

Civil Design Requirements for Developers

Part A: Integrated Stormwater Management

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REVISIONS AND AMENDMENTS

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List of Abbreviations

- Integrated Stormwater Management (ISWM)
- Model for Urban Stormwater Improvement Conceptualization (MUSIC)
- Site Environmental Management Plan (SEMP)
- Stormwater Treatment Objective Relative Measure (STORM) Calculator
- Water Sensitive Urban Design (WSUD)
- Special Building Overlays (SBO)
A planning scheme control that identify areas prone to overland flooding.
- Land Subject to Inundation Overlays (LSIO)
A planning scheme controls that apply to land affected by flooding associated with waterways and open drainage systems. Such areas are commonly known as floodplains.
- Floodway Overlays (FO)
Land which is identified as carrying active flood flows associated with waterways and open drainage systems. This overlay is categorised by depths in excess of one metre.

TABLE OF CONTENTS

1. Introduction.....4

2. Development Size.....4

3. Documents to be Submitted5

General Requirements6

4. Flood Management.....7

4.1 Floor Levels7

4.2 Overland Flowpaths.....7

4.3 Basement Garages7

4.4 Additional requirements for Large Scale developments & Road Designs8

5. Pipe capacity and storage8

5.1 Private Drainage Systems8

5.2 Council Drainage Systems.....11

6. Stormwater Treatment and Reuse.....14

6.1 Small Scale Developments14

6.2 Medium Scale Developments16

6.3 Large Scale Developments16

 Preliminary Approval Phase16

 Detail Design Phase.....18

6.4 Safety in Design.....19

6.5 Detail Design & Construction of WSUD Assets.....19

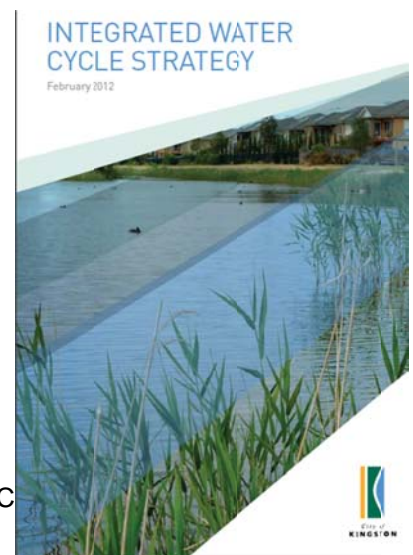
7. References.....21

8. Appendices.....21

Background

The Kingston Integrated Water Cycle Strategy was developed in 2012 to respond to climate changes and increased urbanization, which place immense pressure on every part of the water cycle including water security, stormwater quality, flooding, groundwater quality, wastewater quantity and waterway health.

The Strategy recognises that all elements of the water cycle are linked and need to be addressed holistically to meet Kingston’s goal of becoming a water sensitive city by 2040. The Strategy can be found on the City of Kingston website at www.kingston.vic.gov.au and provides details of the guiding principles of integrated water cycle management.



1. Introduction

The City of Kingston's 'Civil Design Requirements for Developers' consists of:

Part A: Integrated Stormwater Management [this Document].

Explains the requirements for addressing all aspects of stormwater management including:

- Flood management by catering for 1 in 100 year storm events – See section 4
- Pipe capacity and on-site detention systems – See section 5
- Water Sensitive Urban Design (WSUD) principles – See section 6
- Stormwater and rainwater reuse for potable water conservation – See section 6

and

Part B : Roads Design Standards and Presentation of Designs

Explains the presentation standards for submitting detailed drainage design plans and external roadworks plans for subdivisions and council assets.

This document forms one part of the broader 'Application for Planning Permit' process.

Applicants are encouraged to refer to the City of Kingston website www.kingston.vic.gov.au for further information including planning application flowchart, checklist and facts sheets or contact Council's Statutory Planning Department on **1300 653 356** to discuss the specifics relating to your development.

This document is intended for use by consultants with appropriate expertise and experience in the design, construction and maintenance of stormwater infrastructure. Where required, the external references listed under Section 7 should be used for further information and guidance.

2. Development Size

Council recognises that the type and complexity of information required should be proportional to the type of development taking into consideration the risks and opportunities associated with each.

The level of documentation required is based on the following categories of planning applications:

Small Scale

- Residential and/or mixed use developments of 1 to 2 dwellings.
- Residential developments and/or mixed use developments with a new building gross floor area greater than 500 m².
- Non-residential developments with a new gross floor area less than 500 m².

Medium Scale

- Residential and/or mixed use developments of 3 to 9 dwellings.
- Non residential developments with a new building gross floor area between 500m² and 1,000m².
- Subdivision of vacant land between 1,000m² and 4,999m².

Large Scale

- Residential and/or mixed use developments of 10 or more dwellings.
- Non residential developments with a new building gross floor area greater than 1,000m².
- Subdivision of vacant land greater than 4,999m².
- Subdivision of land involving public road networks or public open space as determined by Council.

3. Documents to be Submitted

The applicant’s proposed approach to Integrated Stormwater Management (ISWM) should be discussed with Council officer(s) during the preliminary consultant phase with the outcomes influencing the proposed development’s site layout and configuration as appropriate.

The following ***Integrated Stormwater Management*** documentation shall be submitted as part of the Council approval process. Further information will be requested where this documentation is incomplete or at Council’s sole discretion based on individual site or development characteristics.

Small Scale

- A signed copy of Kingston’s ***‘Development Engineer - On-site Drainage Declaration Form’*** that has been signed by the drainage designer (see attachment B).
- A set of Civil design drawings that document drainage and construction details.
- Drainage computations confirming onsite detention storage requirement (where applicable - see section 5).
- The provision of minimum 2000 litre rainwater tank clearly nominated for each new dwelling with water re-use for toilet flushing.
- Soil and percolation test report and computations (where applicable - see section 5.1).
- Please refer to sections 4.1, 4.2, 5.1 & 6.1 that are typically applicable to this type of development. Other sections may also apply.

Medium Scale

- A signed copy of Kingston’s ***‘Development Engineer - On-site Drainage Declaration Form’*** that has been signed by the drainage designer (see attachment B).
- A set of Civil design drawings that document construction details and cater for:
 - (i) Flood management requirements (see section 4).
 - (ii) Internal and external drainage requirements (see section 5).
 - (iii) Stormwater treatment & reuse requirements (see section 6).
- Drainage reports (e.g detention systems, pumps, soil and percolation tests & soakwell design) and computations confirming onsite detention storage requirement (see section 5).
- A copy of a STORM program output demonstrating how the proposal achieves 100% storm rating (see section 6).

Large Scale

- An ‘Integrated Water Management Plan’ in the form of a comprehensive report that addresses all the requirements of section 6.3
- MUSIC model outputs demonstrating how the proposal achieves best practice objectives.
- Stormwater layout drawings demonstrating how the proposed treatment system and drainage assets will function.
- A signed copy of Kingston’s ***‘Development Engineer - On-site Drainage Declaration Form’*** will be required if the development includes private drainage assets (see Attachment B).

All developments shall satisfy the following Council requirements (unless otherwise directed by Council) and the requirements of Melbourne Water (where they are the responsible drainage authority).

General Requirements

Typical requirements that may be imposed on a planning permit or at the building permit stage may include:

1. Stormwater drainage of the site must be provided so as to prevent any overflows onto adjacent properties and be directed to the nominated point of discharge;
2. The development of the site must be provided with stormwater works which incorporates the use of water sensitive urban design principles to improve stormwater runoff quality and which also retains on site any increase in runoff as a result of the approved development. The system must be maintained to the satisfaction of the Responsible Authority. Council's Development Engineer can advise on satisfactory options to achieve these desired outcomes which may include the use of an infiltration or bioretention system, rainwater tanks connected for reuse and a detention system;
3. The provision of minimum 2000 litre rainwater tank clearly nominated for each new dwelling with water re-use for toilet flushing;
4. Road Opening permits and applicable fees apply to connections to Council assets.
5. Plan Checking and Construction Supervision fees apply to all works which will become Council assets;
6. "All internal drainage works must be in accordance with AS/NZS 3500.3: 2015 Stormwater Drainage";
7. "All concrete works must comply with AS3600 - Concrete Structures Code";
8. "Minimum allowable concrete compressive strength is 32 MPa" at 28 days;
9. "All works within the road reserve and easement/laneway must comply with the City of Kingston Specification and Drawings current at the time of commencement of construction";
10. "The Contractor must contact Council's Development Engineer on ☎1300 653 356 seven (7) days prior to the commencement of any works within the road reserve/easement/laneway to arrange for an on-site inspection";
11. "The Contractor must provide to the Council a copy of their Public Liability Policy (to the value of \$20 million) which nominates Council as the interested party, prior to the commencement of any works in road reserve/easement/laneway";
12. "The Contractor must provide notice to all affected properties seven (7) days prior to the commencement of any works. The notice must include the Contractor's name and contact telephone number";
13. "At the completion of construction works, all areas disturbed during the construction are to be reinstated by the Contractor at the Contractor's cost";
14. "Builder Note: The infiltration system must be protected from silt during constructions works to maintain the design absorption rate";
15. The location of the existing trees to be retained and proposed trees as indicated on the endorsed landscaped plans must be verified prior to drainage works commencing, and any conflict must be reported to the designer for re-design;
16. Excavate all trenches by hand for the pipes/services within the tree protection zone/canopy drip line. This condition also applies to trees on neighbouring property where the tree protection zone/drip line occurs on the subject site. The Contractor must contact Council's Vegetation Management Officer to arrange for an on-site inspection.

4. Flood Management

All developments (small, medium & large scale) shall be designed to cater for 1 in 100 year storm events and shall address the following requirements as a minimum:

4.1 Floor Levels

All developments within designated flood overlay areas shall cater for the following freeboard above designated flood levels:

<u>Land subject to</u>	<u>Building Type</u>	<u>Minimum freeboard</u>
Special Building Overlay (overland flow path)	Main buildings / Extensions	300mm
Special Building Overlay (overland flow path)	Outbuilding / garage	150mm

Refer to the Victorian Planning Scheme for relevant Melbourne Water and Kingston overlays impacting on your development site.

In areas close to the coast or subject to risk of inundation from sea-level rise, floor levels should also account for sea-level rise forecasts in accordance with the policy described in the Kingston Planning Scheme from time to time. At the time of writing clause 13.01-1 of the Kingston Planning Scheme sets out policy that:

In planning for possible sea level rise, an increase of 0.2 meters over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill).

Plan for possible sea level rise of 0.8 metres by 2100 and, and allow for the combined effects of tides, storm surges, coastal processes and local conditions such as topography and geology when assessing risks and coastal impacts associated with climate change.

4.2 Overland Flowpaths

- The major storm drainage system may consist of overland flow along streets, through parks and through private property where floodways are constructed within easements;
- The drainage system shall be designed such that flooding from a 1 in 100 year storm will not:
 - (i) Flow over private property other than through a designated floodway;
 - (ii) Build up within private property such that it floods the floor of a dwelling, or commercial or industrial premises.
- Site levels shall cater for a 1 in 100 year ARI flowpath around all dwellings and garages to prevent inundation. Where this is not achievable, the design will need to include a storage system to detain 1 in 100 year flows from the upstream catchment.

4.3 Basement Garages

- The pavement level at the entrance into basements shall be designed and constructed a minimum of 100mm above the 1 in 100 year flows along the adjacent roadway. This requires a calculation of the depth and width of flows along the kerb and channel based on the upstream catchment area. Contact Council for further information.
- Based on the above calculation, the 'apex' at the top of the ramp (before it starts grading down) will need to be set at the required level in situations where the footpath level is insufficient to provide 100mm freeboard.

- Council does not accept sub-surface water (groundwater) into the stormwater system. It is the responsibility of the developer to dispose of any groundwater either on site or reach an agreement with the local sewer authority. This is particularly relevant for basement and subsurface structures. Refer to Council's "Basements and Deep Building Construction Policy 2014" and "Basements and Deep Building Construction Guidelines 2014" for further details.

4.4 Additional requirements for Large Scale developments & Road Designs

- Trapped low points in streets and reserves adjacent to private property shall only be permitted where an overland flow path that has been approved by Council can be provided which caters for the 100 year ARI storm event.
- All building entrances and surrounds, outdoor access areas, ingress and egress routes, streets, driveways, footpaths and cycle paths that are subject to flooding meeting the following safety criteria:

Maximum depth:	0.35 metres
Maximum velocity:	1.5 metres per second
Maximum depth x velocity:	0.35 metres squared per second

5. Pipe capacity and storage

All drainage designs shall comply with the current edition of Australian Rainfall and Runoff, published by the Institution of Engineers, Australia with computations based on the following criteria:

- Based on Rational method or alternative hydraulic program approved by Council.
- Rainfall intensity based on Bureau of Meteorology data for Kingston (see Appendix A).

5.1 Private Drainage Systems

The following requirements apply to the design and construction of privately owned and maintained drainage assets:

- Refer to section 5.2 where projects include public drainage assets such as easement drains or pipes within the road reserve.
- An application for a 'Legal point of Discharge' must be submitted (the application form is available on Council Website). Council will provide drainage information and applicable conditions. Only one nominated legal point of discharge can be used per site unless otherwise approved.
- The drainage designer must complete and submit the City of Kingston's: 'Development Engineer – On-site Drainage Declaration Form' (the form is available on Council Website) and submit with the required drainage documents.
- An 'Opening Permit' is required for all connections into Council's assets and shall be constructed in accordance with the relevant City of Kingston standard drawing (e.g S501: Connection to kerb & channel, S503: Connection to Council drain, etc).
- All private drainage shall be designed in accordance with AS/NZS 3500.3: 2015 Plumbing and drainage, Part 3: Stormwater Drainage.
- Stormwater discharging from the site, shall not exceed the 'Permissible Site Discharge' as detailed below.
- Detention of stormwater on site using 'water sensitive urban design' principles (e.g rainwater tanks with water re-use for toilet flushing, vegetated swales, porous pavers, infiltration systems, etc) to reduce stormwater run-off and improve discharge quality is required prior to discharge.

- Stormwater discharge shall be prevented from flowing onto adjacent properties.
- Groundwater shall not be allowed to discharge into the drainage system (see also section 4.3 for further information on basement garages).
- For connections into Council pipes, the Council pipe must be 225mm diameter or larger.
- No private drainage works shall be located within easements unless specifically requested by Council.

Permissible Site Discharge

The maximum piped stormwater discharge from the site shall not exceed the following requirements. Council reserves the right to vary these requirements to cater for unusual sites and/or to address significant limitations with the capacity of the existing drainage system.

(i) All residential developments shall be calculated based on:

- 1 in 5 year ARI storm event using a 'Coefficient of Runoff' based on $C=0.4$ regardless of the existing site imperviousness.
- 5 minute time of concentration for lots smaller than 1000 sqm and determined by the designer based on the critical storm duration for the lots greater than 1000sqm (see Appendix A for Kingston rainfall intensity charts).
- The difference in discharge rates between $C=0.4$ and post development (as a result of increased site imperviousness based on a 1 in 5 year ARI) shall be stored in accordance with the 'Onsite Detention' requirements detailed below.

(ii) All Industrial and Commercial developments shall be calculated based on:

- 1 in 10 year ARI storm event using a 'Coefficient of Runoff' based on the lower of; existing site imperviousness (where $C < 0.7$) or $C=0.7$ (maximum allowable upper limit due to a lack of capacity in the existing council drainage system).
Alternatively, the designer may choose to investigate the capacity of Council's downstream pipe network (to point where the pipe is at least 600mm diameter) to review the proposed impact of the development for Council's consideration.
- 7 minute time of concentration for lots smaller than 1000 sqm and determined by the designer for lots greater than 1000sqm (see Appendix A for Kingston rainfall intensity charts).
- Industrial developments shall store the difference between the 'permissible site discharge' rate (based on 1 in 10 year ARI) and the discharge rate for the proposed development based on a 1 in 10 year ARI storm event.
- Commercial developments shall store the difference between the 'permissible site discharge' rate (based on 1 in 10 year ARI) and the discharge rate for the proposed development based on a 1 in 10 year ARI storm event.
- Refer to 'Onsite Detention' requirements detailed below.

Onsite Detention

Onsite detention systems shall be designed in accordance with AS/NZS 3500.3 and the following requirements:

- All hard surfaces shall be included in calculations including all driveways, paved areas, garages and dwellings.
- Designers are encouraged to achieve storage requirements via appropriately designed WSUD elements as described under Section 6.

- All rainwater tanks shall be a minimum of 2,000 litres for each dwelling and connected to a minimum roof area of 50m² unless otherwise approved. Refer to section 6 for further guidance. Rainwater tanks can contribute towards storage volumes on the following basis: 500 litres of storage for each 2,000 litre tank or 1,000 litres of storage for tanks equal or greater than 2,500 litres.
- Where soakwells are proposed, a soil and percolation test by a geotechnical engineer must be provided (no exceptions). Acceptance of soakwells are subject to Council approval. As a minimum, they must:
 - Be above the groundwater level as indicated on a percolation report; and
 - The outside edge of the soakwell must to be least 2m away from building foundations and property boundaries.

Calculations shall be based on the Rational method, OSD4, Boyds method and designed to cater for the following criteria:

- 1 in 5 year ARI with piped overflow connected to the kerb and channel or Council drainage system, or
- 1 in 10 year ARI without a piped overflow but with an acceptable overland flow path.
- 1 in 100 year capacity at trapped low points.

Design plans and drafting standards

Plans of private drainage systems shall comply with the following minimum requirements:

- Plan to be drawn to scale at 1:100, 1:200 or 1:250.
- Plans size shall be a minimum of A3 with all text legible.
- Plans need to be submitted in hard copies unless advised by Council otherwise.
- Plans to include the following information as a minimum:
 - North point
 - Layout Plan showing all dwelling and drainage alignments (existing as well as proposed)
 - Pit numbers and pit schedule
 - Pavement makeup (typically concrete or asphalt)
 - Construction notes required by the City of Kingston
 - Details of all detention systems, tanks, soakwell or pump systems
 - Floor levels of all dwellings and garages (consistent with endorsed development / architectural plans, if applicable)
 - Percentage of impervious area on development site
 - Engineers contact details
 - Easements and council assets
 - All other additional details as directed by Council.

5.2 Council Drainage Systems

This section applies to the design and construction of drainage assets that will become the responsibility of Council.

Developers must comply with the following Council requirement and liaise with Melbourne Water (when required) for applicable conditions.

Design plans and drafting standards (for Council assets)

- Refer to 'Part B : Roads Design Standards and Presentation of Designs' for Council standards applicable to public drainage systems designed as part of subdivisions, external roadworks, outfall drains and easement drain.
- All works within the road reserve, public land and easements must be in accordance with the City of Kingston Standard Drawings and specification (the current version at the time of construction) which can be downloaded from Council's website www.kingston.vic.gov.au

Minor Flow Objectives

The underground drainage system designed to cater for minor flows shall:

- cater for the specified storm frequency
- limit flow through intersections and past tram crossings
- limit flow widths within the road reserve to a parking lane and/or back of path level
- Storm Frequency and Coefficient of Runoff shall be based on the following unless otherwise advised by Council:

<u>Land Use</u>	<u>Storm Frequency</u>	<u>Coeff. of Runoff</u>
Residential	1 in 5 year storm	0.6
Commercial	1 in 20 year storm	0.9
Industrial	1 in 10 year storm	0.9

Minimum Pipe Size

Pipes to be maintained by Council: 225 mm dia
Pipe sizes shall not decrease downstream.

Pipe Flow Velocity

- Minimum: 1 metre per second, running full.
- Maximum: 3 metres per second, running full.

Pipe Depth

Desirable minimum cover to be in accordance with manufacturer's specification or 450 mm whichever is greater.

Pipe Material

- Reinforced Concrete, rubber ring joints
- Fibre Reinforced Concrete, rubber ring joints
- UPVC, sewer quality, rubber ring or solvent joints (preferred material for easements)

Pipe Class

A pipe class shall be selected that will enable the pipe to withstand the working (service) loads resulting from overlying materials and superimposed loads for the particular installation.

Reinstatement

Reinstatement of any disturbed surfaces shall be undertaken in accordance with the City of Kingston's current Guidelines for Road Openings.

Sub-soil Drains

Sub-soil drains shall be laid behind all kerb and channel to adequately drain the road subgrade.

The sub-soil drains are to connect to the nearest downstream stormwater pit. Where a pit does not exist at the upstream end of the sub-soil drain, construct a 450mm x 450mm flushing pit with a 750mm x 750mm concrete frame and lid insert. Pit walls and base to be 150mm thick.

Sub-soil drains may not be necessary in coarse sandy soils. Approval for their omission must be obtained from Council's Representative.

Property Drain connections to Council Drain

- The design shall provide drainage for each property.
- All pipes and fittings for property drains within the road reserve (from individual allotments < 750sqm) shall be 100mm dia. SN8 sewer quality UPVC, with an inspection opening placed at each change of direction.
- Property drains shall connect to a piped drain or pit where available or into the kerb and channel. Connections to the front of a property shall be located at least 6 metres from the side boundary to maintain clearance to future vehicle crossings.
- Where property drains connects to a drain in an easement, a junction pit shall be provided at the point of connection.
- For connections into Council pipes, the Council pipe must be 225mm diameter or larger.
- Grades to be no flatter than 1 in 100 unless otherwise approved.
- Property drains shall connect to the kerb and channel at right angles. Where a minimum grade of 1 in 100 cannot be achieved, the pipe can be redirected to improve the grade. This distance shall not exceed 10 metres or extend in front of a neighbouring property.
- Property drain connections are to be kept clear of vehicle crossing locations.
- The location of property (house) drains shall be marked on the face of kerb with a "H", 50 mm high.

Stormwater Pits

Where practical, stormwater pits shall:

- be placed at all changes in direction, grade or pipe size.
- be spaced no more than 60 metres apart and spaced to reduce channel flow to the specified width.
- not be located within 1.0 metre of a vehicle crossing.
- be located at least 6 metres from side boundaries to maintain clearance to future vehicle crossings.
- have step irons where pit is deeper than 1.0 metre.
- be located at the upstream tangent point of kerb returns.
- in the case of an easement drain be positioned in the low corner of each property.

Pit Lids

Location	New Subdivisions and Industrial Areas	Other Areas
Side entry pits	R&S Grating – Eco-Lite	Concrete surround and insert
Side entry pits where vehicle damage is evident or likely	R&S Grating – Eco-Lite	R&S Grating – Eco-Lite
Junction pits in nature strips	R&S Grating – Eco-Lite	Concrete surround and insert
Junction pits in easements (not subject to vehicle loads)	Residential - Concrete surround and insert Industrial or Commercial - Concrete surround and insert	Concrete surround and insert
Junction pits in easements (subject to vehicle loads)	R&S Grating – Eco-Lite	R&S Grating – Eco-Lite
Junction pits in road pavements	Concrete filled cast iron complying with AS 3996	Concrete filled cast iron complying with AS 3996
Junction pits in vehicle crossings and footpaths	R&S Grating – Eco-Lite	R&S Grating – Eco-Lite

- Refer to City of Kingston Standard Drawings for pit details which can be downloaded from Council's website at www.kingston.vic.gov.au

6. Stormwater Treatment and Reuse

Water Sensitive Urban Design

Implementing Water Sensitive Urban Design (WSUD) principles are strongly encouraged for all development projects to ensure a sustainable approach to managing rain water and stormwater run-off.

The benefits of WSUD include:

- improvement to stormwater quality;
- water conservation;
- reduce local inundation; and
- outcomes that closely mimic the pre-developed natural system.

The City of Kingston's Integrated Water Cycle Strategy 2012 is available on Council's website at www.kingston.vic.gov.au

This strategy explains Council's aspirations and targets around pollution reduction and the provision of alternative water source for uses where potable water is not required (e.g. toilet flushing and garden irrigation).

Best Practice stormwater treatment objectives

The Best Practice Environmental Management Guidelines (BPEMG) were developed and published by the Victorian Stormwater Committee to establish specific stormwater quality objectives to meet the State Environmental Protection Policy (SEPP) requirements. The Victorian best practice performance objectives for removing target pollutants are:

- 80% of suspended solids
- 45% of total Nitrogen
- 45% of total Phosphorous
- 70% of litter

6.1 Small Scale Developments

The recommended tool for modeling stormwater treatment for basic systems is the Melbourne Water STORM Calculator. Applicants will need to achieve 100% storm rating. The calculator assesses whether best practice water quality objectives have been achieved for the site, and is available online at: www.storm.melbournewater.com.au

Rainwater Tanks

To meet council best practice standards for stormwater management, rainwater tanks should be sized to capture the majority of rainwater, and plumbed primarily for consistent year round water use (such as toilet flushing, washing machine, shower/bath and hot water service). If the year round consistent reuse of rainwater is not feasible on site, then the water reuse can be considered for secondary objectives such as irrigation of gardens/landscapes etc. Developments which do not meet this requirement must demonstrate how water efficiency can be satisfactorily achieved within the development.

Rainwater tanks shall be designed in accordance with the Criteria and Guidelines for Selection and Installation of Water Tanks at Kingston Council Facilities, 2007. These guidelines are applicable to installation of rainwater tanks for residential, commercial and industrial properties and can be found on City of Kingston's website.

The following standards for rainwater tanks apply:

- The recommended tool for sizing tanks is the *Alternative Technology Association's Tankulator*. Details are available at www.tankulator.ata.org.au
- All tanks shall be a minimum of 2,000 litres for each dwelling and connected to a minimum roof area of 50m² unless otherwise approved.
- The overflow pipe from the rainwater tank shall have a cross sectional area that is equal or greater than the cross sectional area of the inflow pipe(s).
- Tanks must be plumbed for toilet reuse and may be plumbed for other uses such as gardening, washing machine, shower/bath and hot water service. See SDAPP facts sheet 3.0 – Water Efficiency for further information.
- Pump size to be selected considering system end use flow demand for optimal pump energy efficiency.
- Rainwater tanks can contribute towards storage volumes on the following basis:
 - 500 litres of storage for each 2,000 litre tank or
 - 1,000 litres of storage for tanks equal or greater than 2,500 litres.
- Refer to the following publications for further guidance:
 - Use of Rainwater In and Around the Home (2007), EPA.
Refer to the EPA website for additional information and publications:
www.epa.vic.gov.au/your-environment/water/stormwater/stormwater-harvesting-and-use
 - With a Tank, the Choice is Yours!, South East Water.
 - Criteria and Guidelines for Selection and installation of Water Tanks at Kingston Council Facilities (2007). Refer to City of Kingston website under Water Conservation at:
www.kingston.vic.gov.au

Construction Site Management

Construction sites should apply Australian Best Practice to manage stormwater runoff, sediment and erosion during construction. Additional site management objectives include, but not limited to chemical contamination, dust, litter, concrete and other construction wastes.

The following references are recommended for construction stormwater management and can be found on the City of Kingston website:

- Kingston Building Stormwater Code of Practice
- Kingston Building Site Management Booklet
- Kingston Industry Stormwater Guidebook
- Kingston Factsheet: Sediment Control

Developers should adopt stormwater management systems and practices to protect Water Sensitive Urban Design (WSUD) assets prior to and during construction.

WSUD assets that will become the responsibility of Council shall be designed and constructed in accordance with the requirements of section 6.5.

6.2 Medium Scale Developments

The criteria is the same as for small scale developments (see section 6.1) however, Council has an expectation that applications relating to Medium Scale developments will be more comprehensive and investigate the opportunities to maximise best practice outcomes in more detail.

6.3 Large Scale Developments

Water Sensitive Urban Design

The applicant is encouraged to discuss preliminary WSUD opportunities and constraints with Council officers prior to formalizing a submission. The planning, design and maintenance of WSUD infrastructure should be in accordance with City of Kingston's requirements and the following publications which can be found on Melbourne Water's website:

- Water Sensitive Urban Design - Engineering Procedures: Stormwater, Melbourne Water, 2005
- Melbourne Water Constructed Wetlands Guideline, 2010
- WSUD Guidelines for Southeastern Councils, Melbourne Water, 2012
- Stormwater Biofiltration Systems Adoption Guidelines, Facility for Advancing Water Biofiltration (FAWB) Guidelines, 2009

Preliminary Approval Phase

Integrated Water Management Plan (IWMP)

An IWMP shall be submitted for Council approval prior to proceeding with the detailed stormwater design drawings. The IWMP shall take the form of a comprehensive report with associated functional drawings that demonstrate how the development meets best practice and satisfies Council's requirements.

The IWMP shall address the following:

- Flood management including allowance for overland flow (see section 4).
- A STORM program report demonstrating 100% rating (Medium scale) or a MUSIC program report demonstrating how best practice WSUD requirements are to be achieved.
- Stormwater network capacity, allowable discharge and onsite detention requirements.
- Integration between existing and proposed drainage systems.
- Proposed stormwater treatment system details.
- Stormwater quality modelling results (comparison against best practice pollution reduction targets via a MUSIC report or approved alternative).
- Comparison of water use demands vs proposed stormwater and rainwater reuse systems.
- Stormwater layout drawings demonstrating how the proposed treatment system and drainage assets will function. Drawings to be based on sufficient preliminary design and investigation of site constraints and levels to confirm the overall feasibility of the recommended solutions.
- Constructability and maintenance considerations including:
 - Silt and erosion control management during and after construction.
 - Strategy for protecting of filter media from construction activity.
 - Maintenance regime including costs, frequency, practicality and access arrangements.
 - Minimising energy use and greenhouse gas emissions
- Conclusions and recommendations

Sustainable Neighbourhoods provisions (Clause 56) introduced by the Department of Sustainability and Environment require all new residential subdivisions to meet the targets within each subdivision. Refer to Council for further details regarding the applicability of Melbourne Water's *Stormwater Quality Offsets Scheme*.

http://library.melbournewater.com.au/content/wsud/Stormwater_Quality_Offset_Scheme.pdf

Rainwater Tanks

Design calculations supporting tank size and expected potable water substitution shall be submitted to Council as part of the initial permit application. The recommended tool for sizing tanks is the *Alternative Technology Association's Tankulator*. Details are available at www.tankulator.ata.org.au

Detail Design Phase

WSUD assets that will become the responsibility of Council shall be designed and constructed in accordance with the requirements of section 6.5.

Modelling treatment performance

WSUD treatment performance should be modelled using MUSIC software or an approved alternative. Modelling can be completed for individual assets or for a collection of WSUD measures.

Refer to the MUSIC Guidelines (Melbourne Water, 2010) for more information on treatment nodes and associated input parameters.

Stormwater harvesting performance should be determined using a water balance model. MUSIC can provide a basic water balance model, however in some cases this may not be accurate enough and a more detailed model may need to be used. Demand profiles in the water balance model are typically estimated as a monthly percentage of an annual demand, however can also be input as an annual demand or daily demand. The system performance can be measured as a percentage of time that the water supply meets the demand. This can be calculated as a percentage for each time step in the model.

The following table summarises the City of Kingston's on input parameters:

Parameter	Council requirements														
Fraction impervious	Based on land use type. Refer MUSIC Guidelines (Melbourne Water, 2010) for typical values.														
Rainfall data to be used	<p>The Rainfall Distribution Plan in the MUSIC Guidelines (Melbourne Water, 2010) shows Kingston City Council sits within the following rainfall bands:</p> <table border="1"> <thead> <tr> <th>Model type</th> <th>Rainfall reference station</th> <th>Reference year</th> <th>Time step</th> </tr> </thead> <tbody> <tr> <td rowspan="2">Stormwater treatment</td> <td>Melbourne City (MAR 650-750mm)</td> <td>1966</td> <td rowspan="2">6 minute</td> </tr> <tr> <td>Koo Wee Rup (MAR 750-850mm)</td> <td>2004</td> </tr> <tr> <td>Stormwater harvesting</td> <td>Melbourne City (MAR 650-750mm) Koo Wee Rup (MAR 750-850mm)</td> <td>Up to 10 years of data</td> <td>1 day</td> </tr> </tbody> </table>	Model type	Rainfall reference station	Reference year	Time step	Stormwater treatment	Melbourne City (MAR 650-750mm)	1966	6 minute	Koo Wee Rup (MAR 750-850mm)	2004	Stormwater harvesting	Melbourne City (MAR 650-750mm) Koo Wee Rup (MAR 750-850mm)	Up to 10 years of data	1 day
Model type	Rainfall reference station	Reference year	Time step												
Stormwater treatment	Melbourne City (MAR 650-750mm)	1966	6 minute												
	Koo Wee Rup (MAR 750-850mm)	2004													
Stormwater harvesting	Melbourne City (MAR 650-750mm) Koo Wee Rup (MAR 750-850mm)	Up to 10 years of data	1 day												
Modelling for stormwater treatment	<ul style="list-style-type: none"> ▪ Rainfall data and time step should be based table above. ▪ Stormwater treatment assets should be chosen based on site characteristics and may include a combination of the following assets: <ul style="list-style-type: none"> ○ Wetlands, ○ Rain gardens, swales & WSUD Tree Pits, ○ Rainwater tanks, porous pavers & GPTs. ▪ Achieve Victorian best practice performance objectives. 														
Modelling for reuse	<ul style="list-style-type: none"> ▪ Rainfall data and time step should be based on the table above. ▪ The input demand profile should be determined for each site. 														

6.4 Safety in Design

The following safety issues should be considered in the detailed design of all private and public assets:

- site access (for construction and maintenance) – for staff and machinery/vehicles
- safety considerations for construction
- public access
- appropriate signage to identify risks (for example deep water, use of recycled water, confined spaces etc.)
- batters to open water (refer to Melbourne Water guidelines – wetlands and ponds)
- batters for maintenance – minimum of 1 in 5
- risks of using recycled water, refer to NWQMS Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) – Stormwater Harvesting and Reuse (2009)
- flood depths and water velocities

6.5 Detail Design & Construction of WSUD Assets

This section applies to the design and construction of WSUD assets that will become the responsibility of Council and may be used as a guide for assets that are privately owned.

Detail design drawings and reports shall be consistent with the approved preliminary design unless otherwise approved by Council. Documentation shall address the following requirements:

Rain Garden design

- Slope batters within 5m of trafficable or pedestrian areas shall not exceed 1 in 5 or alternatively shall be terraced with landscaped steps not exceeding 200mm in height.
- Filter media shall have a hydraulic conductivity of between 200mm/hr and 400mm/hr.
- Exposed landscaped surfaces to be covered with 75mm depth of crushed sandstone with 20mm nominal size.

Landscape and planting

Landscape and planting is an important component of WSUD not only for aesthetics but also for functionality. Landscape and planting plans are to be submitted with the detailed design.

Species that have proven to perform well within rain gardens constructed within streetscape around the City of Kingston include:

Plants	Ground Cover
Dietes Grandiflora (Wild Iris)	Carpobrotus glaucescens (coastal pigface)
Ficinia Nodosa (Knobby Club Rush)	Myoporum parvifolium (Creeping Boobialla)
Lomandra longifolia (Spiny-head Mat-rush)	
Gaura lindheimeri (Butterfly Bush)	

The following references provide further guidance on landscape and planting:

- Landscape Character Planting Guide (fact sheet)
- WSUD Engineering Procedures: Stormwater – Appendix A Suggested plant species for WSUD treatment elements (Melbourne Water, 2005)
- Constructed Wetlands Guidelines – Appendix 4 Suggested plant species for wetlands (Melbourne Water, 2010)
- Stormwater Biofiltration Systems Adoption Guidelines – Section 3.5.12 Vegetation (Facility for Advancing Water Biofiltration, 2009)

Construction, maintenance and defect liability requirements

The following construction and maintenance issues should be addressed and documented in the detailed design report:

- All items listed under section 6.1.
- Timing of construction of WSUD assets within site construction schedule and construction site management including measures to be implemented to protect assets during construction.
- Defect liability period and designation of maintenance and management responsibilities during plant establishment (first 12 months following construction). This is to be responsibility of developer for council owned assets.
- Proposed maintenance program including activity description, frequency and cost for plant establishment (first 2 years following construction) and ongoing maintenance and renewal activities.
- Asset handover arrangements including education of private owner on maintenance and management responsibilities or checklist for handover to council .
- A Site Environmental Management Plan (SEMP) may also be requested following the initial permit application review at the Council's discretion depending on individual site conditions.

The defect liability period applicable to WSUD assets owned by Council will commence following practical completion and is to be a minimum of 12 months unless otherwise agreed. Council may require a longer defects liability period where the circumstances are warranted, or where required by a relevant authority.

7. References

Integrated stormwater management systems are to be designed in accordance with requirements of the latest version of the following documents:

- Victorian Planning Provisions (Clause 55 and 56)
- State Environment Protection Policy (Waters of Victoria), Environment Protection Authority, 2003
- Urban Stormwater Best Practice Environmental Management Guidelines (CSIRO Publishing 1999)
- Australian Runoff Quality Guidelines (Engineers Australia)
- Australian Rainfall and Runoff (Institute of Engineers Australia)
- Land Development Manual (Melbourne Water)
- Fibre Reinforced Concrete Pipes and fittings (AS 4139-2003)
- Design for Installation of buried concrete pipes (AS 3725-2007)
- Specification and Supply of Concrete (AS 1379-2007)
- Grey Water Use around the Home and Code of Practice – Onsite Wastewater Management EPA Vic, www.epa.vic.gov.au
- Melbourne Water MUSIC Guidelines (2010)
- Water Sensitive Urban Design - Engineering Procedures: Stormwater, Melbourne Water, 2005
- Melbourne Water constructed Wetlands Guideline
- Kingston's Industry Stormwater Guidebook, 2007
- EPA Publication No. 275 Construction Techniques for Sediment Pollution Control, May 1991
- Water Sensitive Urban Design - Engineering Procedures: Stormwater, Melbourne Water, 2005
- Water Efficient Labeling and Standards Schemes (WELS), Australian Government waterrating.gov.au

8. Appendices

Appendix A – Kingston rainfall intensity tables

Appendix B – Development Engineer On-Site Drainage Declaration Form

Appendix A: Kingston rainfall intensity tables

ARI (YEARS) : 5

Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)
5.0	82.7	10.1	61.8	15.1	50.8	20.1	43.7	25.1	38.7	30.1	34.9
5.1	82.1	10.2	61.5	15.2	50.6	20.2	43.6	25.2	38.6	30.2	34.9
5.2	81.6	10.3	61.2	15.3	50.5	20.3	43.5	25.3	38.5	30.3	34.8
5.3	81.0	10.4	61.0	15.4	50.3	20.4	43.4	25.4	38.5	30.4	34.7
5.4	80.4	10.5	60.7	15.5	50.1	20.5	43.3	25.5	38.4	30.5	34.7
5.5	79.9	10.6	60.4	15.6	50.0	20.6	43.2	25.6	38.3	30.6	34.6
5.6	79.3	10.7	60.2	15.7	49.8	20.7	43.0	25.7	38.2	30.7	34.5
5.7	78.8	10.8	59.9	15.8	49.6	20.8	42.9	25.8	38.1	30.8	34.5
5.8	78.2	10.9	59.6	15.9	49.5	20.9	42.8	25.9	38.0	30.9	34.4
5.9	77.7	11.0	59.4	16.0	49.3	21.0	42.7	26.0	38.0	31.0	34.3
6.0	77.2	11.1	59.1	16.1	49.2	21.1	42.6	26.1	37.9	31.1	34.3
6.1	76.7	11.2	58.9	16.2	49.0	21.2	42.5	26.2	37.8	31.2	34.2
6.2	76.2	11.3	58.6	16.3	48.9	21.3	42.4	26.3	37.7	31.3	34.1
6.3	75.7	11.4	58.4	16.4	48.7	21.4	42.3	26.4	37.6	31.4	34.1
6.4	75.3	11.5	58.1	16.5	48.5	21.5	42.2	26.5	37.5	31.5	34.0
6.5	74.8	11.6	57.9	16.6	48.4	21.6	42.1	26.6	37.5	31.6	34.0
6.6	74.3	11.7	57.7	16.7	48.2	21.7	42.0	26.7	37.4	31.7	33.9
6.7	73.9	11.8	57.4	16.8	48.1	21.8	41.8	26.8	37.3	31.8	33.8
6.8	73.4	11.9	57.2	16.9	47.9	21.9	41.7	26.9	37.2	31.9	33.8
6.9	73.0	12.0	57.0	17.0	47.8	22.0	41.6	27.0	37.2	32.0	33.7
7.0	72.6	12.1	56.7	17.1	47.7	22.1	41.5	27.1	37.1	32.1	33.7
7.1	72.1	12.2	56.5	17.2	47.5	22.2	41.4	27.2	37.0	32.2	33.6
7.2	71.7	12.3	56.3	17.3	47.4	22.3	41.3	27.3	36.9	32.3	33.5
7.3	71.3	12.4	56.1	17.4	47.2	22.4	41.2	27.4	36.8	32.4	33.5
7.4	70.9	12.5	55.8	17.5	47.1	22.5	41.1	27.5	36.8	32.5	33.4
7.5	70.5	12.6	55.6	17.6	46.9	22.6	41.0	27.6	36.7	32.6	33.4
7.6	70.1	12.7	55.4	17.7	46.8	22.7	40.9	27.7	36.6	32.7	33.3
7.7	69.7	12.8	55.2	17.8	46.7	22.8	40.8	27.8	36.5	32.8	33.2
7.8	69.3	12.9	55.0	17.9	46.5	22.9	40.7	27.9	36.5	32.9	33.2
7.9	69.0	13.0	54.8	18.0	46.4	23.0	40.6	28.0	36.4	33.0	33.1
8.0	68.6	13.1	54.6	18.1	46.2	23.1	40.5	28.1	36.3	33.1	33.1
8.1	68.2	13.2	54.4	18.2	46.1	23.2	40.4	28.2	36.2	33.2	33.0
8.2	67.9	13.3	54.2	18.3	46.0	23.3	40.3	28.3	36.2	33.3	32.9
8.3	67.5	13.4	54.0	18.4	45.8	23.4	40.2	28.4	36.1	33.4	32.9
8.4	67.1	13.5	53.8	18.5	45.7	23.5	40.2	28.5	36.0	33.5	32.8
8.5	66.8	13.6	53.6	18.6	45.6	23.6	40.1	28.6	36.0	33.6	32.8
8.6	66.5	13.7	53.4	18.7	45.5	23.7	40.0	28.7	35.9	33.7	32.7
8.7	66.1	13.8	53.2	18.8	45.3	23.8	39.9	28.8	35.8	33.8	32.7
8.8	65.8	13.9	53.0	18.9	45.2	23.9	39.8	28.9	35.7	33.9	32.6
8.9	65.4	14.0	52.8	19.0	45.1	24.0	39.7	29.0	35.7	34.0	32.6
9.0	65.1	14.1	52.6	19.1	44.9	24.1	39.6	29.1	35.6	34.1	32.5
9.1	64.8	14.2	52.4	19.2	44.8	24.2	39.5	29.2	35.5	34.2	32.4
9.2	64.5	14.3	52.2	19.3	44.7	24.3	39.4	29.3	35.5	34.3	32.4
9.3	64.2	14.4	52.0	19.4	44.6	24.4	39.3	29.4	35.4	34.4	32.3
9.4	63.9	14.5	51.9	19.5	44.4	24.5	39.2	29.5	35.3	34.5	32.3
9.5	63.6	14.6	51.7	19.6	44.3	24.6	39.1	29.6	35.3	34.6	32.2
9.6	63.3	14.7	51.5	19.7	44.2	24.7	39.1	29.7	35.2	34.7	32.2
9.7	63.0	14.8	51.3	19.8	44.1	24.8	39.0	29.8	35.1	34.8	32.1
9.8	62.7	14.9	51.2	19.9	44.0	24.9	38.9	29.9	35.1	34.9	32.1
9.9	62.4	15.0	51.0	20.0	43.8	25.0	38.8	30.0	35.0	35.0	32.0
10.0	62.1										

ARI (YEARS) : 10

Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)
5.0	98.6	10.1	73.3	15.1	59.9	20.1	51.4	25.1	45.4	30.1	40.8
5.1	97.9	10.2	72.9	15.2	59.7	20.2	51.2	25.2	45.3	30.2	40.8
5.2	97.2	10.3	72.6	15.3	59.5	20.3	51.1	25.3	45.1	30.3	40.7
5.3	96.5	10.4	72.3	15.4	59.3	20.4	51.0	25.4	45.0	30.4	40.6
5.4	95.9	10.5	71.9	15.5	59.1	20.5	50.8	25.5	44.9	30.5	40.5
5.5	95.2	10.6	71.6	15.6	58.9	20.6	50.7	25.6	44.8	30.6	40.4
5.6	94.5	10.7	71.3	15.7	58.7	20.7	50.6	25.7	44.7	30.7	40.4
5.7	93.9	10.8	71.0	15.8	58.5	20.8	50.4	25.8	44.6	30.8	40.3
5.8	93.3	10.9	70.6	15.9	58.3	20.9	50.3	25.9	44.5	30.9	40.2
5.9	92.6	11.0	70.3	16.0	58.1	21.0	50.1	26.0	44.4	31.0	40.1
6.0	92.0	11.1	70.0	16.1	57.9	21.1	50.0	26.1	44.4	31.1	40.1
6.1	91.4	11.2	69.7	16.2	57.7	21.2	49.9	26.2	44.3	31.2	40.0
6.2	90.8	11.3	69.4	16.3	57.6	21.3	49.8	26.3	44.2	31.3	39.9
6.3	90.3	11.4	69.1	16.4	57.4	21.4	49.6	26.4	44.1	31.4	39.8
6.4	89.7	11.5	68.8	16.5	57.2	21.5	49.5	26.5	44.0	31.5	39.8
6.5	89.1	11.6	68.5	16.6	57.0	21.6	49.4	26.6	43.9	31.6	39.7
6.6	88.6	11.7	68.2	16.7	56.8	21.7	49.2	26.7	43.8	31.7	39.6
6.7	88.0	11.8	68.0	16.8	56.6	21.8	49.1	26.8	43.7	31.8	39.5
6.8	87.5	11.9	67.7	16.9	56.5	21.9	49.0	26.9	43.6	31.9	39.5
6.9	86.9	12.0	67.4	17.0	56.3	22.0	48.9	27.0	43.5	32.0	39.4
7.0	86.4	12.1	67.1	17.1	56.1	22.1	48.7	27.1	43.4	32.1	39.3
7.1	85.9	12.2	66.8	17.2	55.9	22.2	48.6	27.2	43.3	32.2	39.2
7.2	85.4	12.3	66.6	17.3	55.8	22.3	48.5	27.3	43.2	32.3	39.2
7.3	84.9	12.4	66.3	17.4	55.6	22.4	48.4	27.4	43.1	32.4	39.1
7.4	84.4	12.5	66.0	17.5	55.4	22.5	48.3	27.5	43.0	32.5	39.0
7.5	83.9	12.6	65.8	17.6	55.2	22.6	48.1	27.6	42.9	32.6	39.0
7.6	83.4	12.7	65.5	17.7	55.1	22.7	48.0	27.7	42.9	32.7	38.9
7.7	82.9	12.8	65.2	17.8	54.9	22.8	47.9	27.8	42.8	32.8	38.8
7.8	82.5	12.9	65.0	17.9	54.7	22.9	47.8	27.9	42.7	32.9	38.8
7.9	82.0	13.0	64.7	18.0	54.6	23.0	47.7	28.0	42.6	33.0	38.7
8.0	81.6	13.1	64.5	18.1	54.4	23.1	47.5	28.1	42.5	33.1	38.6
8.1	81.1	13.2	64.2	18.2	54.3	23.2	47.4	28.2	42.4	33.2	38.5
8.2	80.7	13.3	64.0	18.3	54.1	23.3	47.3	28.3	42.3	33.3	38.5
8.3	80.2	13.4	63.7	18.4	53.9	23.4	47.2	28.4	42.2	33.4	38.4
8.4	79.8	13.5	63.5	18.5	53.8	23.5	47.1	28.5	42.2	33.5	38.3
8.5	79.4	13.6	63.3	18.6	53.6	23.6	47.0	28.6	42.1	33.6	38.3
8.6	79.0	13.7	63.0	18.7	53.5	23.7	46.9	28.7	42.0	33.7	38.2
8.7	78.6	13.8	62.8	18.8	53.3	23.8	46.7	28.8	41.9	33.8	38.1
8.8	78.1	13.9	62.6	18.9	53.1	23.9	46.6	28.9	41.8	33.9	38.1
8.9	77.7	14.0	62.3	19.0	53.0	24.0	46.5	29.0	41.7	34.0	38.0
9.0	77.3	14.1	62.1	19.1	52.8	24.1	46.4	29.1	41.6	34.1	37.9
9.1	76.9	14.2	61.9	19.2	52.7	24.2	46.3	29.2	41.6	34.2	37.9
9.2	76.6	14.3	61.7	19.3	52.5	24.3	46.2	29.3	41.5	34.3	37.8
9.3	76.2	14.4	61.4	19.4	52.4	24.4	46.1	29.4	41.4	34.4	37.7
9.4	75.8	14.5	61.2	19.5	52.2	24.5	46.0	29.5	41.3	34.5	37.7
9.5	75.4	14.6	61.0	19.6	52.1	24.6	45.9	29.6	41.2	34.6	37.6
9.6	75.1	14.7	60.8	19.7	52.0	24.7	45.8	29.7	41.2	34.7	37.6
9.7	74.7	14.8	60.6	19.8	51.8	24.8	45.7	29.8	41.1	34.8	37.5
9.8	74.3	14.9	60.3	19.9	51.7	24.9	45.6	29.9	41.0	34.9	37.4
9.9	74.0	15.0	60.1	20.0	51.5	25.0	45.5	30.0	40.9	35.0	37.4
10.0	73.6										

ARI (YEARS) : 20

Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)
5.0	119.8	10.1	88.6	15.1	72.1	20.1	61.6	25.1	54.3	30.1	48.8
5.1	118.9	10.2	88.1	15.2	71.8	20.2	61.4	25.2	54.1	30.2	48.7
5.2	118.1	10.3	87.7	15.3	71.6	20.3	61.3	25.3	54.0	30.3	48.6
5.3	117.3	10.4	87.3	15.4	71.3	20.4	61.1	25.4	53.9	30.4	48.5
5.4	116.4	10.5	86.9	15.5	71.1	20.5	60.9	25.5	53.8	30.5	48.4
5.5	115.6	10.6	86.5	15.6	70.8	20.6	60.8	25.6	53.6	30.6	48.3
5.6	114.8	10.7	86.1	15.7	70.6	20.7	60.6	25.7	53.5	30.7	48.2
5.7	114.0	10.8	85.7	15.8	70.4	20.8	60.4	25.8	53.4	30.8	48.1
5.8	113.3	10.9	85.3	15.9	70.1	20.9	60.3	25.9	53.3	30.9	48.0
5.9	112.5	11.0	84.9	16.0	69.9	21.0	60.1	26.0	53.2	31.0	47.9
6.0	111.7	11.1	84.5	16.1	69.6	21.1	59.9	26.1	53.0	31.1	47.8
6.1	111.0	11.2	84.2	16.2	69.4	21.2	59.8	26.2	52.9	31.2	47.7
6.2	110.3	11.3	83.8	16.3	69.2	21.3	59.6	26.3	52.8	31.3	47.6
6.3	109.6	11.4	83.4	16.4	68.9	21.4	59.5	26.4	52.7	31.4	47.5
6.4	108.8	11.5	83.0	16.5	68.7	21.5	59.3	26.5	52.6	31.5	47.5
6.5	108.1	11.6	82.7	16.6	68.5	21.6	59.1	26.6	52.4	31.6	47.4
6.6	107.5	11.7	82.3	16.7	68.3	21.7	59.0	26.7	52.3	31.7	47.3
6.7	106.8	11.8	82.0	16.8	68.0	21.8	58.8	26.8	52.2	31.8	47.2
6.8	106.1	11.9	81.6	16.9	67.8	21.9	58.7	26.9	52.1	31.9	47.1
6.9	105.5	12.0	81.3	17.0	67.6	22.0	58.5	27.0	52.0	32.0	47.0
7.0	104.8	12.1	80.9	17.1	67.4	22.1	58.4	27.1	51.9	32.1	46.9
7.1	104.2	12.2	80.6	17.2	67.2	22.2	58.2	27.2	51.8	32.2	46.8
7.2	103.5	12.3	80.3	17.3	67.0	22.3	58.1	27.3	51.7	32.3	46.8
7.3	102.9	12.4	79.9	17.4	66.8	22.4	57.9	27.4	51.5	32.4	46.7
7.4	102.3	12.5	79.6	17.5	66.5	22.5	57.8	27.5	51.4	32.5	46.6
7.5	101.7	12.6	79.3	17.6	66.3	22.6	57.6	27.6	51.3	32.6	46.5
7.6	101.1	12.7	79.0	17.7	66.1	22.7	57.5	27.7	51.2	32.7	46.4
7.7	100.5	12.8	78.6	17.8	65.9	22.8	57.3	27.8	51.1	32.8	46.3
7.8	99.9	12.9	78.3	17.9	65.7	22.9	57.2	27.9	51.0	32.9	46.2
7.9	99.4	13.0	78.0	18.0	65.5	23.0	57.1	28.0	50.9	33.0	46.2
8.0	98.8	13.1	77.7	18.1	65.3	23.1	56.9	28.1	50.8	33.1	46.1
8.1	98.3	13.2	77.4	18.2	65.1	23.2	56.8	28.2	50.7	33.2	46.0
8.2	97.7	13.3	77.1	18.3	64.9	23.3	56.6	28.3	50.6	33.3	45.9
8.3	97.2	13.4	76.8	18.4	64.7	23.4	56.5	28.4	50.5	33.4	45.8
8.4	96.6	13.5	76.5	18.5	64.5	23.5	56.4	28.5	50.4	33.5	45.7
8.5	96.1	13.6	76.2	18.6	64.3	23.6	56.2	28.6	50.3	33.6	45.7
8.6	95.6	13.7	75.9	18.7	64.1	23.7	56.1	28.7	50.2	33.7	45.6
8.7	95.1	13.8	75.6	18.8	64.0	23.8	55.9	28.8	50.1	33.8	45.5
8.8	94.6	13.9	75.3	18.9	63.8	23.9	55.8	28.9	49.9	33.9	45.4
8.9	94.1	14.0	75.0	19.0	63.6	24.0	55.7	29.0	49.8	34.0	45.3
9.0	93.6	14.1	74.8	19.1	63.4	24.1	55.5	29.1	49.7	34.1	45.3
9.1	93.1	14.2	74.5	19.2	63.2	24.2	55.4	29.2	49.6	34.2	45.2
9.2	92.6	14.3	74.2	19.3	63.0	24.3	55.3	29.3	49.5	34.3	45.1
9.3	92.1	14.4	73.9	19.4	62.8	24.4	55.2	29.4	49.4	34.4	45.0
9.4	91.7	14.5	73.7	19.5	62.7	24.5	55.0	29.5	49.3	34.5	44.9
9.5	91.2	14.6	73.4	19.6	62.5	24.6	54.9	29.6	49.2	34.6	44.9
9.6	90.8	14.7	73.1	19.7	62.3	24.7	54.8	29.7	49.1	34.7	44.8
9.7	90.3	14.8	72.9	19.8	62.1	24.8	54.6	29.8	49.1	34.8	44.7
9.8	89.9	14.9	72.6	19.9	62.0	24.9	54.5	29.9	49.0	34.9	44.6
9.9	89.4	15.0	72.3	20.0	61.8	25.0	54.4	30.0	48.9	35.0	44.5
10.0	89.0										

ARI (YEARS) : 100

Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)	Tc (min)	Intensity (mm/hr)
5.0	176.1	10.1	129.0	15.1	104.1	20.1	88.4	25.1	77.5	30.1	69.4
5.1	174.8	10.2	128.3	15.2	103.7	20.2	88.1	25.2	77.3	30.2	69.3
5.2	173.6	10.3	127.7	15.3	103.3	20.3	87.9	25.3	77.1	30.3	69.1
5.3	172.4	10.4	127.1	15.4	102.9	20.4	87.6	25.4	76.9	30.4	69.0
5.4	171.1	10.5	126.5	15.5	102.6	20.5	87.4	25.5	76.8	30.5	68.9
5.5	169.9	10.6	125.8	15.6	102.2	20.6	87.1	25.6	76.6	30.6	68.7
5.6	168.7	10.7	125.2	15.7	101.8	20.7	86.9	25.7	76.4	30.7	68.6
5.7	167.6	10.8	124.6	15.8	101.5	20.8	86.6	25.8	76.2	30.8	68.4
5.8	166.4	10.9	124.0	15.9	101.1	20.9	86.4	25.9	76.1	30.9	68.3
5.9	165.3	11.0	123.5	16.0	100.7	21.0	86.2	26.0	75.9	31.0	68.2
6.0	164.1	11.1	122.9	16.1	100.4	21.1	85.9	26.1	75.7	31.1	68.0
6.1	163.0	11.2	122.3	16.2	100.0	21.2	85.7	26.2	75.5	31.2	67.9
6.2	161.9	11.3	121.7	16.3	99.7	21.3	85.4	26.3	75.4	31.3	67.8
6.3	160.9	11.4	121.2	16.4	99.4	21.4	85.2	26.4	75.2	31.4	67.6
6.4	159.8	11.5	120.6	16.5	99.0	21.5	85.0	26.5	75.0	31.5	67.5
6.5	158.7	11.6	120.1	16.6	98.7	21.6	84.7	26.6	74.8	31.6	67.4
6.6	157.7	11.7	119.5	16.7	98.3	21.7	84.5	26.7	74.7	31.7	67.2
6.7	156.7	11.8	119.0	16.8	98.0	21.8	84.3	26.8	74.5	31.8	67.1
6.8	155.7	11.9	118.5	16.9	97.7	21.9	84.1	26.9	74.3	31.9	67.0
6.9	154.7	12.0	117.9	17.0	97.3	22.0	83.8	27.0	74.2	32.0	66.9
7.0	153.7	12.1	117.4	17.1	97.0	22.1	83.6	27.1	74.0	32.1	66.7
7.1	152.7	12.2	116.9	17.2	96.7	22.2	83.4	27.2	73.8	32.2	66.6
7.2	151.8	12.3	116.4	17.3	96.4	22.3	83.2	27.3	73.7	32.3	66.5
7.3	150.8	12.4	115.9	17.4	96.1	22.4	82.9	27.4	73.5	32.4	66.3
7.4	149.9	12.5	115.4	17.5	95.8	22.5	82.7	27.5	73.3	32.5	66.2
7.5	149.0	12.6	114.9	17.6	95.4	22.6	82.5	27.6	73.2	32.6	66.1
7.6	148.1	12.7	114.4	17.7	95.1	22.7	82.3	27.7	73.0	32.7	66.0
7.7	147.2	12.8	113.9	17.8	94.8	22.8	82.1	27.8	72.9	32.8	65.8
7.8	146.3	12.9	113.5	17.9	94.5	22.9	81.9	27.9	72.7	32.9	65.7
7.9	145.4	13.0	113.0	18.0	94.2	23.0	81.7	28.0	72.5	33.0	65.6
8.0	144.6	13.1	112.5	18.1	93.9	23.1	81.4	28.1	72.4	33.1	65.5
8.1	143.7	13.2	112.1	18.2	93.6	23.2	81.2	28.2	72.2	33.2	65.4
8.2	142.9	13.3	111.6	18.3	93.3	23.3	81.0	28.3	72.1	33.3	65.2
8.3	142.1	13.4	111.1	18.4	93.0	23.4	80.8	28.4	71.9	33.4	65.1
8.4	141.3	13.5	110.7	18.5	92.7	23.5	80.6	28.5	71.8	33.5	65.0
8.5	140.5	13.6	110.2	18.6	92.5	23.6	80.4	28.6	71.6	33.6	64.9
8.6	139.7	13.7	109.8	18.7	92.2	23.7	80.2	28.7	71.5	33.7	64.7
8.7	138.9	13.8	109.4	18.8	91.9	23.8	80.0	28.8	71.3	33.8	64.6
8.8	138.1	13.9	108.9	18.9	91.6	23.9	79.8	28.9	71.2	33.9	64.5
8.9	137.4	14.0	108.5	19.0	91.3	24.0	79.6	29.0	71.0	34.0	64.4
9.0	136.6	14.1	108.1	19.1	91.1	24.1	79.4	29.1	70.9	34.1	64.3
9.1	135.9	14.2	107.7	19.2	90.8	24.2	79.2	29.2	70.7	34.2	64.2
9.2	135.2	14.3	107.3	19.3	90.5	24.3	79.0	29.3	70.6	34.3	64.0
9.3	134.4	14.4	106.8	19.4	90.2	24.4	78.8	29.4	70.4	34.4	63.9
9.4	133.7	14.5	106.4	19.5	90.0	24.5	78.6	29.5	70.3	34.5	63.8
9.5	133.0	14.6	106.0	19.6	89.7	24.6	78.4	29.6	70.1	34.6	63.7
9.6	132.3	14.7	105.6	19.7	89.4	24.7	78.3	29.7	70.0	34.7	63.6
9.7	131.6	14.8	105.2	19.8	89.2	24.8	78.1	29.8	69.8	34.8	63.5
9.8	131.0	14.9	104.8	19.9	88.9	24.9	77.9	29.9	69.7	34.9	63.4
9.9	130.3	15.0	104.5	20.0	88.7	25.0	77.7	30.0	69.6	35.0	63.2
10.0	129.6										



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