PART D.WASTEWATER AND STORMWATER NETWORK DESIGN

CONTENTS

DEFINITIONS

DEFINITIONS

Unless the context indicates otherwise:

“Culvert”	Means any stormwater pipe whose length is less than 20 meters. It does not mean a large drain or a drain made from brick.
“Infiltration”	Is extraneous flow that enters the sewer system through faults in the integrity of the pipes. It is typically a constant flow over a day, and is normally present in all sewers. Such faults include: leaking joints, cracked or corroded pipes, porous pipes and broken pipes.
“Inflow”	Is extraneous water which enters the sewer system directly from sources other than those causing infiltration. It typically varies greatly over a day and is usually associated with rainfall or very high tides. It normally comes from faults in the layout of the drainage system or from overflows from the stormwater system. Examples of faults which cause inflow are: the connection of rainwater downpipes to sewer gully traps, cross connections of private stormwater leads to sewer mains and connections of sumps to sewer mains.
“New City Datum “ (NCD)	The datum reference used by WCC. Mean sea level (WHB standard) = RL 0.012m NCD. To convert readings from the New Zealand tide tables to NCD subtract 0.912m from the tide table figures. To convert Old City Datum to NCD, convert from feet to metres, then subtract 11.57m
“Drain”	A generic term for streams, watercourses or enclosed pipes. Can be either wastewater or stormwater.
“Drainage Engineer”	“The Drainage Engineer is as designated by the Wellington City Council Infrastructure Director.

"Stormwater" Stormwater is rain which has not evaporated or percolated to ground. Most runs off hard, impervious surfaces such as roads, roofs, car parks and surface water, and some runs off, hillsides and other land areas,

The stormwater network includes the pipes, tunnels and culverts and watercourses.

"Wastewater" Wastewater, also known as 'sewage', originates from household activities (toilets, kitchens, bathrooms and laundries) and commercial and industrial premises. It is predominantly water but includes organic matter such as human waste, food scraps, fats, oil and grease, and pharmaceuticals, chemicals, paint and other debris.

The wastewater (or sanitary sewer) network includes the pipes, tunnels, pumping stations, rising mains and treatment plants.

"Watercourse" Includes open channels or streams including ephemeral streams

OBJECTIVES

The objective of the wastewater section of this Code is to have a safe, affordable, reliable, environmentally friendly public wastewater network.

The objective of the stormwater section of the Code is ensure the public stormwater network protects property, public health and the environment by the safe disposal of rainwater and associated runoff.

No type or form of stormwater network shall be connected to any wastewater network.

GENERAL PERFORMANCE CRITERIA

The criteria within this chapter apply throughout the city to all urban and rural areas. They apply to all alterations, amendments or addition to the public wastewater and stormwater networks whether they are for Council, Council agent's contracts, or for land development to provide new services. They also will apply to all utility service operators wishing to alter existing services.

The engineering design of any alterations, amendments or additions to the public stormwater and/or wastewater networks shall:

- define the scope of works and incorporate all of the components required for the intended project
- be legible and understandable and supported by sufficient drawings, calculations, reports and associated documentation to facilitate appraisal
- position pipe layout to conform to natural fall, as much as possible
- provide sufficient information for construction purposes
- provide for :
    - safety
    - the whole of the catchment
    - sudden or catastrophic failure
    - future development
    - efficiency in operation and maintenance
- be prepared and endorsed by a suitably qualified and experienced person

- demonstrate compliance with resource consent conditions, this Code and other regulatory and statutory requirements
- position pipelines to avoid conflict with other services
- be a platform for approvals and acceptance
- be buildable.

All wastewater and stormwater networks shall be designed for an asset life of at least 100 years, with appropriate maintenance. The design is to minimise lifecycle costs for the whole period.

Assets designed to minimise capital cost at the expense of overall lifecycle cost will not be accepted.

The constructed public drainage network must be:

- functional,
- resilient,
- cost-effective; to construct, maintain and operate. Whole of Life" cost must be considered

Detailed requirements and standards for construction are set out in the "Wellington City Council Drainage Network Construction Specification"

D.1 GENERAL DRAINAGE DESIGN CONSIDERATIONS

D.1.1 Diverted Catchments

No development, subdivision, or other works altering, adding to, or amending the public drainage network may cause water to be diverted from one catchment to another either directly or indirectly.

D.1.2 Design for Earthquakes and Settlement

All network structures shall be designed with adequate flexibility and special provisions to minimise the risk of damage during earthquake or differential settlement.

Flexible joints are required at all junctions between rigid structures (wet-well, manholes, dry-wells, pumping stations, streams and bridge crossings etc) and natural or made ground – detailed requirements/standards for construction are set out in the "Wellington City Council Drainage Network Construction Specification"

D.1.3 Provision of Drains

As part of a proposed land development; public drains shall be provided by the developer to enable separate connections to all proposed lots and building platforms.

The Drainage Engineer may allow a lateral to run across one property to serve another, under easement.

D.1.4 Design Fieldwork

Although electronic data relating to the wastewater and stormwater networks is available and is useful in the feasibility stage of a design, the final design shall be based on information confirmed by carrying out topographical surveys, levelling (in particular accurate manhole inverts) and field checks/investigation (i.e. manhole inspections).

D.1.4.1 Levels

All network levels shall be in terms of "New City Datum" (Mean Sea Level).

Invert levels shall be calculated to at least two decimal places and shall be accurate to +/-20mm.

Levels shall be taken from an approved benchmark, unless written dispensation is granted by the Public Drainage Engineer: where access to a benchmark is not possible or reasonable.

With written dispensation levels may be taken from the invert of an existing drain, provided there is no significant drop in the manhole. The accuracy of any invert used under dispensation must be established before use.

Council will require the source of all data used for the design to be documented on submitted plans and documents.

D.1.4.2 Confirming position of other services / utilities

All service / utility authorities / owners shall be contacted at the start of the design process to establish the location of any / all services within the design area.

If a service authority has services in the design area, copies of their service plans are to be obtained. Any services near the proposed design area are to be shown on the proposal plan.

There shall be a minimum clearance of 300mm vertical and horizontal between a public drain and other services.

The accurate position of services which are potentially in conflict with the network shall be confirmed as part of the design process; by digging test holes and /or using ground penetrating radar, depth finding locators etc.

D.1.5 Drawings and Plans

All drawings and plans submitted for approval must be in accordance with the current Wellington City Council Drawing and Asbuilt Specification - Drainage and Water Networks.

D.1.6 Consultation with Utility Authorities

Further to D.1.4.2, prior to submitting a design to Council; utility authorities / owners, of services within the design area, are to have been consulted to gain their clearance. They may have requirements for working near their service or additional information.

If a conflict has been established (refer D.1.4.2) there may need to be further consultation to discuss modifying or shifting of a service – this shall be carried out as part of the design process.

The consultation is to include the option of the service authority adding a service of their own during construction.

D.1.7 Lateral Connections

Any design replacing, relocating, or abandoning existing parts of the public drainage network shall include establishment of active lateral connections to the relevant sections of the network.

The design will allow for reconnecting, extending or relaying all active laterals and connections, where required.

All proposed sections and building platforms of a development require separate connections to the public drainage network.

A lateral connection/reconnection table shall be submitted as part of the design and construction plan documentation. Refer to the Wellington City Council – Drainage and Water Network Drawing and Asbuilt Specification.

D.2 APPROVALS

D.2.1 Approval to alter, amend or add to the Public Drainage Network

Approval to alter, amend or add to the Public Drainage network will only be given if, prior to any works starting, the following have been prepared, submitted and written approval gained:

- design and construction plans – including long sections, catchment plan, locality plan and details – refer to the Wellington City Council Water and Drainage Network Drawing and Asbuilt Specification.
- for stormwater designs, a plan showing the secondary flow path – this can be included on the catchment plan if suitable.
- design calculations - calculations shall include all design assumptions and any specific structural design as appropriate
- for designs relating to developments of 20 units/ lots or more, a full catchment study must be submitted for approval to the Drainage Engineer

- an analysis of the impact of the proposed development on the existing stormwater and / or wastewater system capacity

NOTE: If the existing stormwater or wastewater system is under capacity, the developer is responsible for the upgrade of the affected network as a part of the conditions of approval.

- Utility Authority clearance – refer to D.1.6
- Road Corridor Manager approval
- written approval from the Drainage Engineer for dispensation/s to the code of practice where any part of design falls outside this Code.
- a Wellington City Council Drainage Network Design Certificate: refer to D.2.3
- a resource consent from Greater Wellington Regional Council if altering, amending or discharging stormwater to a natural watercourse.
- a Wellington City Council land use resource consent is required for work within 5m of a watercourse.

Note: These items must be prepared by a chartered professional engineer and/or a competent and experienced person approved by the Drainage Engineer.

D.2.2 Approval for Assets to become Public Drainage Network

Council will only consider taking ownership and vesting of works carried out under D.2.1, if the following have been prepared, completed and submitted:

- all approvals, consents & dispensations have been applied for and approved / given in writing
- the drains have been designed using this code of practice
- a public Drainage Permit has been uplifted – as applicable
- a Wellington City Council: Drainage Network Design Certificate

- a Wellington City Council: Drainage Network Contractors Certificate Upon Completion and / or a Wellington City Council: Drainage Network Certificate Upon Completion, to be submitted: refer to D.2.3, as required.

- all works shall have been constructed to meet the requirements set out in the Wellington City Council Drainage Network Construction Specification and other applicable standards

- any changes to the approved construction drawings, during construction, must be documented along with reasons for changes, and approval for said changes by the Drainage Engineer.

- the assumptions made in the design have been fulfilled in construction

- evidence that all testing required has been carried out and that the results comply with relevant specifications.

- the work passes final inspection, which shall routinely include CCTV inspection and others as required –refer to Wellington City Council Drainage Network Construction Specification

- compliant “As Built” plans have been provided - refer to the Wellington City Council Water and Drainage Network Drawing and Asbuilt Specification

Alternative stormwater solution proposals must meet the performance objectives of this code and the Building Code (Clause E1 Surface Water). The detail of proposals will be subject to building consent and Drainage Engineer approval.

Rural Sanitary Sewer Septic Tanks and effluent disposal systems must meet the performance objectives of this code, be in compliance with section E1 of the Building Code and be approved by the Drainage Engineer.

Council provisions for wastewater and stormwater disposal and treatment are based on the following statutory documents:

- Resource Management Act 1991
- Local Government Act 2002
- Building Act 1991
- Health Act 1956

- Health and Safety in Employment Act 1992
- Civil Defence Emergency Management Act 2002
- Soil Conservation and Rivers Control Act 1941
- Utilities Access Act 2010
- New Zealand Building Code – Clause E1, Surface water

D.2.3 Certification Certificates

These certificates are, based on producer statements under the Building Code and similar certificates in NZS4404. They are required to be submitted with the design and upon completion of construction – as applicable.

There are three certificates:

1. **Wellington City Council: Drainage Network Design Certification:**

   This certificate states that the designer is taking professional responsibility for the design submitted.

2. **Wellington City Council: Drainage Network Contractors Certification Upon Completion:**

   This certificate from the contractor states that works have been carried out and construction completed in accordance with a contract, approved drawings and code / specifications.

3. **Wellington City Council: Drainage Network Certification Upon Completion:**

   This certificate from an approved certified engineer states that from observation and review of information supplied by the contractor the works have been carried out in compliance with the contract, approved drawings and the code and specifications.

Refer to Appendix D for copies of certificates.

D.3 STORMWATER NETWORK

The objective of a well designed public stormwater network is to regulate stormwater surface run-off and control groundwater levels to protect property, public health and the environment.

Potential adverse results of a poorly designed stormwater network include flood damage, surface and channel erosion and sedimentation, water pollution, loss of biodiversity and damage to aquatic ecosystems.

A well designed public stormwater network serves four functions:

1. conveying storm surface run-off with minimal flood damage;
2. control of water quality;
3. protection of bio-diversity and ecological function;
4. ground water control and protection.

All four aspects are to be considered in the engineering design of any section of public stormwater network.

Stormwater pumping stations will not be approved for sub-divisional development.

Stormwater network design is divided in to three elements:

1. **General stormwater design criteria:** relating primarily to the collection and transportation of stormwater to a nominated point in the network. – Refer to sections D.3.1- D.3.7

2. **Stormwater hydrological design:** relates to determining the peak flow from a catchment for critical rainfalls – Refer to sections D.4 – D.5.7

3. **Hydraulic design of wastewater & stormwater networks:** hydraulic design relates to calculating the behaviour of the flow once inside a network system – Refer to section D.7 – D.13

The design methods presented here are considered “acceptable solutions” for the purposes of complying with the objectives and performance criteria of this standard. Deviation from these methods will be considered with suitable evidence that the method is equivalent in relevance and application.

D.3.1 General Stormwater Design Criteria

All public stormwater networks shall be designed to the following criteria:

- They meet all relevant criteria defined within this document.
- Remove, or direct stormwater ruff-off in a manner that protects people, property, and the environment from adverse effects.
- Provide a secondary flow path clear of all buildings and high use areas.
- Cater for the whole of the design catchment.
- Provide/consider for future development.
- Water quality to be maintained or enhanced.
- Land stability and erosion control maximised.
- Soil moisture content optimised.
- On going maintenance costs of assets minimised.
- Be compatible with connecting networks.
- Not interfere with other utilities.
- Avoid the likelihood of blockage.
- Provide gravity connections for each allotment.
- Low level of pipeline infiltration/ex-filtration/inflow over the life of the system.
- Have resistance to penetration of tree roots.
- Structurally designed to resist applied loads.
- Where possible all stormwater flow shall be by smooth gravity flow in evenly graded pipes.
- Where applicable provide for fish passage; e.g. culvert construction.
- All stormwater drains shall be designed as a separate network with no cross-connections with the wastewater network.

All drains are to be sized to current requirements regardless of the downstream pipe size. Where existing downstream drains are under-capacity, the Drainage Engineer shall be notified. The capacity of a drain shall not be less than that of the drain upstream.

Introducing Alternative Stormwater Management Solutions:
Urban areas need to be drained to remove surface water that could cause flooding. Conventionally, this was done using pipes to convey water away as quickly as possible. This concentrated flow and can lead to problems such as erosion and flooding elsewhere in the catchment. Intensive urban development is generating runoff that exceeds the networks design capacity.

Emphasis has turned to reducing the flow volume and the contaminants in the stormwater discharged into receiving environments. These objectives can be partly met through on-site stormwater management, which involves retaining the runoff to reduce peak flows and/or to filter out contaminants at source.

Where practical alternative approaches to stormwater management including attenuation and/or some disposal on site will be considered. This is for the primary purpose of controlling the peak stormwater flow and preventing the further degradation of the water quality and ecology in receiving waters. There is also the prospect of these options being a more cost effective solution than simply using pipes.

Other methods (not covered within this document) may be more suited to some complex catchments, but in those cases it must be demonstrated explicitly that the design and results are at least as conservative as if the rational method was used throughout, as described in the Sections below and approved by the Drainage Engineer. This provides a consistent approach to built works within the city.

D.3.1.1 Climate change considerations

Current mean high water springs[3] in Wellington Harbour is 0.835m. In July 2008 the Ministry for the Environment issued updated guidance to local government on the impacts of climate change.

3 The dividing line between land and sea under both the Resource Management Act and Foreshore & Seabed Act.

The advice included updated information on sea level rise and advice on what assumptions Council should make when planning for activity in coastal zones or building/maintaining infrastructure/buildings in coastal zones with timeframes out to the 2090s.

Council is planning for a sea-level rise of 0.8m by 2090. Beyond 2100, Council is currently planning for sea-level rise of 10cm per decade. These values may be adapted in future as more information is made available.

Note: Where a drains capacity is affected by the sea level it shall be designed assuming the sea-level is at 1.35m NCD.

D.3.2 Water Quality

Stormwater quality consideration is a Resource Management Act (RMA) requirement. There is a growing importance being placed on the quality of stormwater.
Stormwater treatment devices may be required to avoid adverse water quality effects on receiving waters. Special consideration may be required where the proposed stormwater discharges directly to a watercourse or coastal waters.

Strategies to treat water at source or near the top of the catchment are to be encouraged. The practicalities of this are fully recognised; lifecycle costs are unreasonable and in Wellington the topography and geology are not always suitable. Where the possibility of treatment by means of wetlands or retention exists though, the opportunity is to be considered and may be required.

Water can be treated and quality enhanced through a range of best management practice alternative solutions, forming a treatment train. Water quality work is best implemented through integrated catchment management plans or other planning mechanisms that incorporate the principles of low impact urban design and development. This helps to meet the Council's outcomes of a healthier environment and a more sustainable city.

D.3.3 Secondary Flow Path

The secondary flow path is the path stormwater would take if the primary drain was in-operable; either due to blockage or flow (rainfall) exceeding design capacity.
Lots shall be shaped so that they fall towards roadways, which may be used as secondary flow paths.

Secondary flow velocities are to be kept low, except where it is unavoidable on hillsides. On hillsides the secondary flow is to be channelled as directly & safely as possible to a public stormwater network.

Where the secondary flow path cannot, by good design, be kept on a roadway, it should be sited through public land such as reserves, parks. Secondary flow paths over private property shall be protected with an easement in favour of the Council and must be avoided. Minimum floor levels may apply if a secondary flow path crosses private property.
Designers shall demonstrate that existing and proposed dwellings are not affected by the secondary flow during the design storm event. The secondary flow path shall be designed so erosion or land instability will not occur.

The secondary flow path should be sited to ensure that it remains unobstructed throughout the life of the subdivision. Where extensive damage could result from obstruction of the secondary flow path land should be formally reserved, configured or other steps taken to ensure that further development does not reduce the efficiency of the flow path.

The secondary flow path shall be shown on the submitted design and subsequent as-built plans.

D.3.3.1 Formed secondary flow path

A formed secondary flow path is required when there is only one intake on a stormwater drain.

They shall be sited to ensure that they remain unobstructed.

It is preferred that the road / carriageway be used for this purpose.

This formed flow path shall be sized as follows:

- When there is only one intake; all of the stormwater flow.
- When there is a secondary intake in addition to the primary intake, the difference between a 50 year flow and the capacity of the stormwater system assuming the primary intake is blocked.

D.3.3.2 Flow on carriageways

Secondary and primary flow along a carriageway shall have standard kerbs edge blocks directed to standard Council sumps (Section C.5). The rear of the footpath shall be above the kerb level.

D.3.4 Watercourses

Council's Biodiversity Action Plan (2007) states that the natural character of watercourses are to be retained wherever possible. Major watercourses and their natural character shall be retained wherever possible, and be located in public reserves. Piping more than dry weather flow in large watercourses is often unnecessary and uneconomic.

All development work should be located away from the riparian buffer where possible and impediments to the natural flow with barriers to fauna should be avoided.

There shall be no general modification of an existing stream system unless it is for flood mitigation purposes, and there are no viable alternative flood management methods available.

Short lengths of piping within intensive built up areas maybe considered.

Resource consent from Greater Wellington Regional Council is required in any proposal to alter, amend or discharge stormwater to a natural watercourse.

Wellington City Council land use resource consent is required for work within 5m of a watercourse, wetland or the marine area; except the following areas:

- Within 10m of the suburban centre area adjoining the Porirua Stream from the intersection of Main Road (Tawa) and Middleton Road and extending north
- Within 20m in rural areas.

D.3.4.1 Flood levels in watercourses

When setting flood levels for watercourses a nominal freeboard allowance of 0.3m is to be included. Consideration is also to be made for wave action, possible constrictions and possible deficiencies in assumptions made such as roughness coefficients.

D.3.4.2 Bridges over watercourses

Where a bridge is proposed to cross a watercourse the design shall allow for a minimum of 500mm freeboard between the level of the water during peak design flows, and the underside of any part of the bridge structure.

As far as practical and reasonable the design of the bridge shall minimise potential adverse effects to the floodway or adjacent property, including from overdesign floods or obstruction and accumulation of detritus by the bridge.

A Building Consent is required for any proposed bridge structure.

D.3.5 Entries to and Exits from Stormwater Systems

The entry or intake to any piped stormwater system needs to be protected to avoid the entry of material which would result in limiting of flow, the pipe blocking or safety issues.

This is normally addressed by the construction of either:

1. a standard intake grid / grill – refer to D.3.5.3
2. or an advanced grid – *also know as a debris trap – refer to D.3.5.4*

An access way must be provided to the entrance of all intakes for inspection and maintenance.

All structures are to be constructed in reinforced concrete and have a tidy, site suitable appearance.

Culverts and pipe outfalls are to be constructed to allow fish passage to enable the fish to migrate further upstream. Further information can be found in Chapter F Open Spaces.

Intakes and outlets of a piped stormwater network shall be designed to accept or release the design flow without scour or erosion of the area surrounding the pipe entrance or exit.

D.3.5.1 Intake structures

In general, the intake structure shall be a RRJ concrete pipe flush with the headwall – refer to the Wellington City Council Drainage Construction Specification. Such an intake has an entrance loss coefficient of 0.2. If an alternative headwall structure is used the intake shall be constructed in accordance with the entrance loss assumed in the design.

All intake structures shall meet the requirements set out below:

- All pipe intakes are to be provided with adequate wing walls, aprons and detritus traps and/or pits to prevent scouring or blocking.
- In general, the minimum height of headwall above the design stream flow should be 300mm and the headwalls should extend 300mm above finished ground level.
- Barriers complying with Building Act shall be required above an intake where a fall of 1 m or greater is possible from above the intake headwall, and where public access is possible.
- Provision shall be made so that no water can bypass the inlet structure and flow into compacted fill or areas where damage may occur.

Note: Details of the proposed entrance shall be detailed on the drawings.

D.3.5.2 Secondary Intakes

The need for a secondary intake shall be investigated for each design.

When there is serious risk of damage from heading-up or overtopping a secondary intake must be provided.

The preferred form of secondary intake in a confined ponding area is a mushroom intake, where entry of floating debris into the intake is minimised.

Protection may be necessary where the water returns to the stream and in other places where a secondary intake is used.

The design of any secondary intake shall be based on the assumption that the main intake is completely blocked.

D.3.5.3 Standard intake grids

Standard intake grids must be placed on all pipe entries, refer to the Wellington City Council Drainage Construction Specification for standard structures.

All grids shall meet the requirements set out below:

- The grid shall be bolted to the headwall using hot dipped galvanised or stainless steel bolts.
- The grid shall be bolted to the headwall in such a fashion that it can be readily replaced.
- The grid shall consist of a vertical front face of a height at least equal to the pipe diameter and a sloping "top". The angle of the top shall be steeper than 1 in 4 (v to h)
- The vertical portion of the grid shall be at the greater of 500mm or one pipe diameter from the headwall.
- The maximum gap in the grid or any point between the grid and the headwall on a pipe less than 675mmϕ shall be 115mm[4].
- For pipes equal to or greater than 675mmϕ, the maximum gap in the grid shall either be less than 115mm or greater than 450mm[5].
- Grids shall be sufficiently strong to resist the impact of any debris which may come down the water-course.

[4] This is to prevent a child entering the drain.

[5] This is to allow an adult to squeeze through to rescue a child.

- Grids which can physically be cleaned by an excavator should be constructed from a material sufficiently strong to resist the impact of an excavator bucket. As a guide, grid members with a section modulus (Z) of 1.2 cm^3 have proven to be suitable for grids on drains of about 450mm - 600mm diameter.

- The top grill of the grid shall not protrude out in front of the vertical grill (to avoid the risk of an excavator bucket catching/ripping the top grill off).

D.3.5.4 Advance Grid or Debris Traps

Advanced grids or debris traps may be required upstream of an intake at the request of the Drainage Engineer.

An advanced grid or debris trap may be required upstream of larger diameter pipe or tunnel entrances.

The advanced grid shall be a coarse screen designed to restrict the entry of large objects (i.e. logs) into the intake structure. Typically these are constructed from vertically set steel railway sections or similar. The screen's bar spacing shall be approximately 1.5 times the diameter of the intake pipe.

D.3.5.5 Grid Access-ways

Access-ways are to be constructed to allow inspection and maintenance of all intake structures. The access way must lead to an area big enough for machinery to work at the intake.

- Access-ways to intakes on drains 375mm diameter or smaller shall be suitable for pedestrian access and should be suitable for wheel barrow use.

- Access-ways to intakes on drains over 375mm diameter shall be suitable for vehicle access and machinery.

Access-ways to intakes larger that 375mm shall be appropriately designated to ensure that access will always be available. In general, either an easement or a right of way would be suitable. The access should be at least 3m wide and no steeper than 1 in 5 and suitable for use by trucks. In exceptional circumstances, the Drainage Engineer may approve an access suitable for plant only. Under no circumstances though, will approval be given for an access steeper than 1 in 2. There must be room for plant to work at the intake.

The access shall be in public land or protected by an easement.

D.3.5.6 Pipe Outlets, Outfalls, and Energy Dissipaters

The discharge from a development must be approved by the Drainage Engineer.

The outlet or outfall from either a public drain or a private drain must be either to the public stormwater network or an approved alternative stormwater disposal solution.

Adequate provision shall be made to prevent scour when returning water from a section of piped drain outlet to a watercourse. Approved dissipating structures are to be provided at outlets.

The outlet from a piped stormwater may also require a grid to address safety issues. The need for an outlet grid will depend on the site location, and is to be discussed with the Drainage Engineer.

Stormwater outfalls should avoid the discharge of contaminated stormwater to streams, the harbour and coastal areas or other water bodies.

Discharging to land sloping down to receiving waters is to be avoided where possible.

Further details and requirements:

- Discharging to land may be considered where the designer can demonstrate that the flows can be controlled, there are no adverse environmental effects and overland flow is contained to within the developer’s property before reaching an acceptable/approved receiving body of water.

- Discharging to land will not be considered where the slope is large and scouring is likely.
- Where significant turbulence is likely, such as at a large change in cross-sectional area, specific measures shall be taken to eliminate scour and erosion of the receiving drain. This may take the form of protective aprons and linings of the receiving channel or flow calming or energy dissipating structures.
- As a general rule, exit velocities in drains of up to 1.8 m/s may be tolerated without specific energy dissipation structures. Short duration flows up to 3 m/s may be tolerated if it can be shown that the channel is in stable strong ground, potential maintenance has been considered and addressed, and the consequences of erosion are small.
- Where the outlet discharges to a natural stream or channel, the outlet shall, as a minimum, be protected by a proprietary wing wall structure, concrete apron and concrete embedded downstream riprap with the intention of reducing scouring velocities. Any structure should be designed to minimise the collection of debris. Where collection of debris is likely, access considerations equivalent to those of an intake (see section D.3.5.1) shall be incorporated into the design to allow for removal of the debris.

Directing outfall to streams or the sea may require resource consent from Greater Wellington Regional Council.

Consideration towards the Freshwater Plan and Coastal Plan should be made when proposing direct discharges to streams, rivers and coastal areas.

An energy dissipater may be required at the outlet of a drain.

D.3.6 Subsoil Drains in Earth Fills

Additional to the requirements set in the Earthworks Chapter B are the following conditions:

The recommendations of NZS 4431:1989, Code of Practice for Earthfill for Residential Development shall be followed except where otherwise specified in this code:

Permanent subsoil drains shall be installed except where all of the following criteria can be demonstrated:

- There are no natural springs which will discharge at the base of the fill
- Positive provisions (e.g. cut-off subsoil drain) are made to prevent surface runoff entering the fill at the exposed fill/natural ground contact.
- The natural ground on which the fill is to be placed is contoured and scarified prior to the placement of fill to ensure that, over the whole base of the fill, the fill can be fully compacted to specification and continuity achieved between the fill and natural ground.
- The fill material is uniform, of relatively low permeability and is not erodible.

D.3.6.1 Surface infiltration cut-off drains

Subsoil drains to prevent water entry at exposed fill/natural ground contacts shall skirt the fill area at approximately 1 m below finished level.

The drains shall be permanent drains detailed as set out below, but with the upper 200 mm of the trench backfilled with a high permeability capping material.

The exit point location and the disposal of flows shall be as for permanent subsoil drains.

D.3.6.2 Sub-soil drains

Permanent sub-soil drains shall be laid as public drains and a Public Drainage permit obtained. The requirements for a public drain will in general apply, though the access requirements may be eased.

Subsoil drains shall be constructed as follows:

- They should be laid in a narrow trench, though if the loading permits, they may be laid in the cleaned out bed of the old water course with gentle horizontal and vertical curves. There shall be no abrupt changes in grade.

- The drains in the main gullies shall be a minimum diameter of 225mm and shall be at least one pipe size larger than any connecting branch drain.
- Branch drains shall be laid in all adjacent gullies and to any wet areas such as a spring.
- Branch drains shall be a minimum of 100mm diameter and shall be connected to the main by means of Y junctions only. Open butt joints will not be permitted.
- Where the design load allows, perforated concrete, or HDPE pipes may be used:
- These pipes must all be bedded and surrounded with a minimum of 150mm of suitable graded filter material. Alternatively a suitable permanent filter fabric may be placed around granular pipe bedding in lieu of the graded filter.
- Where the design load precludes the use of these pipes or where significant localised inflows or ground water are to be intercepted then drain shall be laid as a sealed drain of adequate strength and may have multiple branches with multiple inlets to collect ground water.
- Where perforated pipes can not be used stones larger than the pipe diameter shall be hand placed over the inlets. The larger stones are to be covered with 50mm of ballast. A suitable graded filter material shall be placed over this ballast.
- Where perforated pipes are used, the ends of the branch drains shall be sealed off and the drain backfilled as normal.
- They shall have a surface opening, in the form of a manhole and in some circumstances lamphole cleaning eyes, at the top and bottom ends to facilitate flushing of the line.
- All sub-soil drains must be connected to a manhole at, at least one point.

D.3.6.3 Pipes under fill

All pipes under fills shall be of a suitable capacity to cope with the design storm with no surcharge at the inlet.

Where the design storm is less than the 100 year flow, design checks shall be carried out under the 100 year design flow to assess the extent of the surcharge and to show that it will not present a risk to the stability of the adjacent embankments or increase the flooding risk to upstream properties. If either of these situations applies, the pipe size shall be increased to overcome the problem.

Grills are not typically required for intake to pipes under fill unless specifically requested by the Drainage Engineer.

Pipes under fill are required to have access provisions for clearing similar to those of intakes as outlined in section D.4.5.1.

D.3.7 Alternative Stormwater Disposal Solutions

Well designed and maintained alternative systems can not only reduce adverse environmental effects but also enhance amenity and ecological values.

Alternative stormwater disposal solutions with the aim of allowing infiltration and filtering to occur will be considered on a case by case basis subject to appropriate site investigations, geotechnical survey; and specific engineering design.

The topography, slope, neighbouring properties, etc of the development shall be considered in approving the design. The successful implementation of alternative solutions depends on individual circumstances. Each application will be assessed against criteria which include topography and soakage.

Alternative solutions involving soakage as a means of stormwater disposal will only be considered when there is sufficient proven soakage capability available on the section and subject to satisfactory test by an engineer. Available soakage can be established from the Department of Building and Housing’s Verification Method E1/VM1 December 2000.

Where topography, soils and slope permit vegetated channels should be used to convey and treat stormwater. Where soils and slope are not suitable for vegetated channels, rock lined channels or other filtration practices will be considered.

New Zealand Water and Environmental Research Foundation's (NZWERF) On-Site Stormwater Management Guideline provides the information needed to select and design appropriate on-site stormwater management devices for the majority of applications in New Zealand. A combination of devices will be favoured.

The design guide SNZHB44:2001, Subdivision for People and the Environment promotes innovation in developments and provides alternative methods of compliance.

Alternative solutions sometimes rely on secondary flow paths to a much greater extent than conventional piped systems, particularly for large long storms in saturated conditions producing excessive runoff. These flow paths require careful conservative design and protection into the future – refer to D.3.3

Alternative stormwater solution proposals must meet the performance objectives of this code and the Building Code (Clause E1 Surface Water) and the detail of proposals will be subject to building consent approval.

Note: Approval of alternative solutions will be subject to the Drainage Engineers approval.

D.3.7.1 Ongoing Maintenance of Alternative Stormwater Solutions

Council requires that sufficient information is provided by the applicants to address on going management and maintenance considerations i.e. private versus public ownership of infrastructure, and future maintenance of components of alternative solutions.

On public land, where Council is to have the asset vested, alternative solutions are to be designed such that Council is willing to maintain the device.

Alternative solutions should have the same or better whole life costs than gravity piped systems.

Council will not maintain alternative solutions constructed on private land. Any devices on private land will be contained within the property and are to have an overflow to the reticulated system. This is to ensure if the alternative system fails, there is no adverse effect.

D.3.7.2 Detention, attenuation and retention structures

Attenuation and detention systems temporarily detain runoff on a site before discharging flow to a pipe network or watercourse.

Retention systems temporarily retain runoff then disposes of flow on site by infiltration.

Detention systems must have formed access for maintenance to at least the standard required for intakes (refer to D.3.5.1), and are subject to specific design.

Moderate lengths of oversized pipes may also be used for detention purposes with provision for overflow to the downstream pipeline. Manholes are to be provided at each end. Provision for other utility services is to be considered during design including passage across or through the detention pipe.

Alternative “on site” detention and retention systems typically receive stormwater from small scale impervious areas such as individual sections and temporarily detain run off to meet one or more of the following :

- Flow and volume control
- Water quality control, i.e. to filter out contaminants associated with sediments
- Provide dispersal, i.e. through an infiltration trench

Sufficient soakage capability available on the section should be proven and is subject to satisfactory test by an engineer.

Overflows from such a system must drain to an approved outfall and the downstream systems have sufficient capacity to carry the full flow.

D.4 STORMWATER NETWORK HYDROLOGICAL DESIGN

The rational method is a simple and commonly used technique used to calculate peak discharge for stormwater catchments which are less than 500ha – refer to Equation 1.

Peak discharges for stormwater catchments greater than 500 ha are calculated using the modified rational method – refer to Equation 2.

D.4.1 Peak flow determination: Rational method

The Rational Method to be used for catchments under 500ha is:

Equation 1:

$$Q = \frac{CiA}{360}$$

Where:

Q = Peak discharge (m^3/s)
C = Runoff coefficient (dimensionless) – *refer to section D.4.4*)
i = Rainfall intensity (mm/hour)
A = area of catchment (hectares)

Determination of rainfall intensity (i) requires analysis of the time for concentration (Tc) which is covered further in section D.4.6

D.4.2 Peak flow determination: Modified rational method

The Modified Rational Method to be used for catchments over 500ha is:

Equation 2:

$$Q = \frac{CiASF}{360}$$

Where:

Q = Peak discharge
C = Runoff coefficient (dimensionless)
i = Rainfall intensity (mm/hour)
A = area of catchment (hectares)
S = Shape factor
F = Area Factor

D.4.2.1 Determining Shape factor (S) and Area factor (F)

Shape factor (S) and Area factor (F) can be either determined from using tables or calculated using formula.

S and F can be determined using the formula below:

Equation 3:

$$S = 0.4253 + 1.266k - 0.3952k^2$$

(but not less than 0.8)

Equation 4:

$$k = \frac{A}{100 \quad L^2}$$

Where L (km) is the straight line length to catchment head

Equation 5:

$$F = 0.6 + 0.4e^{\left(\frac{-A}{7700}\right)}$$

Or **S** and **F** can be determined from the following table:

k:	0.33	0.35	0.40	0.45	0.50	0.60	0.80	1.00	1.20	1.40	1.60
s:	0.80	0.82	0.87	0.91	0.96	1.04	1.19	1.30	1.38	1.42	1.44

A (ha):	500	800	1,000	1,500	2,000	3,000	5,000	7,000	10,000
F:	0.975	0.96	0.95	0.93	0.91	0.87	0.81	0.76	0.71

Table 1: Determining Shape (S) and area (F) factors

D.4.3 Stormwater Catchment Area

The catchment used for all stormwater design calculations shall be all the area that drains or could physically and legally drain to the point under consideration.

Note: The ground is to be considered to be fully saturated from previous rain.

The limits of a given catchment area are the normally heights of land-often called drainage divides, or watersheds-separating it from neighbouring drainage systems.

All stormwater design calculations should be based on the catchment that can be expected to ultimately exist when the catchment is fully developed as allowed under the District Plan.

A catchment may be split into a number of area types where each area type has a runoff coefficient – refer to Table 2 below.

Catchment areas will usually need to be calculated manhole to manhole; as additional flow entering from connections (including sumps & private laterals) along a pipeline may require the diameter of downstream sections to be larger than the upper pipeline sections.

Catchment area is normally expected to be calculated in hectares (ha).

D.4.4 Runoff Coefficient - C

The runoff coefficient is the fraction of the rainfall which reaches the stream by flowing off the surface. The ground is considered to be saturated from previous rain.

Area	Coefficient C
Fully paved/CBD areas or urban areas with greater than 65% coverage: industrial, commercial and institutional areas	0.95
Urban areas allowing between 36% and 65% impervious site coverage (inner residential, infill housing, intensive residential development)	0.70
Urban areas allowing coverage up to 35% (residential or outer areas)	0.50
Parks, reserves, green spaces, rural areas	0.35

Table 2: Runoff Coefficients (C) - Minimum runoff coefficients

A catchment may include more than one type of area, runoff coefficient.

Where the catchment has more than one area type, the design runoff coefficient shall be calculated as follows:

Equation 6:

$$C = \frac{(c1 \times a1) + (c2 \times a2)}{A}$$

Where:

C	= Design Runoff coefficient (dimensionless)
c1,c2	= runoff coefficients for each area type
a1,a2	= area of catchment for each area type (ha)
A	= total area of catchment (ha)

D.4.5 Rainfall Intensity - i

The design rainfall intensity is the intensity of a constant intensity design storm having the specified design return period and duration equal to the time of concentration for the drainage area.

Rainfall intensity is to be determined from the Wellington City Council intensity-duration-frequency graph in Figure 1: after having established the values of the following parameters:

- Duration of critical storm, which equals the time of concentration - refer to section D.4.6
- Return period of the design storm - refer to section D.4.7

Note: Rainfall intensities gained from the intensity-duration-frequency graph shown in figure.1 should be increased by 16% to accommodate the predicted effects of climate change as at 2011[6].

[6] The Ministry for the Environment has published “Preparing for Climate Change – A Guide for Local Government in New Zealand” (July 2008) which suggests that the average annual temperature will increase by around 2.1° by 2090. For Wellington this translates to an increase in precipitation of up to 16% for most storm events. This document is free online from the MfE website.

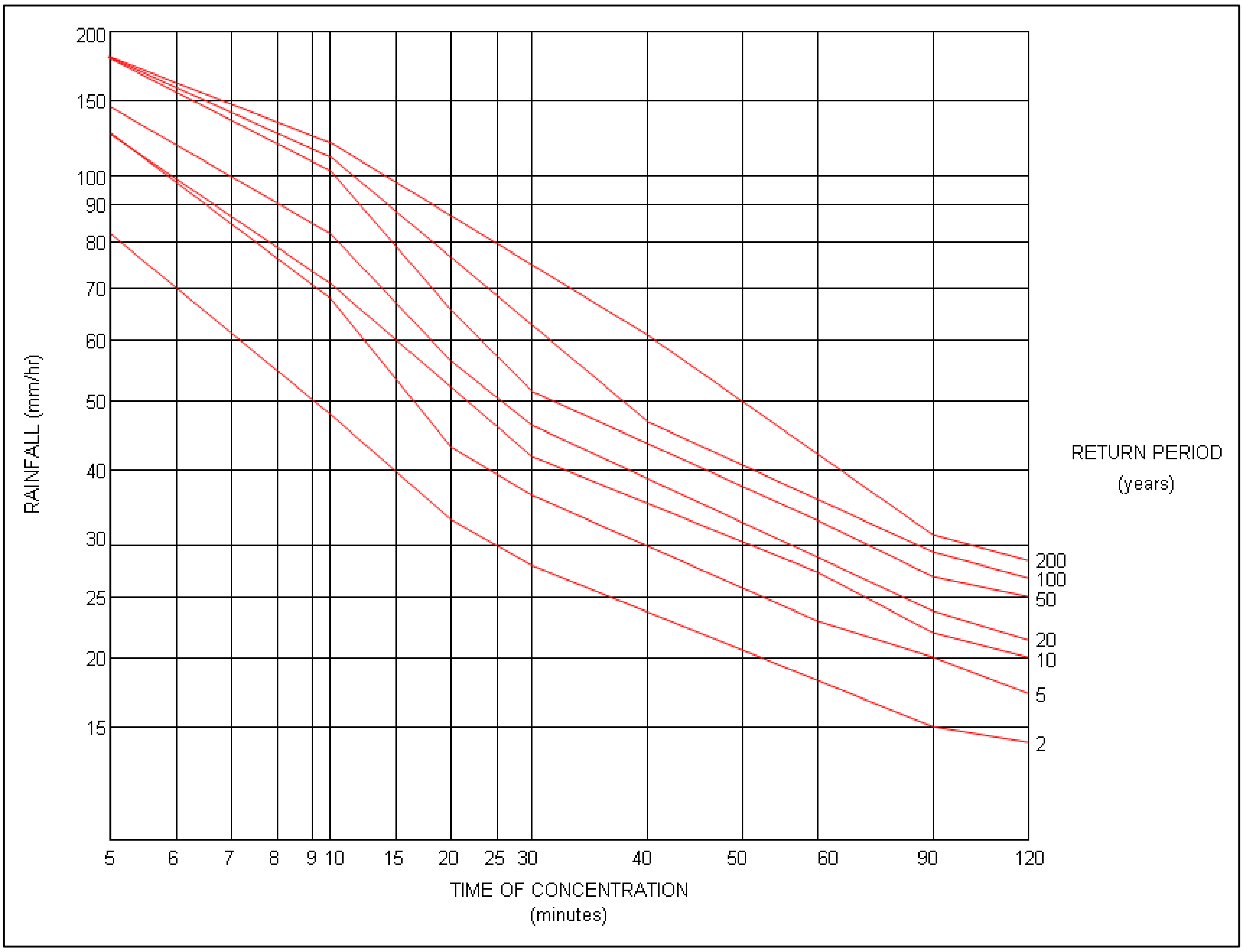


Figure 1 - Wellington City Council intensity-duration-frequency graph

D.4.6 Time of Concentration - (Tc)

The time to be used in selecting rainfall intensity is the time of concentration (Tc) for the watershed/catchment or time taken for surface water to travel from the remotest part of the watershed to the head of the section of the drain or culvert in question.

The time of concentration shall be the lesser of the two values calculated using the following flow paths:

- Those flow paths that can be reasonably expected to exist when the catchment is fully developed to the full extent permitted in the District Plan.

or

- The existing flow paths

Note: the ground is to be considered to be already saturated from previous rain and flow time calculations shall take account of catchment run-off coefficients and slopes.

The time of concentration shall be calculated as follows:

Equation 7:

$$T_c = T_e + T_f$$

Where:

T_c = time of concentration (minutes)
T_e = time of entry (minutes) – which is the runoff time for overland travel (i.e. via ground, roofs, downpipes, carriageways or road channels) to the point of entry to the drain or watercourse - refer to D.4.6.1 Equation 5
T_f = time of network flow (minutes) –which is the time of flow in pipes and or open channels to design point – refer to D.5.6.2

D.4.6.1 Time of entry – Te

Time of entry (**T_e**) shall not be less than 5 minutes.

Where the catchment area has a well defined and regularly repeated pattern for directing the surface water to the drain or watercourse and the catchment is less than 1.0km long, the time of entry (T_e) may be taken as:

- **T_e** = 5 minutes for commercial or industrial areas where greater than 50% of the surface of the catchment area feeding the drain or open channel consists of roofed, asphalt, concrete, paved or metalled surfaces.
- **T_e** = 7 minutes for residential areas where the impervious area exceeds 50% of gross area.
- **T_e** = 10 minutes for low density residential areas where the impervious area is 36% to 50% of gross area.

Where the catchment area does not have a well defined and regularly repeated pattern or where the catchment is longer than 1.0km, the time of entry (Te) shall be the sum of the time of overland flow and, if applicable, the time of road channel flow as given in i) and ii).

i) The time of overland flow shall be determined by the formula:

Equation 8:

$$t = \frac{100\,nL^{0.33}}{s^{0.2}}$$

Where:

t = time (minutes)
L= length of overland flow (m)
s = slope (%)
n = Manning's 'n' (roughness coefficients) (refer to section D.7.1 - Table 7a & b)

The results from this formula, for normal surface types, are shown in Figure 2.

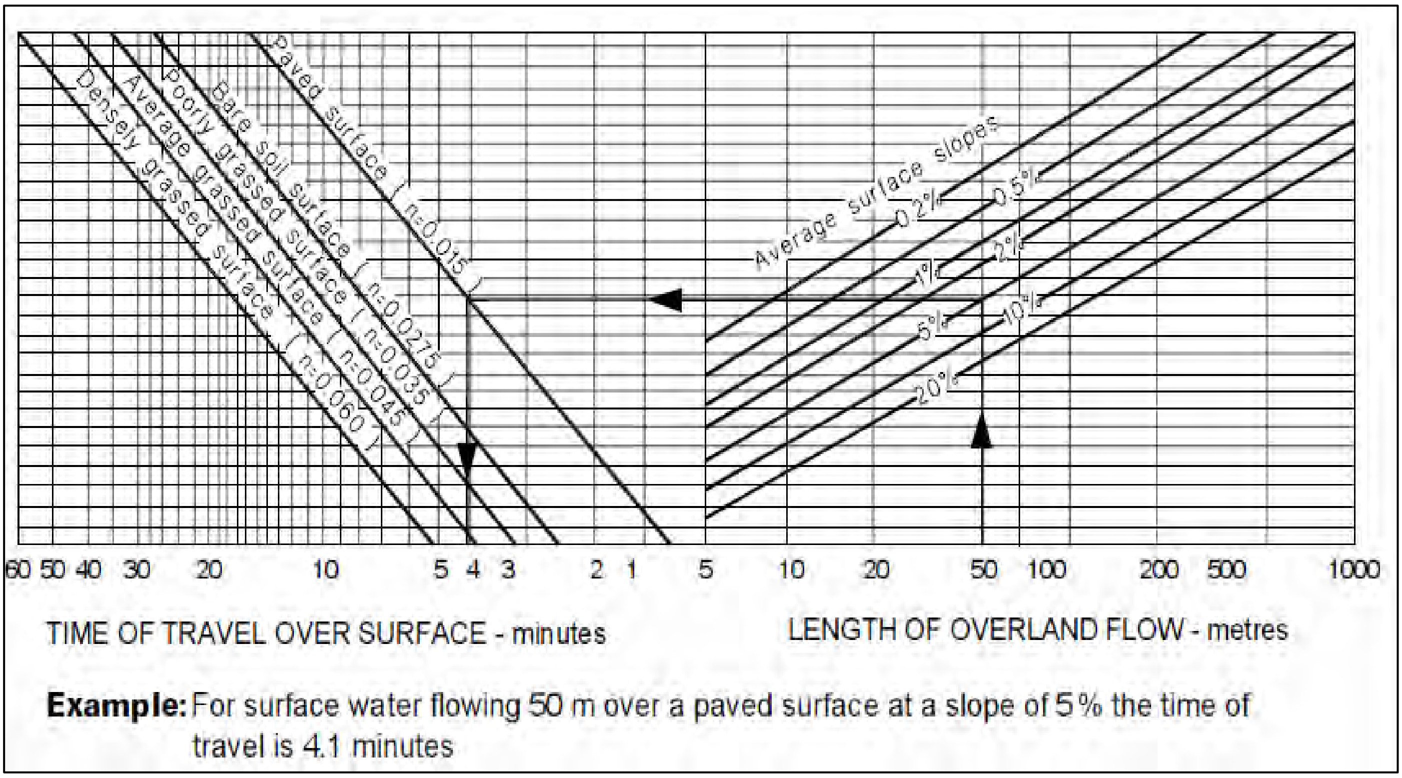
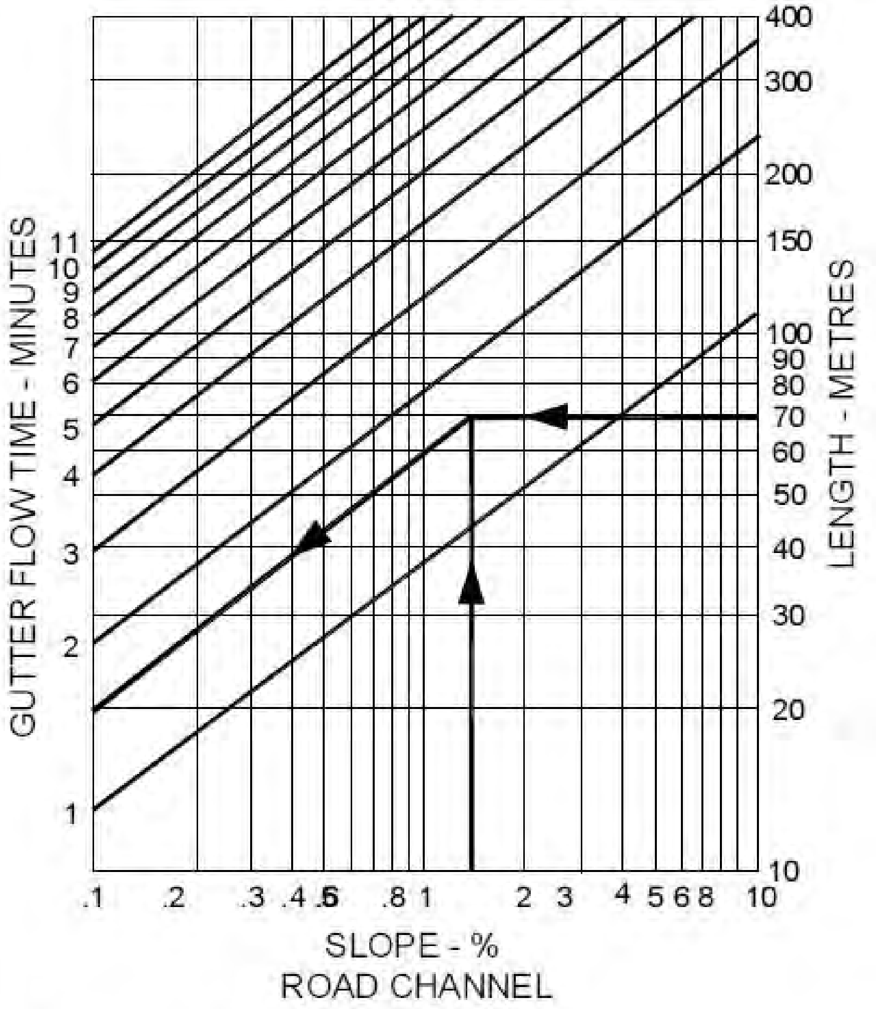


Figure 2: Times for overland flow[7]

[7] Figures 2 and 3 are taken from *Compliance Document for New Zealand Building Code. Surface Water*

ii) The time of road channel flow, which is the time taken for water to flow from the point of entering the road channel, to the point of discharge to a sump, drain or other outlet, shall be determined from Figure 3.



Example: For a slope of 1.4% and a road channel length of 70 metres the time of road channel flow is 1.7 minutes

Figure 3: Road Channel Flow Time

D.4.6.2 Time of network flow - Tf

The time of network flow (T_f) shall be determined from adding travel times from pipes and watercourse to the design point.

D.4.6.3 Time of pipe flow

Time of pipe flow shall be calculated using the following average pipe flow velocities shown in table 3:

Pipe Gradient	Average pipe flow velocities
moderate to steep gradients	5 m/s
low gradients (less than 1-20)	3 m/s

Table 3: Average pipe flow velocities

D.4.6.4 Time of channel flow

The time of flow in open channels (either watercourses or lined channels) may be calculated by means of the Manning's Formula (refer to D.7.1).

The photographs in Ven Te Chow "Open-channel Hydraulics" (McGraw-Hill, 1959), may also be of assistance for determining Manning "n" values.

The length of channel used in the calculation should be measured along the deepest part of the stream channel.

Flood storage and flood routing may be considered when calculating the time of concentration and the peak flow.

D.4.7 Return Period

Stormwater pipe and channel systems shall be designed for the minimum return period as set out in table 4, for the catchment environment that can reasonably be expected to exist once the catchment is fully developed as allowed under the district plan.

Catchment Environment	Return Period
Arterial roads, major community facilities related to essential services	100 year flow
Internal flooding of houses, commercial and industrial buildings,	50 year flow
Primary roads, detention structures designed to withstand damage and failure from being over-topped.	20 year flow
Garages, sheds and unoccupied basements, internal flooding	10 year flow
Active recreational areas, urban roads, property access and backyards of property. Secondary overland flow paths through private property where nuisance and damage will be minimal.	5 year flow
Gardens, yards, passive recreation areas, flooding >150mm deep over more than 20 square meters Parks and reserves, secondary overland flow paths through publicly controlled land or drainage easements.	2 year flow

Table 4: Determining Return Period for new designs.

Note: Where the consequences of the design flow being exceeded is severe (e.g. total inundation of buildings) then the Drainage Engineer can require a higher Return Period than specified above.

D.5 WASTEWATER NETWORK

The objective of a well designed public wastewater network is to collect, convey and dispose of wastewater in a manner that is safe, protects public health, reliable, affordable and environmentally friendly.

There are two major characteristics of flows in wastewater pipes:

- Wastewater contains particles in suspension, which settle to the bottom of the pipe when flow velocity reduces this can result in blockages. To avoid this it is necessary that pipes be laid at such a gradient, as to generate self cleansing velocities.
- Wastewater / sewer pipes carry sewage as gravity conduits, and are therefore to be laid at a continuous gradient in the downward direction.

All public wastewater drains shall be designed so that they meet two performance criteria:

1. they are self cleansing, and
2. they flow un-surcharged under the maximum expected flow

Wastewater disposal is not open to alternative solutions. The provision of adequate disposal and treatment of wastewater must be compliant with minimum engineering standards as outlined in this document.

Wastewater network design is divided in to three elements:

1. **General wastewater design criteria** - reviewing the importance of grade and self cleansing velocity – Refer to sections D.5.1- D.5.2

2. **Wastewater hydrological design** - relates to determining maximum expected or Ultimate Design flow that may occur at any stage during the development of the catchment – Refer to section D.6.

3. **Hydraulic design of wastewater & stormwater networks** - hydraulic design relates to calculating the behaviour of the flow once inside a network system – Refer sections D7– D.13.

The design methods presented here are considered “acceptable solutions” for the purposes of complying with the objectives and performance criteria of this standard. Deviation from these methods will be considered with suitable evidence that the method is equivalent in relevance and application.

D.5.1 General Wastewater Design Criteria

All public wastewater systems shall be designed with regard to the following criteria:

- They meet all relevant criteria defined within this Code
- They are self cleansing with the current or minimum expected peak dry weather flow – refer to Section D.5.2.
- That they have sufficient capacity for the ultimate design flow
- Cater for the whole of the design catchment.
- Provide for future development.
- On going maintenance costs of assets minimised
- Be compatible with connecting networks
- Not interfere with other utilities
- Avoid the likelihood of blockage.
- Provide gravity connections for each allotment.
- Low level of pipeline infiltration/ex-filtration/inflow over the life of the system
- Have resistance to penetration of tree roots
- Structurally designed to resist applied loads
- Where possible all sewage flow shall be by smooth gravity flow in evenly graded pipes.
- A pumping station is not permitted if a gravity connection is possible.
- Any pumping station requires specific approval by the Drainage Engineer – refer to section D.12

Due to the earthquake risk in Wellington City, HDPE (PE80c) pipes shall be used for all public sanitary sewer mains.

All drains are to be sized to current requirements regardless of the downstream pipe size.

Where existing downstream drains are under-capacity, the Drainage Engineer shall be notified. The capacity of a drain shall not be less than that of the drain upstream.

D.5.2 Self Cleansing Flow - Velocity

The drain must be designed (i.e. to be laid at a grade) to maintain self-cleansing velocity (i.e. a flow that will not allow particles to accumulate).

A drain will only be considered to be of self cleansing if the velocity of the self cleansing flow exceeds 0.75m/sec at least once per day.

If a self cleansing velocity doesn't occur at least once a day particles will deposit, and if not removed will cause further deposits to build up, finally leading to a potential blockage of the sewer.

Where no factor indicates otherwise the flow used to calculate the self cleansing velocity shall be the minimum expected peak dry weather flow (PDWF).

Unusual factors, such as an entire industrial catchment with little flow in the weekends, will require special consideration. In this case the Drainage Engineer should be consulted.

Alternative approaches to establishing self cleansing velocity, e.g. tractive stress analysis, are permissible.

Where it is not possible to provide a drain with suitable self cleansing velocity in the first five years of an entirely new catchment, the Drainage Engineer may waive the self cleansing requirement if alternate arrangements are made available e.g. provision of flushing tanks.

Velocity can be calculated using Manning's equation:

Equation 9:

$$v = \frac{1}{n} R^{2/3} \sqrt{S}$$

Where:

v = flow velocity *(m2/s)*
R = hydraulic radius – flow cross sectional area/wetted perimeter *(m) **
S = decimal slope *(m/m)*
n = roughness coefficient or *coefficient of friction (dimensionless)*–refer D.7.1 to Tables 7a and 7b

*For a circular pipe flowing full, the hydraulic radius is: R = D/4. Where D = pipe diameter

D.6 WASTEWATER NETWORK HYDROLOGICAL DESIGN

D.6.1 Maximum expected wastewater flow

Where no factor indicates otherwise the maximum expected or Ultimate Design flow shall be the peak wet weather flow (**PWWF**) that may occur at any stage during the development of the catchment.

Unusual factors, such as the presence of a high water use industry will require special treatment. In these cases the Drainage Engineer should be consulted.

Except in unusual circumstances, peak wet weather flow is defined as being:

Equation 10: **PWWF = PSWF + PGWF + PRWF**

where:

PSWF = the peak sewerage wastewater flow, l/s – *refer to D.6.3.2*
PGWF = the peak groundwater flow; or infiltration, l/s – *refer to D.6.3.3*
PRWF = the peak rainwater flow; or inflow, l/s – *refer to D.6.3.4*

The components of sanitary sewer flows are: sewage wastewater flow (**SWF**), infiltration or ground water flow (**GWF**) and illegal inflow or rainwater flow (**RWF**).

The prefix "**P**" before the abbreviation indicates the peak value of the component whereas the prefix "**A**" indicates the average value of this component.

The peak wet weather flow (**PWWF**) for a catchment is the sum of: peak waste water flow, peak infiltration, and peak inflow for that catchment.

D.6.2 Sewer Catchment Area

The catchment used for all sewer design calculations shall be all the area that drains/discharges wastewater or could physically and legally drain/discharge wastewater to the point under consideration.

When determining the maximum expected flow, the catchment shall be, as a minimum, considered to be developed to the full extent allowed by the district plan.

A catchment may be split into a number of zones where each zone has uniform rules governing development, style of development and corresponding sewage wastewater generation. The total flow for the catchment is the sum of the flows of each of the zones – refer section D.6.3, Table 5.

All permissible bonuses etc. which increase building floor area or coverage, or otherwise increase the likely occupant population shall be considered to the maximum extent normally permissible without a special hearing.

Where further development is possible in the future (i.e. if a District Plan change is likely or possible) the possibility of extra future flows and Council cost contributions is to be discussed with the Drainage Engineer.

Sewage flows from the areas listed below require special treatment. These shall be determined in consultation with the Drainage Engineer:

- Wellington Hospital
- Massey University ,Wellington (including the old National Museum)
- Te Papa
- Oriental Parade high rise residential
- Taylor Preston Ltd Abattoir
- The Lambton Harbour foreshore facilities
- The commercial port area
- The foreshore area seaward of Evans Bay Parade
- Flows from residential and inner city apartment buildings in excess of 3 stories
- Central Business District

Sewer catchment areas will usually need to be calculated manhole to manhole; as additional flow entering from connections along a pipeline may require the diameter of downstream sections to be larger than the upper pipeline.

Catchment areas are normally expected to be calculated / recorded in hectares (ha).

D.6.3 Calculating components of Peak Wet Weather Flow – PWWF

D.6.3.1 Average sewage wastewater flow (ASWF)

The average sewage wastewater flow (ASWF) shall be calculated as follows:

Equation 11: $$ASWF = EPz * pz$$

where:

ASWF	= average sewage wastewater flow (l/s)
EPz	= the total number of population of the area (# of population)
pz	= the average flow rate per person (l/s/per person)

Measured wastewater flows shall be used in preference to calculated flows where accurate current flows are required. Sites suspected of discharging significantly atypical wastewater flows shall be investigated individually to determine what the correct current flow is.

Average sewage wastewater flows shall be calculated using data in *Table 5.*

In calculating ultimate flows from a zone, the average waste water flow rate shall be the greater of:

- The flow which would result from current use
- The flow which would result if the zone was redeveloped as per the majority use of the catchment.

For example, if a school was in a residential area, then the ultimate average wastewater flow rate would be based on the greater of:

- The existing school
- The school being replaced with residences.

Area Zone	Population Density (pz)		Average Wastewater Flow
	per ha of site	*per ha of floor*	*l/s/person*
Inner Residential	400		0.00230
Outer Residential	140		0.00230
Suburban Centre	1,200		0.00230
Central Area		400	0.00230

Table5: Average sewage wastewater flows

The current population in residential areas may be estimated by counting the number of dwelling units and assuming an occupancy rate of 3.1 people per unit.

The current population in non-residential areas may be estimated by estimating the floor area of other buildings and presuming an occupancy rate of 1 person per 25 m^2.

The ultimate population for the Central Area shall be determined by the equation:

***Equation 12**:* $$EPz = pz * Af$$

where :

EPz = ultimate Central Area population (# population)
Af = the maximum likely floor area (#)
pz = the population density as shown in *Table 5* (dimensionless)

The maximum likely floor area (Af) shall be determined as follows:

1. Determine the number of permissible floors (Nf). This may be either taken from the District Plan or calculated by dividing the District Plan's height limit by 3.0m
2. Determine the maximum permitted coverage area (C) as specified in the District Plan (use 100% where none is specified).
3. Af is the product of site area (AS), number o f floors (Nf) and coverage area (C).

The maximum likely floor area shall be determined by calculating the floor area that may be present in a catchment.

The number of permissible floors (Nf) shall be taken directly from the District Plan, or determined by dividing the District Plan's height limit by 3.0m, and the area of each floor is the product of the area site area and the area's maximum coverage **(C)** as specified in the District Plan for that area (or 100% where none is given), except that for the ninth and higher floors the maximum coverage need not to be considered to be more than 50% for the purposes of this calculation –to Equation 13.

***Equation 13**:* $$Af = As*(C*min(Nf,8)+min(C,0.5)*max(0,Nf-8))$$

Where:

Af	= the maximum likely floor area (#)
As	= site area
C	= coverage
Nf	**=** number of floors

D.6.3.2 Peak sewage wastewater flow (PSWF)

The peak sewage wastewater flow (**PSWF**) in a catchment shall be calculated as follows:

Equation 14: $$PSWF = ASWF * PF$$

Where:

PSWF	= peak sewage wastewater flow (l/s)
ASWF	= the average sewage wastewater flow (l/s) - refer *to D.6.3.1*
PF	= the peak factor of the catchment (dimensionless) *refer Table 6*

The *peak factor* depends on the population and the maximum possible reticulated area of the catchment and is set out in table 6. The maximum possible reticulated area is measured as land area only, and is not increased by multiple floors.

Consideration shall be given to industries producing more wastewater or a greater peak wastewater flow than allowed by the general rules.

D.6.3.3 Peak groundwater flow - infiltration (PGWF)

Peak infiltration (**PGWF**) shall be calculated as follows:

Equation 15:

$$PGWF = A_{wet} * 0.347 + A_{dry} * 0.044$$

Where:

PGWF = peak groundwater flow (l/s)
A_{wet} = is the area with a high water table including (but not limited to) those areas with a surface level below 3.0m NCD (ha)
A_{dry} = is all other areas (ha)

D.6.3.4 Peak rain water flow – inflow (PRWF)

Peak inflow (**PRWF**) shall be calculated as follows:

Equation 16:

$$PRWF = A_{res} * 0.440 + A_{other} * 0.232$$

Where:

PRWF = peak rainwater - inflow – flow (l/s)
A_{res} = the area of residential area (ha)
A_{other} = all other areas (ha)

POPULATION

AREA (ha)	20	50	100	200	500	1,000	2,000	5,000	10,000	20,000	50,000	100,000	200,000
1	13.6	9.8	8.3	7.3	6.6	6.3							
2	12.3	8.8	7.4	6.6	6.0	5.7	5.4						
3		8.3	7.0	6.2	5.6	5.3	5.1						
4		7.9	6.7	6.0	5.4	5.1	4.9	4.7					
5		7.7	6.5	5.8	5.2	4.9	4.7	4.6					
6			6.3	5.6	5.1	4.8	4.6	4.5					
7			6.2	5.5	4.9	4.7	4.5	4.4	4.3				
8			6.0	5.4	4.8	4.6	4.4	4.3	4.2				
9			5.9	5.3	4.8	4.5	4.3	4.2	4.1				
10			5.8	5.2	4.7	4.4	4.3	4.1	4.1				
20				4.7	4.2	4.0	3.9	3.7	3.7	3.6			
30					4.0	3.8	3.6	3.5	3.5	3.4			
40					3.8	3.6	3.5	3.4	3.3	3.3	3.2		
50					3.7	3.5	3.4	3.2	3.2	3.2	3.1		
60						3.4	3.3	3.2	3.1	3.1	3.0		
70						3.3	3.2	3.1	3.0	3.0	3.0	3.0	
80						3.2	3.1	3.0	3.0	2.9	2.9	2.9	
90						3.2	3.1	3.0	2.9	2.9	2.9	2.8	
100						3.1	3.0	2.9	2.9	2.8	2.8	2.8	
200							2.7	2.6	2.6	2.6	2.5	2.5	2.5
300								2.5	2.4	2.4	2.4	2.4	2.4
400								2.4	2.3	2.3	2.3	2.3	2.3
500								2.3	2.3	2.2	2.2	2.2	2.2
600									2.2	2.2	2.2	2.1	2.1
700									2.2	2.1	2.1	2.1	2.1
800									2.1	2.1	2.1	2.1	2.0
900									2.1	2.0	2.0	2.0	2.0
1,000									2.0	2.0	2.0	2.0	2.0
2,000										1.8	1.8	1.8	1.8
3,000											1.7	1.7	1.7
4,000											1.6	1.6	1.6
5,000											1.6	1.6	1.6
6,000												1.5	1.5
7,000												1.5	1.5
8,000												1.5	1.4
9,000												1.4	1.4
10,000												1.4	1.4

PEAK FACTOR

Table 6 – Wellington City Council Peak Factors Table

D.7 HYDRAULIC DESIGN OF WASTEWATER & STORMWATER NETWORKS

The designer may use the Manning's formula for hydraulic calculations.

The Colebrook-White method is not suitable for free-surface or open channel flow, but is not specifically excluded from use where a suitable situation is presented. However where the Colebrook-White's formula is used the roughness chosen shall be demonstrated to be equivalent to relevant Manning's 'n' for the typical pipeline sections concerned.

The hydraulic design must take into account:

- Allowance for air entrainment
- Energy losses at bends and changes in direction
- Energy losses and pipe entries and exits
- Energy losses through manholes and structures
- Energy losses at junctions or other connections
- Changes in grade, invert level or pipe size
- Existing and potential sea levels

Generally all pipes connecting to manholes shall be aligned on grade at soffit level, and with the appropriate additional drop allowance included for the energy losses through the manhole.

Head losses due to pipe friction and joints can be estimated using the friction factors presented in Table 4 below.

Large drops in invert level must be taken out through special structures.

The fall through a manhole consists of the sum of:

- That provided as a consequence of the grade of the drain.
- That provided to compensate for energy losses at manholes caused by a change in direction and an increase or decrease in pipe size.

D.7.1 Manning's Formula:

Simply Manning's discharge formula is ***Q = A .V****, where Q is discharge, A = cross sectional area and V = flow velocity – or:*

Equation 17:

$$Q = \frac{1}{n} A R^{\frac{2}{3}} \sqrt{S}$$

Where:

Q = design flow *(m³/s)*
A = cross sectional area of the water-way / wetted area (m²)
R = hydraulic radius – wetted area/wetted perimeter *(m)*
S = decimal slope *(m/m)*
n = roughness coefficient or *coefficient of friction (dimensionless)*–refer to D.7.1 Tables 7a and 7b

The cross sectional area of a full pipe can be calculated using:

Equation 18:

$$A = \pi \times \frac{D^2}{4}$$

Where:

A = cross sectional area of the water-way / wetted area (m²)
D = pipe diameter *(m)*
π = pi

Head losses due to pipe friction and joints can be estimated using the roughness factors presented in Table 7a.

Pipe material	Manning's n
HDPE(PE100), PE, PVC – Stormwater	0.011
HDPE(PE80c), PE, PVC – Wastewater	0.013
Precast Concrete pipe	0.013
Cast Insitu Concrete	0.015
GRP - Glass Reinforced Plastic	0.011
Corrugated Metal	0.025

Table 7a: Hydraulic Roughness Coefficients for Pipes

Watercourse	Manning's n
Straight uniform channel in earth and gravel in good condition	0.0225
Unlined channel in earth and gravel with some bends and in fair condition	0.025
Channel with rough stoney bed or with weeds on earth bank and natural streams with clean straight banks	0.030
Winding natural streams with generally clean bed but with some pools and shoals	0.035
Winding natural streams with irregular cross sections and some obstruction with vegetation and debris	0.045
Irregular natural stream with some obstruction with vegetation and debris	0.060
Very irregular winding stream obstructed with significant overgrown vegetation and debris.	0.100

Table 7b: Hydraulic Roughness Coefficients for Watercourses

D.7.2 Air Entrainment

Where the pipe grade exceeds 1 in 10, allowances shall be made for bulking of the flow due to air entrainment and special precautions taken to release the air and surplus energy. The air to water ratio may be calculated from the formula:

Equation 19:

$$\frac{air}{water} = \frac{kv^2}{gR}$$

Where:

k = coefficient of entrainment (dimensionless), 0.004 for smooth concrete pipes or 0.008 for cast Insitu concrete pipes
v = velocity (m/s)
g = gravity (9.81 m/s^2)
R = hydraulic radius (m)

(*Reference "Hydro-Electric Handbook" Creager &Justin. John Wiley and Sons, second edition 1950)*

D.7.3 Increase in Pipe Size

When a pipe section diameter is to be increased in size from the section above this increase shall be situated within a manhole.

The hydraulic grade line should be designed to continue through the manhole with no heading up.

Generally the soffits of the drains at the manhole shall be on grade.

D.7.4 Reduction in Pipe Size

In cases where a reduction in drain size is justified by a large increase in gradient, the pipe size reduction is to be at a manhole and to the approval of the Drainage Engineer.

In designing the transition structure, it shall be assumed in general, that the velocity exiting a manhole is the same as the velocity entering the manhole. An additional head loss of 0.25v2/2g shall also be allowed for.

Note: Reductions in size are only considered where the exit pipe is 300mm or greater.

Where the Drainage Engineer has approved to reduce the size of the pipe, detailed documentation shall be submitted showing calculations and drawings of the hydraulics. The documentation shall include calculations, a long section of the drain and show the hydraulic grade line and the total energy line.

D.7.5 Change in Pipeline Direction or Grade

Any change in direction or grade of a pipeline shall be situated within a manhole – except as described below.

The head loss across a 1050mm manhole with a smooth bend shall be calculated using:

Equation 20:

$$Head\ loss = \frac{kv^2}{2g}$$

Where k is from the Head loss (across a 1050mm manhole) graph in Appendix D.

D.7.5.1 Changes of grade between Manholes

There shall be no more than one change of grade between manholes and this shall not exceed 45 degrees.

D.7.5.2 Change of direction - Drains laid on a curve

PE80c or HDPE drains may be laid on a curve provided that the following conditions are met:

- There is good reason for the drain not to be laid in a straight line.
- The bends are made by bending straight lengths of pipe. The minimum radius of curvature for bending shall be 50 x the OD of the pipe.
- The entire length of the pipe is surveyed to +/- 100mm to NZMG.
- If there are creek entries or un-trapped sumps upstream, the pipe size is greater than 300mm.
- Detector tape is placed on top of the pipe.

- A twin 1.0mm TPS electrical locator cable is laid along the top of the pipes. The ends are to be extended into the manholes and up to the lid, as provision for connection of locating instruments. If it is necessary to make joints in the cable, they are to be made with electrical connectors and shall be completely encased in a silicon rubber sealant to seal the joint against corrosion.

D.7.5.3 Bends outside of manholes

Bends will be permitted outside of a manhole provided the following conditions are met and approved:

D.7.5.4 Bends outside of manholes of drains 350mm – 750mm

Bends will be permitted outside of a manhole on a pipe between 350mm – 750mm if these conditions are met:

- There is good reason for the bend not to be fully within the manhole.
- There is a manhole within 5m of the bend.
- There are no connections to the bend and it is most unlikely that a connection will be required to the bend sometime in the future.
- The manhole spacing is less than 60m.
- The as-built of the drain shows sufficient co-ordinates or references to known marks to enable the position of the entire bend and drain to be defined to $^{+}/-$ 100mm to NZMG.
- The manhole should be down-stream rather than up-stream of the bend.

D.7.5.5 Bends outside of manholes of drains greater than 750mm

Bends will be permitted outside of a manhole on a pipe greater than 750mm if the as-built of the pipe shows sufficient co-ordinates or references to known marks to enable the position of the entire bend and pipe to be defined to +/- 100mm to NZMG.

D.7.6 Energy Dissipation Structures

Where analysis of the hydraulics of the proposed flow demonstrates that significant turbulence or a velocity high enough to scour the channel will occur, (e.g. greater than 1.8m/s for grass) due account is to be taken of this and structures designed to eliminate damage to either the drainage structures or any existing natural formations. Backwater or similar calculations may be necessary to analyse flows and determine stream velocities.

Short duration local velocities up to 3m/s max may be acceptable in some cases without a dissipater where it can be shown that the channel is in stable strong ground, the consequences of erosion are small, and maintenance is easy.

Energy dissipation structures are to be designed to minimise the collection of debris. Where debris will collect, provision and access must be made for easy removal.

The design of energy dissipation structures shall be to the approval of the Drainage Engineer.

D.7.7 Location of Public Drains

Wherever possible, public drains and manholes are to be located in public land, and where surface access for machinery and maintenance is possible at all time at reasonable cost and least possible disruption to the public.

Where practical, drains should be laid with a cover between 1m and 2m and in road carriageway.

Where two pipes are located in one trench the minimum distance between the two pipes will be 150mm, unless specifically approved by the Drainage Engineer.

Where drains are to be located in private property, they shall be located clear of existing and future building sites.

Public drains shall not be laid under permanent buildings or retaining walls and shall be laid at least 1.5 m clear of existing buildings. Surface openings shall be situated clear of existing or possible future boundary fences.

No building footprint or retaining wall shall impose extra load on the drain and any drain shall be placed outside the 45 degree surcharge line from the centre of the drain, unless by special design solution to the satisfaction of the Council.

As discussed under D.1.3 a public drain is to be provided within 10m of proposed lots and building platforms within intensive developments.

D.7.8 Minimum Drain Size, Grades and Velocities

D.7.8.1 Minimum drain size

To avoid blockages, capacity and maintenance issues the public drainage network shall have the following minimum pipe diameters:

- The minimum diameter for a new wastewater pipeline is 150mm nominal diameter.

- The minimum diameter for a new stormwater concrete pipeline laid in the roadway is 300mm nominal diameter.
  Elsewhere stormwater pipe diameters are to be determined by consultation with the Drainage Engineer.

- Single road sumps shall be served as a minimum by a 225mm nominal diameter sump lead.

D.7.8.2 Minimum drain grades and velocities

All sewers must be laid to achieve a self cleansing velocity during the minimum expected peak dry weather flow.

The normal minimum gradient for a 150mm diameter drain is 1 in 100 though gradients down to 1 in 150 are acceptable. Gradients flatter than 1 in 150 will require the permission of the Drainage Engineer.

However for HDPE sewers laid with manhole spacing greater than that normally permitted, the minimum grade is 1 in 50. Under no circumstances will approval be given for gradients flatter than 1 in 200 for a new small sewer.

Grit traps will be required on all tributary sewers to the main intercepting sewer.

D.7.9 Connecting to the Existing Public Drainage Network

The connection point shall be approved by Drainage Engineer.

The condition of an existing manhole is to be established prior to approval to connect is given.

Connections to existing public drainage services are to be carried out by Citi Operations upon application and payment of the appropriate fee.

Connections in Subdivisions are to be carried out as part of the Public Drainage permit.

Where a drainage connection has to be carried out on private property not owned by the Subdivider, the Subdivider shall provide written evidence of the owner's approval for entry onto the property.

Connections shall be made at angles 90 degrees or less to the direction of the flow.

Connections shall not be made to public mains with 5m or greater cover. A shallower public drain will be required to collect private connections before joining the deeper main.

D.7.10 Water Stops and Trench Ground Water

Water stops help control unwanted movement of groundwater along the trench and pipe bedding and minimize trench scour potential. Water stops shall be provided at intervals as specified in table 8.

Where necessary and practicable additional small subsoil drains should be provided within an enlarged trench and bedding. The outlets of small subsoil drains are then connected into an adjacent stormwater system at manholes, to discharge above the nominal design flow levels. Where these small subsoil drains pass a water stop, or leave the trench, they should be 'sealed'. This can lead to multiple pipes being needed.

Manholes can be considered to be water-stops provided they are constructed in a manner that restricts the passage of water past the structure.

These water-stops or anti-scour blocks shall be constructed from 17 MPa concrete, shall be 150 thick and shall be set a minimum of 150mm into the sides and floor of the trench. They shall extend 300mm above the top of the pipe.

Care shall be taken to ensure that the pipeline is well supported on each side of the barrier.

Grade	Spacing
Steeper than 1 in 5	5m
1 in 5 – 1 in 8	7.5m
1 in 8 – 1 in 15	15m
1 in 15 – 1 in 100	90m

Table 8: Water stop spacing

D.7.11 Structural Design

All structural design is to be carried out by a competent person and the plans approved by the Drainage Engineer.

The class of earthenware or reinforced pipes shall be as set out on the charts in Appendix D unless they are specifically designed.

Where pipes are specifically designed, then the conditions set out below shall apply:

- They shall be designed to either NZ/AS 3725:1989, Loads on Buried Concrete Pipes, ASCE Manual of Engineering Practice No. 37 (WPCF Manual of practice No. 9) Design and Construction of Sanitary Storm Sewers or AS2566:1982 Plastic Pipelaying Design.
- The design assumptions shall be appropriately detailed on the drawings and appropriate supervision of the works shall be carried out by the designer or his/her nominated agent to ensure that the design assumptions are met.
- The design assumptions used shall be as set out in Table 10.

D.7.12 Trenching, Bedding and Loading Design Assumptions

Pipes shall be assumed to be in embankment conditions as trench conditions requires a very narrow trench width; too narrow for timbering or compaction of backfill material.

The bedding type assumed for pipes in roads with less than 2m cover shall be H1. This is to allow for the pipe to be exposed by other utility operators at some time in its life and inadequately backfilled.

- Pipes in private property where it is feasible to be subject to traffic loading shall be designed to carry a truck with a 5t wheel load.
- Pipes in minor roads private roads, footpaths and areas where traffic loading is possible, shall be designed to carry a traffic load of two trucks with wheel loads of 10 tonne.
- Pipes in main roads, CBD, industrial and commercial areas shall be designed to carry a traffic load of two trucks with wheel loads of 10 tonne or one truck with wheel loads of 15 tonnes.

Table 9 shows the maximum load factor (LF) (or bedding factor (BF)) to be used in calculations.

Description	Bedding Type	Load Factor
Drainage Bedding Material for D/10 with uncompacted side fill:	Class C, H1	1.5
Drainage Bedding Material for D/4 depth with selected compacted fill for side support	Class B, H2	2.0
Drainage Bedding Material for bedding and compacted road base for side support	-	2.25
Drainage Bedding Material for bedding and side support	HS2	2.5

Table 9: The maximum Load Factor (LF) (or Bedding Factor (BF))

As a minimum all pipes shall be designed to the following assumptions:

Location	Design Assumptions
All pipes during construction	Embankment conditions unless specifically designed and constructed otherwise.
Pipes in private property where it is unlikely that they will be disturbed and there will be no traffic loading.	Embankment conditions with a projection ratio of +1. Drains <300mm, HS2 bedding (full surround with Drainage Bedding Material). Drains >=300mm, H2 bedding
Pipes in private property subject to domestic traffic loading.	Embankment conditions, p = +1. HS2 or H2 bedding as appropriate. One truck with 5t wheel load.
Pipes in roads other than listed below. Includes private roads.	Embankment conditions, p = +1. Minimal bedding for pipes with less than 2m cover (H1 bedding). For pipes deeper than 2m cover, either HS2 or H2 bedding as appropriate. Two trucks with 10t wheel load.
Pipes in the following areas: • CBD Wellington • Bus routes • Main or arterial roads • Main thorough-fares Industrial, commercial and shopping roads and access to these areas.	Embankment conditions, p = +1. Minimal bedding for pipes with less than 2m cover (H1 bedding). For pipes deeper than 2m cover, either HS2 or H2 bedding as appropriate. The worst case of two trucks with 10t wheel loads or one truck with 15t wheel load).

Table 10: Pipe design strength requirements

D.8 LAYING OF PIPES

All public stormwater and wastewater drains shall be constructed as set out in the Wellington City Council Drainage Network Construction Specification.

D.8.1 Pipe Materials

Due to the earthquake risk in Wellington City, HDPE (PE100) pipes shall be used for all public wastewater mains.

Information regarding liquefaction hazard areas is available from Greater Wellington Regional Council.

Table 11 sets out the permitted materials for pipes.

Material	Stormwater	Wastewater
Earthenware : to AS 1741	Acceptable	Acceptable for private drains laid in road reserve – and repairs to public mains
Cast-in-situ concrete	Approved in special circumstances only	Approved special circumstances only
RRJ Reinforced Concrete Pipe – min Class 2 / Titan branded roller compacted pipes : AS/NZS 4058 225mm-600mm diameter only	Acceptable	Unacceptable
Cast iron to BS 437	Unacceptable	Approved in special circumstances only
PE100 (HDPE) or similar , to AS/NZS 5065 - 2005	Acceptable	Acceptable
Lined steel	Approved in special circumstances only	Approved in special circumstances only
uPVC : to AS/NZS 1260	Acceptable for private drains in private property not subject to heavy traffic[8]	Acceptable for private drains in private property not subject to heavy traffic
uPVC: class C equivalent.	Acceptable for private drains laid in road reserve	Acceptable for private drains laid in road reserve
ABS – Acrylonitrile Butadiene Styrene	Approved in special circumstances only	Approved in special circumstances only
GRP- Glass Reinforced Plastic	Approved in special circumstances only	Approved in special circumstances only
Aluminium, Hi Flow or Aluflo : AS/NZS 2041	Approved in special circumstances	Unacceptable
Corrugated steel	Unacceptable	Unacceptable

Table 11: Permitted pipe materials

[8] uPVC will not perform as well as other pipe materials in the event of an earthquake or in heavy traffic situations.

Good benching will minimise imperfections that create sediment traps and slime growth which deplete dissolved oxygen.

Note : The use of unreinforced concrete pipes will not be considered.

D.8.1.1 Pipe Jointing

All pipes shall be joined using an approved flexible joint (i.e. typically a rubber ring joint). The method of jointing shall be noted on the proposed, construction and asbuilt drawings.

Details of any special methods of sealing a joint shall be specified on the drawings and relevant technical information shall be included in the document set submitted for approval.

D.8.2 Pipe Cover and Classes

D.8.2.1 Pipe cover

All pipes in vehicular trafficked areas should have a cover of more than 900mm. Pipes with a cover of less than 900mm require the written permission of the Drainage Engineer.

All pipes in private property are to have cover of 600mm or more or are to be provided with appropriate protection.

Pipes in steep, un-developable land shall have sufficient cover to protect the drain from physical damage, ultraviolet light, extreme temperature changes and be visually acceptable.

D.8.2.2 Reinforced concrete and ceramic pipes

The minimum class for Reinforced Concrete shall be X.
The minimum class for ceramic shall be Y.

In Arterial, Primary and main city streets, the pipes shall be 50% over-strength.

D.8.2.3 HDPE (PE100) pipes

All HDPE (PE100) or similar pipes and fittings for gravity pipelines shall be to "Hard Metric" sizes (i.e. 160, 250, 315, 400, 500, 560, 630, 710, 800, 900, 1000mm OD).

Rising mains shall be to one of the above sizes or 50mm, 63mm, 110mm, 125 and 200.

The required minimum SDR[9] for 160-355mm O.D pipes with a cover of 0.9m to 4m shall be SDR 17.

D.8.3 Private Stormwater and Sanitary Sewer Laterals

All private laterals shall be designed with regard to the following criteria:

- The minimum size pipe for residential private drains is 100mm.
- Each connection to the public system shall be capable of serving the entire lot.
- Each lot shall have separate sewer and stormwater connections.
- Industrial and commercial lots shall have a minimum size of 150 mm.
- Council lids are not to be used on private drains.

Note: All extended laterals/leads up to the connection to the public main will remain private and belong to the section which they are intended to serve.

- Generally it is preferable for private leads to be connected to manholes rather than to the pipe, but this is subject to the number of existing or proposed connections – refer to D9.3
- Connections provided to lots must be at sufficient depth that they can be extended to the building platform in a manner compliant with the NZBC.
- The Drainage Engineer may allow a lateral to run across one property to serve another under easement and obtainment of written consent if applicable.

Laterals are to be provided as follows:

- Where the public drain is in the roadway, 100mm leads extended to inside the section.
- Where the public drain is more than 2m deep, 100mm leads extended to between 1.0m to 1.5 of the ground surface.
- Connections provided to lots must be at sufficient depth that they can be extended to the building platform in a manner compliant with the NZBC.
- Where it will be necessary for a lead to cross private property other than the section which it is intended to serve, then that lead is to be provided at the time of subdivision and laid within an easement.
- Where a section of public drain has been laid it is to terminate at least 0.5m within a private section.

Where the connection is to an empty lot, the terminal connection shall be:

- laid to the boundary of the property,
- end in a method that can accept an approved spigot, and
- be blanked off or sealed with a removable cap.
- Documented and submitted

D.8.3.1 Private Stormwater Laterals

- All private stormwater disposal systems are to be designed to carry the full flow from their catchment.
- In residential areas a stormwater disposal system for each lot, which may include alternative solutions, is to be provided to serve all sections.
- Alternative solutions with provisions for infiltration or detention for individual sections can percolate through the ground where long term capability is available and is satisfactory to the Drainage Engineer. However overflows from a section where alternative solutions are incorporated must drain to an approved outfall.
- 100mm private stormwater leads from buildings may flow to a watercourse or swale, where a public stormwater system is not available.

- Private 100mm stormwater leads to the kerb may be approved in short streets and right of ways where there is no piped network, except where mountable kerb and channel has been constructed.
- Kerb connections will not be approved in commercial or heavy built-up areas.
- Any connections to the kerb must show that they will not cause or increase flooding in the downstream catchment for the street.
- Where a private stormwater drain discharges to the kerb, the section of the drain crossing the footpath and though the kerb shall be cast iron or galvanised steel and have a Road and Traffic Maintenance section approved stormwater kerb connection.
- Connections greater than 300mm need the specific approval of the Drainage Engineer.
- Drop manholes shall be used where connections are made to a pipe greater than 3 m deep.

D.8.3.2 Private wastewater/sewer laterals

- All sanitary sewer disposal systems are to be designed to carry the full flow from their catchment.
- A sewer lateral shall convey only wastewater from within the premises to the sewer system i.e. rain water shall not be discharged into any wastewater system.
- All sewer laterals are to discharge directly to an approved wastewater network.
- Connections greater than 100mm need the specific approval of the Drainage Engineer.
- Drop manholes shall be used where connections are made to a pipe greater than 3 m deep.

D.8.3.3 Abandoning and reuse of existing private laterals

Where an existing building has be demolished or replaced the end of the lateral is to be capped at the main or relaid for future use. The public drainage team shall be advised of the final treatment.

The reuse of a previous used lateral over 25 years old is not permitted.

D.9 MANHOLES

Primarily manholes are required to allow physical entry of a person and equipment to the pipe network for purposes of maintenance, connection and investigation.

General manhole considerations:

- All manholes constructed for the public drainage network shall be to the standard set out in the Wellington City Council Wastewater and Stormwater Construction Specification.
- A manhole is to be constructed at every junction of the public drainage network – excluding inline Y junctions to single 100mm laterals.
- There shall only be one change of grade between manholes
- A manhole may be required over a significant feature to allow access, monitoring etc.
- A manhole or LHCE (refer to D.10) must be used at the upstream termination of any public drain.
- All bends shall be fully within a manhole except as set in section D.7.5.
- The access holes for manholes shall be in the centre of the top slab for 1050mm diameter manholes, and offset for larger diameter manholes to be positioned over the rungs.
- Concrete manholes subjected to high concentrations of hydrogen sulphide are to be constructed of a suitable sulphate resisting concrete, or contain a suitable corrosion inhibiter additive.
- All connections to a manhole shall be made watertight.

- Connections to a manhole at the same invert level shall not form acute angles with the pipes that lead away from the manhole.

Wherever possible, manholes are to be located in public land, not in traffic lanes, and situated for minimal disruption to the public along with safe and easy access for workers and machinery.

D.9.1 Manhole Size

A manhole must be large enough to accommodate the body of a worker and maintain a clear working space sufficient for performing any necessary work.

Manholes shall have a minimum riser diameter of 1050mm.

Except in exceptional circumstances and with the written permission of the Drainage Engineer, a manhole riser diameter[10] shall not be smaller than as set out in Table 12.

Manhole location	Riser diameter
Manholes less than 2m deep.[11]	1050mm
Manholes 2-4m deep.	1200mm
Manholes in the CBD and other streets which are likely to be become congested with utility services in the future.	1200mm
Manholes over 4-5m deep.	1500mm
Manholes over 5m deep usually require special engineering design (see D11.7)	Specific design

Table 12 - Minimum manhole riser diameter

Pipes larger than 750mm require a manhole diameter of 1200 minimum, or when the manhole diameter is smaller than the pipe a pre cast manhole tee may be used.

Tee manholes likely to receive traffic loading shall be designed and installed to take full traffic loading.

[10] These sizes are the minimum necessary to adequately maintain the drain and allow for future rehabilitation.

[11] Minimum size is 1050mm as this has been found by experience to be the minimum practical size for CCTV, trenchless repairs and rehabilitation techniques and health and safety considerations.

Manholes in the CBD and other streets which are likely to be become congested with utility services in the future shall have a precast floor 300mm below drain invert.

Bends must be sufficiently gentle for the flow not to leave the channel and deposit debris on the benching[12].

Manholes shall be designed to allow all drains entering (and leaving) the manhole to be inspected by a CCTV camera. The size of the design camera shall be taken as a body size of 470 x 85 x 85mm (and 130mm wide to outside of the wheels) [13].

Allowance shall be made for adequate benching of existing connections and the installation of likely future connections.

Manholes shall be designed to pass the flow with minimal loss of energy.

The following manhole sizes have been found to be suitable to enable the adequate construction of the manhole where there is a change of direction at a manhole and the bend is fully within the manhole:

Pipe Diameter *(mm)*	**Change of Direction** *(Degrees)*	**Diameter of Manhole Riser** *(mm)*
450	10-55	1050
450	55-65	1200
525	10-30	1050
525	30-55	1200
600 / 675	10-15	1050
600 / 675	15-35	1200
600 / 675	35-50	1350
750	5-25	1350
750	25-35	1500

Table 13: Minimum manhole riser diameter when there is to be a change of direction within the chamber.

[12] This normally requires channels of 45° or less.

[13] . It is not possible to insert a camera in a 150mm drain if there is 45° channel hard up against the manhole wall and the invert is benched to full pipe height.

D.9.2 Manhole Materials

Manholes shall be constructed using manufactured pre-cast concrete manhole risers.

Manholes are to be constructed with the minimum possible number of pre-cast concrete risers to minimise infiltration.

D.9.3 Connections to Manholes

A standard 1050mm diameter manhole will have a maximum of 4 connections compromising of up to 3 inlets and 1 outlet. . This includes sump leads, private connections and main pipelines.

D.9.4 Manhole Spacing

In road reserve, the maximum manhole spacing shall be 90m for pipes of up to 1m diameter or 90D for pipes larger than 1m diameter.

In private property, the normal maximum manhole spacing shall be 60m.

A greater spacing may be permitted, by the Drainage Engineer, provided that the following conditions are met:

- The pipe is laid in PE80c or HDPE.
- There are no connections between manholes.
- For stormwater drains, there are no creek entries or un-trapped sumps upstream of the drain.
- The grade is steeper than 1 in 30 over the entire length of the drain.

D.9.5 Manhole Loadings

Covers, lids, raisers and manhole installations shall be designed to withstand HN-HO-72 loadings.

Lids in traffic areas, or where there is the potential for vehicle loadings, shall be a minimum of 150mm think.

Where the manhole is in an area likely to be subjected to high ground water levels, the manholes shall be designed to withstand uplift from at least 1.25 times the expected uplift pressures.

D.9.6 Manhole Rungs

Manhole rungs are to be constructed in all manholes greater than 1m in depth.

They are to be constructed of non corrosive metal, non slip material and as detailed in the Wellington City Council Wastewater and Stormwater Construction Specification.

They are to be positioned parallel to the main flow so they are over the benching.

D.9.7 Deep Manholes

Deep manholes are considered to be manholes greater than 5 metres in depth. Manholes deeper than 5m shall be at least 1800mm in diameter and must be specially designed for access and strength. Health and safety, maintenance and rehabilitation needs are to be considered.

Deep manholes typically have:

- Landings, or if not landings are to be provided at distances of 5m maximum, to reduce potential falls.
- The level of the lowest landing must be at least 2m above the level of the benching.
- The access through the landing is to have a hinged cover opening into the centre of the manhole and be positioned over the rungs.
- Suitable permanent ladders may be approved in lieu of rungs.

D.9.8 Drops at Manholes

Sump leads or normally dry stormwater drains may enter above the benching. The rest of this section does not apply to these drains.

A drop in a manhole shall not exceed 500mm. Drops up to this size are to be benched in the manhole.

Where the drop at the manhole exceeds 500mm and the drain is smaller than 250mm, an internal drop pipe as per the Wellington City Council Wastewater and Stormwater Construction Specification may be used provided that the manhole diameter has a minimum diameter of 1200mm.

The manhole required to house the internal drop is to be sized by adding the standard diameter as set out in section 0- Table 12, the outside diameter of the drop pipe and an additional 150mm allowance.
In all other cases, drops shall either be by way of laying a steep length of pipe with a manhole at the top and bottom or by way of a special structure (with facility for access and cleaning). Large drains laid on a steep slope may require an energy dissipater system.

Where flow in a steep drain can move into a low surcharged state, it may be necessary to provide special outlet capacity from vulnerable manholes. This is to avoid entrance control causing undue heading up and potentially blowing the manhole top.

D.10 LAMPHOLE CLEANING EYES - LHCE

Where circumstances dictate the Drainage Engineer may approve the use of a lamphole cleaning eye (LHCE), instead of a manhole.

NOTE: A lamphole cleaning eye can only be used on pipelines of under 225mm internal diameter.

Circumstances where LHCE may be considered are:

- at the upstream termination point of a drain section less than 50m long.
- at the top of a steep change of grade where a manhole is likely to be an unsafe or precarious position.
- as an upstream termination point of a Sub soil drain
- there can be no connections to a LHCE
- a LHCE must have a 45deg bend or y junction at its base, to allow for cleaning rods to be used

D.11 ABANDONING PUBLIC DRAINAGE NETWORK

No section of public wastewater or stormwater network shall be abandoned until it is confirmed that there are no active / live laterals or connections connected.

The upper end of all abandoned pipes shall be sealed as part of the works.

The abandoned pipe may remain connected to a lower manhole, if the abandoned pipe is required to act as a field drain.

Documentation stating methods of abandonment of public network, i.e. pipes and manholes – generally removal, filling or disconnection - shall be submitted as part of the design and construction plan documentation.

D.12 WASTEWATER PUMPING STATIONS AND RISING MAINS

Wastewater pumping stations will only be considered where gravity drainage is not feasible.

- The pumping of wastewater shall require the specific approval of the Drainage Engineer.
- The Pumping Station design and equipment is to be specifically approved by the Council Pump Station Engineer.

The capacity of the receiving gravity network to which the pump station discharges shall be proven to be able to accommodate combined peak flows from both the pump station and adjoining gravity system.

Pumping stations serving more than 10 lots may be vested in the Council, after discussion and approval from the Drainage Engineer.

Pumping stations and rising mains shall be subject to specific design and approval.

Pumping stations must be connected with Council's telemetry system at the developer's expense.

The rising main shall have gradient that eliminates or minimises over vertical and under verticals.
The rising main shall terminate at a discharge manhole on the main pipeline.

Where a private pump station is permitted, the rising main shall be connected to the public system through a manhole on the main line or into a private manhole or chamber with a gravity pipe connection to the main pipeline.

D.12.1 Public Wastewater Pumping Stations

Council will only consider taking ownership and vesting of a pump station if the requirements set out below have been met.

D.12.1.1 Public Wastewater Pump Station Requirements

The minimum design requirements for a public wastewater pump station are:

- The station shall be placed completely within a separately titled lot. A sealed access of not less than 3.5 m width shall be provided to the nearest public street. The immediate area around the station shall be fenced and provided with a locked gate.
- Water supply, with an appropriate backflow preventer, shall be supplied to the station.
- Chains of high tensile quality steel shall for lifting are to be provided for the maintenance and servicing of all pumps.
- The wet well shall be sized based on 12 starts per hour.

- Pipe work shall be arranged such that each pump can be isolated whilst others are in operation. Similarly, all non-return valves should be able to be isolated and maintained while the standby pump is operating. All valves and non-return valves are to be in a chamber external to the wet well.

- A valve is to be provided to allow the wet well to be fully isolated from the reticulation.

- All iron and steel shall be suitably internally and externally protected against corrosion. Flanged or welded fittings shall be provided throughout, with a proprietary dismantling joint or similar in the system to facilitate dismantling.

- All pipe work within the wet well shall be ABS or stainless steel.

- Chambers shall be designed against flotation when empty.

- All pumps stations are required to have 4 hours emergency storage based on ADWF calculations using this Code. Storage shall be provided either in the wet well, or offline. This storage shall be in addition to the operational wet well storage.

- The control of odours shall be included in the design.

- Any dry wells shall be adequately force ventilated using ducted mechanical exhaust and drawing air from near the base of the dry well. Exceptions may be made for shallow chambers at the discretion of the Council.

- Provision for an emergency overflow, notwithstanding the overflow storage, shall be made. The overflow level shall be determined such that manhole surcharge upstream of station is avoided. A discharge permit must be obtained from Greater Wellington for the overflow.

- Chamber lids shall be placed centrally over the pump sets and shall be suitable of withstanding HN-HO-72 loads when in the carriageway, berm or footpath.

- Any other further specific requirements of the Drainage Engineer or Councils Pump station Engineer.

D.12.1.2 Public Wastewater Pump Requirements

The minimum requirements for the design of a public wastewater pump station pump are:

- The station shall be designed to convey the peak wet-weather wastewater flow under normal duty.
- Stations shall be designed in a duty-standby arrangement with each individual pump capable of conveying the design peak wet-weather wastewater flow, i.e. 100% standby pumping capacity.
- For large stations a three pump Duty-Assist-Standby arrangement may be considered, where a single pump cannot provide the full design flow. All three pumps shall be of identical hydraulic performance and the standby pumping capacity shall be at least 50% of design flow.
- For smaller stations a minimum of two pumps may be considered, where each is capable of a minimum of 4 hours storage based on ADWF calculations using this Code.
- The duty shall be interchangeable between pumps.
- Pumps shall have non-clogging impellors with a throughlet of between 75 and 100mm where possible.
- The Councils preferred pump make shall be used. The Council should be contacted prior to design to determine the appropriate manufacturer.
- Pumps shall be selected based on a system curve developed for the proposed station pipe work and rising main.
- Pumps shall be capable of a minimum 12 starts per hour.
- Pump rates shall be set taking into considerations any capacity limitations of the downstream gravity network.

D12.1.3 Public Wastewater Pump Station - Electrical and Controls requirements

The minimum requirements for the design of a public wastewater pump station electronics and controls are:

- Pumping stations shall incorporate all necessary control, monitoring, alarm and telemetry systems to Council standards at the time of design. Liaison with the Councils pumping station engineer shall be made, prior to design, to determine the necessary electrical and control specifications.
- All electrical equipment is to be flame resistant, installed above the 1% AEP (100 year) flood level and in a stainless steel weather-proof cabinet.
- All equipment shall be designed to Hazard Safety Rating Zone 1 Class 1 in NZS/AS 3000.
- Cables shall be sealed to prevent sewer gases entering the electrical cabinet.
- For pumps over 2kW, soft starter systems, capable of not less than 15 starts per hour, shall be provided to mitigate starting currents.
- Terminals are to be provided to allow the connection of a suitable generator. Both a single phase and a 3 phase plug shall be provided on the board to allow for equipment connections.

D12.1.4 Private Wastewater Pumping Stations

Private wastewater pump stations will only be considered:

- for multiple household units
- where connection to the public network is not possible
- if designed by a suitable professional
- if approval is given by the Drainage Engineer
- if the design is approved by the Pump Station Engineer

Private wastewater pumping stations may be permitted provided they comply with the above and following criteria:

- Pumps shall have an open multi-channelled impellor with a macerator/grinder on the intake (allowing maximum 8 mm free passing). Pumps shall also have thermal overload protection and a liquid temperature rating of 40℃
- The rising main shall be a minimum of 50 mm NB.
- Wet well design and pumps shall be based on 4 starts per hour.
- Chambers shall be designed against floatation and chamber hatches shall be designed to be impervious to inflow and infiltration.
- All controls, electrical equipment and cables to be provided with suitable weatherproof enclosures and sited above 1% AEP flood level.
- The station shall be fitted with an audible and visual alarm system indicating pump failure and overflow.
- Non-return valves shall not be installed on the private discharge main in a way that prevents the un-discharged effluent to return to the wet well when pumping stops. This avoids septic conditions in the rising main. Notwithstanding this, the rising main discharge shall be placed and designed to eliminate the potential for sewage from the main pipeline to surcharge and backflow down the rising main and overflow the wet well.
- The wet well shall be of a size to hold 24 hours ASWF (refer to section D.6.3) plus the volume of the rising main.
- Consent notices shall be placed on titles of properties connected to the private pump station.

The Resource Consent may require additional emergency storage or an emergency disposal field depending on the surrounding environs and scope of the development.

As well as adding the Consent Notice to the titles, the Developer shall take the responsibility to alert any future owners of all sites served by the private pump station that:

- the sites are serviced by a private pumping station;
- the owners are fully responsible for the maintenance and operation of the station;
- the owners are responsible for any fines or consequences from a failure adequately to maintain the station;
- a 24 hour message service and on-going maintenance contract must be acquired for the station; and
- the station must be kept to a standard acceptable to Council and does not cause a nuisance to other property owners, adverse effects to the surrounding environment, or discharge material that may damage or cause negative effects to the Council's sewer network and the environment.

D.12.2 Rising Mains

The minimum requirements for the design and construction of rising mains are:

Rising mains shall be to one of the above sizes or 50mm, 63mm, 110mm, 125 and 200 HDPE (PE80c) or similar.

Rising mains shall generally be designed to withstand the dynamic head expected in the pipeline including allowances for surge, water-hammer and fatigue.

The pipes shall generally be minimum DN100 PE80b SDR11 but the design presented shall be that which achieves the best operational and efficient result for Council.

D.12.2.1 Rising main design attributes

- Rising mains shall be sized to ensure a minimum velocity of 0.9 m/s is achieved with the design flow, whilst at the same time avoiding excessive discharge pressures and associated power consumption.
- The maximum velocity shall be 4.5m/s.
- A friction coefficient of Ks = 1.5mm shall be used for calculating the flows in rising mains.
- Generally the maximum rise shall be 20.0m.
- The maximum working pressure shall be 200 kPa.

D.12.3 Venting

Venting of structures is required to eliminate the collection of noxious and corrosive conditions within the pipe air space.

Venting shall be required at all:

- Pumping station wet wells,
- Manholes which receive rising main discharges,
- Points where inverted siphons enter or discharge.

Odour treatment will be required where vents discharge to urban areas. Odour treatment can be in the form of activated carbon filters or odour beds. Solutions for odour treatment must be approved by the Drainage Engineer.

D.13 RURAL SITUATIONS

Council recognises that the disposal of wastewater and stormwater within a rural situation requires separate consideration and requirements.

Rural Sanitary Sewer Septic Tanks and effluent disposal systems must meet the performance objectives of this code, be in compliance with section E1 of the Building Code and be approved by the Drainage Engineer.

D.13.1 Rural Wastewater

Onsite disposal for residential waste may be approved in rural and rural residential areas where there is no available potential for a connection to the public wastewater network, and the provision of a community system for vesting to the council is not considered appropriate by the Council.

Detailed design of septic tanks and effluent disposal systems are to be submitted for approval. The design must provide assurance that the system will not be affected by flooding in compliance with section E1 of the Building Code.

For any sub-division for which on-site disposal is proposed, proof of the ability to provide a suitable system for each lot or group of lots shall be submitted with the resource consent application.
The preliminary design and supporting report shall be based on field testing carried out on each lot or group of lots.

Any design shall comply with Council's Consolidated Bylaw

D.13.2 Rural Stormwater

The design of a rural stormwater system differs from the standard network design in that for rural catchments, the time of concentration may be calculated from the following formula:

Equation 21:

$$Tc = 0.0195\left[\left(\frac{L^3}{H}\right)^{0.385}\right]$$

Where:

Tc = time of concentration
L = length of catchment in metres measured along the flow path
H = rise from bottom to top of catchment in metres

Note : A runoff coefficient of 0.35 would normally apply to rural situations.

D.14 BENCHMARKS

D.14.1 New Benchmarks

All as built levels are to be taken from an approved permanent benchmark (i.e. a WCC Benchmark or LINZ survey marks with the required accuracy).

- All developments shall be required to establish a new Council benchmark, unless there is an approved benchmark, within 1km of the development.

and/or

- The developer shall be required to install additional benchmarks if the total area of the final development is greater than $1km^2$.

In new developments or capital works the Drainage Engineer shall dictate the requirement and approve the placement of new benchmarks.

Methodology of establishing new benchmarks levels shall be discussed with the Drainage Engineer.

The levelling of new benchmarks is to be carried out by a Licensed Cadastral or Registered Professional Surveyor.

All new benchmarks shall be established in accordance with the specifications detailed below and have the following documentation provided upon placement:

- a finder diagram, there must be a least three measurements from known permanent features to the new benchmark shown in the finder diagram and/ or
- NZMG and NZTM co-ordinates.
- survey methodology
- Certification from a Licensed Cadastral or Registered Professional Surveyor – refer to appendix A for sample.

The Drainage Engineer has the discretion to grant dispensation, in the form of cost sharing, upon consideration of:

- total development size (not just an individual stage),
- location,
- ongoing development in the area,
- distance from existing Benchmarks, and
- benefit to Wellington City Council.

The final decision rests with Council.

D.14.2 Installation of new benchmarks

Situating of new benchmarks is to be dictated by the Drainage Engineer, taking into account factors including:

- likelihood for future disturbance, - stability, permanence
- existing services,
- survey visibility, line of site
- accessibility, clear of traffic
- on going development, construction areas
- within road reserve, council right of way or easement.

There may be circumstances where a benchmark may be able to be attached to a suitable existing or proposed structure (steps, ramps).

Before any digging the developer will be responsible for checking with other service utility providers to ensure that there is no conflict with the proposed benchmark location and existing or proposed services.

A standard WCC Benchmark plaque will be issued upon application from the Drainage Engineer.

The type of ground conditions will influence the method used to install the new benchmark. Ground conditions fall into one of two categories:

1) Good ground: consists of weathered greywacke parent material and soils less than 300m deep.

2) Adverse ground: consists of soft colluviums, deep soils and/or sand.

Refer to drawings S/A001 and S/A002 in Appendix D.

In good conditions (Fig. S/A001), a 0.35 x 0.35 by 0.5 metre deep hole is to be dug. A standard WCC benchmark plaque is to be set, with the base of the plaque recessed below the surface, within a block of concrete.

In adverse conditions (Fig. S/A002) for added stability the base of the hole may increase to 0.55 m^2, and re-bars or warratahs maybe set into the concrete block, angling into the surrounding strata.

Upon completion of the work the site is to be left in compliance with Section A.15 of this Code of Practice.

D.15 ASBUILT REQUIREMENTS

All as-built plans submitted for approval must be in accordance with the current Wellington City Council – Drainage and Water Network Drawing and Asbuilt Specification