Cowes4day	INTENSITY	180 min.
Cowes60min	Cowes60min	INTENSITY	5 min.
Cowes6hr	Cowes6hr	INTENSITY	15 min.
Cowes90min	Cowes90min	INTENSITY	5 min.

****
Subcatchment Summary
****

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
S01	0.07	8.00	46.00	1.0000	Cowes90min	J07
S02	0.15	7.50	58.00	1.0000	Cowes90min	J06
S03	0.59	80.00	43.00	1.0000	Cowes90min	J03
S04	0.07	8.00	42.00	1.0000	Cowes90min	J04
S05	0.10	20.00	75.00	1.0000	Cowes90min	J14
S06	0.35	60.00	28.00	1.0000	Cowes90min	J12
S07	0.32	70.00	37.00	1.0000	Cowes90min	J13
S08	0.20	30.00	56.00	1.0000	Cowes90min	J11
S09	0.07	7.00	49.00	1.0000	Cowes90min	J09

```
  S10                          0.18     46.00     74.00    1.0000 Cowes90min
J23
  S11                          0.61    100.00     28.00    1.0000 Cowes90min
J22
  S12                          0.10     25.00     58.00    0.5000 Cowes90min
J18
  S13                          0.29     60.00     35.00    1.0000 Cowes90min
J01
  S14                          0.26     30.00     63.00    0.5000 Cowes90min
J21
  S15                          0.09     13.00     50.00    0.5000 Cowes90min
J20
  S16                          0.15     25.00     37.00    0.5000 Cowes90min
J19
  S17                          0.02      8.00     56.00    0.5000 Cowes90min
J15
  S18                          0.32     50.00     29.00    0.5000 Cowes90min
J16
  S19                          0.20     35.00     37.00    0.5000 Cowes90min
J17
  S20                          0.25     25.00     80.00    0.5000 Cowes90min
J02
  S21                          0.09     45.00    100.00    0.5000 Cowes90min
OF1


  ************
  Node Summary
  ************
                                           Invert      Max.    Ponded    External
  Name                 Type                 Elev.     Depth      Area    Inflow
  -------------------------------------------------------------------------------
  J01                  JUNCTION              3.72      1.28       0.0
  J02                  JUNCTION              4.29      0.70       0.0
  J03                  JUNCTION              4.12      1.22       0.0
  J04                  JUNCTION              4.46      0.85       0.0
  J05                  JUNCTION              4.95      0.85       0.0
  J06                  JUNCTION              5.01      0.80       0.0
  J07                  JUNCTION              5.14      0.70       0.0
  J08                  JUNCTION              4.22      1.40       0.0
  J09                  JUNCTION              6.07      0.82       0.0
  J10                  JUNCTION              6.18      0.80       0.0
  J11                  JUNCTION              6.33      0.72       0.0
  J12                  JUNCTION              6.22      0.75       0.0
  J13                  JUNCTION              6.39      0.62       0.0
  J14                  JUNCTION              6.45      0.90       0.0
  J15                  JUNCTION              4.09      1.00       0.0
  J16                  JUNCTION              4.26      0.84       0.0
  J17                  JUNCTION              4.62      0.60       0.0
  J18                  JUNCTION              3.87      1.28       0.0
  J19                  JUNCTION              3.94      1.37       0.0
  J20                  JUNCTION              4.44      0.92       0.0
  J21                  JUNCTION              4.50      0.70       0.0
  J22                  JUNCTION              4.74      0.55       0.0
  J23                  JUNCTION              4.84      0.68       0.0
  OF1                  OUTFALL               2.08      0.45       0.0


  ************
  Link Summary
  ************
  Name             From Node        To Node          Type            Length
%Slope Roughness
  ---------------------------------------------------------------------------------
------------
  C01              J01              OF1              CONDUIT           81.3
2.0179    0.0120
```

```
  C02                J02                J01                CONDUIT           13.8
4.1460     0.0120
  C03                J03                J01                CONDUIT           69.6
0.5747     0.0120
  C04                J04                J03                CONDUIT            8.1
4.2117     0.0120
  C05                J05                J03                CONDUIT           67.2
1.2354     0.0120
  C06                J06                J05                CONDUIT           12.8
0.4688     0.0120
  C07                J07                J06                CONDUIT            7.4
1.7570     0.0120
  C08                J08                J03                CONDUIT            5.7
1.7639     0.0120
  C09                J09                J08                CONDUIT          112.3
1.6473     0.0120
  C10                J10                J09                CONDUIT           17.9
0.6156     0.0120
  C11                J11                J10                CONDUIT            7.8
1.9136     0.0120
  C12                J12                J09                CONDUIT           17.6
0.8542     0.0120
  C13                J13                J12                CONDUIT            7.8
2.1772     0.0120
  C14                J14                J12                CONDUIT           59.2
0.3885     0.0120
  C15                J15                J01                CONDUIT           20.4
1.8122     0.0120
  C16                J16                J15                CONDUIT           17.2
0.9878     0.0120
  C17                J17                J16                CONDUIT           59.7
0.6034     0.0120
  C18                J18                J01                CONDUIT            7.2
2.0954     0.0120
  C19                J19                J18                CONDUIT           10.4
0.6744     0.0120
  C20                J20                J19                CONDUIT           65.2
0.7667     0.0120
  C21                J21                J20                CONDUIT           14.0
0.4289     0.0120
  C22                J22                J21                CONDUIT            7.8
3.0943     0.0120
  C23                J23                J22                CONDUIT           23.0
0.4346     0.0120


  *********************
  Cross Section Summary
  *********************
                                        Full     Full     Hyd.     Max.   No. of
Full
  Conduit            Shape             Depth     Area     Rad.    Width  Barrels
Flow
  ---------------------------------------------------------------------------------
------
  C01                CIRCULAR           0.45     0.16     0.11     0.45        1
0.44
  C02                CIRCULAR           0.30     0.07     0.07     0.30        1
0.21
  C03                CIRCULAR           0.45     0.16     0.11     0.45        1
0.23
  C04                CIRCULAR           0.30     0.07     0.07     0.30        1
0.22
  C05                CIRCULAR           0.30     0.07     0.07     0.30        1
0.12
  C06                CIRCULAR           0.30     0.07     0.07     0.30        1
0.07
```

```
  C07               CIRCULAR             0.23      0.04      0.06      0.23          1
0.06
  C08               CIRCULAR             0.30      0.07      0.07      0.30          1
0.14
  C09               CIRCULAR             0.23      0.04      0.06      0.23          1
0.06
  C10               CIRCULAR             0.23      0.04      0.06      0.23          1
0.04
  C11               CIRCULAR             0.23      0.04      0.06      0.23          1
0.07
  C12               CIRCULAR             0.23      0.04      0.06      0.23          1
0.04
  C13               CIRCULAR             0.23      0.04      0.06      0.23          1
0.07
  C14               CIRCULAR             0.23      0.04      0.06      0.23          1
0.03
  C15               CIRCULAR             0.23      0.04      0.06      0.23          1
0.07
  C16               CIRCULAR             0.23      0.04      0.06      0.23          1
0.05
  C17               CIRCULAR             0.23      0.04      0.06      0.23          1
0.04
  C18               CIRCULAR             0.23      0.04      0.06      0.23          1
0.07
  C19               CIRCULAR             0.23      0.04      0.06      0.23          1
0.04
  C20               CIRCULAR             0.23      0.04      0.06      0.23          1
0.04
  C21               CIRCULAR             0.23      0.04      0.06      0.23          1
0.03
  C22               RECT_CLOSED          0.30      0.07      0.07      0.25          1
0.18
  C23               CIRCULAR             0.23      0.04      0.06      0.23          1
0.03


  *********************************************************
  NOTE: The summary statistics displayed in this report are
  based on results found at every computational time step,
  not just on results from each reporting time step.
  *********************************************************

  ****************
  Analysis Options
  ****************
  Flow Units ............... CMS
  Process Models:
    Rainfall/Runoff ........ YES
    RDII ................... NO
    Snowmelt ............... NO
    Groundwater ............ NO
    Flow Routing ........... YES
    Ponding Allowed ........ NO
    Water Quality .......... NO
  Infiltration Method ...... HORTON
  Flow Routing Method ...... DYNWAVE
  Starting Date ............ 07/02/2019 00:05:00
  Ending Date .............. 07/02/2019 02:05:00
  Antecedent Dry Days ...... 0.0
  Report Time Step ......... 00:01:00
  Wet Time Step ............ 00:01:00
  Dry Time Step ............ 00:05:00
  Routing Time Step ........ 5.00 sec
  Variable Time Step ....... YES
  Maximum Trials ........... 8
  Number of Threads ........ 4
  Head Tolerance ........... 0.001500 m
```

```
  **************************        Volume         Depth
  Runoff Quantity Continuity     hectare-m            mm
  **************************     ---------       -------
  Total Precipitation ......         0.110        24.599
  Evaporation Loss .........         0.000         0.000
  Infiltration Loss ........         0.060        13.424
  Surface Runoff ...........         0.048        10.671
  Final Storage ............         0.002         0.512
  Continuity Error (%) .....        -0.032


  **************************        Volume        Volume
  Flow Routing Continuity        hectare-m      10^6 ltr
  **************************     ---------     ---------
  Dry Weather Inflow .......         0.000         0.000
  Wet Weather Inflow .......         0.048         0.478
  Groundwater Inflow .......         0.000         0.000
  RDII Inflow ..............         0.000         0.000
  External Inflow ..........         0.000         0.000
  External Outflow .........         0.048         0.476
  Flooding Loss ............         0.000         0.001
  Evaporation Loss .........         0.000         0.000
  Exfiltration Loss ........         0.000         0.000
  Initial Stored Volume ....         0.000         0.000
  Final Stored Volume ......         0.000         0.002
  Continuity Error (%) .....        -0.061


  ***************************
  Time-Step Critical Elements
  ***************************
  Link C18 (69.55%)
  Link C08 (15.73%)


  ********************************
  Highest Flow Instability Indexes
  ********************************
  Link C06 (23)
  Link C19 (10)
  Link C22 (6)
  Link C21 (4)
  Link C18 (1)


  *************************
  Routing Time Step Summary
  *************************
  Minimum Time Step           :     0.50 sec
  Average Time Step           :     2.79 sec
  Maximum Time Step           :     5.00 sec
  Percent in Steady State     :     0.00
  Average Iterations per Step :     2.13
  Percent Not Converging      :     0.66


  ***************************
  Subcatchment Runoff Summary
  ***************************

  --------------------------------------------------------------------------------
-----------------------
                            Total      Total      Total      Total      Total
Total      Peak  Runoff
                           Precip      Runon       Evap      Infil     Runoff
Runoff    Runoff    Coeff
```

```
  Subcatchment                         mm          mm          mm          mm          mm
10^6 ltr      CMS
  ---------------------------------------------------------------------------------------
------------------------
  S01                                 24.60        0.00        0.00       13.28       10.31
0.01      0.00    0.419
  S02                                 24.60        0.00        0.00       10.33       12.89
0.02      0.01    0.524
  S03                                 24.60        0.00        0.00       14.02       10.05
0.06      0.03    0.409
  S04                                 24.60        0.00        0.00       14.27        9.42
0.01      0.00    0.383
  S05                                 24.60        0.00        0.00        6.15       17.41
0.02      0.01    0.708
  S06                                 24.60        0.00        0.00       17.71        6.61
0.02      0.01    0.269
  S07                                 24.60        0.00        0.00       15.50        8.80
0.03      0.01    0.358
  S08                                 24.60        0.00        0.00       10.82       13.23
0.03      0.01    0.538
  S09                                 24.60        0.00        0.00       12.55       10.94
0.01      0.00    0.445
  S10                                 24.60        0.00        0.00        6.40       17.74
0.03      0.02    0.721
  S11                                 24.60        0.00        0.00       17.71        6.69
0.04      0.02    0.272
  S12                                 24.60        0.00        0.00       10.33       13.66
0.01      0.01    0.555
  S13                                 24.60        0.00        0.00       15.99        8.36
0.02      0.01    0.340
  S14                                 24.60        0.00        0.00        9.10       14.66
0.04      0.02    0.596
  S15                                 24.60        0.00        0.00       12.30       11.94
0.01      0.01    0.486
  S16                                 24.60        0.00        0.00       15.50        8.67
0.01      0.01    0.352
  S17                                 24.60        0.00        0.00       10.82       12.62
0.00      0.00    0.513
  S18                                 24.60        0.00        0.00       17.47        6.67
0.02      0.01    0.271
  S19                                 24.60        0.00        0.00       15.50        8.90
0.02      0.01    0.362
  S20                                 24.60        0.00        0.00        4.92       18.68
0.05      0.02    0.760
  S21                                 24.60        0.00        0.00        0.00       24.47
0.02      0.01    0.995


  ******************
  Node Depth Summary
  ******************

  ---------------------------------------------------------------------------------
                                 Average  Maximum  Maximum  Time of Max    Reported
                                   Depth    Depth      HGL   Occurrence   Max Depth
  Node                 Type       Meters   Meters   Meters  days hr:min      Meters
  ---------------------------------------------------------------------------------
  J01                  JUNCTION     0.12     0.23     3.95     0  01:25        0.23
  J02                  JUNCTION     0.04     0.06     4.35     0  01:25        0.06
  J03                  JUNCTION     0.11     0.20     4.32     0  01:25        0.20
  J04                  JUNCTION     0.01     0.03     4.49     0  01:25        0.03
  J05                  JUNCTION     0.04     0.07     5.02     0  01:25        0.07
  J06                  JUNCTION     0.05     0.09     5.10     0  01:25        0.09
  J07                  JUNCTION     0.02     0.04     5.18     0  01:25        0.04
  J08                  JUNCTION     0.07     0.15     4.37     0  01:25        0.15
  J09                  JUNCTION     0.08     0.16     6.23     0  01:25        0.16
  J10                  JUNCTION     0.05     0.09     6.27     0  01:25        0.09
  J11                  JUNCTION     0.04     0.07     6.40     0  01:25        0.07
```

J12	JUNCTION	0.08	0.15	6.37	0	01:25	0.15
J13	JUNCTION	0.04	0.07	6.46	0	01:25	0.07
J14	JUNCTION	0.04	0.08	6.53	0	01:25	0.08
J15	JUNCTION	0.05	0.09	4.18	0	01:25	0.09
J16	JUNCTION	0.05	0.10	4.36	0	01:25	0.10
J17	JUNCTION	0.04	0.07	4.69	0	01:25	0.07
J18	JUNCTION	0.09	0.20	4.07	0	01:25	0.20
J19	JUNCTION	0.12	0.30	4.24	0	01:23	0.29
J20	JUNCTION	0.14	0.62	5.06	0	01:23	0.61
J21	JUNCTION	0.16	0.70	5.20	0	01:23	0.70
J22	JUNCTION	0.06	0.49	5.23	0	01:23	0.47
J23	JUNCTION	0.07	0.58	5.42	0	01:23	0.39
OF1	OUTFALL	0.12	0.23	2.31	0	01:25	0.22

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
J01	JUNCTION	0.012	0.220	0	01:25	0.0242	0.454	0.117
J02	JUNCTION	0.021	0.021	0	01:25	0.0467	0.0467	0.059
J03	JUNCTION	0.030	0.098	0	01:25	0.059	0.195	0.149
J04	JUNCTION	0.003	0.003	0	01:25	0.00626	0.00626	0.069
J05	JUNCTION	0.000	0.013	0	01:25	0	0.0263	0.416
J06	JUNCTION	0.009	0.013	0	01:25	0.0193	0.0263	0.137
J07	JUNCTION	0.004	0.004	0	01:25	0.00701	0.00701	0.086
J08	JUNCTION	0.000	0.052	0	01:25	0	0.104	0.101
J09	JUNCTION	0.004	0.053	0	01:25	0.00798	0.104	0.088
J10	JUNCTION	0.000	0.014	0	01:25	0	0.0271	0.083
J11	JUNCTION	0.014	0.014	0	01:25	0.0271	0.0271	0.038
J12	JUNCTION	0.012	0.035	0	01:25	0.0235	0.0686	0.063
J13	JUNCTION	0.014	0.014	0	01:25	0.0278	0.0278	0.013
J14	JUNCTION	0.009	0.009	0	01:25	0.0174	0.0174	0.280
J15	JUNCTION	0.001	0.021	0	01:25	0.00227	0.0415	0.055
J16	JUNCTION	0.011	0.020	0	01:25	0.0215	0.0393	0.111
J17	JUNCTION	0.009	0.009	0	01:25	0.0178	0.0178	0.099
J18	JUNCTION	0.007	0.068	0	01:25	0.0137	0.147	0.017

```
  J19                  JUNCTION     0.007    0.061     0  01:25       0.0134
0.133       0.100
  J20                  JUNCTION     0.005    0.055     0  01:25       0.0103
0.12       0.090
  J21                  JUNCTION     0.018    0.055     0  01:25       0.0375
0.11       0.062
  J22                  JUNCTION     0.021    0.037     0  01:25       0.0408
0.0727      -0.014
  J23                  JUNCTION     0.016    0.016     0  01:25       0.0319
0.0319       0.024
  OF1                  OUTFALL      0.011    0.230     0  01:25       0.0225
0.476       0.000


  *********************
  Node Surcharge Summary
  *********************

  Surcharging occurs when water rises above the top of the highest conduit.
  ---------------------------------------------------------------------
                                               Max. Height   Min. Depth
                                   Hours       Above Crown    Below Rim
  Node                 Type      Surcharged        Meters       Meters
  ---------------------------------------------------------------------
  J19                  JUNCTION        0.12         0.075        1.070
  J20                  JUNCTION        0.15         0.398        0.297
  J21                  JUNCTION        0.14         0.400        0.000
  J22                  JUNCTION        0.05         0.193        0.057
  J23                  JUNCTION        0.05         0.355        0.100


  *********************
  Node Flooding Summary
  *********************

  Flooding refers to all water that overflows a node, whether it ponds or not.
  --------------------------------------------------------------------------
                                                             Total   Maximum
                                 Maximum   Time of Max       Flood    Ponded
                       Hours       Rate     Occurrence      Volume     Depth
  Node                Flooded       CMS   days hr:min    10^6 ltr    Meters
  --------------------------------------------------------------------------
  J21                    0.03     0.006       0  01:23       0.001     0.000


  ***********************
  Outfall Loading Summary
  ***********************

  -----------------------------------------------------------
                         Flow       Avg       Max       Total
                         Freq      Flow      Flow      Volume
  Outfall Node           Pcnt       CMS       CMS    10^6 ltr
  -----------------------------------------------------------
  OF1                   97.06     0.090     0.230       0.476
  -----------------------------------------------------------
  System                97.06     0.090     0.230       0.476


  ********************
  Link Flow Summary
  ********************

  -----------------------------------------------------------------------------
                                 Maximum  Time of Max   Maximum    Max/    Max/
                                  |Flow|   Occurrence   |Veloc|    Full    Full
  Link                 Type          CMS  days hr:min     m/sec    Flow   Depth
  -----------------------------------------------------------------------------
```

C01	CONDUIT	0.220	0	01:25	2.76	0.50	0.50
C02	CONDUIT	0.021	0	01:25	0.63	0.10	0.48
C03	CONDUIT	0.097	0	01:25	1.31	0.42	0.48
C04	CONDUIT	0.003	0	01:25	0.14	0.02	0.38
C05	CONDUIT	0.013	0	01:25	0.42	0.11	0.45
C06	CONDUIT	0.013	0	01:25	0.91	0.18	0.25
C07	CONDUIT	0.004	0	01:25	0.43	0.06	0.27
C08	CONDUIT	0.053	0	01:25	1.24	0.38	0.59
C09	CONDUIT	0.052	0	01:25	1.80	0.84	0.69
C10	CONDUIT	0.014	0	01:25	0.59	0.36	0.56
C11	CONDUIT	0.014	0	01:25	1.06	0.20	0.36
C12	CONDUIT	0.035	0	01:25	1.19	0.78	0.69
C13	CONDUIT	0.014	0	01:25	0.75	0.20	0.49
C14	CONDUIT	0.009	0	01:25	0.43	0.29	0.52
C15	CONDUIT	0.021	0	01:25	0.72	0.32	0.70
C16	CONDUIT	0.020	0	01:25	1.26	0.41	0.42
C17	CONDUIT	0.009	0	01:25	0.62	0.23	0.39
C18	CONDUIT	0.068	0	01:24	1.78	0.97	0.93
C19	CONDUIT	0.061	0	01:25	1.59	1.54	0.93
C20	CONDUIT	0.055	0	01:25	1.37	1.28	1.00
C21	CONDUIT	0.050	0	01:25	1.26	1.57	1.00
C22	CONDUIT	0.037	0	01:25	0.85	0.20	1.00
C23	CONDUIT	0.016	0	01:25	0.99	0.50	1.00

****
Flow Classification Summary
****

	Adjusted	---------- Fraction of Time in Flow Class -------								
Conduit	/Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
C01	1.00	0.02	0.00	0.00	0.00	0.97	0.00	0.00	0.47	0.00
C02	1.00	0.02	0.00	0.00	0.94	0.03	0.00	0.00	0.95	0.00
C03	1.00	0.02	0.00	0.00	0.22	0.75	0.00	0.00	0.78	0.00
C04	1.00	0.02	0.09	0.00	0.89	0.00	0.00	0.00	0.82	0.00
C05	1.00	0.02	0.02	0.00	0.95	0.00	0.00	0.00	0.92	0.00
C06	1.00	0.03	0.00	0.00	0.04	0.93	0.00	0.00	0.05	0.00
C07	1.00	0.03	0.08	0.00	0.89	0.00	0.00	0.00	0.82	0.00
C08	1.00	0.02	0.02	0.00	0.12	0.84	0.00	0.00	0.33	0.00
C09	1.00	0.03	0.00	0.00	0.01	0.96	0.00	0.00	0.06	0.00
C10	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.90	0.00
C11	1.00	0.03	0.00	0.00	0.01	0.97	0.00	0.00	0.90	0.00
C12	1.00	0.03	0.00	0.00	0.09	0.88	0.00	0.00	0.58	0.00
C13	1.00	0.02	0.00	0.00	0.85	0.12	0.00	0.00	0.93	0.00
C14	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.95	0.00

C15	1.00	0.02	0.01	0.00	0.96	0.00	0.00	0.00	0.94	0.00
C16	1.00	0.03	0.00	0.00	0.01	0.96	0.00	0.00	0.02	0.00
C17	1.00	0.03	0.00	0.00	0.97	0.01	0.00	0.00	0.81	0.00
C18	1.00	0.02	0.00	0.00	0.06	0.91	0.00	0.00	0.49	0.00
C19	1.00	0.03	0.00	0.00	0.15	0.83	0.00	0.00	0.55	0.00
C20	1.00	0.03	0.00	0.00	0.39	0.58	0.00	0.00	0.62	0.00
C21	1.00	0.03	0.00	0.00	0.82	0.16	0.00	0.00	0.00	0.00
C22	1.00	0.02	0.00	0.00	0.96	0.01	0.00	0.00	0.88	0.00
C23	1.00	0.02	0.00	0.00	0.13	0.84	0.00	0.00	0.01	0.00

****
Conduit Surcharge Summary
****

	Hours Full			Hours	Hours
Conduit	Both Ends	Upstream	Dnstream	Above Full Normal Flow	Capacity Limited
C15	0.01	0.01	0.01	0.01	0.01
C18	0.01	0.01	0.01	0.01	0.01
C19	0.01	0.12	0.01	0.25	0.01
C20	0.12	0.15	0.12	0.19	0.12
C21	0.15	0.19	0.15	0.28	0.15
C22	0.05	0.05	0.14	0.01	0.01
C23	0.05	0.05	0.09	0.01	0.01

Analysis begun on: Sun Oct 13 20:28:14 2019
Analysis ended on: Sun Oct 13 20:28:14 2019

Appendix G: Cowes max development PCSWMM results

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.012)
  --------------------------------------------------------------

  4.53 ha catchment at Beach Road, Cowes

  WARNING 01: wet weather time step reduced to recording interval for Rain Gage
Chicago_3h

  *************
  Element Count
  *************
  Number of rain gages ...... 10
  Number of subcatchments ... 21
  Number of nodes ........... 24
  Number of links ........... 23
  Number of pollutants ...... 0
  Number of land uses ....... 0


  ****************
  Raingage Summary
  ****************
                                                               Data       Recording
  Name                 Data Source                             Type       Interval
  ------------------------------------------------------------------------
  Chicago_3h           Chicago_3h                              INTENSITY    1 min.
  Cowes120min          Cowes120min                             INTENSITY    5 min.
  Cowes120min(2)       Cowes120min(2)                          INTENSITY    5 min.
  Cowes180min          Cowes180min                             INTENSITY   15 min.
  Cowes30min           Cowes30min                              INTENSITY    5 min.
  Cowes45min           Cowes45min                              INTENSITY    5 min.
  Cowes4day            Cowes4day                               INTENSITY  180 min.
  Cowes60min           Cowes60min                              INTENSITY    5 min.
  Cowes6hr             Cowes6hr                                INTENSITY   15 min.
  Cowes90min           Cowes90min                              INTENSITY    5 min.


  ********************
  Subcatchment Summary
  ********************
  Name                       Area     Width    %Imperv    %Slope Rain Gage
Outlet
  -----------------------------------------------------------------------------------
--------------------------
  S01                        0.07      8.00      46.00    1.0000 Cowes90min
J07
  S02                        0.15      7.50      60.00    1.0000 Cowes90min
J06
  S03                        0.59     80.00      60.00    1.0000 Cowes90min
J03
  S04                        0.07      8.00      42.00    1.0000 Cowes90min
J04
  S05                        0.10     20.00      75.00    1.0000 Cowes90min
J14
  S06                        0.35     60.00      60.00    1.0000 Cowes90min
J12
  S07                        0.32     70.00      60.00    1.0000 Cowes90min
J13
  S08                        0.20     30.00      60.00    1.0000 Cowes90min
J11
  S09                        0.07      7.00      49.00    1.0000 Cowes90min
J09
```

```
  S10                         0.18     46.00     74.00    1.0000 Cowes90min
J23
  S11                         0.61    100.00     60.00    1.0000 Cowes90min
J22
  S12                         0.10     25.00     60.00    0.5000 Cowes90min
J18
  S13                         0.29     60.00     60.00    1.0000 Cowes90min
J01
  S14                         0.26     30.00     63.00    0.5000 Cowes90min
J21
  S15                         0.09     13.00     60.00    0.5000 Cowes90min
J20
  S16                         0.15     25.00     60.00    0.5000 Cowes90min
J19
  S17                         0.02      8.00     56.00    0.5000 Cowes90min
J15
  S18                         0.32     50.00     60.00    0.5000 Cowes90min
J16
  S19                         0.20     35.00     60.00    0.5000 Cowes90min
J17
  S20                         0.25     25.00     80.00    0.5000 Cowes90min
J02
  S21                         0.09     45.00    100.00    0.5000 Cowes90min
OF1


  ************
  Node Summary
  ************
                                           Invert      Max.    Ponded    External
  Name                 Type                 Elev.     Depth      Area    Inflow
  -----------------------------------------------------------------------------
  J01                  JUNCTION              3.72      1.28       0.0
  J02                  JUNCTION              4.29      0.70       0.0
  J03                  JUNCTION              4.12      1.22       0.0
  J04                  JUNCTION              4.46      0.85       0.0
  J05                  JUNCTION              4.95      0.85       0.0
  J06                  JUNCTION              5.01      0.80       0.0
  J07                  JUNCTION              5.14      0.70       0.0
  J08                  JUNCTION              4.22      1.40       0.0
  J09                  JUNCTION              6.07      0.82       0.0
  J10                  JUNCTION              6.18      0.80       0.0
  J11                  JUNCTION              6.33      0.72       0.0
  J12                  JUNCTION              6.22      0.75       0.0
  J13                  JUNCTION              6.39      0.62       0.0
  J14                  JUNCTION              6.45      0.90       0.0
  J15                  JUNCTION              4.09      1.00       0.0
  J16                  JUNCTION              4.26      0.84       0.0
  J17                  JUNCTION              4.62      0.60       0.0
  J18                  JUNCTION              3.87      1.28       0.0
  J19                  JUNCTION              3.94      1.37       0.0
  J20                  JUNCTION              4.44      0.92       0.0
  J21                  JUNCTION              4.50      0.70       0.0
  J22                  JUNCTION              4.74      0.55       0.0
  J23                  JUNCTION              4.84      0.68       0.0
  OF1                  OUTFALL               2.08      0.45       0.0


  ************
  Link Summary
  ************
  Name             From Node        To Node          Type                Length
%Slope Roughness
  -------------------------------------------------------------------------------
------------
  C01              J01              OF1              CONDUIT               81.3
2.0179    0.0120
```

C02	J02	J01	CONDUIT	13.8	4.1460	0.0120
C03	J03	J01	CONDUIT	69.6	0.5747	0.0120
C04	J04	J03	CONDUIT	8.1	4.2117	0.0120
C05	J05	J03	CONDUIT	67.2	1.2354	0.0120
C06	J06	J05	CONDUIT	12.8	0.4688	0.0120
C07	J07	J06	CONDUIT	7.4	1.7570	0.0120
C08	J08	J03	CONDUIT	5.7	1.7639	0.0120
C09	J09	J08	CONDUIT	112.3	1.6473	0.0120
C10	J10	J09	CONDUIT	17.9	0.6156	0.0120
C11	J11	J10	CONDUIT	7.8	1.9136	0.0120
C12	J12	J09	CONDUIT	17.6	0.8542	0.0120
C13	J13	J12	CONDUIT	7.8	2.1772	0.0120
C14	J14	J12	CONDUIT	59.2	0.3885	0.0120
C15	J15	J01	CONDUIT	20.4	1.8122	0.0120
C16	J16	J15	CONDUIT	17.2	0.9878	0.0120
C17	J17	J16	CONDUIT	59.7	0.6034	0.0120
C18	J18	J01	CONDUIT	7.2	2.0954	0.0120
C19	J19	J18	CONDUIT	10.4	0.6744	0.0120
C20	J20	J19	CONDUIT	65.2	0.7667	0.0120
C21	J21	J20	CONDUIT	14.0	0.4289	0.0120
C22	J22	J21	CONDUIT	7.8	3.0943	0.0120
C23	J23	J22	CONDUIT	23.0	0.4346	0.0120

****
Cross Section Summary
****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
C01	CIRCULAR	0.45	0.16	0.11	0.45	1	0.44
C02	CIRCULAR	0.30	0.07	0.07	0.30	1	0.21
C03	CIRCULAR	0.45	0.16	0.11	0.45	1	0.23
C04	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C05	CIRCULAR	0.30	0.07	0.07	0.30	1	0.12
C06	CIRCULAR	0.30	0.07	0.07	0.30	1	0.07

```
  C07              CIRCULAR            0.23      0.04      0.06      0.23          1
0.06
  C08              CIRCULAR            0.30      0.07      0.07      0.30          1
0.14
  C09              CIRCULAR            0.23      0.04      0.06      0.23          1
0.06
  C10              CIRCULAR            0.23      0.04      0.06      0.23          1
0.04
  C11              CIRCULAR            0.23      0.04      0.06      0.23          1
0.07
  C12              CIRCULAR            0.23      0.04      0.06      0.23          1
0.04
  C13              CIRCULAR            0.23      0.04      0.06      0.23          1
0.07
  C14              CIRCULAR            0.23      0.04      0.06      0.23          1
0.03
  C15              CIRCULAR            0.23      0.04      0.06      0.23          1
0.07
  C16              CIRCULAR            0.23      0.04      0.06      0.23          1
0.05
  C17              CIRCULAR            0.23      0.04      0.06      0.23          1
0.04
  C18              CIRCULAR            0.23      0.04      0.06      0.23          1
0.07
  C19              CIRCULAR            0.23      0.04      0.06      0.23          1
0.04
  C20              CIRCULAR            0.23      0.04      0.06      0.23          1
0.04
  C21              CIRCULAR            0.23      0.04      0.06      0.23          1
0.03
  C22              RECT_CLOSED         0.30      0.07      0.07      0.25          1
0.18
  C23              CIRCULAR            0.23      0.04      0.06      0.23          1
0.03


  *********************************************************
  NOTE: The summary statistics displayed in this report are
  based on results found at every computational time step,
  not just on results from each reporting time step.
  *********************************************************

  ****************
  Analysis Options
  ****************
  Flow Units ............... CMS
  Process Models:
    Rainfall/Runoff ........ YES
    RDII ................... NO
    Snowmelt ............... NO
    Groundwater ............ NO
    Flow Routing ........... YES
    Ponding Allowed ........ NO
    Water Quality .......... NO
  Infiltration Method ...... HORTON
  Flow Routing Method ...... DYNWAVE
  Starting Date ............ 07/02/2019 00:05:00
  Ending Date .............. 07/02/2019 02:05:00
  Antecedent Dry Days ...... 0.0
  Report Time Step ......... 00:01:00
  Wet Time Step ............ 00:01:00
  Dry Time Step ............ 00:05:00
  Routing Time Step ........ 5.00 sec
  Variable Time Step ....... YES
  Maximum Trials ........... 8
  Number of Threads ........ 4
  Head Tolerance ........... 0.001500 m
```

```
  **************************        Volume         Depth
  Runoff Quantity Continuity     hectare-m            mm
  **************************     ---------       -------
  Total Precipitation ......         0.110        24.599
  Evaporation Loss .........         0.000         0.000
  Infiltration Loss ........         0.042         9.266
  Surface Runoff ...........         0.066        14.667
  Final Storage ............         0.003         0.676
  Continuity Error (%) .....        -0.041


  **************************        Volume        Volume
  Flow Routing Continuity        hectare-m      10^6 ltr
  **************************     ---------     ---------
  Dry Weather Inflow .......         0.000         0.000
  Wet Weather Inflow .......         0.066         0.657
  Groundwater Inflow .......         0.000         0.000
  RDII Inflow ..............         0.000         0.000
  External Inflow ..........         0.000         0.000
  External Outflow .........         0.064         0.644
  Flooding Loss ............         0.001         0.011
  Evaporation Loss .........         0.000         0.000
  Exfiltration Loss ........         0.000         0.000
  Initial Stored Volume ....         0.000         0.000
  Final Stored Volume ......         0.000         0.003
  Continuity Error (%) .....        -0.076


  ***************************
  Time-Step Critical Elements
  ***************************
  Link C18 (57.74%)
  Link C08 (29.93%)


  ********************************
  Highest Flow Instability Indexes
  ********************************
  Link C06 (22)
  Link C19 (14)
  Link C22 (5)
  Link C21 (4)
  Link C18 (3)


  *************************
  Routing Time Step Summary
  *************************
  Minimum Time Step           :     0.50 sec
  Average Time Step           :     2.51 sec
  Maximum Time Step           :     5.00 sec
  Percent in Steady State     :    -0.00
  Average Iterations per Step :     2.27
  Percent Not Converging      :     2.12


  ***************************
  Subcatchment Runoff Summary
  ***************************

  ---------------------------------------------------------------------------------
----------------------
                            Total      Total      Total      Total      Total
Total      Peak  Runoff
                           Precip      Runon       Evap      Infil     Runoff
Runoff    Runoff    Coeff
```

Subcatchment	mm	mm	mm	mm	mm	10^6 ltr		CMS
S01	24.60	0.00	0.00	13.28	10.31	0.01	0.00	0.419
S02	24.60	0.00	0.00	9.84	13.77	0.02	0.01	0.560
S03	24.60	0.00	0.00	9.84	14.14	0.08	0.04	0.575
S04	24.60	0.00	0.00	14.27	9.42	0.01	0.00	0.383
S05	24.60	0.00	0.00	6.15	17.41	0.02	0.01	0.708
S06	24.60	0.00	0.00	9.84	14.18	0.05	0.03	0.576
S07	24.60	0.00	0.00	9.84	14.21	0.04	0.02	0.578
S08	24.60	0.00	0.00	9.84	14.15	0.03	0.01	0.575
S09	24.60	0.00	0.00	12.55	10.94	0.01	0.00	0.445
S10	24.60	0.00	0.00	6.40	17.74	0.03	0.02	0.721
S11	24.60	0.00	0.00	9.84	14.17	0.09	0.04	0.576
S12	24.60	0.00	0.00	9.84	14.18	0.01	0.01	0.577
S13	24.60	0.00	0.00	9.84	14.20	0.04	0.02	0.577
S14	24.60	0.00	0.00	9.10	14.69	0.04	0.02	0.597
S15	24.60	0.00	0.00	9.84	14.09	0.01	0.01	0.573
S16	24.60	0.00	0.00	9.84	14.10	0.02	0.01	0.573
S17	24.60	0.00	0.00	10.82	12.62	0.00	0.00	0.513
S18	24.60	0.00	0.00	9.84	14.09	0.05	0.02	0.573
S19	24.60	0.00	0.00	9.84	14.12	0.03	0.01	0.574
S20	24.60	0.00	0.00	4.92	18.68	0.05	0.02	0.760
S21	24.60	0.00	0.00	0.00	24.47	0.02	0.01	0.995

****
Node Depth Summary
****

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
J01	JUNCTION	0.15	0.26	3.98	0 01:25	0.26
J02	JUNCTION	0.04	0.06	4.35	0 01:25	0.06
J03	JUNCTION	0.13	0.23	4.35	0 01:25	0.23
J04	JUNCTION	0.01	0.03	4.49	0 01:25	0.03
J05	JUNCTION	0.04	0.07	5.02	0 01:25	0.07
J06	JUNCTION	0.05	0.09	5.10	0 01:25	0.09
J07	JUNCTION	0.02	0.04	5.18	0 01:25	0.04
J08	JUNCTION	0.09	0.18	4.40	0 01:25	0.17
J09	JUNCTION	0.12	0.72	6.79	0 01:25	0.45
J10	JUNCTION	0.07	0.63	6.81	0 01:25	0.36
J11	JUNCTION	0.05	0.49	6.82	0 01:25	0.22

J12	JUNCTION	0.12	0.75	6.97	0	01:25	0.46
J13	JUNCTION	0.06	0.62	7.01	0	01:25	0.30
J14	JUNCTION	0.05	0.90	7.35	0	01:25	0.25
J15	JUNCTION	0.07	0.12	4.21	0	01:25	0.12
J16	JUNCTION	0.08	0.15	4.41	0	01:25	0.15
J17	JUNCTION	0.05	0.09	4.71	0	01:25	0.09
J18	JUNCTION	0.12	0.26	4.13	0	01:25	0.26
J19	JUNCTION	0.16	0.37	4.31	0	01:25	0.36
J20	JUNCTION	0.21	0.64	5.08	0	01:18	0.63
J21	JUNCTION	0.24	0.70	5.20	0	01:18	0.70
J22	JUNCTION	0.12	0.53	5.27	0	01:18	0.49
J23	JUNCTION	0.11	0.63	5.47	0	01:18	0.41
OF1	OUTFALL	0.15	0.26	2.34	0	01:25	0.25

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
J01	JUNCTION	0.021	0.271	0	01:25	0.0412	0.622	0.112
J02	JUNCTION	0.021	0.021	0	01:25	0.0467	0.0467	0.057
J03	JUNCTION	0.042	0.122	0	01:25	0.083	0.266	0.148
J04	JUNCTION	0.003	0.003	0	01:25	0.00626	0.00626	0.070
J05	JUNCTION	0.000	0.013	0	01:25	0	0.0276	0.370
J06	JUNCTION	0.010	0.013	0	01:25	0.0206	0.0276	0.134
J07	JUNCTION	0.004	0.004	0	01:25	0.00701	0.00701	0.091
J08	JUNCTION	0.000	0.068	0	01:25	0	0.149	0.096
J09	JUNCTION	0.004	0.071	0	01:22	0.00798	0.149	0.056
J10	JUNCTION	0.000	0.015	0	01:26	0	0.029	0.057
J11	JUNCTION	0.015	0.015	0	01:25	0.029	0.029	0.016
J12	JUNCTION	0.025	0.057	0	01:25	0.0503	0.113	0.084
J13	JUNCTION	0.023	0.023	0	01:25	0.0449	0.0449	0.007
J14	JUNCTION	0.009	0.011	0	01:24	0.0174	0.0175	0.152
J15	JUNCTION	0.001	0.037	0	01:25	0.00227	0.0758	0.063
J16	JUNCTION	0.023	0.037	0	01:25	0.0454	0.0736	0.119
J17	JUNCTION	0.014	0.014	0	01:25	0.0283	0.0283	0.150
J18	JUNCTION	0.007	0.071	0	01:25	0.0142	0.193	0.015

```
  J19                 JUNCTION     0.011     0.064     0  01:21       0.0218
0.179        0.091
  J20                 JUNCTION     0.006     0.054     0  01:27       0.0121
0.157        0.089
  J21                 JUNCTION     0.018     0.078     0  01:25       0.0376
0.156        0.052
  J22                 JUNCTION     0.044     0.060     0  01:25       0.0865
0.118       -0.011
  J23                 JUNCTION     0.016     0.016     0  01:25       0.0319
0.0319       -0.020
  OF1                 OUTFALL      0.011     0.281     0  01:25       0.0225
0.644        0.000


  *********************
  Node Surcharge Summary
  *********************

  Surcharging occurs when water rises above the top of the highest conduit.
  ---------------------------------------------------------------------
                                               Max. Height   Min. Depth
                                   Hours       Above Crown    Below Rim
  Node                 Type      Surcharged        Meters       Meters
  ---------------------------------------------------------------------
  J09                  JUNCTION        0.11         0.495        0.100
  J10                  JUNCTION        0.07         0.409        0.166
  J11                  JUNCTION        0.01         0.267        0.228
  J12                  JUNCTION        0.12         0.525        0.000
  J13                  JUNCTION        0.04         0.390        0.005
  J14                  JUNCTION        0.02         0.675        0.000
  J18                  JUNCTION        0.10         0.032        1.023
  J19                  JUNCTION        0.27         0.141        1.004
  J20                  JUNCTION        0.33         0.414        0.281
  J21                  JUNCTION        0.31         0.400        0.000
  J22                  JUNCTION        0.18         0.230        0.020
  J23                  JUNCTION        0.18         0.405        0.050


  ********************
  Node Flooding Summary
  ********************

  Flooding refers to all water that overflows a node, whether it ponds or not.
  --------------------------------------------------------------------------
                                                             Total   Maximum
                                 Maximum   Time of Max       Flood    Ponded
                         Hours      Rate    Occurrence      Volume     Depth
  Node                 Flooded       CMS   days hr:min    10^6 ltr    Meters
  --------------------------------------------------------------------------
  J12                     0.01     0.003      0  01:25       0.000     0.000
  J14                     0.01     0.005      0  01:25       0.000     0.000
  J21                     0.15     0.031      0  01:25       0.011     0.000


  **********************
  Outfall Loading Summary
  **********************

  -----------------------------------------------------------
                         Flow       Avg       Max       Total
                         Freq      Flow      Flow      Volume
  Outfall Node           Pcnt       CMS       CMS    10^6 ltr
  -----------------------------------------------------------
  OF1                   97.35     0.122     0.281       0.644
  -----------------------------------------------------------
  System                97.35     0.122     0.281       0.644
```

```
*******************
Link Flow Summary
*******************
```

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days	hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
C01	CONDUIT	0.270	0	01:25	2.90	0.62	0.57
C02	CONDUIT	0.021	0	01:25	0.56	0.10	0.53
C03	CONDUIT	0.121	0	01:25	1.39	0.52	0.54
C04	CONDUIT	0.003	0	01:25	0.12	0.02	0.43
C05	CONDUIT	0.013	0	01:25	0.37	0.11	0.50
C06	CONDUIT	0.013	0	01:25	0.92	0.18	0.26
C07	CONDUIT	0.004	0	01:25	0.42	0.06	0.27
C08	CONDUIT	0.067	0	01:25	1.43	0.48	0.67
C09	CONDUIT	0.068	0	01:25	1.90	1.10	0.89
C10	CONDUIT	0.015	0	01:26	0.49	0.40	1.00
C11	CONDUIT	0.015	0	01:26	1.06	0.22	1.00
C12	CONDUIT	0.058	0	01:25	1.45	1.28	1.00
C13	CONDUIT	0.023	0	01:25	0.81	0.32	1.00
C14	CONDUIT	0.014	0	01:28	0.43	0.45	1.00
C15	CONDUIT	0.037	0	01:25	1.14	0.57	0.77
C16	CONDUIT	0.036	0	01:25	1.47	0.75	0.59
C17	CONDUIT	0.014	0	01:25	0.65	0.37	0.53
C18	CONDUIT	0.071	0	01:24	1.78	1.00	1.00
C19	CONDUIT	0.064	0	01:21	1.62	1.59	1.00
C20	CONDUIT	0.054	0	01:27	1.37	1.28	1.00
C21	CONDUIT	0.050	0	01:27	1.26	1.58	1.00
C22	CONDUIT	0.060	0	01:25	0.93	0.33	1.00
C23	CONDUIT	0.016	0	01:25	0.78	0.50	1.00

```
*************************
Flow Classification Summary
*************************
```

Conduit	Adjusted /Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
		---------- Fraction of Time in Flow Class ----------								
C01	1.00	0.02	0.00	0.00	0.00	0.97	0.00	0.00	0.48	0.00
C02	1.00	0.02	0.00	0.00	0.95	0.02	0.00	0.00	0.95	0.00
C03	1.00	0.02	0.00	0.00	0.23	0.75	0.00	0.00	0.70	0.00
C04	1.00	0.02	0.08	0.00	0.90	0.00	0.00	0.00	0.82	0.00
C05	1.00	0.02	0.01	0.00	0.96	0.00	0.00	0.00	0.93	0.00
C06	1.00	0.02	0.00	0.00	0.03	0.95	0.00	0.00	0.05	0.00
C07	1.00	0.02	0.08	0.00	0.90	0.00	0.00	0.00	0.82	0.00
C08	1.00	0.02	0.01	0.00	0.13	0.83	0.00	0.00	0.28	0.00
C09	1.00	0.03	0.00	0.00	0.01	0.96	0.00	0.00	0.05	0.00
C10	1.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.84	0.00

C11	1.00	0.02	0.00	0.00	0.11	0.87	0.00	0.00	0.87	0.00
C12	1.00	0.02	0.00	0.00	0.17	0.81	0.00	0.00	0.51	0.00
C13	1.00	0.02	0.00	0.00	0.90	0.08	0.00	0.00	0.88	0.00
C14	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.90	0.00
C15	1.00	0.02	0.01	0.00	0.97	0.00	0.00	0.00	0.94	0.00
C16	1.00	0.02	0.00	0.00	0.01	0.97	0.00	0.00	0.10	0.00
C17	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.95	0.00
C18	1.00	0.02	0.00	0.00	0.17	0.81	0.00	0.00	0.38	0.00
C19	1.00	0.02	0.00	0.00	0.27	0.71	0.00	0.00	0.45	0.00
C20	1.00	0.02	0.00	0.00	0.59	0.38	0.00	0.00	0.53	0.00
C21	1.00	0.02	0.00	0.00	0.85	0.13	0.00	0.00	0.00	0.00
C22	1.00	0.02	0.00	0.00	0.97	0.01	0.00	0.00	0.80	0.00
C23	1.00	0.02	0.00	0.00	0.28	0.70	0.00	0.00	0.03	0.00

****
Conduit Surcharge Summary
****

Conduit	Hours Full Both Ends	Hours Full Upstream	Hours Full Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
C09	0.01	0.11	0.01	0.11	0.01
C10	0.07	0.07	0.11	0.01	0.01
C11	0.01	0.01	0.07	0.01	0.01
C12	0.10	0.12	0.11	0.16	0.09
C13	0.04	0.04	0.12	0.01	0.01
C14	0.02	0.02	0.12	0.01	0.01
C15	0.01	0.01	0.16	0.01	0.01
C18	0.10	0.10	0.16	0.03	0.03
C19	0.10	0.27	0.10	0.50	0.10
C20	0.27	0.33	0.27	0.39	0.27
C21	0.33	0.39	0.33	0.52	0.33
C22	0.18	0.18	0.31	0.01	0.01
C23	0.18	0.18	0.21	0.01	0.01

Analysis begun on: Thu Oct 17 07:52:57 2019
Analysis ended on: Thu Oct 17 07:52:58 2019

Appendix H: Inverloch existing PCSWMM results

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.012)
  --------------------------------------------------------------

  WARNING 01: wet weather time step reduced to recording interval for Rain Gage
Chicago_3h

  *************
  Element Count
  *************
  Number of rain gages ...... 10
  Number of subcatchments ... 95
  Number of nodes ........... 106
  Number of links ........... 105
  Number of pollutants ...... 0
  Number of land uses ....... 0


  ****************
  Raingage Summary
  ****************
                                                               Data       Recording
  Name                 Data Source                             Type       Interval
  ---------------------------------------------------------------------------------
  Chicago_3h           Chicago_3h                              INTENSITY    1 min.
  Cowes120min          Cowes120min                             INTENSITY    5 min.
  Cowes120min(2)       Cowes120min(2)                          INTENSITY    5 min.
  Cowes180min          Cowes180min                             INTENSITY   15 min.
  Cowes30min           Cowes30min                              INTENSITY    5 min.
  Cowes45min           Cowes45min                              INTENSITY    5 min.
  Cowes4day            Cowes4day                               INTENSITY  180 min.
  Cowes60min           Cowes60min                              INTENSITY    5 min.
  Cowes6hr             Cowes6hr                                INTENSITY   15 min.
  Cowes90min           Cowes90min                              INTENSITY    5 min.


  ********************
  Subcatchment Summary
  ********************
  Name                       Area     Width   %Imperv    %Slope Rain Gage
Outlet
  --------------------------------------------------------------------------------
--------------------------
  S1                         0.07     20.00    100.00    1.0000 Cowes90min
OF1
  S10                        0.20     35.00     41.00    8.3000 Cowes90min
J9
  S11                        0.12     25.00      0.00    3.3300 Cowes90min
J8
  S12                        0.07     25.00     65.00    5.0000 Cowes90min
J10
  S13                        0.35     25.00     50.00    3.0000 Cowes90min
J13
  S14                        0.02      6.00     75.00    3.0000 Cowes90min
J12
  S15                        0.06      7.00     33.00    4.5000 Cowes90min
J14
  S16                        0.08     18.00     48.00    3.3300 Cowes90min
J17
  S17                        0.38     30.00     35.00    3.3300 Cowes90min
J16
  S18                        0.04      8.00     45.00    4.5000 Cowes90min
J15
```

S19	0.09	11.00	43.00	3.0000	Cowes90min	J18
S2	0.71	50.00	37.00	3.3300	Cowes90min	J1
S20	0.29	35.00	32.00	3.0000	Cowes90min	J19
S21	0.15	8.50	38.00	4.5000	Cowes90min	J25
S22	0.12	8.50	56.00	4.5000	Cowes90min	J24
S23	0.02	7.00	68.00	4.5000	Cowes90min	J23
S24	0.35	60.00	40.00	4.5000	Cowes90min	J22
S25	0.01	8.00	50.00	2.5000	Cowes90min	J20
S26	0.09	12.00	44.00	2.5000	Cowes90min	J21
S27	0.70	75.00	40.00	3.3300	Cowes90min	J26
S28	0.10	10.00	62.00	3.3300	Cowes90min	J27
S29	0.13	10.00	59.00	3.3300	Cowes90min	J44
S3	0.93	50.00	5.00	5.5500	Cowes90min	J65
S30	0.02	7.00	77.00	3.3300	Cowes90min	J43
S31	0.22	8.00	55.00	2.5000	Cowes90min	J45
S32	0.46	60.00	47.00	4.0000	Cowes90min	J28
S33	0.13	30.00	67.00	4.0000	Cowes90min	J29
S34	0.05	6.50	48.00	1.0000	Cowes90min	J33
S35	0.03	10.00	33.00	1.0000	Cowes90min	J30
S36	0.22	18.00	67.00	2.0000	Cowes90min	J35
S37	0.23	45.00	47.00	0.5000	Cowes90min	J34
S38	0.13	10.00	36.00	2.0000	Cowes90min	J36
S39	0.13	30.00	45.00	4.0000	Cowes90min	J37
S4	0.14	10.00	56.00	3.3300	Cowes90min	J2
S40	0.14	40.00	37.00	4.0000	Cowes90min	J41
S41	0.24	38.00	23.00	4.0000	Cowes90min	J38
S42	0.11	20.00	38.00	4.0000	Cowes90min	J39
S43	0.10	9.00	43.00	3.3300	Cowes90min	J42
S44	0.20	35.00	34.00	3.0000	Cowes90min	J46
S45	0.14	35.00	68.00	2.8000	Cowes90min	J49
S46	0.25	48.00	47.00	2.8000	Cowes90min	J50
S47	0.34	45.00	30.00	3.3300	Cowes90min	J54
S48	0.07	20.00	30.00	3.3300	Cowes90min	J55
S49	0.07	25.00	32.00	3.3300	Cowes90min	J56

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  S5                          0.22     35.00      22.00    1.0000 Cowes90min
J3
  S50                         0.02      9.00      60.00    3.3300 Cowes90min
J57
  S51                         0.06      7.50      46.00    2.5000 Cowes90min
J59
  S52                         0.11     25.00      57.00    2.5000 Cowes90min
J52
  S53                         0.13     25.00      30.00    3.3300 Cowes90min
J51
  S54                         0.14     35.00      39.00    3.3300 Cowes90min
J53
  S55                         0.44     50.00      36.00    3.3300 Cowes90min
J47
  S56                         0.12      7.00      51.00    2.5000 Cowes90min
J61
  S57                         0.02      7.00      71.00    3.3300 Cowes90min
J60
  S58                         0.32     45.00      38.00    2.5000 Cowes90min
J62
  S59                         0.06     18.00      69.00    2.5000 Cowes90min
J63
  S6                          0.05     50.00     100.00    5.5500 Cowes90min
J66
  S60                         0.31     45.00      46.00    3.3300 Cowes90min
J64
  S61                         0.52     28.00      20.00    6.6600 Cowes90min
J67
  S62                         0.10     25.00      45.00    6.6600 Cowes90min
J74
  S63                         0.07     20.00      53.00    6.6600 Cowes90min
J77
  S64                         0.14     40.00      26.00    4.0000 Cowes90min
J76
  S65                         0.18     38.00      56.00   15.0000 Cowes90min
J69
  S66                         0.02      5.00      55.00    5.5500 Cowes90min
J70
  S67                         0.29     50.00      45.00    3.5000 Cowes90min
J72
  S68                         0.21     35.00      54.00    5.5500 Cowes90min
J73
  S69                         0.28     55.00       0.00    7.5000 Cowes90min
J71
  S7                          0.36     60.00      30.00    6.3600 Cowes90min
J4
  S70                         0.39     55.00      20.00    7.5000 Cowes90min
J79
  S71                         0.12     38.00      16.00    4.2000 Cowes90min
J81
  S72                         0.13     28.00      30.00   13.0000 Cowes90min
J82
  S73                         0.07     20.00      56.00   20.0000 Cowes90min
J83
  S74                         0.11     23.00      57.00   10.0000 Cowes90min
J84
  S75                         0.13     50.00      26.00   10.0000 Cowes90min
J85
  S76                         0.10     20.00      45.00    5.7000 Cowes90min
J87
  S77                         0.02     10.00      67.00    5.7000 Cowes90min
J86
  S78                         0.05      8.50      69.00    6.5000 Cowes90min
J88
  S79                         0.19     30.00      64.00    6.5000 Cowes90min
J89
  S8                          0.05      8.50      35.00    4.0000 Cowes90min
J5
```

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  S80                        0.01     15.00     70.00    6.5000 Cowes90min
J90
  S81                        0.07     10.00     50.00    3.3300 Cowes90min
J91
  S82                        0.09     25.00     52.00   20.0000 Cowes90min
J92
  S83                        0.35     40.00     29.00   15.0000 Cowes90min
J93
  S84                        0.15     45.00     38.00    5.8000 Cowes90min
J94
  S85                        0.07     25.00     53.00    5.8000 Cowes90min
J96
  S86                        0.26     15.00     66.00    5.3000 Cowes90min
J98
  S87                        0.20     40.00     47.00   20.0000 Cowes90min
J97
  S88                        0.15     33.00     52.00   20.0000 Cowes90min
J99
  S89                        0.07     20.00     62.00    4.0000 Cowes90min
J100
  S9                         0.16     30.00     10.00    5.4000 Cowes90min
J6
  S90                        0.06     25.00     48.00    7.0000 Cowes90min
J99
  S91                        0.16     50.00     25.00   11.1100 Cowes90min
J102
  S92                        0.03      6.00     59.00    0.5000 Cowes90min
J101
  S93                        0.02      7.00     45.00    0.5000 Cowes90min
J104
  S94                        0.02      7.00     57.00    0.5000 Cowes90min
J103
  S95                        0.02      7.00     71.00    5.0000 Cowes90min
J105


  ************
  Node Summary
  ************
                                          Invert      Max.    Ponded    External
  Name                 Type                Elev.     Depth      Area    Inflow
  -------------------------------------------------------------------------------
  J1                   JUNCTION             2.90      1.54       0.0
  J10                  JUNCTION            13.52      0.69       0.0
  J100                 JUNCTION            18.00      1.50       0.0
  J101                 JUNCTION             7.33      0.75       0.0
  J102                 JUNCTION             7.45      0.80       0.0
  J103                 JUNCTION             7.96      1.05       0.0
  J104                 JUNCTION             7.22      1.14       0.0
  J105                 JUNCTION             7.39      1.12       0.0
  J11                  JUNCTION             7.96      1.37       0.0
  J12                  JUNCTION             8.43      0.73       0.0
  J13                  JUNCTION             8.59      0.69       0.0
  J14                  JUNCTION             8.72      0.95       0.0
  J15                  JUNCTION             9.22      0.62       0.0
  J16                  JUNCTION             9.87      0.96       0.0
  J17                  JUNCTION            12.22      0.70       0.0
  J18                  JUNCTION             9.02      0.85       0.0
  J19                  JUNCTION             8.53      1.47       0.0
  J2                   JUNCTION             2.94      1.50       0.0
  J20                  JUNCTION            10.81      1.47       0.0
  J21                  JUNCTION            11.35      1.40       0.0
  J22                  JUNCTION            11.80      1.51       0.0
  J23                  JUNCTION            12.37      0.75       0.0
  J24                  JUNCTION            13.08      1.09       0.0
  J25                  JUNCTION            13.45      0.83       0.0
  J26                  JUNCTION            13.57      1.53       0.0
  J27                  JUNCTION            13.88      0.93       0.0
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J28	JUNCTION	15.41	0.80	0.0
J29	JUNCTION	16.40	0.30	0.0
J3	JUNCTION	3.47	1.13	0.0
J30	JUNCTION	16.29	1.16	0.0
J31	JUNCTION	16.34	1.02	0.0
J32	JUNCTION	16.63	0.80	0.0
J33	JUNCTION	16.80	0.80	0.0
J34	JUNCTION	16.64	0.70	0.0
J35	JUNCTION	16.85	0.90	0.0
J36	JUNCTION	17.03	0.74	0.0
J37	JUNCTION	17.38	0.98	0.0
J38	JUNCTION	18.35	0.90	0.0
J39	JUNCTION	20.35	0.40	0.0
J4	JUNCTION	6.29	1.28	0.0
J40	JUNCTION	17.47	0.90	0.0
J41	JUNCTION	17.96	0.89	0.0
J42	JUNCTION	18.77	0.65	0.0
J43	JUNCTION	16.94	1.24	0.0
J44	JUNCTION	17.37	0.71	0.0
J45	JUNCTION	17.41	1.20	0.0
J46	JUNCTION	17.64	1.07	0.0
J47	JUNCTION	17.66	1.27	0.0
J48	JUNCTION	18.80	0.70	0.0
J49	JUNCTION	19.70	0.37	0.0
J5	JUNCTION	9.14	0.37	0.0
J50	JUNCTION	20.20	1.55	0.0
J51	JUNCTION	20.65	1.35	0.0
J52	JUNCTION	20.89	1.61	0.0
J53	JUNCTION	23.02	0.48	0.0
J54	JUNCTION	19.21	0.70	0.0
J55	JUNCTION	21.20	0.80	0.0
J56	JUNCTION	22.10	0.40	0.0
J57	JUNCTION	21.83	0.82	0.0
J58	JUNCTION	21.99	0.62	0.0
J59	JUNCTION	23.14	0.43	0.0
J6	JUNCTION	9.17	0.83	0.0
J60	JUNCTION	19.85	0.66	0.0
J61	JUNCTION	19.89	1.26	0.0
J62	JUNCTION	20.02	1.20	0.0
J63	JUNCTION	20.11	0.82	0.0
J64	JUNCTION	20.32	0.70	0.0
J65	JUNCTION	3.80	0.55	0.0
J66	JUNCTION	4.43	3.30	0.0
J67	JUNCTION	4.82	3.85	0.0
J68	JUNCTION	5.48	2.60	0.0
J69	JUNCTION	7.19	1.46	0.0
J7	JUNCTION	10.79	0.96	0.0
J70	JUNCTION	10.85	1.13	0.0
J71	JUNCTION	5.71	1.10	0.0
J72	JUNCTION	12.39	1.20	0.0
J73	JUNCTION	13.80	1.20	0.0
J74	JUNCTION	14.05	1.12	0.0
J75	JUNCTION	14.30	2.22	0.0
J76	JUNCTION	14.41	2.11	0.0
J77	JUNCTION	15.66	0.79	0.0
J78	JUNCTION	14.75	0.55	0.0
J79	JUNCTION	11.10	1.17	0.0
J8	JUNCTION	14.10	0.90	0.0
J80	JUNCTION	15.31	0.67	0.0
J81	JUNCTION	16.60	1.00	0.0
J82	JUNCTION	6.04	1.36	0.0
J83	JUNCTION	7.24	0.95	0.0
J84	JUNCTION	13.68	1.00	0.0
J85	JUNCTION	16.95	0.80	0.0
J86	JUNCTION	13.97	1.45	0.0
J87	JUNCTION	14.27	1.00	0.0
J88	JUNCTION	15.24	1.24	0.0
J89	JUNCTION	15.53	1.27	0.0

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  J9                    JUNCTION            14.26      0.91       0.0
  J90                   JUNCTION            18.14      1.83       0.0
  J91                   JUNCTION            18.78      1.78       0.0
  J92                   JUNCTION             6.25      2.25       0.0
  J93                   JUNCTION             6.48      3.10       0.0
  J94                   JUNCTION            19.50      1.50       0.0
  J95                   JUNCTION            20.50      1.50       0.0
  J96                   JUNCTION            21.00      1.50       0.0
  J97                   JUNCTION             6.81      2.80       0.0
  J98                   JUNCTION            17.03      1.40       0.0
  J99                   JUNCTION             6.90      0.95       0.0
  OF1                   OUTFALL              2.23      0.75       0.0


  ************
  Link Summary
  ************
  Name             From Node        To Node          Type            Length
%Slope Roughness
  ---------------------------------------------------------------------------------
------------
  C1               J1               OF1              CONDUIT          128.6
0.5208    0.0120
  C10              J10              J8               CONDUIT           59.6    -
0.9725    0.0120
  C100             J101             J99              CONDUIT           35.4
1.2138    0.0120
  C101             J102             J101             CONDUIT            7.7
1.5506    0.0120
  C102             J104             J102             CONDUIT           40.2    -
0.5726    0.0120
  C103             J105             J104             CONDUIT           21.8
0.7806    0.0120
  C104             J103             J104             CONDUIT            4.7
16.0486    0.0120
  C105             J100             J99              CONDUIT           61.9
18.2307    0.0120
  C11              J11              J4               CONDUIT           47.1
3.5501    0.0120
  C12              J12              J11              CONDUIT            3.7
12.9129    0.0120
  C13              J13              J12              CONDUIT           12.0
1.3368    0.0120
  C14              J14              J11              CONDUIT            8.6
8.8823    0.0120
  C15              J15              J14              CONDUIT            5.8
8.5932    0.0120
  C16              J16              J15              CONDUIT           32.9
1.9779    0.0120
  C17              J17              J16              CONDUIT           35.0
6.7372    0.0120
  C18              J19              J11              CONDUIT           23.3
2.4429    0.0120
  C19              J18              J19              CONDUIT            3.8
12.9341    0.0120
  C2               J2               J1               CONDUIT           13.2
0.3030    0.0120
  C20              J20              J19              CONDUIT           76.2
2.9950    0.0120
  C21              J24              J20              CONDUIT           28.4
8.0186    0.0120
  C22              J25              J24              CONDUIT            8.6
4.3265    0.0120
  C23              J21              J20              CONDUIT           14.4
3.7657    0.0120
  C24              J22              J21              CONDUIT           10.3
4.3646    0.0120
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C25	J23	J22	CONDUIT	7.6	7.5612	0.0120
C26	J26	J22	CONDUIT	79.1	2.2394	0.0120
C27	J27	J26	CONDUIT	11.7	2.6415	0.0120
C28	J28	J26	CONDUIT	41.1	4.4770	0.0120
C29	J29	J28	CONDUIT	72.3	1.3704	0.0120
C3	J3	J2	CONDUIT	5.8	9.2083	0.0120
C30	J30	J28	CONDUIT	43.0	2.0474	0.0120
C31	J31	J30	CONDUIT	14.8	0.3385	0.0120
C32	J32	J31	CONDUIT	8.4	3.4380	0.0120
C33	J33	J32	CONDUIT	6.4	2.6739	0.0120
C34	J34	J31	CONDUIT	6.8	4.4096	0.0120
C35	J35	J30	CONDUIT	16.9	3.3233	0.0120
C36	J36	J35	CONDUIT	8.2	2.1957	0.0120
C37	J37	J35	CONDUIT	14.7	3.6078	0.0120
C38	J38	J37	CONDUIT	51.2	1.8956	0.0120
C39	J39	J38	CONDUIT	35.3	5.6829	0.0120
C4	J4	J3	CONDUIT	80.3	3.5153	0.0120
C40	J40	J37	CONDUIT	5.5	1.6218	0.0120
C41	J41	J40	CONDUIT	21.7	2.2586	0.0120
C42	J42	J41	CONDUIT	27.3	2.9683	0.0120
C43	J43	J26	CONDUIT	96.3	3.5002	0.0120
C44	J44	J43	CONDUIT	12.5	3.4393	0.0120
C45	J45	J43	CONDUIT	11.6	4.0691	0.0120
C46	J47	J43	CONDUIT	24.7	2.9127	0.0120
C47	J46	J45	CONDUIT	7.7	2.9806	0.0120
C48	J48	J46	CONDUIT	47.1	2.4620	0.0120
C49	J49	J48	CONDUIT	8.8	10.2694	0.0120
C5	J5	J4	CONDUIT	79.8	3.5733	0.0120
C50	J50	J49	CONDUIT	48.2	1.0370	0.0120
C51	J51	J50	CONDUIT	44.0	1.0232	0.0120
C52	J52	J51	CONDUIT	23.7	1.0001	0.0120
C53	J53	J52	CONDUIT	30.6	6.9830	0.0120
C54	J54	J48	CONDUIT	38.6	1.0631	0.0120
C55	J55	J54	CONDUIT	53.2	3.7411	0.0120

C56	J56	J55	CONDUIT	29.9	3.0164	0.0120
C57	J57	J55	CONDUIT	17.6	3.5880	0.0120
C58	J58	J57	CONDUIT	8.4	1.8938	0.0120
C59	J59	J57	CONDUIT	16.3	8.0430	0.0120
C6	J6	J5	CONDUIT	13.5	0.2222	0.0120
C60	J60	J47	CONDUIT	91.5	2.3944	0.0120
C61	J61	J60	CONDUIT	11.2	0.3565	0.0120
C62	J62	J61	CONDUIT	7.7	1.6864	0.0120
C63	J63	J62	CONDUIT	9.3	0.9678	0.0120
C64	J64	J63	CONDUIT	6.8	3.1034	0.0120
C65	J65	J2	CONDUIT	2.0	48.8290	0.0120
C66	J66	J2	CONDUIT	102.3	1.4567	0.0120
C67	J67	J66	CONDUIT	43.7	0.8931	0.0120
C68	J68	J67	CONDUIT	56.5	1.1674	0.0120
C69	J69	J68	CONDUIT	4.3	43.2226	0.0120
C7	J7	J6	CONDUIT	35.4	4.5811	0.0120
C70	J70	J69	CONDUIT	26.4	13.9718	0.0120
C71	J72	J70	CONDUIT	27.4	5.6232	0.0120
C72	J73	J72	CONDUIT	44.0	3.2069	0.0120
C73	J74	J73	CONDUIT	9.4	2.6605	0.0120
C74	J75	J74	CONDUIT	25.8	0.9705	0.0120
C75	J76	J75	CONDUIT	28.3	0.3892	0.0120
C76	J77	J76	CONDUIT	6.8	18.7295	0.0120
C77	J78	J76	CONDUIT	35.1	0.9695	0.0120
C78	J71	J68	CONDUIT	47.6	0.4832	0.0120
C79	J79	J71	CONDUIT	51.4	10.5342	0.0120
C8	J8	J7	CONDUIT	13.7	24.8404	0.0120
C80	J80	J79	CONDUIT	39.8	10.6484	0.0120
C81	J81	J80	CONDUIT	20.1	6.4440	0.0120
C82	J82	J71	CONDUIT	60.5	0.5454	0.0120
C83	J83	J82	CONDUIT	16.8	7.1654	0.0120
C84	J84	J83	CONDUIT	46.1	14.1205	0.0120
C85	J85	J84	CONDUIT	43.5	7.5351	0.0120
C86	J86	J83	CONDUIT	41.8	16.3133	0.0120

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  C87               J87               J86               CONDUIT           8.4
3.5567    0.0120
  C88               J88               J86               CONDUIT          18.7
6.7926    0.0120
  C89               J89               J88               CONDUIT           9.2
3.1641    0.0120
  C9                J9                J8                CONDUIT          16.7
0.9510    0.0120
  C90               J90               J89               CONDUIT          51.2
5.1073    0.0120
  C91               J91               J90               CONDUIT           9.6
6.7167    0.0120
  C92               J92               J82               CONDUIT          40.3
0.5216    0.0120
  C93               J93               J92               CONDUIT          30.6
0.7509    0.0120
  C94               J94               J93               CONDUIT          79.2
16.6726    0.0120
  C95               J95               J94               CONDUIT          34.8
2.8731    0.0120
  C96               J96               J95               CONDUIT          10.3
4.8554    0.0120
  C97               J97               J93               CONDUIT          55.0
0.6001    0.0120
  C98               J98               J97               CONDUIT          29.3
37.2325    0.0120
  C99               J99               J97               CONDUIT          60.2
0.1496    0.0120


  *********************
  Cross Section Summary
  *********************
                                        Full     Full     Hyd.     Max.   No. of
Full
  Conduit           Shape              Depth     Area     Rad.    Width  Barrels
Flow
  ---------------------------------------------------------------------------------
------
  C1                CIRCULAR            0.75     0.44     0.19     0.75        1
0.87
  C10               CIRCULAR            0.15     0.02     0.04     0.15        1
0.02
  C100              CIRCULAR            0.30     0.07     0.07     0.30        1
0.12
  C101              CIRCULAR            0.38     0.11     0.09     0.38        1
0.24
  C102              CIRCULAR            0.30     0.07     0.07     0.30        1
0.08
  C103              CIRCULAR            0.30     0.07     0.07     0.30        1
0.09
  C104              CIRCULAR            0.30     0.07     0.07     0.30        1
0.42
  C105              CIRCULAR            0.23     0.04     0.06     0.23        1
0.21
  C11               CIRCULAR            0.45     0.16     0.11     0.45        1
0.58
  C12               CIRCULAR            0.30     0.07     0.07     0.30        1
0.38
  C13               CIRCULAR            0.30     0.07     0.07     0.30        1
0.12
  C14               CIRCULAR            0.30     0.07     0.07     0.30        1
0.31
  C15               CIRCULAR            0.23     0.04     0.06     0.23        1
0.14
  C16               CIRCULAR            0.23     0.04     0.06     0.23        1
0.07
```

C17	CIRCULAR	0.15	0.02	0.04	0.15	1	0.04
C18	CIRCULAR	0.45	0.16	0.11	0.45	1	0.48
C19	CIRCULAR	0.30	0.07	0.07	0.30	1	0.38
C2	CIRCULAR	0.75	0.44	0.19	0.75	1	0.66
C20	CIRCULAR	0.45	0.16	0.11	0.45	1	0.53
C21	CIRCULAR	0.38	0.11	0.09	0.38	1	0.54
C22	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C23	CIRCULAR	0.53	0.22	0.13	0.53	1	0.90
C24	CIRCULAR	0.53	0.22	0.13	0.53	1	0.97
C25	CIRCULAR	0.23	0.04	0.06	0.23	1	0.13
C26	CIRCULAR	0.53	0.22	0.13	0.53	1	0.70
C27	CIRCULAR	0.30	0.07	0.07	0.30	1	0.17
C28	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C29	CIRCULAR	0.23	0.04	0.06	0.23	1	0.06
C3	CIRCULAR	0.45	0.16	0.11	0.45	1	0.94
C30	CIRCULAR	0.30	0.07	0.07	0.30	1	0.15
C31	CIRCULAR	0.30	0.07	0.07	0.30	1	0.06
C32	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C33	CIRCULAR	0.30	0.07	0.07	0.30	1	0.17
C34	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C35	CIRCULAR	0.30	0.07	0.07	0.30	1	0.19
C36	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07
C37	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C38	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07
C39	CIRCULAR	0.15	0.02	0.04	0.15	1	0.04
C4	CIRCULAR	0.45	0.16	0.11	0.45	1	0.58
C40	CIRCULAR	0.23	0.04	0.06	0.23	1	0.06
C41	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07
C42	CIRCULAR	0.23	0.04	0.06	0.23	1	0.08
C43	CIRCULAR	0.38	0.11	0.09	0.38	1	0.36
C44	CIRCULAR	0.30	0.07	0.07	0.30	1	0.19
C45	CIRCULAR	0.38	0.11	0.09	0.38	1	0.38
C46	CIRCULAR	0.30	0.07	0.07	0.30	1	0.18
C47	CIRCULAR	0.30	0.07	0.07	0.30	1	0.18

C48	CIRCULAR	0.30	0.07	0.07	0.30	1	0.16
C49	CIRCULAR	0.23	0.04	0.06	0.23	1	0.16
C5	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C50	CIRCULAR	0.23	0.04	0.06	0.23	1	0.05
C51	CIRCULAR	0.23	0.04	0.06	0.23	1	0.05
C52	CIRCULAR	0.15	0.02	0.04	0.15	1	0.02
C53	CIRCULAR	0.15	0.02	0.04	0.15	1	0.04
C54	CIRCULAR	0.23	0.04	0.06	0.23	1	0.05
C55	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C56	CIRCULAR	0.15	0.02	0.04	0.15	1	0.03
C57	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C58	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07
C59	CIRCULAR	0.15	0.02	0.04	0.15	1	0.05
C6	RECT_CLOSED	0.23	0.07	0.06	0.30	1	0.04
C60	CIRCULAR	0.30	0.07	0.07	0.30	1	0.16
C61	CIRCULAR	0.30	0.07	0.07	0.30	1	0.06
C62	CIRCULAR	0.30	0.07	0.07	0.30	1	0.14
C63	CIRCULAR	0.30	0.07	0.07	0.30	1	0.10
C64	CIRCULAR	0.30	0.07	0.07	0.30	1	0.18
C65	CIRCULAR	0.23	0.04	0.06	0.23	1	0.34
C66	CIRCULAR	0.60	0.28	0.15	0.60	1	0.80
C67	CIRCULAR	0.45	0.16	0.11	0.45	1	0.29
C68	CIRCULAR	0.45	0.16	0.11	0.45	1	0.33
C69	CIRCULAR	0.30	0.07	0.07	0.30	1	0.69
C7	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C70	CIRCULAR	0.30	0.07	0.07	0.30	1	0.39
C71	CIRCULAR	0.30	0.07	0.07	0.30	1	0.25
C72	CIRCULAR	0.30	0.07	0.07	0.30	1	0.19
C73	CIRCULAR	0.23	0.04	0.06	0.23	1	0.08
C74	CIRCULAR	0.23	0.04	0.06	0.23	1	0.05
C75	CIRCULAR	0.23	0.04	0.06	0.23	1	0.03
C76	CIRCULAR	0.15	0.02	0.04	0.15	1	0.07
C77	CIRCULAR	0.15	0.02	0.04	0.15	1	0.02
C78	CIRCULAR	0.45	0.16	0.11	0.45	1	0.21

```
  C79              CIRCULAR            0.23      0.04      0.06      0.23          1
0.16
  C8               CIRCULAR            0.30      0.07      0.07      0.30          1
0.52
  C80              CIRCULAR            0.23      0.04      0.06      0.23          1
0.16
  C81              CIRCULAR            0.23      0.04      0.06      0.23          1
0.12
  C82              CIRCULAR            0.45      0.16      0.11      0.45          1
0.23
  C83              CIRCULAR            0.23      0.04      0.06      0.23          1
0.13
  C84              CIRCULAR            0.23      0.04      0.06      0.23          1
0.18
  C85              CIRCULAR            0.15      0.02      0.04      0.15          1
0.05
  C86              CIRCULAR            0.23      0.04      0.06      0.23          1
0.20
  C87              CIRCULAR            0.30      0.07      0.07      0.30          1
0.20
  C88              CIRCULAR            0.30      0.07      0.07      0.30          1
0.27
  C89              CIRCULAR            0.30      0.07      0.07      0.30          1
0.19
  C9               CIRCULAR            0.30      0.07      0.07      0.30          1
0.10
  C90              CIRCULAR            0.23      0.04      0.06      0.23          1
0.11
  C91              CIRCULAR            0.30      0.07      0.07      0.30          1
0.27
  C92              CIRCULAR            0.45      0.16      0.11      0.45          1
0.22
  C93              CIRCULAR            0.38      0.11      0.09      0.38          1
0.16
  C94              CIRCULAR            0.23      0.04      0.06      0.23          1
0.20
  C95              CIRCULAR            0.30      0.07      0.07      0.30          1
0.18
  C96              CIRCULAR            0.15      0.02      0.04      0.15          1
0.04
  C97              CIRCULAR            0.30      0.07      0.07      0.30          1
0.08
  C98              CIRCULAR            0.23      0.04      0.06      0.23          1
0.30
  C99              CIRCULAR            0.30      0.07      0.07      0.30          1
0.04


  *********************************************************
  NOTE: The summary statistics displayed in this report are
  based on results found at every computational time step,
  not just on results from each reporting time step.
  *********************************************************

  ****************
  Analysis Options
  ****************
  Flow Units ............... CMS
  Process Models:
    Rainfall/Runoff ........ YES
    RDII ................... NO
    Snowmelt ............... NO
    Groundwater ............ NO
    Flow Routing ........... YES
    Ponding Allowed ........ NO
    Water Quality .......... NO
  Infiltration Method ...... HORTON
```

```
Flow Routing Method ...... DYNWAVE
Starting Date ............ 07/02/2019 00:00:00
Ending Date .............. 07/02/2019 02:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:01:00
Dry Time Step ............ 00:05:00
Routing Time Step ........ 5.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 4
Head Tolerance ........... 0.001500 m


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         0.392        24.599
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.241        15.118
Surface Runoff ...........         0.145         9.079
Final Storage ............         0.007         0.410
Continuity Error (%) .....        -0.031


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.145         1.447
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.144         1.435
Flooding Loss ............         0.000         0.001
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.001         0.012
Continuity Error (%) .....        -0.087


*************************
Highest Continuity Errors
*************************
Node J104 (25.27%)
Node J10 (6.67%)


***************************
Time-Step Critical Elements
***************************
Link C3 (87.89%)
Link C47 (1.01%)


********************************
Highest Flow Instability Indexes
********************************
Link C2 (27)
Link C61 (21)
Link C60 (5)
Link C1 (3)
Link C78 (1)


*************************
Routing Time Step Summary
```

```
*************************
Minimum Time Step           :     0.78 sec
Average Time Step           :     1.66 sec
Maximum Time Step           :     5.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.01
Percent Not Converging      :     0.02
```

```
***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff CMS	Runoff Coeff
S1	24.60	0.00	0.00	0.00	24.44	0.02	0.01	0.993
S10	24.60	0.00	0.00	14.51	9.69	0.02	0.01	0.394
S11	24.60	0.00	0.00	24.60	0.00	0.00	0.00	0.000
S12	24.60	0.00	0.00	8.61	15.35	0.01	0.01	0.624
S13	24.60	0.00	0.00	12.30	11.68	0.04	0.02	0.475
S14	24.60	0.00	0.00	6.15	16.93	0.00	0.00	0.688
S15	24.60	0.00	0.00	16.48	7.45	0.00	0.00	0.303
S16	24.60	0.00	0.00	12.79	11.31	0.01	0.00	0.460
S17	24.60	0.00	0.00	15.99	8.36	0.03	0.02	0.340
S18	24.60	0.00	0.00	13.53	10.17	0.00	0.00	0.413
S19	24.60	0.00	0.00	14.02	9.69	0.01	0.00	0.394
S2	24.60	0.00	0.00	15.50	8.75	0.06	0.03	0.356
S20	24.60	0.00	0.00	16.73	7.62	0.02	0.01	0.310
S21	24.60	0.00	0.00	15.25	8.76	0.01	0.01	0.356
S22	24.60	0.00	0.00	10.82	12.94	0.02	0.01	0.526
S23	24.60	0.00	0.00	7.87	15.37	0.00	0.00	0.625
S24	24.60	0.00	0.00	14.76	9.41	0.03	0.02	0.382
S25	24.60	0.00	0.00	12.30	11.31	0.00	0.00	0.460
S26	24.60	0.00	0.00	13.78	9.91	0.01	0.00	0.403
S27	24.60	0.00	0.00	14.76	9.43	0.07	0.03	0.384
S28	24.60	0.00	0.00	9.35	13.91	0.01	0.01	0.565
S29	24.60	0.00	0.00	10.09	13.21	0.02	0.01	0.537

S3	24.60	0.00	0.00	23.37	1.13	0.01	0.01	0.046
S30	24.60	0.00	0.00	5.66	17.40	0.00	0.00	0.707
S31	24.60	0.00	0.00	11.07	12.49	0.03	0.01	0.508
S32	24.60	0.00	0.00	13.04	11.24	0.05	0.03	0.457
S33	24.60	0.00	0.00	8.12	16.21	0.02	0.01	0.659
S34	24.60	0.00	0.00	12.79	10.77	0.01	0.00	0.438
S35	24.60	0.00	0.00	16.48	7.46	0.00	0.00	0.303
S36	24.60	0.00	0.00	8.12	15.62	0.03	0.02	0.635
S37	24.60	0.00	0.00	13.04	11.17	0.03	0.01	0.454
S38	24.60	0.00	0.00	15.74	8.48	0.01	0.01	0.345
S39	24.60	0.00	0.00	13.53	10.82	0.01	0.01	0.440
S4	24.60	0.00	0.00	10.82	12.52	0.02	0.01	0.509
S40	24.60	0.00	0.00	15.50	8.87	0.01	0.01	0.361
S41	24.60	0.00	0.00	18.94	5.38	0.01	0.01	0.219
S42	24.60	0.00	0.00	15.25	9.19	0.01	0.00	0.374
S43	24.60	0.00	0.00	14.02	9.67	0.01	0.01	0.393
S44	24.60	0.00	0.00	16.24	8.02	0.02	0.01	0.326
S45	24.60	0.00	0.00	7.87	16.29	0.02	0.01	0.662
S46	24.60	0.00	0.00	13.04	11.29	0.03	0.01	0.459
S47	24.60	0.00	0.00	17.22	6.95	0.02	0.01	0.283
S48	24.60	0.00	0.00	17.22	7.38	0.00	0.00	0.300
S49	24.60	0.00	0.00	16.73	7.87	0.01	0.00	0.320
S5	24.60	0.00	0.00	19.19	5.40	0.01	0.01	0.220
S50	24.60	0.00	0.00	9.84	13.57	0.00	0.00	0.552
S51	24.60	0.00	0.00	13.28	10.35	0.01	0.00	0.421
S52	24.60	0.00	0.00	10.58	13.52	0.01	0.01	0.549
S53	24.60	0.00	0.00	17.22	7.07	0.01	0.00	0.287
S54	24.60	0.00	0.00	15.01	9.48	0.01	0.01	0.385
S55	24.60	0.00	0.00	15.74	8.45	0.04	0.02	0.343
S56	24.60	0.00	0.00	12.05	11.37	0.01	0.01	0.462
S57	24.60	0.00	0.00	7.13	16.05	0.00	0.00	0.652
S58	24.60	0.00	0.00	15.25	9.01	0.03	0.01	0.366
S59	24.60	0.00	0.00	7.63	16.64	0.01	0.01	0.676
S6	24.60	0.00	0.00	0.00	24.61	0.01	0.01	1.001

S60	24.60	0.00	0.00	13.28	10.77	0.03	0.02	0.438
S61	24.60	0.00	0.00	19.68	4.72	0.02	0.01	0.192
S62	24.60	0.00	0.00	13.53	10.76	0.01	0.01	0.437
S63	24.60	0.00	0.00	11.56	12.69	0.01	0.00	0.516
S64	24.60	0.00	0.00	18.20	6.27	0.01	0.00	0.255
S65	24.60	0.00	0.00	10.82	13.45	0.02	0.01	0.547
S66	24.60	0.00	0.00	11.07	12.42	0.00	0.00	0.505
S67	24.60	0.00	0.00	13.53	10.70	0.03	0.02	0.435
S68	24.60	0.00	0.00	11.32	12.78	0.03	0.01	0.520
S69	24.60	0.00	0.00	24.60	0.00	0.00	0.00	0.000
S7	24.60	0.00	0.00	17.22	7.33	0.03	0.01	0.298
S70	24.60	0.00	0.00	19.68	4.71	0.02	0.01	0.191
S71	24.60	0.00	0.00	20.66	3.74	0.00	0.00	0.152
S72	24.60	0.00	0.00	17.22	7.23	0.01	0.00	0.294
S73	24.60	0.00	0.00	10.82	13.58	0.01	0.00	0.552
S74	24.60	0.00	0.00	10.58	13.78	0.01	0.01	0.560
S75	24.60	0.00	0.00	18.20	6.26	0.01	0.00	0.254
S76	24.60	0.00	0.00	13.53	10.60	0.01	0.01	0.431
S77	24.60	0.00	0.00	8.12	15.15	0.00	0.00	0.616
S78	24.60	0.00	0.00	7.63	15.56	0.01	0.00	0.632
S79	24.60	0.00	0.00	8.86	15.20	0.03	0.02	0.618
S8	24.60	0.00	0.00	15.99	7.91	0.00	0.00	0.321
S80	24.60	0.00	0.00	7.38	15.85	0.00	0.00	0.644
S81	24.60	0.00	0.00	12.30	11.27	0.01	0.00	0.458
S82	24.60	0.00	0.00	11.81	12.42	0.01	0.01	0.505
S83	24.60	0.00	0.00	17.47	6.97	0.02	0.01	0.283
S84	24.60	0.00	0.00	15.25	9.21	0.01	0.01	0.374
S85	24.60	0.00	0.00	11.56	12.46	0.01	0.00	0.506
S86	24.60	0.00	0.00	8.36	14.86	0.04	0.02	0.604
S87	24.60	0.00	0.00	13.04	11.33	0.02	0.01	0.461
S88	24.60	0.00	0.00	11.81	12.51	0.02	0.01	0.508
S89	24.60	0.00	0.00	9.35	14.92	0.01	0.01	0.606
S9	24.60	0.00	0.00	22.14	2.26	0.00	0.00	0.092
S90	24.60	0.00	0.00	12.79	11.53	0.01	0.00	0.469

S91	24.60	0.00	0.00	18.45	6.03	0.01	0.00	0.245
S92	24.60	0.00	0.00	10.09	13.20	0.00	0.00	0.537
S93	24.60	0.00	0.00	13.53	10.15	0.00	0.00	0.412
S94	24.60	0.00	0.00	10.58	12.84	0.00	0.00	0.522
S95	24.60	0.00	0.00	7.13	16.04	0.00	0.00	0.652

****
Node Depth Summary
****

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days	Time of Max Occurrence hr:min	Reported Max Depth Meters
J1	JUNCTION	0.29	0.52	3.42	0	01:25	0.51
J10	JUNCTION	0.59	0.69	14.21	0	00:25	0.69
J100	JUNCTION	0.01	0.03	18.03	0	01:25	0.03
J101	JUNCTION	0.04	0.06	7.39	0	01:25	0.06
J102	JUNCTION	0.03	0.05	7.50	0	01:25	0.05
J103	JUNCTION	0.01	0.01	7.97	0	01:25	0.01
J104	JUNCTION	0.23	0.28	7.50	0	01:24	0.28
J105	JUNCTION	0.08	0.11	7.50	0	01:24	0.11
J11	JUNCTION	0.16	0.28	8.24	0	01:25	0.28
J12	JUNCTION	0.03	0.05	8.48	0	01:25	0.05
J13	JUNCTION	0.05	0.09	8.68	0	01:25	0.09
J14	JUNCTION	0.03	0.06	8.78	0	01:25	0.06
J15	JUNCTION	0.04	0.06	9.28	0	01:25	0.06
J16	JUNCTION	0.05	0.09	9.96	0	01:25	0.09
J17	JUNCTION	0.02	0.03	12.25	0	01:25	0.03
J18	JUNCTION	0.01	0.02	9.04	0	01:25	0.02
J19	JUNCTION	0.16	0.29	8.82	0	01:25	0.29
J2	JUNCTION	0.31	0.54	3.48	0	01:25	0.54
J20	JUNCTION	0.15	0.26	11.07	0	01:25	0.26
J21	JUNCTION	0.13	0.22	11.57	0	01:25	0.22
J22	JUNCTION	0.12	0.21	12.01	0	01:25	0.21
J23	JUNCTION	0.01	0.02	12.39	0	01:25	0.02
J24	JUNCTION	0.03	0.04	13.12	0	01:25	0.04
J25	JUNCTION	0.02	0.04	13.49	0	01:25	0.04
J26	JUNCTION	0.15	0.25	13.82	0	01:25	0.25
J27	JUNCTION	0.03	0.04	13.92	0	01:25	0.04
J28	JUNCTION	0.08	0.15	15.56	0	01:25	0.15
J29	JUNCTION	0.04	0.06	16.46	0	01:25	0.06
J3	JUNCTION	0.13	0.25	3.72	0	01:25	0.25
J30	JUNCTION	0.08	0.14	16.43	0	01:25	0.14
J31	JUNCTION	0.06	0.11	16.45	0	01:25	0.11
J32	JUNCTION	0.02	0.03	16.66	0	01:25	0.03
J33	JUNCTION	0.02	0.03	16.83	0	01:25	0.03
J34	JUNCTION	0.03	0.05	16.69	0	01:25	0.05
J35	JUNCTION	0.06	0.11	16.96	0	01:25	0.11
J36	JUNCTION	0.03	0.04	17.07	0	01:25	0.04
J37	JUNCTION	0.05	0.09	17.47	0	01:25	0.09
J38	JUNCTION	0.04	0.06	18.41	0	01:25	0.06
J39	JUNCTION	0.02	0.04	20.39	0	01:25	0.04
J4	JUNCTION	0.17	0.30	6.59	0	01:25	0.30
J40	JUNCTION	0.04	0.07	17.54	0	01:25	0.07
J41	JUNCTION	0.04	0.06	18.02	0	01:25	0.06
J42	JUNCTION	0.02	0.04	18.81	0	01:25	0.04
J43	JUNCTION	0.10	0.18	17.12	0	01:25	0.18
J44	JUNCTION	0.03	0.04	17.41	0	01:25	0.04
J45	JUNCTION	0.07	0.12	17.53	0	01:25	0.12
J46	JUNCTION	0.08	0.14	17.78	0	01:25	0.14

J47	JUNCTION	0.07	0.12	17.78	0	01:25	0.12
J48	JUNCTION	0.08	0.13	18.93	0	01:25	0.13
J49	JUNCTION	0.05	0.08	19.78	0	01:25	0.08
J5	JUNCTION	0.04	0.07	9.21	0	01:25	0.07
J50	JUNCTION	0.08	0.14	20.34	0	01:25	0.14
J51	JUNCTION	0.06	0.10	20.75	0	01:25	0.10
J52	JUNCTION	0.06	0.11	20.99	0	01:25	0.11
J53	JUNCTION	0.02	0.04	23.06	0	01:25	0.04
J54	JUNCTION	0.06	0.10	19.31	0	01:25	0.10
J55	JUNCTION	0.03	0.05	21.25	0	01:25	0.05
J56	JUNCTION	0.02	0.03	22.13	0	01:25	0.03
J57	JUNCTION	0.02	0.03	21.86	0	01:25	0.03
J58	JUNCTION	0.00	0.00	21.99	0	00:00	0.00
J59	JUNCTION	0.02	0.03	23.17	0	01:25	0.03
J6	JUNCTION	0.05	0.09	9.26	0	01:25	0.08
J60	JUNCTION	0.06	0.11	19.96	0	01:25	0.11
J61	JUNCTION	0.10	0.17	20.06	0	01:25	0.17
J62	JUNCTION	0.06	0.12	20.14	0	01:25	0.12
J63	JUNCTION	0.06	0.10	20.21	0	01:25	0.10
J64	JUNCTION	0.04	0.06	20.38	0	01:25	0.06
J65	JUNCTION	0.01	0.02	3.82	0	01:25	0.02
J66	JUNCTION	0.13	0.22	4.65	0	01:25	0.22
J67	JUNCTION	0.16	0.29	5.11	0	01:25	0.29
J68	JUNCTION	0.15	0.26	5.74	0	01:25	0.26
J69	JUNCTION	0.04	0.06	7.25	0	01:25	0.06
J7	JUNCTION	0.03	0.05	10.84	0	01:25	0.05
J70	JUNCTION	0.04	0.07	10.92	0	01:25	0.07
J71	JUNCTION	0.16	0.28	5.99	0	01:25	0.28
J72	JUNCTION	0.05	0.09	12.48	0	01:25	0.09
J73	JUNCTION	0.05	0.08	13.88	0	01:25	0.08
J74	JUNCTION	0.04	0.07	14.12	0	01:25	0.07
J75	JUNCTION	0.04	0.07	14.37	0	01:25	0.07
J76	JUNCTION	0.05	0.08	14.49	0	01:25	0.08
J77	JUNCTION	0.02	0.03	15.69	0	01:25	0.03
J78	JUNCTION	0.00	0.00	14.75	0	00:00	0.00
J79	JUNCTION	0.02	0.04	11.14	0	01:25	0.04
J8	JUNCTION	0.02	0.03	14.13	0	01:25	0.03
J80	JUNCTION	0.01	0.02	15.33	0	01:25	0.02
J81	JUNCTION	0.01	0.02	16.62	0	01:25	0.02
J82	JUNCTION	0.15	0.26	6.30	0	01:25	0.26
J83	JUNCTION	0.05	0.09	7.33	0	01:25	0.09
J84	JUNCTION	0.02	0.04	13.72	0	01:25	0.04
J85	JUNCTION	0.02	0.03	16.98	0	01:25	0.03
J86	JUNCTION	0.04	0.06	14.03	0	01:25	0.06
J87	JUNCTION	0.02	0.03	14.30	0	01:25	0.03
J88	JUNCTION	0.04	0.06	15.30	0	01:25	0.06
J89	JUNCTION	0.04	0.07	15.60	0	01:25	0.07
J9	JUNCTION	0.04	0.07	14.33	0	01:25	0.07
J90	JUNCTION	0.02	0.03	18.17	0	01:25	0.03
J91	JUNCTION	0.02	0.03	18.81	0	01:25	0.03
J92	JUNCTION	0.11	0.20	6.45	0	01:25	0.20
J93	JUNCTION	0.11	0.19	6.67	0	01:25	0.19
J94	JUNCTION	0.02	0.04	19.54	0	01:25	0.04
J95	JUNCTION	0.02	0.03	20.53	0	01:25	0.03
J96	JUNCTION	0.02	0.04	21.04	0	01:25	0.04
J97	JUNCTION	0.11	0.19	7.00	0	01:25	0.19
J98	JUNCTION	0.02	0.04	17.07	0	01:25	0.04
J99	JUNCTION	0.10	0.19	7.09	0	01:25	0.19
OF1	OUTFALL	0.28	0.52	2.75	0	01:25	0.51

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Node Inflow Summary
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Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
J1	JUNCTION	0.032	0.712	0	01:25	0.0623	1.42	0.073
J10	JUNCTION	0.006	0.006	0	01:25	0.0107	0.0109	7.150
J100	JUNCTION	0.005	0.005	0	01:25	0.0107	0.0107	-0.078
J101	JUNCTION	0.002	0.011	0	01:25	0.00416	0.0191	0.122
J102	JUNCTION	0.005	0.009	0	01:25	0.00971	0.0159	-0.119
J103	JUNCTION	0.001	0.001	0	01:25	0.00237	0.00237	-0.008
J104	JUNCTION	0.001	0.004	0	01:24	0.00193	0.0086	33.807
J105	JUNCTION	0.002	0.002	0	00:36	0.00329	0.00354	6.945
J11	JUNCTION	0.000	0.410	0	01:25	0	0.808	0.023
J12	JUNCTION	0.002	0.022	0	01:25	0.00305	0.0435	0.022
J13	JUNCTION	0.021	0.021	0	01:25	0.0405	0.0404	0.042
J14	JUNCTION	0.002	0.025	0	01:25	0.00447	0.0494	0.012
J15	JUNCTION	0.002	0.023	0	01:25	0.00381	0.0449	0.028
J16	JUNCTION	0.016	0.021	0	01:25	0.0321	0.0412	0.051
J17	JUNCTION	0.005	0.005	0	01:25	0.00904	0.00904	0.019
J18	JUNCTION	0.004	0.004	0	01:25	0.00833	0.00833	0.023
J19	JUNCTION	0.011	0.363	0	01:25	0.0224	0.715	0.044
J2	JUNCTION	0.010	0.684	0	01:25	0.0182	1.36	0.096
J20	JUNCTION	0.001	0.348	0	01:25	0.00147	0.685	0.040
J21	JUNCTION	0.005	0.332	0	01:25	0.00848	0.654	0.005
J22	JUNCTION	0.017	0.328	0	01:25	0.0329	0.646	0.035
J23	JUNCTION	0.002	0.002	0	01:25	0.00284	0.00284	0.022
J24	JUNCTION	0.008	0.015	0	01:25	0.0161	0.0294	0.028
J25	JUNCTION	0.007	0.007	0	01:25	0.0133	0.0133	0.038
J26	JUNCTION	0.034	0.311	0	01:25	0.0658	0.61	0.072
J27	JUNCTION	0.008	0.008	0	01:25	0.0142	0.0142	0.080
J28	JUNCTION	0.026	0.106	0	01:25	0.0516	0.209	0.049
J29	JUNCTION	0.010	0.010	0	01:25	0.0204	0.0204	-0.022
J3	JUNCTION	0.006	0.445	0	01:25	0.0117	0.882	0.022

J30	JUNCTION	0.001	0.070	0	01:25	0.00224	0.138	0.063
J31	JUNCTION	0.000	0.016	0	01:25	0	0.0309	0.090
J32	JUNCTION	0.000	0.003	0	01:25	0	0.00511	0.126
J33	JUNCTION	0.003	0.003	0	01:25	0.00511	0.00511	0.074
J34	JUNCTION	0.013	0.013	0	01:25	0.0258	0.0258	0.023
J35	JUNCTION	0.017	0.053	0	01:25	0.0342	0.104	0.028
J36	JUNCTION	0.006	0.006	0	01:25	0.0114	0.0114	0.059
J37	JUNCTION	0.007	0.030	0	01:25	0.0141	0.0589	0.029
J38	JUNCTION	0.007	0.012	0	01:25	0.0131	0.0229	0.035
J39	JUNCTION	0.005	0.005	0	01:25	0.00978	0.00978	0.009
J4	JUNCTION	0.013	0.440	0	01:25	0.0267	0.87	0.054
J40	JUNCTION	0.000	0.011	0	01:25	0	0.022	0.057
J41	JUNCTION	0.006	0.011	0	01:25	0.0121	0.022	0.014
J42	JUNCTION	0.005	0.005	0	01:25	0.00996	0.00996	0.120
J43	JUNCTION	0.001	0.164	0	01:25	0.0027	0.321	0.054
J44	JUNCTION	0.009	0.009	0	01:25	0.017	0.017	0.077
J45	JUNCTION	0.013	0.089	0	01:25	0.028	0.176	0.011
J46	JUNCTION	0.008	0.075	0	01:25	0.0164	0.148	0.020
J47	JUNCTION	0.019	0.065	0	01:24	0.0375	0.126	0.046
J48	JUNCTION	0.000	0.067	0	01:25	0	0.131	0.045
J49	JUNCTION	0.012	0.045	0	01:25	0.0228	0.0887	0.014
J5	JUNCTION	0.002	0.018	0	01:25	0.00387	0.0362	0.069
J50	JUNCTION	0.015	0.033	0	01:25	0.0287	0.0659	0.065
J51	JUNCTION	0.005	0.019	0	01:25	0.0093	0.0372	0.041
J52	JUNCTION	0.008	0.014	0	01:25	0.0149	0.0279	0.064
J53	JUNCTION	0.007	0.007	0	01:25	0.0131	0.0131	-0.007
J54	JUNCTION	0.012	0.022	0	01:25	0.0234	0.0426	0.067
J55	JUNCTION	0.002	0.010	0	01:25	0.00491	0.0193	0.034
J56	JUNCTION	0.003	0.003	0	01:25	0.00582	0.00582	-0.023
J57	JUNCTION	0.001	0.005	0	01:25	0.00237	0.00858	0.092
J58	JUNCTION	0.000	0.000	0	00:00	0	0	0.000 ltr
J59	JUNCTION	0.003	0.003	0	01:25	0.00621	0.00621	0.056
J6	JUNCTION	0.002	0.016	0	01:25	0.00354	0.0323	0.040
J60	JUNCTION	0.001	0.050	0	01:25	0.00249	0.0886	0.009

J61	JUNCTION	0.007	0.044	0	01:24	0.0131	0.0862	0.092
J62	JUNCTION	0.015	0.038	0	01:25	0.0291	0.0731	0.013
J63	JUNCTION	0.005	0.023	0	01:25	0.0102	0.044	0.033
J64	JUNCTION	0.017	0.017	0	01:25	0.0338	0.0338	0.014
J65	JUNCTION	0.006	0.006	0	01:25	0.0105	0.0105	-0.002
J66	JUNCTION	0.006	0.226	0	01:25	0.0121	0.449	0.061
J67	JUNCTION	0.013	0.221	0	01:25	0.0247	0.437	0.055
J68	JUNCTION	0.000	0.209	0	01:25	0	0.413	0.047
J69	JUNCTION	0.012	0.058	0	01:25	0.0246	0.114	0.001
J7	JUNCTION	0.000	0.014	0	01:25	0	0.0288	0.013
J70	JUNCTION	0.002	0.046	0	01:25	0.00292	0.0895	0.018
J71	JUNCTION	0.000	0.152	0	01:25	0	0.299	0.135
J72	JUNCTION	0.016	0.044	0	01:25	0.0315	0.0866	0.017
J73	JUNCTION	0.014	0.028	0	01:25	0.0265	0.0552	0.020
J74	JUNCTION	0.006	0.015	0	01:25	0.011	0.0287	0.013
J75	JUNCTION	0.000	0.009	0	01:25	0	0.0177	0.090
J76	JUNCTION	0.004	0.009	0	01:25	0.00881	0.0177	0.036
J77	JUNCTION	0.005	0.005	0	01:25	0.00894	0.00894	0.004
J78	JUNCTION	0.000	0.000	0	00:00	0	0	0.000 ltr
J79	JUNCTION	0.010	0.012	0	01:25	0.0184	0.023	-0.081
J8	JUNCTION	0.000	0.014	0	01:25	0	0.0289	-0.013
J80	JUNCTION	0.000	0.002	0	01:25	0	0.0046	0.045
J81	JUNCTION	0.002	0.002	0	01:25	0.0046	0.0046	-0.020
J82	JUNCTION	0.005	0.141	0	01:25	0.00918	0.276	0.079
J83	JUNCTION	0.004	0.048	0	01:25	0.00883	0.0932	0.024
J84	JUNCTION	0.007	0.012	0	01:25	0.0149	0.0233	-0.014
J85	JUNCTION	0.004	0.004	0	01:25	0.00838	0.00838	-0.022
J86	JUNCTION	0.002	0.032	0	01:25	0.00295	0.0611	0.026
J87	JUNCTION	0.005	0.005	0	01:25	0.0104	0.0104	0.001
J88	JUNCTION	0.005	0.025	0	01:25	0.0084	0.0478	0.022
J89	JUNCTION	0.015	0.020	0	01:25	0.0294	0.0394	0.008
J9	JUNCTION	0.010	0.010	0	01:25	0.0197	0.0197	0.013
J90	JUNCTION	0.001	0.005	0	01:25	0.00238	0.01	0.134
J91	JUNCTION	0.004	0.004	0	01:25	0.00766	0.00766	0.026

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  J92                  JUNCTION     0.006    0.089     0  01:25      0.0108
0.174        0.067
  J93                  JUNCTION     0.012    0.084     0  01:25      0.0244
0.163        0.120
  J94                  JUNCTION     0.007    0.012     0  01:25      0.0139
0.0229       -0.097
  J95                  JUNCTION     0.000    0.005     0  01:25           0
0.00903        0.049
  J96                  JUNCTION     0.005    0.005     0  01:25     0.00903
0.00903        0.010
  J97                  JUNCTION     0.011    0.060     0  01:25      0.0223
0.116        0.166
  J98                  JUNCTION     0.020    0.020     0  01:25      0.0379
0.0379        0.039
  J99                  JUNCTION     0.013    0.030     0  01:25      0.0263
0.0561        0.215
  OF1                  OUTFALL      0.008    0.719     0  01:25      0.0165
1.44        0.000


  *********************
  Node Surcharge Summary
  *********************

  Surcharging occurs when water rises above the top of the highest conduit.
  ---------------------------------------------------------------------
                                               Max. Height   Min. Depth
                                   Hours       Above Crown    Below Rim
  Node                 Type      Surcharged         Meters       Meters
  ---------------------------------------------------------------------
  J10                  JUNCTION        1.58          0.540        0.000


  ********************
  Node Flooding Summary
  ********************

  Flooding refers to all water that overflows a node, whether it ponds or not.
  --------------------------------------------------------------------------
                                                             Total   Maximum
                                 Maximum   Time of Max       Flood    Ponded
                        Hours       Rate    Occurrence      Volume     Depth
  Node                 Flooded       CMS   days hr:min    10^6 ltr    Meters
  --------------------------------------------------------------------------
  J10                     0.21     0.003       0  00:25       0.001     0.000


  ***********************
  Outfall Loading Summary
  ***********************

  -----------------------------------------------------------
                         Flow       Avg       Max       Total
                         Freq      Flow      Flow      Volume
  Outfall Node           Pcnt       CMS       CMS    10^6 ltr
  -----------------------------------------------------------
  OF1                   98.16     0.304     0.719       1.435
  -----------------------------------------------------------
  System                98.16     0.304     0.719       1.435


  ********************
  Link Flow Summary
  ********************

  -----------------------------------------------------------------------------
                                 Maximum  Time of Max   Maximum    Max/    Max/
                                  |Flow|   Occurrence   |Veloc|    Full    Full
```

Link	Type	CMS	days	hr:min	m/sec	Flow	Depth
C1	CONDUIT	0.712	0	01:25	2.20	0.82	0.69
C10	CONDUIT	0.004	0	01:25	0.33	0.23	0.61
C100	CONDUIT	0.011	0	01:25	0.39	0.10	0.42
C101	CONDUIT	0.009	0	01:25	0.86	0.04	0.15
C102	CONDUIT	0.004	0	01:26	0.24	0.05	0.56
C103	CONDUIT	0.002	0	01:23	0.10	0.02	0.66
C104	CONDUIT	0.001	0	01:25	0.07	0.00	0.49
C105	CONDUIT	0.005	0	01:25	0.33	0.03	0.48
C11	CONDUIT	0.410	0	01:25	3.77	0.70	0.65
C12	CONDUIT	0.022	0	01:25	0.57	0.06	0.55
C13	CONDUIT	0.021	0	01:25	1.71	0.17	0.23
C14	CONDUIT	0.025	0	01:25	0.67	0.08	0.56
C15	CONDUIT	0.023	0	01:25	2.71	0.16	0.27
C16	CONDUIT	0.021	0	01:25	1.78	0.31	0.34
C17	CONDUIT	0.005	0	01:25	0.68	0.11	0.41
C18	CONDUIT	0.363	0	01:25	3.42	0.75	0.63
C19	CONDUIT	0.004	0	01:25	0.14	0.01	0.52
C2	CONDUIT	0.684	0	01:25	2.09	1.03	0.70
C20	CONDUIT	0.348	0	01:25	3.37	0.65	0.62
C21	CONDUIT	0.015	0	01:25	0.36	0.03	0.41
C22	CONDUIT	0.007	0	01:25	1.23	0.03	0.13
C23	CONDUIT	0.332	0	01:25	3.40	0.37	0.46
C24	CONDUIT	0.328	0	01:25	3.93	0.34	0.41
C25	CONDUIT	0.002	0	01:25	0.09	0.01	0.50
C26	CONDUIT	0.310	0	01:25	3.39	0.44	0.44
C27	CONDUIT	0.008	0	01:25	0.22	0.04	0.49
C28	CONDUIT	0.106	0	01:25	2.13	0.48	0.66
C29	CONDUIT	0.010	0	01:25	0.56	0.18	0.47
C3	CONDUIT	0.445	0	01:25	3.37	0.47	0.77
C30	CONDUIT	0.070	0	01:25	2.06	0.47	0.48
C31	CONDUIT	0.016	0	01:25	0.55	0.26	0.42
C32	CONDUIT	0.003	0	01:25	0.27	0.03	0.30
C33	CONDUIT	0.003	0	01:25	0.88	0.02	0.09
C34	CONDUIT	0.013	0	01:25	0.87	0.06	0.26
C35	CONDUIT	0.053	0	01:25	1.88	0.28	0.42
C36	CONDUIT	0.006	0	01:25	0.49	0.08	0.34
C37	CONDUIT	0.030	0	01:25	1.81	0.33	0.44
C38	CONDUIT	0.012	0	01:25	0.99	0.18	0.34
C39	CONDUIT	0.005	0	01:25	0.96	0.13	0.33
C4	CONDUIT	0.440	0	01:25	4.32	0.76	0.61
C40	CONDUIT	0.011	0	01:25	0.94	0.18	0.34
C41	CONDUIT	0.011	0	01:25	1.24	0.16	0.28
C42	CONDUIT	0.005	0	01:25	0.83	0.06	0.22
C43	CONDUIT	0.164	0	01:25	2.50	0.46	0.57
C44	CONDUIT	0.009	0	01:25	0.38	0.05	0.37
C45	CONDUIT	0.089	0	01:25	2.14	0.23	0.40
C46	CONDUIT	0.065	0	01:25	1.81	0.36	0.51
C47	CONDUIT	0.075	0	01:25	2.59	0.42	0.43
C48	CONDUIT	0.067	0	01:25	2.19	0.41	0.45
C49	CONDUIT	0.045	0	01:25	2.38	0.29	0.48
C5	CONDUIT	0.018	0	01:25	0.65	0.19	0.65
C50	CONDUIT	0.033	0	01:25	1.67	0.67	0.50
C51	CONDUIT	0.019	0	01:25	0.88	0.38	0.53
C52	CONDUIT	0.014	0	01:25	1.11	0.86	0.68
C53	CONDUIT	0.007	0	01:25	0.78	0.15	0.49
C54	CONDUIT	0.022	0	01:25	1.04	0.44	0.53
C55	CONDUIT	0.010	0	01:25	0.82	0.11	0.34
C56	CONDUIT	0.003	0	01:25	0.75	0.10	0.27
C57	CONDUIT	0.005	0	01:25	0.91	0.05	0.19
C58	CONDUIT	0.000	0	00:00	0.00	0.00	0.08
C59	CONDUIT	0.003	0	01:25	1.28	0.07	0.20
C6	CONDUIT	0.016	0	01:25	0.69	0.37	0.34
C60	CONDUIT	0.046	0	01:25	1.80	0.28	0.39
C61	CONDUIT	0.049	0	01:25	1.50	0.78	0.47
C62	CONDUIT	0.038	0	01:24	1.13	0.28	0.48
C63	CONDUIT	0.023	0	01:25	1.01	0.22	0.36

C64	CONDUIT	0.017	0	01:25	1.15	0.09	0.27
C65	CONDUIT	0.006	0	01:25	0.25	0.02	0.54
C66	CONDUIT	0.225	0	01:25	1.20	0.28	0.63
C67	CONDUIT	0.220	0	01:25	2.37	0.76	0.57
C68	CONDUIT	0.209	0	01:25	2.05	0.63	0.61
C69	CONDUIT	0.058	0	01:25	1.69	0.08	0.53
C7	CONDUIT	0.014	0	01:25	1.16	0.06	0.23
C70	CONDUIT	0.046	0	01:25	4.04	0.12	0.22
C71	CONDUIT	0.044	0	01:25	2.91	0.18	0.27
C72	CONDUIT	0.028	0	01:25	1.75	0.15	0.28
C73	CONDUIT	0.015	0	01:25	1.33	0.18	0.32
C74	CONDUIT	0.009	0	01:25	0.94	0.19	0.29
C75	CONDUIT	0.009	0	01:25	0.77	0.30	0.33
C76	CONDUIT	0.005	0	01:25	0.78	0.06	0.37
C77	CONDUIT	0.000	0	00:00	0.00	0.00	0.28
C78	CONDUIT	0.152	0	01:25	1.56	0.71	0.59
C79	CONDUIT	0.012	0	01:25	0.77	0.08	0.59
C8	CONDUIT	0.014	0	01:25	2.30	0.03	0.14
C80	CONDUIT	0.002	0	01:25	0.74	0.02	0.14
C81	CONDUIT	0.002	0	01:25	1.30	0.02	0.09
C82	CONDUIT	0.141	0	01:25	1.44	0.62	0.59
C83	CONDUIT	0.048	0	01:25	1.59	0.37	0.71
C84	CONDUIT	0.012	0	01:25	1.20	0.06	0.30
C85	CONDUIT	0.004	0	01:25	1.37	0.09	0.23
C86	CONDUIT	0.032	0	01:25	2.61	0.16	0.35
C87	CONDUIT	0.005	0	01:25	0.75	0.03	0.16
C88	CONDUIT	0.025	0	01:25	2.40	0.09	0.20
C89	CONDUIT	0.020	0	01:25	1.83	0.11	0.22
C9	CONDUIT	0.010	0	01:25	1.29	0.10	0.17
C90	CONDUIT	0.005	0	01:25	0.80	0.05	0.23
C91	CONDUIT	0.004	0	01:25	1.13	0.02	0.10
C92	CONDUIT	0.088	0	01:25	1.10	0.40	0.50
C93	CONDUIT	0.083	0	01:25	1.45	0.51	0.52
C94	CONDUIT	0.012	0	01:25	0.65	0.06	0.50
C95	CONDUIT	0.005	0	01:25	1.00	0.03	0.12
C96	CONDUIT	0.005	0	01:25	1.48	0.13	0.23
C97	CONDUIT	0.060	0	01:25	1.27	0.74	0.64
C98	CONDUIT	0.020	0	01:25	0.96	0.07	0.51
C99	CONDUIT	0.029	0	01:25	0.62	0.73	0.64

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
		---------- Fraction of Time in Flow Class ----------								
C1	1.00	0.01	0.00	0.00	0.01	0.97	0.00	0.00	0.44	0.00
C10	1.00	0.01	0.00	0.00	0.98	0.00	0.00	0.00	0.15	0.00
C100	1.00	0.01	0.00	0.00	0.98	0.00	0.00	0.00	0.95	0.00
C101	1.00	0.01	0.00	0.00	0.07	0.92	0.00	0.00	0.87	0.00
C102	1.00	0.01	0.00	0.00	0.97	0.01	0.00	0.00	0.21	0.00
C103	1.00	0.02	0.05	0.00	0.94	0.00	0.00	0.00	0.10	0.00

C104	1.00	0.02	0.05	0.00	0.94	0.00	0.00	0.00	0.82	0.00
C105	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.95	0.00
C11	1.00	0.01	0.00	0.00	0.01	0.97	0.00	0.00	0.92	0.00
C12	1.00	0.02	0.00	0.00	0.96	0.02	0.00	0.00	0.94	0.00
C13	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00
C14	1.00	0.02	0.01	0.00	0.95	0.02	0.00	0.00	0.93	0.00
C15	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00
C16	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00
C17	1.00	0.01	0.00	0.00	0.65	0.34	0.00	0.00	0.95	0.00
C18	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.19	0.00
C19	1.00	0.01	0.05	0.00	0.94	0.00	0.00	0.00	0.82	0.00
C2	1.00	0.01	0.00	0.00	0.35	0.63	0.00	0.00	0.11	0.00
C20	1.00	0.01	0.00	0.00	0.01	0.97	0.00	0.00	0.88	0.00
C21	1.00	0.02	0.00	0.00	0.97	0.01	0.00	0.00	0.94	0.00
C22	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.94	0.00
C23	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.86	0.00
C24	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.76	0.00
C25	1.00	0.01	0.05	0.00	0.94	0.00	0.00	0.00	0.82	0.00
C26	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.04	0.00
C27	1.00	0.01	0.05	0.00	0.94	0.00	0.00	0.00	0.82	0.00
C28	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.93	0.00
C29	1.00	0.01	0.00	0.00	0.97	0.01	0.00	0.00	0.95	0.00
C3	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.85	0.00
C30	1.00	0.01	0.00	0.00	0.01	0.97	0.00	0.00	0.64	0.00
C31	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.82	0.00
C32	1.00	0.02	0.05	0.00	0.93	0.00	0.00	0.00	0.81	0.00
C33	1.00	0.06	0.00	0.00	0.00	0.93	0.00	0.00	0.64	0.00
C34	1.00	0.01	0.00	0.00	0.04	0.94	0.00	0.00	0.92	0.00
C35	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.89	0.00
C36	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.95	0.00
C37	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.92	0.00
C38	1.00	0.01	0.00	0.00	0.06	0.93	0.00	0.00	0.95	0.00
C39	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.95	0.00
C4	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00

C40	1.00	0.01	0.00	0.00	0.04	0.94	0.00	0.00	0.83	0.00
C41	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.88	0.00
C42	1.00	0.01	0.05	0.00	0.03	0.91	0.00	0.00	0.82	0.00
C43	1.00	0.01	0.00	0.00	0.02	0.97	0.00	0.00	0.95	0.00
C44	1.00	0.02	0.04	0.00	0.94	0.00	0.00	0.00	0.82	0.00
C45	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.89	0.00
C46	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.89	0.00
C47	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.27	0.00
C48	1.00	0.01	0.00	0.00	0.01	0.97	0.00	0.00	0.75	0.00
C49	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.91	0.00
C5	1.00	0.01	0.02	0.00	0.97	0.00	0.00	0.00	0.91	0.00
C50	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.00	0.00
C51	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.95	0.00
C52	1.00	0.01	0.00	0.00	0.02	0.97	0.00	0.00	0.52	0.00
C53	1.00	0.01	0.00	0.00	0.13	0.85	0.00	0.00	0.93	0.00
C54	1.00	0.01	0.00	0.00	0.13	0.85	0.00	0.00	0.91	0.00
C55	1.00	0.01	0.00	0.00	0.07	0.91	0.00	0.00	0.95	0.00
C56	1.00	0.01	0.00	0.00	0.10	0.89	0.00	0.00	0.91	0.00
C57	1.00	0.01	0.05	0.00	0.02	0.92	0.00	0.00	0.82	0.00
C58	1.00	0.06	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C59	1.00	0.06	0.00	0.00	0.00	0.94	0.00	0.00	0.81	0.00
C6	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.22	0.00
C60	1.00	0.01	0.01	0.00	0.01	0.97	0.00	0.00	0.93	0.00
C61	1.00	0.02	0.00	0.00	0.02	0.97	0.00	0.00	0.05	0.00
C62	1.00	0.01	0.00	0.00	0.08	0.90	0.00	0.00	0.65	0.00
C63	1.00	0.01	0.00	0.00	0.03	0.95	0.00	0.00	0.69	0.00
C64	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.95	0.00
C65	1.00	0.02	0.05	0.00	0.94	0.00	0.00	0.00	0.82	0.00
C66	1.00	0.01	0.00	0.00	0.97	0.02	0.00	0.00	0.92	0.00
C67	1.00	0.01	0.00	0.00	0.01	0.97	0.00	0.00	0.09	0.00
C68	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.76	0.00
C69	1.00	0.01	0.00	0.00	0.10	0.89	0.00	0.00	0.93	0.00
C7	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.68	0.00
C70	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.05	0.00

C71	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00
C72	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.95	0.00
C73	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.95	0.00
C74	1.00	0.01	0.00	0.00	0.02	0.96	0.00	0.00	0.18	0.00
C75	1.00	0.01	0.00	0.00	0.30	0.68	0.00	0.00	0.00	0.00
C76	1.00	0.01	0.00	0.00	0.10	0.88	0.00	0.00	0.95	0.00
C77	1.00	0.01	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C78	1.00	0.02	0.00	0.00	0.05	0.94	0.00	0.00	0.42	0.00
C79	1.00	0.01	0.00	0.00	0.96	0.02	0.00	0.00	0.91	0.00
C8	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.92	0.00
C80	1.00	0.01	0.00	0.00	0.05	0.93	0.00	0.00	0.95	0.00
C81	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.20	0.00
C82	1.00	0.01	0.00	0.00	0.24	0.75	0.00	0.00	0.58	0.00
C83	1.00	0.01	0.00	0.00	0.20	0.79	0.00	0.00	0.95	0.00
C84	1.00	0.01	0.00	0.00	0.06	0.93	0.00	0.00	0.95	0.00
C85	1.00	0.01	0.00	0.00	0.02	0.97	0.00	0.00	0.93	0.00
C86	1.00	0.01	0.00	0.00	0.01	0.97	0.00	0.00	0.95	0.00
C87	1.00	0.01	0.00	0.00	0.10	0.88	0.00	0.00	0.91	0.00
C88	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.04	0.00
C89	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00
C9	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00
C90	1.00	0.01	0.05	0.00	0.02	0.92	0.00	0.00	0.82	0.00
C91	1.00	0.06	0.00	0.00	0.00	0.94	0.00	0.00	0.81	0.00
C92	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.95	0.00
C93	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.58	0.00
C94	1.00	0.01	0.00	0.00	0.92	0.06	0.00	0.00	0.95	0.00
C95	1.00	0.01	0.00	0.00	0.01	0.97	0.00	0.00	0.94	0.00
C96	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.14	0.00
C97	1.00	0.01	0.00	0.00	0.13	0.86	0.00	0.00	0.68	0.00
C98	1.00	0.01	0.00	0.00	0.14	0.84	0.00	0.00	0.95	0.00
C99	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.62	0.00

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*************************
Conduit Surcharge Summary
*************************
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Conduit	Hours Full Both Ends	Hours Full Upstream	Hours Full Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
C10	0.01	0.01	1.58	0.01	0.01
C2	0.01	0.01	0.01	0.04	0.01
C3	0.01	0.01	0.16	0.01	0.01
C5	0.01	0.01	0.24	0.01	0.01
C65	0.01	0.01	1.03	0.01	0.01
C79	0.01	0.01	0.17	0.01	0.01
C83	0.01	0.01	0.13	0.01	0.01

```
Analysis begun on:  Sat Oct 12 21:00:55 2019
Analysis ended on:  Sat Oct 12 21:00:56 2019
```

Appendix I: Inverloch max development PCSWMM results

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.012)
  --------------------------------------------------------------

  WARNING 01: wet weather time step reduced to recording interval for Rain Gage
Chicago_3h

  *************
  Element Count
  *************
  Number of rain gages ...... 10
  Number of subcatchments ... 95
  Number of nodes ........... 106
  Number of links ........... 105
  Number of pollutants ...... 0
  Number of land uses ....... 0


  ****************
  Raingage Summary
  ****************
                                                             Data       Recording
  Name                 Data Source                           Type       Interval
  ------------------------------------------------------------------------
  Chicago_3h           Chicago_3h                            INTENSITY    1 min.
  Cowes120min          Cowes120min                           INTENSITY    5 min.
  Cowes120min(2)       Cowes120min(2)                        INTENSITY    5 min.
  Cowes180min          Cowes180min                           INTENSITY   15 min.
  Cowes30min           Cowes30min                            INTENSITY    5 min.
  Cowes45min           Cowes45min                            INTENSITY    5 min.
  Cowes4day            Cowes4day                             INTENSITY  180 min.
  Cowes60min           Cowes60min                            INTENSITY    5 min.
  Cowes6hr             Cowes6hr                              INTENSITY   15 min.
  Cowes90min           Cowes90min                            INTENSITY    5 min.


  ********************
  Subcatchment Summary
  ********************
  Name                       Area     Width   %Imperv    %Slope Rain Gage
Outlet
  --------------------------------------------------------------------------------
--------------------------
  S1                         0.07     20.00    100.00    1.0000 Cowes90min
OF1
  S10                        0.20     35.00     60.00    8.3000 Cowes90min
J9
  S11                        0.12     25.00      0.00    3.3300 Cowes90min
J8
  S12                        0.07     25.00     65.00    5.0000 Cowes90min
J10
  S13                        0.35     25.00     60.00    3.0000 Cowes90min
J13
  S14                        0.02      6.00     75.00    3.0000 Cowes90min
J12
  S15                        0.06      7.00     33.00    4.5000 Cowes90min
J14
  S16                        0.08     18.00     60.00    3.3300 Cowes90min
J17
  S17                        0.38     30.00     60.00    3.3300 Cowes90min
J16
  S18                        0.04      8.00     45.00    4.5000 Cowes90min
J15
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  S19                       0.09     11.00     43.00    3.0000 Cowes90min
J18
  S2                        0.71     50.00     60.00    3.3300 Cowes90min
J1
  S20                       0.29     35.00     60.00    3.0000 Cowes90min
J19
  S21                       0.15      8.50     60.00    4.5000 Cowes90min
J25
  S22                       0.12      8.50     60.00    4.5000 Cowes90min
J24
  S23                       0.02      7.00     68.00    4.5000 Cowes90min
J23
  S24                       0.35     60.00     60.00    4.5000 Cowes90min
J22
  S25                       0.01      8.00     50.00    2.5000 Cowes90min
J20
  S26                       0.09     12.00     44.00    2.5000 Cowes90min
J21
  S27                       0.70     75.00     60.00    3.3300 Cowes90min
J26
  S28                       0.10     10.00     62.00    3.3300 Cowes90min
J27
  S29                       0.13     10.00     59.00    3.3300 Cowes90min
J44
  S3                        0.93     50.00     60.00    5.5500 Cowes90min
J65
  S30                       0.02      7.00     77.00    3.3300 Cowes90min
J43
  S31                       0.22      8.00     60.00    2.5000 Cowes90min
J45
  S32                       0.46     60.00     60.00    4.0000 Cowes90min
J28
  S33                       0.13     30.00     67.00    4.0000 Cowes90min
J29
  S34                       0.05      6.50     48.00    1.0000 Cowes90min
J33
  S35                       0.03     10.00     33.00    1.0000 Cowes90min
J30
  S36                       0.22     18.00     67.00    2.0000 Cowes90min
J35
  S37                       0.23     45.00     60.00    0.5000 Cowes90min
J34
  S38                       0.13     10.00     60.00    2.0000 Cowes90min
J36
  S39                       0.13     30.00     60.00    4.0000 Cowes90min
J37
  S4                        0.14     10.00     56.00    3.3300 Cowes90min
J2
  S40                       0.14     40.00     60.00    4.0000 Cowes90min
J41
  S41                       0.24     38.00     60.00    4.0000 Cowes90min
J38
  S42                       0.11     20.00     60.00    4.0000 Cowes90min
J39
  S43                       0.10      9.00     43.00    3.3300 Cowes90min
J42
  S44                       0.20     35.00     60.00    3.0000 Cowes90min
J46
  S45                       0.14     35.00     68.00    2.8000 Cowes90min
J49
  S46                       0.25     48.00     47.00    2.8000 Cowes90min
J50
  S47                       0.34     45.00     60.00    3.3300 Cowes90min
J54
  S48                       0.07     20.00     30.00    3.3300 Cowes90min
J55
  S49                       0.07     25.00     32.00    3.3300 Cowes90min
J56
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  S5                         0.22     35.00     60.00    1.0000 Cowes90min
J3
  S50                        0.02      9.00     60.00    3.3300 Cowes90min
J57
  S51                        0.06      7.50     46.00    2.5000 Cowes90min
J59
  S52                        0.11     25.00     60.00    2.5000 Cowes90min
J52
  S53                        0.13     25.00     60.00    3.3300 Cowes90min
J51
  S54                        0.14     35.00     60.00    3.3300 Cowes90min
J53
  S55                        0.44     50.00     60.00    3.3300 Cowes90min
J47
  S56                        0.12      7.00     51.00    2.5000 Cowes90min
J61
  S57                        0.02      7.00     71.00    3.3300 Cowes90min
J60
  S58                        0.32     45.00     60.00    2.5000 Cowes90min
J62
  S59                        0.06     18.00     69.00    2.5000 Cowes90min
J63
  S6                         0.05     50.00    100.00    5.5500 Cowes90min
J66
  S60                        0.31     45.00     60.00    3.3300 Cowes90min
J64
  S61                        0.52     28.00     60.00    6.6600 Cowes90min
J67
  S62                        0.10     25.00     60.00    6.6600 Cowes90min
J74
  S63                        0.07     20.00     60.00    6.6600 Cowes90min
J77
  S64                        0.14     40.00     60.00    4.0000 Cowes90min
J76
  S65                        0.18     38.00     60.00   15.0000 Cowes90min
J69
  S66                        0.02      5.00     55.00    5.5500 Cowes90min
J70
  S67                        0.29     50.00     60.00    3.5000 Cowes90min
J72
  S68                        0.21     35.00     60.00    5.5500 Cowes90min
J73
  S69                        0.28     55.00     60.00    7.5000 Cowes90min
J71
  S7                         0.36     60.00     60.00    6.3600 Cowes90min
J4
  S70                        0.39     55.00     60.00    7.5000 Cowes90min
J79
  S71                        0.12     38.00     60.00    4.2000 Cowes90min
J81
  S72                        0.13     28.00     60.00   13.0000 Cowes90min
J82
  S73                        0.07     20.00     60.00   20.0000 Cowes90min
J83
  S74                        0.11     23.00     60.00   10.0000 Cowes90min
J84
  S75                        0.13     50.00     60.00   10.0000 Cowes90min
J85
  S76                        0.10     20.00     60.00    5.7000 Cowes90min
J87
  S77                        0.02     10.00     67.00    5.7000 Cowes90min
J86
  S78                        0.05      8.50     69.00    6.5000 Cowes90min
J88
  S79                        0.19     30.00     64.00    6.5000 Cowes90min
J89
  S8                         0.05      8.50     35.00    4.0000 Cowes90min
J5
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  S80                        0.01     15.00      70.00     6.5000 Cowes90min
J90
  S81                        0.07     10.00      50.00     3.3300 Cowes90min
J91
  S82                        0.09     25.00      60.00    20.0000 Cowes90min
J92
  S83                        0.35     40.00      60.00    15.0000 Cowes90min
J93
  S84                        0.15     45.00      60.00     5.8000 Cowes90min
J94
  S85                        0.07     25.00      60.00     5.8000 Cowes90min
J96
  S86                        0.26     15.00      66.00     5.3000 Cowes90min
J98
  S87                        0.20     40.00      60.00    20.0000 Cowes90min
J97
  S88                        0.15     33.00      60.00    20.0000 Cowes90min
J99
  S89                        0.07     20.00      62.00     4.0000 Cowes90min
J100
  S9                         0.16     30.00      60.00     5.4000 Cowes90min
J6
  S90                        0.06     25.00      60.00     7.0000 Cowes90min
J99
  S91                        0.16     50.00      60.00    11.1100 Cowes90min
J102
  S92                        0.03      6.00      59.00     0.5000 Cowes90min
J101
  S93                        0.02      7.00      45.00     0.5000 Cowes90min
J104
  S94                        0.02      7.00      57.00     0.5000 Cowes90min
J103
  S95                        0.02      7.00      71.00     5.0000 Cowes90min
J105


  ************
  Node Summary
  ************
                                         Invert      Max.    Ponded    External
  Name                 Type               Elev.     Depth      Area    Inflow
  -------------------------------------------------------------------------------
  J1                   JUNCTION            2.90      1.54       0.0
  J10                  JUNCTION           13.52      0.69       0.0
  J100                 JUNCTION           18.00      1.50       0.0
  J101                 JUNCTION            7.33      0.75       0.0
  J102                 JUNCTION            7.45      0.80       0.0
  J103                 JUNCTION            7.96      1.05       0.0
  J104                 JUNCTION            7.22      1.14       0.0
  J105                 JUNCTION            7.39      1.12       0.0
  J11                  JUNCTION            7.96      1.37       0.0
  J12                  JUNCTION            8.43      0.73       0.0
  J13                  JUNCTION            8.59      0.69       0.0
  J14                  JUNCTION            8.72      0.95       0.0
  J15                  JUNCTION            9.22      0.62       0.0
  J16                  JUNCTION            9.87      0.96       0.0
  J17                  JUNCTION           12.22      0.70       0.0
  J18                  JUNCTION            9.02      0.85       0.0
  J19                  JUNCTION            8.53      1.47       0.0
  J2                   JUNCTION            2.94      1.50       0.0
  J20                  JUNCTION           10.81      1.47       0.0
  J21                  JUNCTION           11.35      1.40       0.0
  J22                  JUNCTION           11.80      1.51       0.0
  J23                  JUNCTION           12.37      0.75       0.0
  J24                  JUNCTION           13.08      1.09       0.0
  J25                  JUNCTION           13.45      0.83       0.0
  J26                  JUNCTION           13.57      1.53       0.0
  J27                  JUNCTION           13.88      0.93       0.0
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J28	JUNCTION	15.41	0.80	0.0
J29	JUNCTION	16.40	0.30	0.0
J3	JUNCTION	3.47	1.13	0.0
J30	JUNCTION	16.29	1.16	0.0
J31	JUNCTION	16.34	1.02	0.0
J32	JUNCTION	16.63	0.80	0.0
J33	JUNCTION	16.80	0.80	0.0
J34	JUNCTION	16.64	0.70	0.0
J35	JUNCTION	16.85	0.90	0.0
J36	JUNCTION	17.03	0.74	0.0
J37	JUNCTION	17.38	0.98	0.0
J38	JUNCTION	18.35	0.90	0.0
J39	JUNCTION	20.35	0.40	0.0
J4	JUNCTION	6.29	1.28	0.0
J40	JUNCTION	17.47	0.90	0.0
J41	JUNCTION	17.96	0.89	0.0
J42	JUNCTION	18.77	0.65	0.0
J43	JUNCTION	16.94	1.24	0.0
J44	JUNCTION	17.37	0.71	0.0
J45	JUNCTION	17.41	1.20	0.0
J46	JUNCTION	17.64	1.07	0.0
J47	JUNCTION	17.66	1.27	0.0
J48	JUNCTION	18.80	0.70	0.0
J49	JUNCTION	19.70	0.37	0.0
J5	JUNCTION	9.14	0.37	0.0
J50	JUNCTION	20.20	1.55	0.0
J51	JUNCTION	20.65	1.35	0.0
J52	JUNCTION	20.89	1.61	0.0
J53	JUNCTION	23.02	0.48	0.0
J54	JUNCTION	19.21	0.70	0.0
J55	JUNCTION	21.20	0.80	0.0
J56	JUNCTION	22.10	0.40	0.0
J57	JUNCTION	21.83	0.82	0.0
J58	JUNCTION	21.99	0.62	0.0
J59	JUNCTION	23.14	0.43	0.0
J6	JUNCTION	9.17	0.83	0.0
J60	JUNCTION	19.85	0.66	0.0
J61	JUNCTION	19.89	1.26	0.0
J62	JUNCTION	20.02	1.20	0.0
J63	JUNCTION	20.11	0.82	0.0
J64	JUNCTION	20.32	0.70	0.0
J65	JUNCTION	3.80	0.55	0.0
J66	JUNCTION	4.43	3.30	0.0
J67	JUNCTION	4.82	3.85	0.0
J68	JUNCTION	5.48	2.60	0.0
J69	JUNCTION	7.19	1.46	0.0
J7	JUNCTION	10.79	0.96	0.0
J70	JUNCTION	10.85	1.13	0.0
J71	JUNCTION	5.71	1.10	0.0
J72	JUNCTION	12.39	1.20	0.0
J73	JUNCTION	13.80	1.20	0.0
J74	JUNCTION	14.05	1.12	0.0
J75	JUNCTION	14.30	2.22	0.0
J76	JUNCTION	14.41	2.11	0.0
J77	JUNCTION	15.66	0.79	0.0
J78	JUNCTION	14.75	0.55	0.0
J79	JUNCTION	11.10	1.17	0.0
J8	JUNCTION	14.10	0.90	0.0
J80	JUNCTION	15.31	0.67	0.0
J81	JUNCTION	16.60	1.00	0.0
J82	JUNCTION	6.04	1.36	0.0
J83	JUNCTION	7.24	0.95	0.0
J84	JUNCTION	13.68	1.00	0.0
J85	JUNCTION	16.95	0.80	0.0
J86	JUNCTION	13.97	1.45	0.0
J87	JUNCTION	14.27	1.00	0.0
J88	JUNCTION	15.24	1.24	0.0
J89	JUNCTION	15.53	1.27	0.0

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  J9                   JUNCTION            14.26      0.91      0.0
  J90                  JUNCTION            18.14      1.83      0.0
  J91                  JUNCTION            18.78      1.78      0.0
  J92                  JUNCTION             6.25      2.25      0.0
  J93                  JUNCTION             6.48      3.10      0.0
  J94                  JUNCTION            19.50      1.50      0.0
  J95                  JUNCTION            20.50      1.50      0.0
  J96                  JUNCTION            21.00      1.50      0.0
  J97                  JUNCTION             6.81      2.80      0.0
  J98                  JUNCTION            17.03      1.40      0.0
  J99                  JUNCTION             6.90      0.95      0.0
  OF1                  OUTFALL              2.23      0.75      0.0


  ************
  Link Summary
  ************
  Name                 From Node        To Node          Type            Length
%Slope Roughness
  ---------------------------------------------------------------------------------
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  C1                   J1               OF1              CONDUIT          128.6
0.5208    0.0120
  C10                  J10              J8               CONDUIT           59.6   -
0.9725    0.0120
  C100                 J101             J99              CONDUIT           35.4
1.2138    0.0120
  C101                 J102             J101             CONDUIT            7.7
1.5506    0.0120
  C102                 J104             J102             CONDUIT           40.2   -
0.5726    0.0120
  C103                 J105             J104             CONDUIT           21.8
0.7806    0.0120
  C104                 J103             J104             CONDUIT            4.7
16.0486    0.0120
  C105                 J100             J99              CONDUIT           61.9
18.2307    0.0120
  C11                  J11              J4               CONDUIT           47.1
3.5501    0.0120
  C12                  J12              J11              CONDUIT            3.7
12.9129    0.0120
  C13                  J13              J12              CONDUIT           12.0
1.3368    0.0120
  C14                  J14              J11              CONDUIT            8.6
8.8823    0.0120
  C15                  J15              J14              CONDUIT            5.8
8.5932    0.0120
  C16                  J16              J15              CONDUIT           32.9
1.9779    0.0120
  C17                  J17              J16              CONDUIT           35.0
6.7372    0.0120
  C18                  J19              J11              CONDUIT           23.3
2.4429    0.0120
  C19                  J18              J19              CONDUIT            3.8
12.9341    0.0120
  C2                   J2               J1               CONDUIT           13.2
0.3030    0.0120
  C20                  J20              J19              CONDUIT           76.2
2.9950    0.0120
  C21                  J24              J20              CONDUIT           28.4
8.0186    0.0120
  C22                  J25              J24              CONDUIT            8.6
4.3265    0.0120
  C23                  J21              J20              CONDUIT           14.4
3.7657    0.0120
  C24                  J22              J21              CONDUIT           10.3
4.3646    0.0120
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  C25                J23               J22               CONDUIT            7.6
7.5612     0.0120
  C26                J26               J22               CONDUIT           79.1
2.2394     0.0120
  C27                J27               J26               CONDUIT           11.7
2.6415     0.0120
  C28                J28               J26               CONDUIT           41.1
4.4770     0.0120
  C29                J29               J28               CONDUIT           72.3
1.3704     0.0120
  C3                 J3                J2                CONDUIT            5.8
9.2083     0.0120
  C30                J30               J28               CONDUIT           43.0
2.0474     0.0120
  C31                J31               J30               CONDUIT           14.8
0.3385     0.0120
  C32                J32               J31               CONDUIT            8.4
3.4380     0.0120
  C33                J33               J32               CONDUIT            6.4
2.6739     0.0120
  C34                J34               J31               CONDUIT            6.8
4.4096     0.0120
  C35                J35               J30               CONDUIT           16.9
3.3233     0.0120
  C36                J36               J35               CONDUIT            8.2
2.1957     0.0120
  C37                J37               J35               CONDUIT           14.7
3.6078     0.0120
  C38                J38               J37               CONDUIT           51.2
1.8956     0.0120
  C39                J39               J38               CONDUIT           35.3
5.6829     0.0120
  C4                 J4                J3                CONDUIT           80.3
3.5153     0.0120
  C40                J40               J37               CONDUIT            5.5
1.6218     0.0120
  C41                J41               J40               CONDUIT           21.7
2.2586     0.0120
  C42                J42               J41               CONDUIT           27.3
2.9683     0.0120
  C43                J43               J26               CONDUIT           96.3
3.5002     0.0120
  C44                J44               J43               CONDUIT           12.5
3.4393     0.0120
  C45                J45               J43               CONDUIT           11.6
4.0691     0.0120
  C46                J47               J43               CONDUIT           24.7
2.9127     0.0120
  C47                J46               J45               CONDUIT            7.7
2.9806     0.0120
  C48                J48               J46               CONDUIT           47.1
2.4620     0.0120
  C49                J49               J48               CONDUIT            8.8
10.2694     0.0120
  C5                 J5                J4                CONDUIT           79.8
3.5733     0.0120
  C50                J50               J49               CONDUIT           48.2
1.0370     0.0120
  C51                J51               J50               CONDUIT           44.0
1.0232     0.0120
  C52                J52               J51               CONDUIT           23.7
1.0001     0.0120
  C53                J53               J52               CONDUIT           30.6
6.9830     0.0120
  C54                J54               J48               CONDUIT           38.6
1.0631     0.0120
  C55                J55               J54               CONDUIT           53.2
3.7411     0.0120
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C56	J56	J55	CONDUIT	29.9	3.0164	0.0120
C57	J57	J55	CONDUIT	17.6	3.5880	0.0120
C58	J58	J57	CONDUIT	8.4	1.8938	0.0120
C59	J59	J57	CONDUIT	16.3	8.0430	0.0120
C6	J6	J5	CONDUIT	13.5	0.2222	0.0120
C60	J60	J47	CONDUIT	91.5	2.3944	0.0120
C61	J61	J60	CONDUIT	11.2	0.3565	0.0120
C62	J62	J61	CONDUIT	7.7	1.6864	0.0120
C63	J63	J62	CONDUIT	9.3	0.9678	0.0120
C64	J64	J63	CONDUIT	6.8	3.1034	0.0120
C65	J65	J2	CONDUIT	2.0	48.8290	0.0120
C66	J66	J2	CONDUIT	102.3	1.4567	0.0120
C67	J67	J66	CONDUIT	43.7	0.8931	0.0120
C68	J68	J67	CONDUIT	56.5	1.1674	0.0120
C69	J69	J68	CONDUIT	4.3	43.2226	0.0120
C7	J7	J6	CONDUIT	35.4	4.5811	0.0120
C70	J70	J69	CONDUIT	26.4	13.9718	0.0120
C71	J72	J70	CONDUIT	27.4	5.6232	0.0120
C72	J73	J72	CONDUIT	44.0	3.2069	0.0120
C73	J74	J73	CONDUIT	9.4	2.6605	0.0120
C74	J75	J74	CONDUIT	25.8	0.9705	0.0120
C75	J76	J75	CONDUIT	28.3	0.3892	0.0120
C76	J77	J76	CONDUIT	6.8	18.7295	0.0120
C77	J78	J76	CONDUIT	35.1	0.9695	0.0120
C78	J71	J68	CONDUIT	47.6	0.4832	0.0120
C79	J79	J71	CONDUIT	51.4	10.5342	0.0120
C8	J8	J7	CONDUIT	13.7	24.8404	0.0120
C80	J80	J79	CONDUIT	39.8	10.6484	0.0120
C81	J81	J80	CONDUIT	20.1	6.4440	0.0120
C82	J82	J71	CONDUIT	60.5	0.5454	0.0120
C83	J83	J82	CONDUIT	16.8	7.1654	0.0120
C84	J84	J83	CONDUIT	46.1	14.1205	0.0120
C85	J85	J84	CONDUIT	43.5	7.5351	0.0120
C86	J86	J83	CONDUIT	41.8	16.3133	0.0120

C87	J87	J86	CONDUIT	8.4	3.5567	0.0120
C88	J88	J86	CONDUIT	18.7	6.7926	0.0120
C89	J89	J88	CONDUIT	9.2	3.1641	0.0120
C9	J9	J8	CONDUIT	16.7	0.9510	0.0120
C90	J90	J89	CONDUIT	51.2	5.1073	0.0120
C91	J91	J90	CONDUIT	9.6	6.7167	0.0120
C92	J92	J82	CONDUIT	40.3	0.5216	0.0120
C93	J93	J92	CONDUIT	30.6	0.7509	0.0120
C94	J94	J93	CONDUIT	79.2	16.6726	0.0120
C95	J95	J94	CONDUIT	34.8	2.8731	0.0120
C96	J96	J95	CONDUIT	10.3	4.8554	0.0120
C97	J97	J93	CONDUIT	55.0	0.6001	0.0120
C98	J98	J97	CONDUIT	29.3	37.2325	0.0120
C99	J99	J97	CONDUIT	60.2	0.1496	0.0120

****
Cross Section Summary
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Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
C1	CIRCULAR	0.75	0.44	0.19	0.75	1	0.87
C10	CIRCULAR	0.15	0.02	0.04	0.15	1	0.02
C100	CIRCULAR	0.30	0.07	0.07	0.30	1	0.12
C101	CIRCULAR	0.38	0.11	0.09	0.38	1	0.24
C102	CIRCULAR	0.30	0.07	0.07	0.30	1	0.08
C103	CIRCULAR	0.30	0.07	0.07	0.30	1	0.09
C104	CIRCULAR	0.30	0.07	0.07	0.30	1	0.42
C105	CIRCULAR	0.23	0.04	0.06	0.23	1	0.21
C11	CIRCULAR	0.45	0.16	0.11	0.45	1	0.58
C12	CIRCULAR	0.30	0.07	0.07	0.30	1	0.38
C13	CIRCULAR	0.30	0.07	0.07	0.30	1	0.12
C14	CIRCULAR	0.30	0.07	0.07	0.30	1	0.31
C15	CIRCULAR	0.23	0.04	0.06	0.23	1	0.14
C16	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07

C17	CIRCULAR	0.15	0.02	0.04	0.15	1	0.04
C18	CIRCULAR	0.45	0.16	0.11	0.45	1	0.48
C19	CIRCULAR	0.30	0.07	0.07	0.30	1	0.38
C2	CIRCULAR	0.75	0.44	0.19	0.75	1	0.66
C20	CIRCULAR	0.45	0.16	0.11	0.45	1	0.53
C21	CIRCULAR	0.38	0.11	0.09	0.38	1	0.54
C22	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C23	CIRCULAR	0.53	0.22	0.13	0.53	1	0.90
C24	CIRCULAR	0.53	0.22	0.13	0.53	1	0.97
C25	CIRCULAR	0.23	0.04	0.06	0.23	1	0.13
C26	CIRCULAR	0.53	0.22	0.13	0.53	1	0.70
C27	CIRCULAR	0.30	0.07	0.07	0.30	1	0.17
C28	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C29	CIRCULAR	0.23	0.04	0.06	0.23	1	0.06
C3	CIRCULAR	0.45	0.16	0.11	0.45	1	0.94
C30	CIRCULAR	0.30	0.07	0.07	0.30	1	0.15
C31	CIRCULAR	0.30	0.07	0.07	0.30	1	0.06
C32	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C33	CIRCULAR	0.30	0.07	0.07	0.30	1	0.17
C34	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C35	CIRCULAR	0.30	0.07	0.07	0.30	1	0.19
C36	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07
C37	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C38	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07
C39	CIRCULAR	0.15	0.02	0.04	0.15	1	0.04
C4	CIRCULAR	0.45	0.16	0.11	0.45	1	0.58
C40	CIRCULAR	0.23	0.04	0.06	0.23	1	0.06
C41	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07
C42	CIRCULAR	0.23	0.04	0.06	0.23	1	0.08
C43	CIRCULAR	0.38	0.11	0.09	0.38	1	0.36
C44	CIRCULAR	0.30	0.07	0.07	0.30	1	0.19
C45	CIRCULAR	0.38	0.11	0.09	0.38	1	0.38
C46	CIRCULAR	0.30	0.07	0.07	0.30	1	0.18
C47	CIRCULAR	0.30	0.07	0.07	0.30	1	0.18

C48	CIRCULAR	0.30	0.07	0.07	0.30	1	0.16
C49	CIRCULAR	0.23	0.04	0.06	0.23	1	0.16
C5	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C50	CIRCULAR	0.23	0.04	0.06	0.23	1	0.05
C51	CIRCULAR	0.23	0.04	0.06	0.23	1	0.05
C52	CIRCULAR	0.15	0.02	0.04	0.15	1	0.02
C53	CIRCULAR	0.15	0.02	0.04	0.15	1	0.04
C54	CIRCULAR	0.23	0.04	0.06	0.23	1	0.05
C55	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C56	CIRCULAR	0.15	0.02	0.04	0.15	1	0.03
C57	CIRCULAR	0.23	0.04	0.06	0.23	1	0.09
C58	CIRCULAR	0.23	0.04	0.06	0.23	1	0.07
C59	CIRCULAR	0.15	0.02	0.04	0.15	1	0.05
C6	RECT_CLOSED	0.23	0.07	0.06	0.30	1	0.04
C60	CIRCULAR	0.30	0.07	0.07	0.30	1	0.16
C61	CIRCULAR	0.30	0.07	0.07	0.30	1	0.06
C62	CIRCULAR	0.30	0.07	0.07	0.30	1	0.14
C63	CIRCULAR	0.30	0.07	0.07	0.30	1	0.10
C64	CIRCULAR	0.30	0.07	0.07	0.30	1	0.18
C65	CIRCULAR	0.23	0.04	0.06	0.23	1	0.34
C66	CIRCULAR	0.60	0.28	0.15	0.60	1	0.80
C67	CIRCULAR	0.45	0.16	0.11	0.45	1	0.29
C68	CIRCULAR	0.45	0.16	0.11	0.45	1	0.33
C69	CIRCULAR	0.30	0.07	0.07	0.30	1	0.69
C7	CIRCULAR	0.30	0.07	0.07	0.30	1	0.22
C70	CIRCULAR	0.30	0.07	0.07	0.30	1	0.39
C71	CIRCULAR	0.30	0.07	0.07	0.30	1	0.25
C72	CIRCULAR	0.30	0.07	0.07	0.30	1	0.19
C73	CIRCULAR	0.23	0.04	0.06	0.23	1	0.08
C74	CIRCULAR	0.23	0.04	0.06	0.23	1	0.05
C75	CIRCULAR	0.23	0.04	0.06	0.23	1	0.03
C76	CIRCULAR	0.15	0.02	0.04	0.15	1	0.07
C77	CIRCULAR	0.15	0.02	0.04	0.15	1	0.02
C78	CIRCULAR	0.45	0.16	0.11	0.45	1	0.21

C79	CIRCULAR	0.23	0.04	0.06	0.23	1	0.16
C8	CIRCULAR	0.30	0.07	0.07	0.30	1	0.52
C80	CIRCULAR	0.23	0.04	0.06	0.23	1	0.16
C81	CIRCULAR	0.23	0.04	0.06	0.23	1	0.12
C82	CIRCULAR	0.45	0.16	0.11	0.45	1	0.23
C83	CIRCULAR	0.23	0.04	0.06	0.23	1	0.13
C84	CIRCULAR	0.23	0.04	0.06	0.23	1	0.18
C85	CIRCULAR	0.15	0.02	0.04	0.15	1	0.05
C86	CIRCULAR	0.23	0.04	0.06	0.23	1	0.20
C87	CIRCULAR	0.30	0.07	0.07	0.30	1	0.20
C88	CIRCULAR	0.30	0.07	0.07	0.30	1	0.27
C89	CIRCULAR	0.30	0.07	0.07	0.30	1	0.19
C9	CIRCULAR	0.30	0.07	0.07	0.30	1	0.10
C90	CIRCULAR	0.23	0.04	0.06	0.23	1	0.11
C91	CIRCULAR	0.30	0.07	0.07	0.30	1	0.27
C92	CIRCULAR	0.45	0.16	0.11	0.45	1	0.22
C93	CIRCULAR	0.38	0.11	0.09	0.38	1	0.16
C94	CIRCULAR	0.23	0.04	0.06	0.23	1	0.20
C95	CIRCULAR	0.30	0.07	0.07	0.30	1	0.18
C96	CIRCULAR	0.15	0.02	0.04	0.15	1	0.04
C97	CIRCULAR	0.30	0.07	0.07	0.30	1	0.08
C98	CIRCULAR	0.23	0.04	0.06	0.23	1	0.30
C99	CIRCULAR	0.30	0.07	0.07	0.30	1	0.04

```
*********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
*********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... HORTON
```

```
Flow Routing Method ...... DYNWAVE
Starting Date ............ 07/02/2019 00:00:00
Ending Date .............. 07/02/2019 02:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:01:00
Dry Time Step ............ 00:05:00
Routing Time Step ........ 5.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 4
Head Tolerance ........... 0.001500 m


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         0.392        24.599
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.160        10.062
Surface Runoff ...........         0.223        13.989
Final Storage ............         0.009         0.559
Continuity Error (%) .....        -0.043


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.223         2.229
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.222         2.216
Flooding Loss ............         0.000         0.001
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.001         0.015
Continuity Error (%) .....        -0.098


*************************
Highest Continuity Errors
*************************
Node J104 (23.45%)
Node J10 (6.60%)


***************************
Time-Step Critical Elements
***************************
Link C65 (75.75%)
Link C3 (17.26%)


********************************
Highest Flow Instability Indexes
********************************
Link C61 (18)
Link C2 (15)
Link C78 (2)
Link C60 (2)
Link C1 (2)


*************************
Routing Time Step Summary
```

```
*************************
Minimum Time Step           :     0.50 sec
Average Time Step           :     1.03 sec
Maximum Time Step           :     5.00 sec
Percent in Steady State     :    -0.00
Average Iterations per Step :     2.07
Percent Not Converging      :     0.57
```

```
***************************
Subcatchment Runoff Summary
***************************
```

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff CMS	Runoff Coeff
S1	24.60	0.00	0.00	0.00	24.44	0.02	0.01	0.993
S10	24.60	0.00	0.00	9.84	14.26	0.03	0.01	0.580
S11	24.60	0.00	0.00	24.60	0.00	0.00	0.00	0.000
S12	24.60	0.00	0.00	8.61	15.47	0.01	0.01	0.629
S13	24.60	0.00	0.00	9.84	14.12	0.05	0.02	0.574
S14	24.60	0.00	0.00	6.15	16.93	0.00	0.00	0.688
S15	24.60	0.00	0.00	16.48	7.45	0.00	0.00	0.303
S16	24.60	0.00	0.00	9.84	14.26	0.01	0.01	0.580
S17	24.60	0.00	0.00	9.84	14.15	0.05	0.03	0.575
S18	24.60	0.00	0.00	13.53	10.17	0.00	0.00	0.413
S19	24.60	0.00	0.00	14.02	9.69	0.01	0.00	0.394
S2	24.60	0.00	0.00	9.84	14.13	0.10	0.05	0.574
S20	24.60	0.00	0.00	9.84	14.20	0.04	0.02	0.577
S21	24.60	0.00	0.00	9.84	14.11	0.02	0.01	0.574
S22	24.60	0.00	0.00	9.84	14.15	0.02	0.01	0.575
S23	24.60	0.00	0.00	7.87	15.37	0.00	0.00	0.625
S24	24.60	0.00	0.00	9.84	14.25	0.05	0.03	0.579
S25	24.60	0.00	0.00	12.30	11.31	0.00	0.00	0.460
S26	24.60	0.00	0.00	13.78	9.91	0.01	0.00	0.403
S27	24.60	0.00	0.00	9.84	14.20	0.10	0.05	0.577
S28	24.60	0.00	0.00	9.35	13.91	0.01	0.01	0.565
S29	24.60	0.00	0.00	10.09	13.21	0.02	0.01	0.537

S3	24.60	0.00	0.00	9.84	14.13	0.13	0.07	0.574
S30	24.60	0.00	0.00	5.66	17.40	0.00	0.00	0.707
S31	24.60	0.00	0.00	9.84	13.84	0.03	0.01	0.563
S32	24.60	0.00	0.00	9.84	14.33	0.07	0.03	0.583
S33	24.60	0.00	0.00	8.12	16.21	0.02	0.01	0.659
S34	24.60	0.00	0.00	12.79	10.77	0.01	0.00	0.438
S35	24.60	0.00	0.00	16.48	7.46	0.00	0.00	0.303
S36	24.60	0.00	0.00	8.12	15.72	0.03	0.02	0.639
S37	24.60	0.00	0.00	9.84	14.21	0.03	0.02	0.578
S38	24.60	0.00	0.00	9.84	14.08	0.02	0.01	0.573
S39	24.60	0.00	0.00	9.84	14.42	0.02	0.01	0.586
S4	24.60	0.00	0.00	10.82	12.52	0.02	0.01	0.509
S40	24.60	0.00	0.00	9.84	14.38	0.02	0.01	0.584
S41	24.60	0.00	0.00	9.84	14.24	0.03	0.02	0.579
S42	24.60	0.00	0.00	9.84	14.49	0.02	0.01	0.589
S43	24.60	0.00	0.00	14.02	9.67	0.01	0.01	0.393
S44	24.60	0.00	0.00	9.84	14.24	0.03	0.01	0.579
S45	24.60	0.00	0.00	7.87	16.29	0.02	0.01	0.662
S46	24.60	0.00	0.00	13.04	11.29	0.03	0.01	0.459
S47	24.60	0.00	0.00	9.84	14.22	0.05	0.02	0.578
S48	24.60	0.00	0.00	17.22	7.38	0.00	0.00	0.300
S49	24.60	0.00	0.00	16.73	7.87	0.01	0.00	0.320
S5	24.60	0.00	0.00	9.84	14.65	0.03	0.02	0.596
S50	24.60	0.00	0.00	9.84	13.57	0.00	0.00	0.552
S51	24.60	0.00	0.00	13.28	10.35	0.01	0.00	0.421
S52	24.60	0.00	0.00	9.84	14.25	0.02	0.01	0.579
S53	24.60	0.00	0.00	9.84	14.25	0.02	0.01	0.579
S54	24.60	0.00	0.00	9.84	14.57	0.02	0.01	0.592
S55	24.60	0.00	0.00	9.84	14.20	0.06	0.03	0.577
S56	24.60	0.00	0.00	12.05	11.37	0.01	0.01	0.462
S57	24.60	0.00	0.00	7.13	16.05	0.00	0.00	0.652
S58	24.60	0.00	0.00	9.84	14.21	0.05	0.02	0.578
S59	24.60	0.00	0.00	7.63	16.64	0.01	0.01	0.676
S6	24.60	0.00	0.00	0.00	24.61	0.01	0.01	1.001

S60	24.60	0.00	0.00	9.84	14.23	0.04	0.02	0.578
S61	24.60	0.00	0.00	9.84	14.14	0.07	0.04	0.575
S62	24.60	0.00	0.00	9.84	14.33	0.01	0.01	0.583
S63	24.60	0.00	0.00	9.84	14.36	0.01	0.01	0.584
S64	24.60	0.00	0.00	9.84	14.45	0.02	0.01	0.587
S65	24.60	0.00	0.00	9.84	14.41	0.03	0.01	0.586
S66	24.60	0.00	0.00	11.07	12.42	0.00	0.00	0.505
S67	24.60	0.00	0.00	9.84	14.25	0.04	0.02	0.579
S68	24.60	0.00	0.00	9.84	14.25	0.03	0.02	0.579
S69	24.60	0.00	0.00	9.84	14.27	0.04	0.02	0.580
S7	24.60	0.00	0.00	9.84	14.26	0.05	0.03	0.580
S70	24.60	0.00	0.00	9.84	14.25	0.06	0.03	0.579
S71	24.60	0.00	0.00	9.84	14.27	0.02	0.01	0.580
S72	24.60	0.00	0.00	9.84	14.45	0.02	0.01	0.587
S73	24.60	0.00	0.00	9.84	14.55	0.01	0.00	0.592
S74	24.60	0.00	0.00	9.84	14.50	0.02	0.01	0.590
S75	24.60	0.00	0.00	9.84	14.43	0.02	0.01	0.587
S76	24.60	0.00	0.00	9.84	14.26	0.01	0.01	0.580
S77	24.60	0.00	0.00	8.12	15.15	0.00	0.00	0.616
S78	24.60	0.00	0.00	7.63	15.56	0.01	0.00	0.632
S79	24.60	0.00	0.00	8.86	15.20	0.03	0.02	0.618
S8	24.60	0.00	0.00	15.99	7.91	0.00	0.00	0.321
S80	24.60	0.00	0.00	7.38	15.85	0.00	0.00	0.644
S81	24.60	0.00	0.00	12.30	11.27	0.01	0.00	0.458
S82	24.60	0.00	0.00	9.84	14.32	0.01	0.01	0.582
S83	24.60	0.00	0.00	9.84	14.40	0.05	0.03	0.585
S84	24.60	0.00	0.00	9.84	14.53	0.02	0.01	0.591
S85	24.60	0.00	0.00	9.84	14.28	0.01	0.01	0.581
S86	24.60	0.00	0.00	8.36	15.53	0.04	0.02	0.631
S87	24.60	0.00	0.00	9.84	14.46	0.03	0.01	0.588
S88	24.60	0.00	0.00	9.84	14.43	0.02	0.01	0.586
S89	24.60	0.00	0.00	9.35	14.92	0.01	0.01	0.606
S9	24.60	0.00	0.00	9.84	14.26	0.02	0.01	0.580
S90	24.60	0.00	0.00	9.84	14.40	0.01	0.00	0.586

S91	24.60	0.00	0.00	9.84	14.46	0.02	0.01	0.588
S92	24.60	0.00	0.00	10.09	13.20	0.00	0.00	0.537
S93	24.60	0.00	0.00	13.53	10.15	0.00	0.00	0.412
S94	24.60	0.00	0.00	10.58	12.84	0.00	0.00	0.522
S95	24.60	0.00	0.00	7.13	16.04	0.00	0.00	0.652

****
Node Depth Summary
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Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days	hr:min	Reported Max Depth Meters
J1	JUNCTION	0.42	1.41	4.31	0	01:23	0.98
J10	JUNCTION	0.61	0.69	14.21	0	00:24	0.69
J100	JUNCTION	0.02	0.03	18.03	0	01:25	0.03
J101	JUNCTION	0.05	0.08	7.41	0	01:25	0.08
J102	JUNCTION	0.04	0.07	7.52	0	01:24	0.07
J103	JUNCTION	0.01	0.01	7.97	0	01:25	0.01
J104	JUNCTION	0.25	0.30	7.52	0	01:25	0.30
J105	JUNCTION	0.09	0.13	7.52	0	01:24	0.13
J11	JUNCTION	0.20	0.36	8.32	0	01:26	0.35
J12	JUNCTION	0.03	0.05	8.48	0	01:25	0.05
J13	JUNCTION	0.06	0.09	8.68	0	01:25	0.09
J14	JUNCTION	0.04	0.07	8.79	0	01:25	0.07
J15	JUNCTION	0.05	0.08	9.30	0	01:25	0.08
J16	JUNCTION	0.07	0.12	9.99	0	01:25	0.12
J17	JUNCTION	0.02	0.04	12.26	0	01:25	0.04
J18	JUNCTION	0.01	0.02	9.04	0	01:25	0.02
J19	JUNCTION	0.21	0.37	8.90	0	01:25	0.37
J2	JUNCTION	0.44	1.34	4.28	0	01:23	1.04
J20	JUNCTION	0.19	0.32	11.13	0	01:25	0.32
J21	JUNCTION	0.16	0.26	11.61	0	01:25	0.26
J22	JUNCTION	0.15	0.25	12.05	0	01:25	0.25
J23	JUNCTION	0.01	0.02	12.39	0	01:25	0.02
J24	JUNCTION	0.03	0.05	13.13	0	01:25	0.05
J25	JUNCTION	0.03	0.05	13.50	0	01:25	0.05
J26	JUNCTION	0.18	0.30	13.87	0	01:25	0.30
J27	JUNCTION	0.03	0.04	13.92	0	01:25	0.04
J28	JUNCTION	0.10	0.17	15.58	0	01:25	0.17
J29	JUNCTION	0.04	0.06	16.46	0	01:25	0.06
J3	JUNCTION	0.20	1.01	4.48	0	01:23	0.73
J30	JUNCTION	0.11	0.18	16.47	0	01:25	0.18
J31	JUNCTION	0.07	0.13	16.47	0	01:25	0.13
J32	JUNCTION	0.02	0.03	16.66	0	01:25	0.03
J33	JUNCTION	0.02	0.03	16.83	0	01:25	0.03
J34	JUNCTION	0.04	0.06	16.70	0	01:25	0.06
J35	JUNCTION	0.08	0.13	16.98	0	01:25	0.13
J36	JUNCTION	0.03	0.05	17.08	0	01:25	0.05
J37	JUNCTION	0.07	0.12	17.50	0	01:25	0.12
J38	JUNCTION	0.06	0.10	18.45	0	01:25	0.10
J39	JUNCTION	0.03	0.05	20.40	0	01:25	0.05
J4	JUNCTION	0.22	1.28	7.57	0	01:25	0.42
J40	JUNCTION	0.05	0.08	17.55	0	01:25	0.08
J41	JUNCTION	0.04	0.07	18.03	0	01:25	0.07
J42	JUNCTION	0.02	0.04	18.81	0	01:25	0.04
J43	JUNCTION	0.13	0.21	17.15	0	01:25	0.21
J44	JUNCTION	0.03	0.04	17.41	0	01:25	0.04
J45	JUNCTION	0.09	0.14	17.55	0	01:25	0.14
J46	JUNCTION	0.10	0.16	17.80	0	01:25	0.16

J47	JUNCTION	0.09	0.15	17.81	0	01:25	0.15
J48	JUNCTION	0.09	0.16	18.96	0	01:25	0.16
J49	JUNCTION	0.06	0.09	19.79	0	01:25	0.09
J5	JUNCTION	0.06	0.09	9.23	0	01:25	0.09
J50	JUNCTION	0.10	0.17	20.37	0	01:25	0.17
J51	JUNCTION	0.07	0.12	20.77	0	01:25	0.12
J52	JUNCTION	0.07	0.14	21.03	0	01:25	0.14
J53	JUNCTION	0.03	0.05	23.07	0	01:25	0.05
J54	JUNCTION	0.08	0.14	19.35	0	01:25	0.14
J55	JUNCTION	0.03	0.05	21.25	0	01:25	0.05
J56	JUNCTION	0.02	0.03	22.13	0	01:25	0.03
J57	JUNCTION	0.02	0.03	21.86	0	01:25	0.03
J58	JUNCTION	0.00	0.00	21.99	0	00:00	0.00
J59	JUNCTION	0.02	0.03	23.17	0	01:25	0.03
J6	JUNCTION	0.07	0.12	9.29	0	01:25	0.12
J60	JUNCTION	0.08	0.13	19.98	0	01:25	0.13
J61	JUNCTION	0.12	0.20	20.09	0	01:24	0.20
J62	JUNCTION	0.08	0.14	20.16	0	01:24	0.14
J63	JUNCTION	0.07	0.11	20.22	0	01:24	0.11
J64	JUNCTION	0.04	0.07	20.39	0	01:25	0.07
J65	JUNCTION	0.05	0.55	4.35	0	01:23	0.20
J66	JUNCTION	0.17	0.28	4.71	0	01:25	0.28
J67	JUNCTION	0.23	0.94	5.76	0	01:25	0.44
J68	JUNCTION	0.20	0.35	5.83	0	01:25	0.35
J69	JUNCTION	0.04	0.07	7.26	0	01:25	0.07
J7	JUNCTION	0.04	0.06	10.85	0	01:25	0.06
J70	JUNCTION	0.05	0.08	10.93	0	01:25	0.08
J71	JUNCTION	0.22	0.40	6.11	0	01:25	0.40
J72	JUNCTION	0.06	0.10	12.49	0	01:25	0.10
J73	JUNCTION	0.06	0.09	13.89	0	01:25	0.09
J74	JUNCTION	0.05	0.08	14.13	0	01:25	0.08
J75	JUNCTION	0.05	0.09	14.39	0	01:25	0.09
J76	JUNCTION	0.07	0.11	14.52	0	01:25	0.11
J77	JUNCTION	0.02	0.03	15.69	0	01:25	0.03
J78	JUNCTION	0.00	0.00	14.75	0	00:00	0.00
J79	JUNCTION	0.05	0.07	11.17	0	01:25	0.07
J8	JUNCTION	0.03	0.04	14.14	0	01:25	0.04
J80	JUNCTION	0.02	0.04	15.35	0	01:25	0.04
J81	JUNCTION	0.03	0.04	16.64	0	01:25	0.04
J82	JUNCTION	0.18	0.31	6.35	0	01:25	0.31
J83	JUNCTION	0.06	0.10	7.34	0	01:25	0.10
J84	JUNCTION	0.03	0.05	13.73	0	01:25	0.05
J85	JUNCTION	0.03	0.05	17.00	0	01:25	0.05
J86	JUNCTION	0.04	0.06	14.03	0	01:25	0.06
J87	JUNCTION	0.02	0.04	14.31	0	01:25	0.04
J88	JUNCTION	0.04	0.06	15.30	0	01:25	0.06
J89	JUNCTION	0.04	0.07	15.60	0	01:25	0.07
J9	JUNCTION	0.05	0.08	14.34	0	01:25	0.08
J90	JUNCTION	0.02	0.03	18.17	0	01:25	0.03
J91	JUNCTION	0.02	0.03	18.81	0	01:25	0.03
J92	JUNCTION	0.14	0.23	6.48	0	01:25	0.23
J93	JUNCTION	0.14	0.23	6.71	0	01:25	0.23
J94	JUNCTION	0.03	0.04	19.54	0	01:25	0.04
J95	JUNCTION	0.02	0.04	20.54	0	01:25	0.04
J96	JUNCTION	0.02	0.04	21.04	0	01:25	0.04
J97	JUNCTION	0.13	0.22	7.03	0	01:25	0.22
J98	JUNCTION	0.03	0.04	17.07	0	01:25	0.04
J99	JUNCTION	0.13	0.23	7.13	0	01:25	0.23
OF1	OUTFALL	0.39	0.64	2.87	0	01:25	0.64

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Node Inflow Summary
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Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days	Time of Max Occurrence hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
J1	JUNCTION	0.050	1.081	0	01:25	0.101	2.2	0.065
J10	JUNCTION	0.006	0.006	0	01:25	0.0108	0.011	7.069
J100	JUNCTION	0.005	0.005	0	01:25	0.0107	0.0107	-0.077
J101	JUNCTION	0.002	0.018	0	01:25	0.00416	0.0326	0.066
J102	JUNCTION	0.012	0.016	0	01:24	0.0233	0.0303	-0.086
J103	JUNCTION	0.001	0.001	0	01:25	0.00237	0.00237	0.011
J104	JUNCTION	0.001	0.005	0	00:33	0.00193	0.00933	30.628
J105	JUNCTION	0.002	0.003	0	00:34	0.00329	0.00342	7.429
J11	JUNCTION	0.000	0.550	0	01:25	0	1.1	0.026
J12	JUNCTION	0.002	0.026	0	01:25	0.00305	0.0519	0.024
J13	JUNCTION	0.024	0.024	0	01:25	0.0489	0.0489	0.043
J14	JUNCTION	0.002	0.037	0	01:25	0.00447	0.074	0.017
J15	JUNCTION	0.002	0.035	0	01:25	0.00381	0.0695	0.033
J16	JUNCTION	0.027	0.033	0	01:25	0.0544	0.0658	0.067
J17	JUNCTION	0.006	0.006	0	01:25	0.0114	0.0114	0.008
J18	JUNCTION	0.004	0.004	0	01:25	0.00833	0.00833	0.026
J19	JUNCTION	0.021	0.488	0	01:25	0.0418	0.973	0.041
J2	JUNCTION	0.010	1.031	0	01:25	0.0182	2.1	0.071
J20	JUNCTION	0.001	0.464	0	01:25	0.00147	0.923	0.040
J21	JUNCTION	0.005	0.444	0	01:25	0.00848	0.883	0.005
J22	JUNCTION	0.025	0.440	0	01:25	0.0499	0.874	0.033
J23	JUNCTION	0.002	0.002	0	01:25	0.00284	0.00284	0.027
J24	JUNCTION	0.009	0.020	0	01:25	0.0176	0.039	0.031
J25	JUNCTION	0.011	0.011	0	01:25	0.0214	0.0214	0.043
J26	JUNCTION	0.050	0.415	0	01:25	0.099	0.822	0.072
J27	JUNCTION	0.008	0.008	0	01:25	0.0142	0.0142	0.084
J28	JUNCTION	0.033	0.140	0	01:25	0.0658	0.278	0.052
J29	JUNCTION	0.010	0.010	0	01:25	0.0204	0.0204	-0.031
J3	JUNCTION	0.015	0.608	0	01:25	0.0316	1.25	0.004

J30	JUNCTION	0.001	0.097	0	01:25	0.00224	0.192	0.055
J31	JUNCTION	0.000	0.019	0	01:25	0	0.038	0.098
J32	JUNCTION	0.000	0.003	0	01:25	0	0.00511	0.125
J33	JUNCTION	0.003	0.003	0	01:25	0.00511	0.00511	0.073
J34	JUNCTION	0.016	0.016	0	01:25	0.0329	0.0329	0.027
J35	JUNCTION	0.017	0.076	0	01:25	0.0344	0.152	0.024
J36	JUNCTION	0.009	0.009	0	01:25	0.0189	0.0189	0.068
J37	JUNCTION	0.009	0.050	0	01:25	0.0187	0.0983	0.028
J38	JUNCTION	0.018	0.025	0	01:25	0.0347	0.0501	0.049
J39	JUNCTION	0.008	0.008	0	01:25	0.0154	0.0154	0.020
J4	JUNCTION	0.027	0.607	0	01:25	0.0519	1.21	0.049
J40	JUNCTION	0.000	0.015	0	01:25	0	0.0295	0.046
J41	JUNCTION	0.010	0.015	0	01:25	0.0195	0.0295	0.013
J42	JUNCTION	0.005	0.005	0	01:25	0.00996	0.00996	0.129
J43	JUNCTION	0.001	0.218	0	01:25	0.0027	0.432	0.052
J44	JUNCTION	0.009	0.009	0	01:25	0.017	0.017	0.079
J45	JUNCTION	0.015	0.117	0	01:25	0.031	0.233	0.012
J46	JUNCTION	0.015	0.102	0	01:25	0.0292	0.202	0.023
J47	JUNCTION	0.032	0.092	0	01:24	0.063	0.179	0.051
J48	JUNCTION	0.000	0.087	0	01:25	0	0.173	0.041
J49	JUNCTION	0.012	0.053	0	01:25	0.0228	0.106	0.015
J5	JUNCTION	0.002	0.032	0	01:25	0.00387	0.0643	0.039
J50	JUNCTION	0.015	0.042	0	01:25	0.0287	0.0832	0.066
J51	JUNCTION	0.010	0.027	0	01:25	0.0187	0.0545	0.044
J52	JUNCTION	0.008	0.018	0	01:25	0.0157	0.0358	0.060
J53	JUNCTION	0.010	0.010	0	01:25	0.0201	0.0201	0.008
J54	JUNCTION	0.024	0.034	0	01:25	0.0478	0.0671	0.072
J55	JUNCTION	0.002	0.010	0	01:25	0.00491	0.0193	0.032
J56	JUNCTION	0.003	0.003	0	01:25	0.00582	0.00582	-0.022
J57	JUNCTION	0.001	0.005	0	01:25	0.00237	0.00858	0.092
J58	JUNCTION	0.000	0.000	0	00:00	0	0	0.000 ltr
J59	JUNCTION	0.003	0.003	0	01:25	0.00621	0.00621	0.057
J6	JUNCTION	0.011	0.030	0	01:25	0.0223	0.0605	0.026
J60	JUNCTION	0.001	0.066	0	01:24	0.00249	0.116	0.017

J61	JUNCTION	0.007	0.058	0	01:25	0.0131	0.114	0.084
J62	JUNCTION	0.023	0.051	0	01:25	0.046	0.101	0.018
J63	JUNCTION	0.005	0.028	0	01:25	0.0102	0.0548	0.031
J64	JUNCTION	0.023	0.023	0	01:25	0.0446	0.0446	0.016
J65	JUNCTION	0.065	0.065	0	01:25	0.131	0.131	-0.004
J66	JUNCTION	0.006	0.349	0	01:25	0.0121	0.708	0.054
J67	JUNCTION	0.037	0.350	0	01:25	0.0739	0.696	0.050
J68	JUNCTION	0.000	0.313	0	01:25	0	0.623	0.045
J69	JUNCTION	0.013	0.074	0	01:25	0.0264	0.146	0.003
J7	JUNCTION	0.000	0.019	0	01:25	0	0.0382	0.027
J70	JUNCTION	0.002	0.061	0	01:25	0.00292	0.119	0.018
J71	JUNCTION	0.021	0.241	0	01:25	0.0401	0.477	0.092
J72	JUNCTION	0.021	0.059	0	01:25	0.0419	0.116	0.020
J73	JUNCTION	0.015	0.038	0	01:25	0.0296	0.0745	0.020
J74	JUNCTION	0.007	0.023	0	01:25	0.0146	0.045	0.018
J75	JUNCTION	0.000	0.015	0	01:25	0	0.0304	0.072
J76	JUNCTION	0.010	0.015	0	01:25	0.0203	0.0304	0.046
J77	JUNCTION	0.005	0.005	0	01:25	0.0101	0.0101	0.006
J78	JUNCTION	0.000	0.000	0	00:00	0	0	0.000 ltr
J79	JUNCTION	0.029	0.037	0	01:25	0.0558	0.0733	0.001
J8	JUNCTION	0.000	0.019	0	01:25	0	0.0383	-0.006
J80	JUNCTION	0.000	0.009	0	01:25	0	0.0175	0.027
J81	JUNCTION	0.009	0.009	0	01:25	0.0176	0.0175	0.005
J82	JUNCTION	0.009	0.184	0	01:25	0.0183	0.364	0.070
J83	JUNCTION	0.005	0.056	0	01:25	0.00946	0.109	0.023
J84	JUNCTION	0.008	0.018	0	01:25	0.0157	0.035	-0.007
J85	JUNCTION	0.010	0.010	0	01:25	0.0193	0.0193	0.001
J86	JUNCTION	0.002	0.034	0	01:25	0.00295	0.0647	0.027
J87	JUNCTION	0.007	0.007	0	01:25	0.014	0.014	0.007
J88	JUNCTION	0.005	0.025	0	01:25	0.0084	0.0478	0.021
J89	JUNCTION	0.015	0.020	0	01:25	0.0294	0.0394	0.009
J9	JUNCTION	0.015	0.015	0	01:25	0.0289	0.0289	0.021
J90	JUNCTION	0.001	0.005	0	01:25	0.00238	0.01	0.134
J91	JUNCTION	0.004	0.004	0	01:25	0.00766	0.00766	0.027

J92	JUNCTION	0.006	0.120	0	01:25	0.0125	0.237	0.055
J93	JUNCTION	0.026	0.114	0	01:25	0.0504	0.225	0.098
J94	JUNCTION	0.011	0.016	0	01:25	0.0219	0.0323	-0.056
J95	JUNCTION	0.000	0.005	0	01:25	0	0.0103	0.042
J96	JUNCTION	0.005	0.005	0	01:25	0.0104	0.0103	0.012
J97	JUNCTION	0.014	0.073	0	01:25	0.0284	0.142	0.133
J98	JUNCTION	0.020	0.020	0	01:25	0.0396	0.0396	0.027
J99	JUNCTION	0.016	0.039	0	01:25	0.0311	0.0744	0.202
OF1	OUTFALL	0.008	1.089	0	01:25	0.0165	2.22	0.000

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
J1	JUNCTION	0.08	0.655	0.135
J10	JUNCTION	1.60	0.540	0.000
J2	JUNCTION	0.09	0.590	0.160
J3	JUNCTION	0.07	0.563	0.117
J4	JUNCTION	0.02	0.830	0.000
J65	JUNCTION	0.01	0.325	0.000
J67	JUNCTION	0.02	0.489	2.911

****
Node Flooding Summary
****

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate CMS	Time of Max Occurrence days hr:min		Total Flood Volume 10^6 ltr	Maximum Ponded Depth Meters
J10	0.19	0.003	0	00:24	0.001	0.000
J4	0.01	0.024	0	01:25	0.000	0.000
J65	0.01	0.019	0	01:23	0.000	0.000

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
OF1	98.86	0.498	1.089	2.216
System	98.86	0.498	1.089	2.216

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Link Flow Summary
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-----------------------------------------------------------------------------
                                   Maximum  Time of Max   Maximum    Max/    Max/
                                    |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type            CMS   days hr:min    m/sec    Flow   Depth
-----------------------------------------------------------------------------
C1                   CONDUIT       1.081      0  01:25      2.53    1.24    0.92
C10                  CONDUIT       0.004      0  01:25      0.33    0.23    0.63
C100                 CONDUIT       0.018      0  01:25      0.50    0.16    0.52
C101                 CONDUIT       0.016      0  01:24      1.05    0.07    0.19
C102                 CONDUIT       0.005      0  01:26      0.29    0.06    0.61
C103                 CONDUIT       0.002      0  00:35      0.05    0.03    0.71
C104                 CONDUIT       0.001      0  01:25      0.04    0.00    0.52
C105                 CONDUIT       0.005      0  01:25      0.28    0.03    0.56
C11                  CONDUIT       0.550      0  01:25      3.95    0.94    0.90
C12                  CONDUIT       0.026      0  01:25      0.60    0.07    0.59
C13                  CONDUIT       0.024      0  01:25      1.81    0.20    0.25
C14                  CONDUIT       0.037      0  01:25      0.82    0.12    0.62
C15                  CONDUIT       0.035      0  01:25      3.10    0.25    0.33
C16                  CONDUIT       0.033      0  01:25      2.02    0.48    0.43
C17                  CONDUIT       0.006      0  01:25      0.65    0.14    0.51
C18                  CONDUIT       0.487      0  01:25      3.57    1.01    0.80
C19                  CONDUIT       0.004      0  01:25      0.12    0.01    0.54
C2                   CONDUIT       1.031      0  01:25      2.33    1.55    1.00
C20                  CONDUIT       0.463      0  01:25      3.51    0.87    0.77
C21                  CONDUIT       0.019      0  01:25      0.37    0.04    0.50
C22                  CONDUIT       0.011      0  01:25      1.51    0.05    0.16
C23                  CONDUIT       0.444      0  01:25      3.59    0.49    0.56
C24                  CONDUIT       0.440      0  01:25      4.24    0.45    0.48
C25                  CONDUIT       0.002      0  01:25      0.07    0.01    0.54
C26                  CONDUIT       0.414      0  01:25      3.64    0.59    0.52
C27                  CONDUIT       0.008      0  01:25      0.18    0.04    0.57
C28                  CONDUIT       0.139      0  01:25      2.34    0.63    0.79
C29                  CONDUIT       0.010      0  01:25      0.49    0.18    0.53
C3                   CONDUIT       0.608      0  01:25      3.82    0.65    1.00
C30                  CONDUIT       0.096      0  01:25      2.27    0.64    0.58
C31                  CONDUIT       0.019      0  01:25      0.52    0.31    0.52
C32                  CONDUIT       0.003      0  01:25      0.22    0.03    0.36
C33                  CONDUIT       0.003      0  01:25      0.88    0.02    0.09
C34                  CONDUIT       0.016      0  01:25      0.87    0.07    0.32
C35                  CONDUIT       0.076      0  01:25      2.09    0.40    0.51
C36                  CONDUIT       0.009      0  01:25      0.60    0.13    0.41
C37                  CONDUIT       0.050      0  01:25      2.21    0.54    0.56
C38                  CONDUIT       0.025      0  01:25      1.36    0.38    0.48
C39                  CONDUIT       0.008      0  01:25      0.95    0.20    0.47
C4                   CONDUIT       0.595      0  01:27      4.23    1.03    1.00
C40                  CONDUIT       0.015      0  01:25      0.90    0.25    0.44
C41                  CONDUIT       0.015      0  01:25      1.30    0.21    0.34
C42                  CONDUIT       0.005      0  01:25      0.72    0.06    0.24
C43                  CONDUIT       0.218      0  01:25      2.72    0.61    0.68
C44                  CONDUIT       0.009      0  01:25      0.31    0.05    0.43
C45                  CONDUIT       0.117      0  01:25      2.27    0.30    0.47
C46                  CONDUIT       0.091      0  01:25      2.04    0.51    0.61
C47                  CONDUIT       0.102      0  01:25      2.85    0.56    0.51
C48                  CONDUIT       0.087      0  01:25      2.31    0.53    0.53
C49                  CONDUIT       0.053      0  01:25      2.39    0.34    0.55
C5                   CONDUIT       0.032      0  01:25      1.07    0.35    0.70
C50                  CONDUIT       0.042      0  01:25      1.77    0.84    0.58
C51                  CONDUIT       0.027      0  01:25      1.02    0.56    0.64
C52                  CONDUIT       0.018      0  01:25      1.12    1.08    0.87
C53                  CONDUIT       0.010      0  01:25      0.93    0.23    0.63
C54                  CONDUIT       0.034      0  01:25      1.25    0.68    0.65
C55                  CONDUIT       0.010      0  01:25      0.64    0.11    0.41
C56                  CONDUIT       0.003      0  01:25      0.75    0.10    0.27
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C57	CONDUIT	0.005	0	01:25	0.91	0.05	0.19
C58	CONDUIT	0.000	0	00:00	0.00	0.00	0.08
C59	CONDUIT	0.003	0	01:25	1.28	0.07	0.20
C6	CONDUIT	0.030	0	01:25	0.93	0.70	0.47
C60	CONDUIT	0.060	0	01:25	1.88	0.37	0.46
C61	CONDUIT	0.065	0	01:24	1.66	1.03	0.55
C62	CONDUIT	0.052	0	01:25	1.27	0.38	0.57
C63	CONDUIT	0.028	0	01:25	0.99	0.27	0.42
C64	CONDUIT	0.023	0	01:25	1.23	0.12	0.31
C65	CONDUIT	0.082	0	01:23	2.15	0.24	1.00
C66	CONDUIT	0.347	0	01:25	1.57	0.43	0.73
C67	CONDUIT	0.344	0	01:25	2.64	1.18	0.81
C68	CONDUIT	0.314	0	01:25	2.14	0.94	0.89
C69	CONDUIT	0.074	0	01:25	1.64	0.11	0.61
C7	CONDUIT	0.019	0	01:25	1.04	0.08	0.30
C70	CONDUIT	0.061	0	01:25	4.43	0.16	0.25
C71	CONDUIT	0.059	0	01:25	3.17	0.24	0.31
C72	CONDUIT	0.038	0	01:25	1.91	0.20	0.32
C73	CONDUIT	0.023	0	01:25	1.61	0.29	0.39
C74	CONDUIT	0.015	0	01:25	1.12	0.32	0.38
C75	CONDUIT	0.015	0	01:25	0.90	0.51	0.44
C76	CONDUIT	0.005	0	01:25	0.64	0.07	0.46
C77	CONDUIT	0.000	0	00:00	0.00	0.00	0.37
C78	CONDUIT	0.240	0	01:25	1.73	1.12	0.84
C79	CONDUIT	0.037	0	01:25	1.33	0.24	0.67
C8	CONDUIT	0.019	0	01:25	2.50	0.04	0.16
C80	CONDUIT	0.009	0	01:25	1.18	0.06	0.25
C81	CONDUIT	0.009	0	01:25	1.93	0.07	0.17
C82	CONDUIT	0.184	0	01:25	1.37	0.81	0.79
C83	CONDUIT	0.056	0	01:25	1.80	0.43	0.73
C84	CONDUIT	0.018	0	01:25	1.52	0.10	0.33
C85	CONDUIT	0.010	0	01:25	2.05	0.22	0.32
C86	CONDUIT	0.034	0	01:25	2.52	0.17	0.37
C87	CONDUIT	0.007	0	01:25	0.90	0.04	0.17
C88	CONDUIT	0.025	0	01:25	2.36	0.09	0.21
C89	CONDUIT	0.020	0	01:25	1.83	0.11	0.22
C9	CONDUIT	0.015	0	01:25	1.48	0.14	0.20
C90	CONDUIT	0.005	0	01:25	0.80	0.05	0.23
C91	CONDUIT	0.004	0	01:25	1.13	0.02	0.10
C92	CONDUIT	0.119	0	01:25	1.20	0.53	0.60
C93	CONDUIT	0.113	0	01:25	1.58	0.69	0.62
C94	CONDUIT	0.016	0	01:25	0.70	0.08	0.60
C95	CONDUIT	0.005	0	01:25	0.96	0.03	0.13
C96	CONDUIT	0.005	0	01:25	1.54	0.15	0.25
C97	CONDUIT	0.072	0	01:25	1.27	0.89	0.75
C98	CONDUIT	0.020	0	01:25	0.83	0.07	0.58
C99	CONDUIT	0.039	0	01:25	0.68	0.95	0.75

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Flow Classification Summary
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	Adjusted	---------- Fraction of Time in Flow Class ----------								
	/Actual		Up	Down	Sub	Sup	Up	Down	Norm	Inlet
Conduit	Length	Dry	Dry	Dry	Crit	Crit	Crit	Crit	Ltd	Ctrl
C1	1.00	0.01	0.00	0.00	0.20	0.79	0.00	0.00	0.41	0.00
C10	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.15	0.00

C100	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.95	0.00
C101	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.87	0.00
C102	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.18	0.00
C103	1.00	0.01	0.03	0.00	0.96	0.00	0.00	0.00	0.07	0.00
C104	1.00	0.01	0.03	0.00	0.96	0.00	0.00	0.00	0.82	0.00
C105	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.95	0.00
C11	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.94	0.00
C12	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.94	0.00
C13	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
C14	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.93	0.00
C15	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
C16	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
C17	1.00	0.01	0.00	0.00	0.94	0.05	0.00	0.00	0.95	0.00
C18	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.22	0.00
C19	1.00	0.01	0.03	0.00	0.96	0.00	0.00	0.00	0.82	0.00
C2	1.00	0.01	0.00	0.00	0.52	0.47	0.00	0.00	0.06	0.00
C20	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.87	0.00
C21	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.93	0.00
C22	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.95	0.00
C23	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.86	0.00
C24	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.69	0.00
C25	1.00	0.01	0.03	0.00	0.96	0.00	0.00	0.00	0.82	0.00
C26	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.05	0.00
C27	1.00	0.01	0.03	0.00	0.96	0.00	0.00	0.00	0.82	0.00
C28	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.95	0.00
C29	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.95	0.00
C3	1.00	0.01	0.00	0.00	0.08	0.91	0.00	0.00	0.74	0.00
C30	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.30	0.00
C31	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.73	0.00
C32	1.00	0.01	0.03	0.00	0.95	0.00	0.00	0.00	0.81	0.00
C33	1.00	0.04	0.00	0.00	0.00	0.96	0.00	0.00	0.63	0.00
C34	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.92	0.00
C35	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.89	0.00
C36	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.95	0.00

C37	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.92	0.00
C38	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.95	0.00
C39	1.00	0.01	0.00	0.00	0.03	0.96	0.00	0.00	0.95	0.00
C4	1.00	0.01	0.00	0.00	0.03	0.96	0.00	0.00	0.04	0.00
C40	1.00	0.01	0.00	0.00	0.07	0.91	0.00	0.00	0.68	0.00
C41	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.88	0.00
C42	1.00	0.01	0.03	0.00	0.05	0.91	0.00	0.00	0.82	0.00
C43	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.95	0.00
C44	1.00	0.01	0.03	0.00	0.96	0.00	0.00	0.00	0.82	0.00
C45	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.89	0.00
C46	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.90	0.00
C47	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.26	0.00
C48	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.87	0.00
C49	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.92	0.00
C5	1.00	0.01	0.00	0.00	0.98	0.00	0.00	0.00	0.94	0.00
C50	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
C51	1.00	0.01	0.00	0.00	0.27	0.72	0.00	0.00	0.95	0.00
C52	1.00	0.01	0.00	0.00	0.11	0.88	0.00	0.00	0.60	0.00
C53	1.00	0.01	0.00	0.00	0.07	0.92	0.00	0.00	0.93	0.00
C54	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.87	0.00
C55	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.95	0.00
C56	1.00	0.01	0.00	0.00	0.07	0.92	0.00	0.00	0.91	0.00
C57	1.00	0.01	0.03	0.00	0.01	0.94	0.00	0.00	0.82	0.00
C58	1.00	0.04	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C59	1.00	0.04	0.00	0.00	0.00	0.96	0.00	0.00	0.81	0.00
C6	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.19	0.00
C60	1.00	0.01	0.01	0.00	0.01	0.98	0.00	0.00	0.93	0.00
C61	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.04	0.00
C62	1.00	0.01	0.00	0.00	0.03	0.96	0.00	0.00	0.54	0.00
C63	1.00	0.01	0.00	0.00	0.04	0.95	0.00	0.00	0.57	0.00
C64	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.94	0.00
C65	1.00	0.01	0.00	0.00	0.48	0.51	0.00	0.00	0.86	0.00
C66	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.94	0.00
C67	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.14	0.00

C68	1.00	0.01	0.00	0.00	0.05	0.94	0.00	0.00	0.70	0.00
C69	1.00	0.01	0.00	0.00	0.16	0.83	0.00	0.00	0.93	0.00
C7	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.93	0.00
C70	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.05	0.00
C71	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
C72	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.95	0.00
C73	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.95	0.00
C74	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.06	0.00
C75	1.00	0.01	0.00	0.00	0.12	0.87	0.00	0.00	0.00	0.00
C76	1.00	0.01	0.00	0.00	0.97	0.02	0.00	0.00	0.95	0.00
C77	1.00	0.01	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C78	1.00	0.01	0.00	0.00	0.15	0.84	0.00	0.00	0.31	0.00
C79	1.00	0.01	0.00	0.00	0.83	0.16	0.00	0.00	0.95	0.00
C8	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.91	0.00
C80	1.00	0.01	0.00	0.00	0.00	0.98	0.00	0.00	0.95	0.00
C81	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
C82	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.81	0.00
C83	1.00	0.01	0.00	0.00	0.33	0.66	0.00	0.00	0.95	0.00
C84	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.95	0.00
C85	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.66	0.00
C86	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.95	0.00
C87	1.00	0.01	0.00	0.00	0.03	0.97	0.00	0.00	0.90	0.00
C88	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.76	0.00
C89	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
C9	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
C90	1.00	0.01	0.03	0.00	0.02	0.94	0.00	0.00	0.82	0.00
C91	1.00	0.04	0.00	0.00	0.00	0.96	0.00	0.00	0.80	0.00
C92	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.90	0.00
C93	1.00	0.01	0.00	0.00	0.01	0.99	0.00	0.00	0.58	0.00
C94	1.00	0.01	0.00	0.00	0.96	0.03	0.00	0.00	0.95	0.00
C95	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.95	0.00
C96	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.14	0.00
C97	1.00	0.01	0.00	0.00	0.54	0.46	0.00	0.00	0.81	0.00
C98	1.00	0.01	0.00	0.00	0.82	0.17	0.00	0.00	0.95	0.00

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  C99                    1.00    0.01   0.00   0.00   0.99   0.00   0.00   0.00   0.23
0.00


  ************************
  Conduit Surcharge Summary
  ************************

  ----------------------------------------------------------------------------
                                                            Hours        Hours
                         --------- Hours Full --------   Above Full   Capacity
  Conduit                Both Ends  Upstream  Dnstream   Normal Flow   Limited
  ----------------------------------------------------------------------------
  C1                          0.01      0.08      0.01      0.15          0.01
  C10                         0.01      0.01      1.60      0.01          0.01
  C105                        0.01      0.01      0.04      0.01          0.01
  C11                         0.01      0.01      0.02      0.01          0.01
  C12                         0.01      0.01      0.12      0.01          0.01
  C14                         0.01      0.01      0.12      0.01          0.01
  C18                         0.01      0.01      0.01      0.02          0.01
  C19                         0.01      0.01      0.15      0.01          0.01
  C2                          0.08      0.09      0.08      0.20          0.08
  C25                         0.01      0.01      0.11      0.01          0.01
  C3                          0.07      0.07      0.40      0.01          0.01
  C4                          0.02      0.02      0.07      0.05          0.01
  C5                          0.01      0.01      0.46      0.01          0.01
  C52                         0.01      0.01      0.01      0.08          0.01
  C61                         0.01      0.01      0.01      0.01          0.01
  C65                         0.01      0.01      1.28      0.01          0.01
  C66                         0.01      0.01      0.16      0.01          0.01
  C67                         0.01      0.02      0.01      0.12          0.01
  C68                         0.01      0.01      0.02      0.01          0.01
  C69                         0.01      0.01      0.13      0.01          0.01
  C78                         0.01      0.01      0.01      0.09          0.01
  C79                         0.01      0.01      0.44      0.01          0.01
  C83                         0.01      0.01      0.20      0.01          0.01
  C94                         0.01      0.01      0.04      0.01          0.01


  Analysis begun on:  Thu Oct 17 07:27:04 2019
  Analysis ended on:  Thu Oct 17 07:27:05 2019
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