Waitakere City Council
Te Tatiao o Waitakere

CODE OF PRACTICE FOR CITY INFRASTRUCTURE & LAND DEVELOPMENT

ENGINEERING STANDARDS MANUAL

SECTION 4

STORMWATER DRAINAGE

Stormwater Drainage

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SECTION 4.0 STORMWATER DRAINAGE

4.1 SCOPE

This section of the Engineering Standards Manual covers the engineering requirements for the storm water drainage issues associated with land development projects and provides;

a) The relevant criteria for performance
b) Methods for design and construction control.
c) Specifications for materials and structures.

The provisions of this Section deal specifically with those components of storm water drainage necessary for the conveyance and treatments of storm water by gravity means. The criteria are to be used irrespective of whether the network created on a site is to be accepted as part of the public network or to remain under private ownership and control.

It does not provide for nor allow the use of subsoil drainage systems necessary for the stability of landforms to be incorporated into the public network. All such systems where approved shall remain under private control and the responsibility of the property owner whose site is protected by the system.

While this section of the manual deals with the engineering aspects associated with the conveyance of stormwater, WCC encourages and supports strong focus on water quality, habitat values and low impact design features in the design and management of stormwater conveyance. Section 4.3.9 has been added to this manual to cover these features.

4.2 PERFORMANCE CRITERIA

a) Meet all standards and criteria of the District Plan and any Regional Plan.
b) Remove stormwater run-off in a manner that protects people, property and the natural environment from adverse effects.
c) Provide a low flow connection point for each allotment.
d) Provide a secondary flow path clear of all buildings and high use areas.
e) Cater for the whole of the design catchment.
f) Provide for future development.
g) Be compatible with connecting networks.
h) Not require undue maintenance.
i) Be easily maintained.
j) Withstand design loads.
k) Avoid the likelihood of blockage.
l) Not interfere with other utilities.
m) Provide a means of water quality treatment.
n) Hydraulic neutrality in rural and developing areas.
o) Inclusion of Low Impact Urban Design (LIUD) features where practicable.
p) Provision for fish passage.

4.3 DESIGN REQUIREMENTS

4.3.1 OTHER STANDARDS

The design of the storm water network shall be in accordance with information on the network supplied by the Drainage Assets Engineer.

Where the particular portion of network has not been modelled, the design of the extension to the network shall be designed using TP 108 ARC Guidelines for Storm water run-off modelling in the Auckland Region. Where the extension is to reticulate a sub-catchment of no more that one hectare the Rational formula will be acceptable.
Peak Flow Calculations

For all sites grater that 1 hectare, peak flow estimates should be derived using the Auckland Regional Council "Guidelines for Stormwater Runoff Modelling in the Auckland Region" (TP 108) – see reference A.

TP 108 utilises the U.S. Soil Conservation Service (SCS) methodology for calculating peak flows. Key inputs to the SCS model have been customised for the Auckland Region by ARC and include:

- 24 hour design rainfall depths provided in the form of rainfall maps covering the Auckland Region;
- A standard 24 hour temporal rainfall pattern incorporating shorter duration rainfall bursts nested within the 24 hour temporal pattern;
- Runoff depth calculated using SCS rainfall-runoff curves, with curve numbers being selected based on soil type. For Waitakere City Group C soils (mudstone/sandstone) should be assumed when selecting Curve numbers;
- The runoff hydrograph is calculated using the standard SCS synthetic hydrograph;
- Time of concentration is estimated using an empirical lag equation derived specifically for the Auckland region;
- Separate analysis of pervious and Impervious components applies in urban catchments; and
- Effects of catchment time response are allowed for using a channelisation factor and runoff parameter in the time of concentration relationship (provided on Worksheet 1).

Runoff calculations can be undertaken using the US Army Corps of Engineers program HECHMS or with Worksheet 2 provided in TP 108 (Graphical peak Flow Rate).

Building consent applications for works in Waitakere City must be supported with the following information:

- Design storm 24 hour rainfall depths used
- Curve numbers assumed in analysis
- Initial abstraction calculated
- Completed Worksheet 1 from TP 108 (Time of concentration calculation)
- Completed Worksheet 2 or HECHMS output

Note: The I.P.E.N.Z manual "Procedure for Hydrological Design of Urban Stormwater Systems" may also be of assistance in designing stormwater systems.

4.3.2 HYDROLOGY

4.3.2.1

The design rainfalls shall be determined in accordance with the intensity/duration curves and higher intensity rainfall area map (Fig 4.1 and 4.2) of this Section.

For the higher intensity rainfall area, as identified in Fig 4.2, the intensities obtained from Fig 4.1 are to be multiplied by a factor of 1.3.

4.3.2.2

a) Primary piped systems within the Totara Creek, Waiarohia Stream and the Hobsonville Peninsula to be designed to accommodate the 10% (1 in 10 year) rainfall event furthermore, greenfield catchments or sites where the stormwater discharges directly into waterways/streams or into an existing stormwater network that has been designed and built to a 10% AEP rainfall event, shall also be designed to accommodate the 10% (1 in 10 year) rainfall event.

b) All other primary piped systems in (i.e. outside the areas included in a) above) to be designed to accommodate the 20% AEP (1 in 5 year) rainfall event.

c) All inlets associated with the primary pipeline design including catchpits shall be designed for the same storm event as the pipeline. Catchpits shall be located and sized to accommodate the design flows that need to be "collected" into the Primary system.

d) Open channels shall be designed to accommodate the 1% AEP (1 in 100 year) rainfall event. The 1% AEP rainfall event may be piped under extenuating circumstances subject to specific approval.

   Overland flow paths and secondary flow paths for pipe networks are to be designed to accommodate the 1% AEP rainfall event as follows:

   - 20% AEP not greater than 0.5 cumec - pipe condition fully blocked
   - 20% AEP between 0.5 cumec and 1.0 cumec – pipe condition fifty per cent blocked
   - 20% AEP over one cumec – pipe condition 25 per cent blocked
   - Where flow paths traverse pedestrian or vehicle access ways or public carriageways, the maximum depth of flow shall not exceed 200mm.

e) Bridges and other traffic bearing structures shall be designed to accommodate the 1% AEP (100 year) rainfall event.

Note: The new Building Code currently calls for primary piped systems to accommodate the 10% AEP (10 year) rainfall event without overflow.

4.3.2.3

A run-off coefficient of 0.65 shall be used for residential urban catchments under 40ha. Larger catchments and other zones shall be subject to specific design.

Where there is a requirement to abate flows to pre-development levels, the following values of C shall be used in determining pre and post development flows:

Grassed and vegetated surfaces	.30
Impervious surfaces – roofs and driveways	.95

Fig 4.1

Fig 4.02

4.3.3 HYDRAULICS

4.3.3.1

Pipes systems shall be designed to cater for the peak design flow, without surcharge, based on a "Colebrook-White" roughness coefficient of Ks+1.50 for pipes up to and including 1000mm dia and Ks+0.60 for larger piped systems.

Open channel systems shall be designed to cater for the peak design flow without over topping based on an appropriate roughness coefficient.

Culverts shall be designed in accordance with the Council's design chart.

Culverts shall be designed for either inlet or outlet control as the specific site conditions demand.

Short culverts in streams shall either be provided with fish passages or preferably shall be designed to allow the pipe to have a minimum depth of 100 mm of silt in the invert of the pipe.

Note: This chart can be obtained from the Drainage Assets Engineer or Ministry of Works culvert charts may be used.

4.3.3.2

The stormwater drainage system shall be capable of servicing the entire catchment upstream of the development with due regard for downstream effects and approved comprehensive catchment schemes.

4.3.3.3

The minimum and maximum velocities in any stormwater drain shall be 0.75m/s and 4.50m/s respectively. These values may be exceeded under extenuating circumstances subject to specific approval.

4.3.4 FLOOD PROTECTION

4.3.4.1

All buildings shall be protected against the adverse effects of flooding resulting from rainfalls up to the 1% (1 in one hundred year) rainfall event.

4.3.4.2

No buildings, structures or alterations to levels and grades of landscape shall be permitted within areas required to accommodate the 1% AEP (1 in one hundred year) rainfall event, in accordance with District Plan requirements (reference B).

4.3.4.3

The required freeboard for building or structures adjacent to 1% AEP flood plains shall be a minimum of 500mm to design habitable floor levels. In the Swanson Stream Catchment this shall be increased to one metre (1000mm).

Note: This is due to uncertainties in the AEP model used for the Swanson Stream catchment

4.3.4.4

In coastal areas, the minimum floor level for all buildings shall be one metre (1000mm) above the highest recorded tide level (refer Fig 1.02). All structures/buildings shall be located outside the contour of the highest recorded tide. This requirement is to be considered in addition to the requirements of 4.3.4.1 and 4.3.4.2.

4.3.5 OPEN WATERCOURSES

4.3.5.1

Open watercourses shall as far as possible be located within Council reserves (recreational, drainage or road) or other open spaces and shall be clear of all existing building or structures or potential building sites.

4.3.5.2

Where the watercourse is through private property it shall be protected by a drainage easement in favour of Council. The extent of the easement shall be related to the flow volume during the 1% AEP and any respective flood plain.

4.3.5.3
Open watercourses shall be left in their natural condition as far as possible and the relevant standards and criteria of the District Plan are to be met.

4.3.6 SECONDARY FLOW PATHS

4.3.6.1

Secondary flow paths shall, as far as possible, be accommodated within Council reserves. Where this is not possible, the flow paths shall be brought through private property by the shortest route to a Council reserve. The route shall be protected by an easement in favour of Council. The easement shall specify the level of protection appropriate for the respective 1% AEP flow as set out in 4.3.6.3.

Note: Allotment refers to each lot whether residential, commercial or industrial use.

4.3.6.2

Secondary flow paths through private property should in the first instance be confined to formed vehicle access ways which, in addition to the normal stormwater control requirements, shall be designed to fully accommodate the respective 1% AEP flow as set out in 4.3.6.3.

Note: Consideration should be given to locating drainage lines within the road reserve in industrial and commercial areas where the systems are likely to be built out.

4.3.6.3

The freeboard to design floor levels of buildings adjacent to the formed and defined overland flow path shall be as follows:

- Concentrated flow from contributory catchment less than two hectare, minimum freeboard 200mm
- Concentrated flow from contributory catchment more than two hectare, minimum freeboard 500mm unless Council is satisfied by information supplied by a Registered Engineer that a reduced freeboard will provide a level of protection commensurate with the 1% AEP flow but in any case not less than 200mm.

- Where a defined flow path is required to pass through either private or public property the freeboard to design floor level for the dwellings shall be appended to the title of the respective property together with any other requirement in respect of maintenance of any defined flow path. The notice on title shall require specific reference to and certification by a Registered Surveyor that the building floor levels meet or exceed the freeboard of the requisite floor level for that site.

4.3.7 DISCHARGE PERMITS

4.3.7.1

Where required discharge permits shall be obtained from the Auckland Regional Council to discharge or divert stormwater run-off.

4.3.7.2

The developer shall obtain discharge consent for all new public stormwater drainage systems that are not currently covered by existing permits or rights, such consents shall be transferred to Council upon acceptance. The terms of consent shall be to the approval of Council.

4.3.8 PRIMARY PIPED SYSTEMS

4.3.8.1

Where a piped stormwater system is to be provided it shall provide each allotment with a suitable connection point capable of serving the whole of the allotment. Dispensation for restricted servicing may be granted under extenuating circumstances provided that the extent of the limitation is recorded on Council's Hazard Register, or when retro-fitting to established developments and topography does not permit.

Note: Allotment refers to each lot whether residential, commercial or industrial use.

4.3.8.2

The piped system shall, as far as possible (except vehicle crossings, medium and high density developments and industrial developments) be located outside of the road reserve area. Lines shall be kept clear of building platforms and manholes shall be kept clear of all boundaries and shall not be located within the road reserve or obstruct other utilities. Pipe systems located within private allotments should be located within the yard areas and consideration should be given to the most likely building location e.g. buildings are usually located towards the southern side of a property in order to gain the maximum northerly exposure. Where possible, drainage lines within working and community environments should be located within the front yard of the allotment. Pipe systems shall be located within the lowest lying portions of the property and shall run along any overland flow path.

Note: Consideration should be given to locating drainage lines within the road reserve in industrial and commercial areas where the systems are likely to be built out.

For medium or high density developments or industrial developments, the pipe system shall not be located in the road carriageway or any location (such as rear or side yards) which may be obstructed by building, fences, etc, except with the approval of the Drainage Asset Engineer.

For medium density developments, each dwelling unit shall be provided with a public stormwater connection provided that two adjacent units may be serviced by a single connection from the public system terminating in a chamber constructed in accordance with drawing SD4.13.

For terraced type housing developments or one into two lot subdivision, each of two adjacent dwellings may be connected to the public line via an inspection chamber complying with SD4.13.

4.3.8.3

A primary piped system shall consist of pipelines of a **minimum internal diameter of 200mm** and shall be laid straight horizontally and to a constant grade vertically between manholes located at each change in grade and direction.

Where a pipeline increases in size this change shall commence from a manhole and the pipes shall be matched soffit to soffit.

4.3.8.4

Drainage lines in front yards shall be at least 500mm below the level of the adjacent kerb line.

Note: This is to prevent lines being exposed when excavating in the front yard of steep sites.

4.3.8.5

Pipelines shall cross roadways as near to right angles as possible to the road centreline with a minimum cover of 1.2m where possible.

4.3.8.6

Piped systems over 1500mm diameter shall be subject to specific hydraulic and structural design and the alternative use of an open water course system shall be considered.

Note: Piped systems may have significant environmental impacts and be subject to resource consents pursuant to the District Plan.

4.3.8.7

Catchpit leads shall be a maximum of twenty-five metres long. Connections to be the manhole shall be such as to be in line of flow and not opposed to the flow.

4.3.8.8

Where fish passages are required to be constructed within a pipe or box culvert, they shall be formed by fixing a length of DE 75 SDR 17 PE 80 pipe to the invert of the box culvert from wall to wall or to the bottom 120° of arc of a circular pipe. This shall not apply when the culvert has been designated to have the bottom 100 of depth of the culvert below inlet and outlet level.

4.3.9 LOW IMPACT DESIGN

WCC encourages and supports low impact urban design approach to stormwater conveyance and treatment, not only for new developments but also for redevelopment of existing areas and property alterations. LIUD (low impact urban design) takes into account the interaction between the Three Waters (stormwater, wastewater and drinking water) and the features of the natural environment, providing an alternative approach to traditional engineering practices.

Examples of this approach include the collection of stormwater to flush toilets and irrigate gardens via rain tanks, swales to convey stormwater instead of piped systems, ponds and other treatment devices to reduce the sediment load in stormwater and

manage the peak water flow. Such devices are required where stormwater reticulation does not currently exist (see section 4.3.10.3).

Further examples of this approach are provided in the WCC and ARC documents in the reference section of this manual (references C and D).

4.3.9.1 Hydraulic Neutrality

One aspect of the low impact design approach is to ensure that the natural water balance, especially in developing and rural areas, is not adversely affected by development. This is referred to as maintaining hydraulic neutrality. In practice this includes ensuring peak flows do not wash away habitat and aquatic life, change a habitat or affect the receiving environment water quality (e.g. by diluting a saline coastal environment). This approach also extends to ensuring minimal natural flows in streams and receiving environments are maintained to protect existing habitats. The requirement for hydraulic neutrality in developing areas is enforced through the District Plan – Rule 4 (Greenfields subdivision, reference E).

4.3.9.2 Fish Passage

WCC requires, in accordance with the Auckland Regional Council requirements, the provision for fish passage when creating vehicle or pedestrian crossings over streams. Fish passage must also be considered for the construction and retrofitting of in stream structures. Design details are discussed in the ARC Technical Publication in reference F. Solutions for low head weirs, artificial channels and dams are also considered in reference F.

4.3.10 MATERIALS

4.3.10.1 Piped system

All pipes smaller than 200mm nominal id shall be plain wall uPVC SN 16 or twin extruded uPVC SN16 SC-Solid complying with AS/NZS 1260 (2002) with minimum wall thicknesses as per the table in 5.3. SN16 is a minimum requirement, however specific design check is required to confirm if SN16 or higher SN rated pipe is required.

All pipes larger than 200mm shall be reinforced concrete pipes to AS/NZS 4058 or subject to specific approval for other pipes, arches, box structures etc.

Where approval has been given to use trenchless technology to install a pipeline, the approved material is PE 80 SDR 17 polyethylene complying with AS/NZS 4130.

A higher SDR rated pipe may be required in specific cases. All PE pipe wall thickness (SDR rating) shall be determined/designed and selected to withstand the thrust, pullback forces and the torque of the drilling or online replacement machine and to suite the flexibility requirements. All joints on pipes and fittings shall be factory made spigot and socket flexible type to:

- Plain wall uPVC AS/NZS 1260
- Reinforced Concrete AS/NZS 4058
- Special joints – thrusting shall be butt welded PN 80 polyethylene as per 5.3.3.1.1.

4.3.10.2 Open channels and secondary flowpaths

Natural materials such as rocks, timber, or grass reinforced to withstand flow velocities shall be utilised as much as possible in accordance with sound engineering practice.

Interference with existing natural features must be kept to a minimum and improvements shall be made where appropriate to mitigate the effects of the development.

4.3.10.3 On Site Disposal Systems

Many sites within the urban limits of the City are not provided with storm water reticulation. The sites can comply with the Works and Services definition of the District Plan by utilising the following principles.

a) Attenuate flows to watercourses or kerb lines to the equivalent pre-development 50% AEP flow. This may be achieved using a suitably designed in ground device such as a permeable trench with an overflow to the watercourse or kerb line. The device is to be fitted with an inlet filter and an outlet throttle.
b) The flow to a watercourse shall mimic natural run-off and the flow shall be by way of a broad flow rather than a concentrated stream. Direct connections to watercourses or kerb lines shall not be permitted.
c) Where the only form of discharge to a kerb line is by way of siphon the method of flow attenuation shall be approved by the Drainage Assets Engineer. This may involve the use of a tank to provide reuse and after peak discharge to the kerb line at a prescribed rate of flow equivalent to the 50% AEP pre-development rate.
d) The use of tanks for re-use in toilets and laundry areas is recommended in all cases where attenuation is to be provided in new dwellings.
e) Re-use tanks shall be mandatory in situations where for geotechnical or other reasons attenuation devices are not practicable.

In situations where re-use tanks are to be used, the tanks shall be designed to deal with the total 20% AEP flow from roof areas. The overflow shall be limited to a discharge equivalent to the 50% AEP for the site assuming a C of 0.3. Thew actual discharge shall be designed to produce a broad swathe flow to mimic natural run-off from the site. Any run-off produced from driveways shall be attenuated via a separate device and discharged using the same criteria as the re-use tank.

4.3.11 STRUCTURAL STRENGTH, BEDDING, PROTECTION AND FLEXIBLE JOINTS

4.3.11.1

All pipes shall be designed for load bearing capacity in relation to their installation condition in accordance with AS/NZS 2566.1 Buried flexible pipelines – Structural design, AS/NZS 2566.2 Buried flexible pipelines – Installation and AS/NZS 3725 Design for installation of buried concrete pipes as appropriate. Temporary construction loading and cover over all the pipes shall be considered and appropriate protection shall be provided for the pipes.

4.3.11.2

All pipes shall be bedded, haunched and covered in accordance with SD 4.01 as appropriate.

4.3.11.3

All pipe lines steeper than 10% shall be laid in accordance with SD 4.02.

4.3.11.4

The minimum cover over pipe lines shall be 750mm in private property or 1200mm in road reserve. Where services cross each other there shall be a minimum clearance of 150mm.

Where these minimum covers cannot be achieved then the pipelines shall be protected in accordance with SD 4.01.

Concrete capping of shallow concrete pipes are not permitted. Alternative use of higher class pipes shall be confirmed with the manufacturer's specifications.

Where the pipe may be subjected to additional loadings such as traffic, tree roots or buildings, specific engineered bedding and protection may be required.

4.3.11.5

Trenched pipelines under carriageways, private ways, or other trafficked areas shall be backfilled with approved compacted hard fill to sub grade level. Such backfill shall extend a minimum of 500mm beyond the paved areas, in accordance with SD 4.08.

4.3.11.6

All pipelines up to and including 375mm diameter connecting into a solid underground structure such as manholes, catchpits, sand filters, detention tanks and the like shall be provided with flexible joint in the pipe between 300mm and 1000mm from the outside face of the structure. For manhole requirements refer to 4.3.12.10 and SD 4.03.

Flexible joints for pipelines greater than 375mm diameter will be required if differential settlement is assessed as a concern by the Council's Asset Engineers.

4.3.12 MANHOLES

4.3.12.1

Manholes shall be provided as each change in direction and grade, at each branch line connection and at a spacing not exceeding 100m. Stormwater manholes shall be constructed in accordance with SD 4.03. Light duty frame and lid may be used in areas which will not be subject to traffic loading. However, heavy duty frame and lids must be installed for all manholes in road reserves, accessways and in any other area where the manhole may be subject to traffic loads.

All manhole joints, riser to riser and riser to lid shall be fitted with holding down bolts and the joints filled with approved jointing compound. This applies to manholes of all diameters.

Note: Titan manholes are not permitted.
Stormwater manholes to be constructed on the existing network shall be constructed by the subdivider under Council's supervision or by Council's maintenance contractor at developer's cost.

4.3.12.2

Manholes up to 2.4m deep shall be constructed of a single riser where possible. A single 300mm riser may be used to make up final ground levels where necessary.

Where final ground level is altered from the design value, a single riser not exceeding 300mm in depth may be used to bring the manhole to final ground level.

Where manholes exceed 2400mm in depth, the base riser shall be a 2400mm riser topped with a single riser to final ground level. Where manholes exceed 5000mm in depth, they shall be built using two 2400mm risers topped with a single riser to final ground level.

Where an existing manhole is to be raised to a higher new ground level and there is currently a short riser on top of the base riser, the short riser is to be removed and replaced with a single riser to new ground level.

4.3.12.3

The minimum drop between the inlet and outlet invert levels through a stormwater manhole shall be 50mm or the distance when soffits are matched, whichever is the greater.

Note: Drops through manholes may be calculated using the head loss in manholes in accordance with SD 4.09.

4.3.12.4

Stormwater manholes on lines over 600mm diameter shall be subject to specific design, refer SD 4.06 for guidelines.

For manholes over lines with pipe diameters not exceeding 450mm, a precast externally flanged manhole is required.

4.3.12.5

Drops through stormwater manholes of more than 300mm shall be avoided and if unavoidable shall be subject to specific design and approval.

Cascade falls into manholes shall generally be acceptable in lines of less than 450mm diameter under the following circumstances:

- the height of the drop does not exceed one metre
- the drop connection is the major inlet to the manhole
- the benching of the manhole is hard finished concrete rather than plaster finish.

Cascade falls of pipes of diameter greater than 450mm diameter into manhole may be permitted subject to the following:

- The benching of the manhole is hard finished concrete rather than plaster
- The flow into the manhole is directed through a deflector unit
- The upstream manhole contains a warning that the downstream outlet has a drop of xyz mm.

4.3.12.6

Manholes deeper than 4.5 metres shall have a minimum of 1200mm internal diameter and manhole ladder as per SD5.11. Refer to SD5.09 and SD5.12 for manhole detail.

The main channel of the manhole shall be located so that the centreline of the channel is offset not more than 130mm from the centre line of the manhole.

Step irons shall be arranged to allow access onto the benching and shall be kept clear of inlet and outlet pipes, particularly cascade inlets.

4.3.12.7

Manholes in heavily vegetated areas shall be finished 500mm above ground level and marked with a 100x75 white painted stake 1000 mm above ground level to assist future location.

Manholes should be located close to the common boundary lines with the outside wall of the manhole a minimum of 0.5 metres from the common boundary lines.

4.3.12.8

All entry points to manholes shall be made using drills or power saws. The use of hammers as the sole means of breaking into the manhole is prohibited.

4.3.12.9

The number of entry/exit points to a manhole is to be strictly controlled to a number compatible with retaining the structural integrity of the manhole liner. In general, no more than four such entry/exit points will be permitted.

4.3.12.10

Manhole shorts (flexible joints) are required for all pipes up to and including 375mm diameter. Flexible joints for pipelines greater then 375mm diameters will be required if differential settlement is assessed as a concern by the Council's Asset Engineers.

Manhole shorts for uPVC pipes up to 200mm nominal id may be employed using a 1000mm long short with a socket and with the barrel being coated with an approved epoxy-grit for a minimum length of 300mm. The entry hole into the manhole is to be made as per 4.3.10.8 with a maximum diameter no more than 50mm greater than the external diameter of the entry pipe. The short is to be fixed and the manhole sealed using an approved epoxy mortar.

4.3.13 BRANCH LINES

4.3.13.1

A branch line is defined as a 150mm pipe originating from a manhole and terminating in a blank cap that:
Does not exceed twenty-five metres in length;
Serves no more than two residential lots of not more than four dwelling units capacity.

4.3.14 CONNECTIONS

4.3.14.1

A connection is defined as a 100mm nominal id pipeline:

a) Not more than six metres long;
b) Passing not more than five metres through an adjacent lot measured from the point of connection on the main line.
c) At the time of subdivision, there shall be at least a 1.0m between the lowest point in the building site and the service connection invert at the Council pipelines or manholes.

Where a connection exceeds these criteria, it must originate from a manhole and be in 150mm nominal id pipe.

Each dwelling or site shall be provided with a connection as defined above, adequate to service the whole of the building platform site in accordance with SD 4.04. Dwellings in medium and high density residential developments and one into two lot developments may be served in accordance with 5.3.2.5 using a stormwater inspection chamber.

Note: Generally the stormwater connection shall be provided at the lowest part of the allotment.

4.3.14.2

Connections shall be made to a manhole wherever practical.

Note:

a) Nominal 100mm diameter stormwater line connections to the existing network shall be constructed by the Council's maintenance contractor at developer's cost.

b) Nominal 100mm diameter stormwater connections on existing manholes shall be constructed by the subdivider under Council's supervision or by Council's maintenance contractor at developer's cost.

c) The costs for 100mm diameter connections by Council's contractor will be in accordance with the schedule of fess current at that date. The current fee structure is available from EcoWater.

4.3.14.3

Connection points deeper than 1.0m (to the crown of the main stormwater line) below the final ground level shall be extended to within 1.0m of the final ground level using a ramped riser in accordance with SD 4.04.

4.3.14.4

Connection points deeper than 2500mm to the crown of the main line will not be permitted.

4.3.14.5

Connection shall be finished with a screw cap, not a solvent welded one. The screw cap shall be painted blue inside and outside. All connections are to be marked with 25mm PVC duct painted blue extending 600mm above ground level.

4.3.15 INLET STRUCTURES

4.3.15.1

The section of pipeline to the first manhole or to the outlet shall be designed as a culvert under either inlet or outlet control according to the site-specific situation.

4.3.15.2

Pre cast wingwall structures are not permitted.

4.3.15.3

Inlet structures would not normally be required in the case of short culverts for driveway crossings. Where it is necessary to retain the driveway over the stream crossing, to limit culvert length and driveway width the inlet structures shall generally be designed in accordance with SD 4.05.

Wing walls and apron shall form part of the vehicle crossing and shall not be included as part of EcoWater's asset register. The hydraulic design of the inlet shall however be in accordance with the requirements below.

The particular circumstances at each site are to be evaluated in terms of

- Direction of upstream flow
- Signs of erosion both lateral and down cutting
- Height of headwall
- Need for overland flow path
- General aesthetics
- Hydraulic efficiency
- Fish passage
- Provision of access to inlet structure for maintenance and cleaning of blockages

4.3.15.4

The inlet should be designed in general accordance with the outcome of the above evaluation and the guidelines shown on SD 4.05. Note that the skew angle of deflection of incoming flow is not to exceed 20°.

Particular attention is to be paid to the depth of the skirt and the shape of the wing walls to ensure minimum disturbance to stream flows and long term erosion of the streambed and banks.

4.3.15.5

Design of the various Structural aspects of the inlet should be undertaken by a competent structural engineer.

4.3.15.6

Where the culvert is designed as a multi-barrel device, the inlet should be designed to favour one barrel to carry the low flow in direct line of the stream with the other barrel(s) off set. The number of barrels should be limited to ensure that the general stream profile is not unduly disturbed. To achieve this it is expected that the overall distance to the outside collars of the barrels would not exceed the naturally available stream channel.

4.3.15.7 Materials to be used in inlet structures

In-situ concrete is the preferred material. Decorative rock facings are acceptable.

As noted above pre-cast concrete structures are not permitted.

Precast concrete blocks with exposed aggregate surfaces.

Gabions and rock-lined structures are acceptable provided that the structure is demonstrated to have the necessary structural strength and meet long-term durability requirements. They should be the last choice.

Driven or drilled timber piles and horizontal walers are accepted provided it can be demonstrated that such structures are appropriate to the circumstances. Generally timber structures are not favoured because of high maintenance costs and the difficulties of construction.

4.3.15.8

In some circumstances of smaller diameter culverts, up to 600 mm diameter, consideration may be given to incorporating the inlet into the structure of a suitable diameter pre-cast manhole with a side inlet. This should be discussed with the Drainage Assets Engineer. The concept is achieved by using a standard precast manhole downstream of the inlet which is formed by using the collar of the pipe and

earth reinforcing and planting of the short – no more than three pipe lengths – of pipeline leading to the manhole.

4.3.15.9

In some particular cases where either no or very restricted overland flow is possible the Drainage Assets Engineer may require a secondary vertical inlet by way of 1050 or larger manhole with a dome inlet to be constructed immediately downstream of the inlet.

4.3.15.10

The general principles should comply with the New Zealand Culvert Design Manual.

4.3.16 PROTECTIVE GRILLE

4.3.16.1

All inlet structures with an inlet diameter greater than 400 mm shall be fitted with a protective inlet grille to prevent access to the culvert by children and large objects likely to cause blockages within the bore of the culvert.

4.3.16.2

All grilles shall be constructed from hot-dipped galvanised steel.
The horizontal gap shall not exceed 100mm.

4.3.16.3.

Grilles are to be designed to be self-cleansing and to withstand the loads imposed by debris blocking the inlet and the resulting hydraulic head.
They shall incorporate clear spaces top and bottom to allow low and high level flows easy entry. This gap shall not exceed 100 mm vertically.

4.3.16.4

Grilles shall be capable of being hinged to allow practicable access for cleaning
For grilles over inlet pipes of diameter greater than 800mm the grille is to be supplied with a hinged access door in the grille.

4.3.16.5

Some inlets may need trash screens upstream of the inlet grille to prevent major items of debris clogging the inlet grille. This will generally be confined to very large structures in areas of heavily vegetated riparian margins.

4.3.17 OUTLET STRUCTURES

Outlet structures shall be designed to achieve the following

- Minimal outlet velocity to preclude downstream scour
- Provide a flow pattern that will not induce side scour of the downstream banks
- Adequate fish passages where necessary
- Be aesthetically pleasing
- Have safe and easy access for maintenance and cleaning

Pre-cast concrete structures are not permitted.

4.3.17.1

Energy dissipation. The most common situation downstream of a culvert or pipeline outlet is a soft side and bottom stream. The outfall designer is to take into consideration the particular situation at the site in terms of the criteria set out above. The generally preferred method of dissipation is a stilling basin formed by the apron and wing walls of the outfall together with a weir towards the end of the apron.

4.3.17.2

The discharge velocity at the weir shall be limited to 0.75 m/s.

4.3.17.3

The general principles should comply with the New Zealand Culvert Design Manual. Particular care is to be taken with the length of the apron from the weir to the end of the apron and the depth of the skirt to prevent erosion at the end of the apron.

4.3.17.4

The height of the weir shall be a minimum of 200mm and shall be set 300 mm back from the edge of the skirt.

4.4 CONSTRUCTION REQUIREMENTS

4.4.1 PIPELINE CONSTRUCTION

All pipelines shall be constructed in accordance with the requirements of NZS 7643AS/NZS 2566, AS/NZS 2032and AS/NZS 2033as appropriate.

4.4.2 BAD GROUND

Where pipelines, manholes or structures are to be constructed in soft or unsuitable ground, remedial measures shall be carried out subject to specific design and approval to suit the circumstances.

4.4.3 CLOSE PROXIMITY

4.4.3.1 General

Building over or close to will only be permitted if diversion of the pipeline or modification of the building footprint is not practicable or where significant additional infrastructure will be created.

Building over or close to structures can and does restrict the ability of the network operator to maintain the network. The costs of maintaining the network can be very significantly increased particularly where the pipeline is at some depth and/or the soils on the site are difficult to work in. In consequence design and installation of temporary or permanent sheet piling of trenches may be necessary where it is essential to excavate down to the pipeline. Similarly the use of concrete slab construction on hardfill places different constraints on subsequent excavation to pipelines. For this reason the minimum or in some specific instances greater separation distances will be applied.

Any diversion of public stormwater pipelines shall be carried out in accordance with the Council's Code of Practice for City Infrastructure and Land Development.

Specific design and approval will be required when building over or in close proximity to public drains. This will need to be dealt with in conjunction with any building consent applications.

Note: A counter handout is available from Council's Service Centre (Civic Centre)

4.4.3.2 Building and Structures

Building over public stormwater pipelines may be permitted for:

a) Stormwater gravity pipelines less than and equal to 375mm internal diameter.

Building close to public stormwater pipelines will generally **NOT** be permitted for:

a. Stormwater gravity pipelines larger than 375mm internal diameter.

Building over public stormwater pipelines and related infrastructure will **NOT** be permitted for:

a) Any stormwater gravity pipeline greater then 375mm internal diameter;
b. Any service connection; and
c. Any stormwater manhole or other structure. No building will be permitted closer than one metre from the outside of a manhole or other surface chamber.

If building over a pipeline is approved (for pipes less than and equal to 375mm diameter) then the following requirements shall be met:

a) For all pipeline material, the pipeline shall be video checked before and after the work. If the pipeline is found to be in poor condition in the pre-construction video, it shall be upgraded by the developer at the developer's expense to the required Council standard for the length that may be influenced by the new building work.
b) The minimum length of pipeline to be replaced is the full length under the building footprint, including decks plus a minimum distance of 2 metres or distance equivalent to the depth to invert of the pipe from finished ground level, beyond the outer line of the foundation wall/piles, which ever is greater. The pipeline shall be video checked after the works and submitted to Council.
c) Horizontal or vertical curvature of pipelines under building platforms in **NOT** permitted.
d) Long section drawing for the pipeline showing the levels of the underside of the foundation along the pipe shall be provided to Council. The distance between the top of the pipe and the under side of the foundation and foundation beams shall be provided clearly in the long section. Cross section details for all structures, beams, footings, piles within 45° zone shall be provided along the length of the pipe replaced.
e) The support structure for the building must be totally independent of the pipeline so no additional loading is applied to the pipeline.
f) Piles shall be constructed where there is a need to bridge the pipeline. No pile ramming is permitted within 5 metres from the stormwater pipe centreline and within the 45° envelope. Piles within 5 meters must be drilled.
Refer to SD4.27 and SD4.28 for bridging details for buildings and structures built over or close to public stormwater pipelines.
g) The pipe shall be reconnected to the existing pipeline using approved shear band couplers.
h) All buildings, especially raft foundation structures shall be protected and isolated from the effects of the trench and any damage caused by future pipe bursting construction techniques.
i) Any damage to public pipeline (including public pipelines upgraded with the building over) identified from post-construction video as a result of the development work will require repairing or replacing at developers' cost to the Asset Engineer's satisfaction.
j) Where existing connections are under the proposed footprint of the building, they shall be located outside the footprint a minimum distance equivalent to the depth of the pipeline (from finished ground level) clear outside of the footprint at the developer's expense. **Note** – there are limits to the minimum

approved clear distance between the top of the pipe and underside of the foundation. Refer to SD 4.28.

k) Where a connection to an adjoining site is located under the proposed footprint the cost of relocating the connection and diverting the service back to the boundary line to reconnect the existing service is to be borne by the developer. This section of pipeline is deemed to be public and shall be constructed as required in the Council's Code of Practice.

If building close to a pipeline is approved the following requirements shall be met:

a) For all pipeline material, the pipeline shall be video checked before and after the works. If the pipeline is found to be in poor condition in the pre-construction video, it may be required to be upgraded by the developer at the developer's expense to the required Council standard for the length that may be influenced by the new building work.

   The minimum length of pipeline to be replaced is the full length along the building footprint, including decks plus a minimum distance equivalent to the depth to invert of the pipe from finished ground level, beyond the corner foundation pile. The pipeline shall be video checked after the works and submitted to Council.

b) Flood/Overland Flow path report associated with the pipeline/gulley/catchment will be required to be submitted with the application. No building or structures will be approved to be built in the flood plain and the overland flowpath. Specific floor level requirements will have to be met.

Council's decision will be based on assessment of pipeline condition, floodplain or overland flow path report submitted by the developers, potential risks that will limit Council to carryout future maintenance and operations, rerouting and upgrading of the pipeline.

4.4.3.2 Retaining Walls

Where it is intended to construct a retaining all of any description within five metres of a stormwater pipeline the details must be submitted to Council for approval prior to the construction of the wall.

Whether the wall requires a building consent or not is irrelevant as the constraints imposed on the infrastructure will need to be assessed.

Matters to be considered will include but not be confined to:

a) Type of wall i.e. cantilevered timber, gravity, cantilevered masonry
b) Separation distance from pipeline
c) Existing depth of the pipeline
d) Surcharge placed on pipeline
e) Whether the wall crosses the pipeline diagonally or at right-angles
f) Pipe material
g) Pipe class
h) Design must allow practical access for future Council maintenance, while maintaining the structural integrity of the wall.

4.4.4 EARTHWORKS AND SEDIMENT CONTROL

The Erosion and Sediment Control Measures appendix of the District Plan (reference H) provides details on the practices to be undertaken while doing earthworks within Waitakere City. In addition to these provisions, ARC Technical Publication 90

(reference G) also provides information and examples of the various control measures that should be employed when undertaking earthworks on sites >1000m^2.

All earthworks within Waitakere City shall make use of erosion and sediment control measures regardless of the size of the site or the volume of earthworks, or whether a resource consent is required.

References G and H address the sediment and erosion control measures required to be considered.

4.5 STORMWATER TREATMENT DEVICES

4.5.1 GENERAL

The selection of a stormwater treatment device or combination of devices for a particular site is dependant on a number of factors, including the size and land-use of the area contributing the runoff, the receiving environment and area of land available to accommodate the device.

There are a number of documents available to assist with the selection and design of stormwater treatment devices and these are listed in the reference section (references I, J and K).

4.5.2 STORMWATER TREATMENT PONDS

Ponds shall provide for public amenity and wild life habitat as well as stormwater detention and treatment. It is vital that ponds not be treated as a stand-alone piece of infrastructure but as an integrated part of the social and environmental community. Features such as irregular pond shape, islands, bird perching logs, shorelines which have a natural appearance, and recreation facilities such as board walks will all help in achieving this aim. See also SD 4.25

Note: Developers are encouraged to visit good practice examples of integrated pond design. EcoWater and Parks and Green Assets can be contacted for such examples and to discuss specific design issues by calling the Council Call Centre on 839 0400. Some good practice examples are also included at the end of this chapter.

Ponds shall be designed for minimum long-term maintenance requirements.

The design shall generally be in accordance with the requirements of the Auckland Regional Council (ARC) Technical Publication 'TP 10-Stormwater Treatment Devices' (reference K) except as amended below.

The maximum depth of any pond shall not exceed 2000mm and no more than 10 percent of the pond area may exceed 1500mm in depth.

Where the requirements of TP 10 and those detailed below are not practicable, application shall be made to the Drainage Assets Engineer to vary those requirements.

Dry ponds shall not be permitted unless approved by Council Asset Engineer.

The maximum water level resulting from the operation of the pond must be contained completely within the drainage reserve area unless otherwise approved by the Drainage Assets Engineer.

A complete set of the stormwater pond design calculations, as built drawings and asset attributes shall be submitted with the final design to EcoWater for approval.

Note: A well-designed pond can become an attractive focal point for a development and may increase section values.

4.5.2.1 Pond slopes

The external slopes of the pond shall be at a maximum gradient of one vertical to five horizontal as detailed on SD 4.20.

A planted shelf with slope of one vertical to fifteen horizontal shall be provided around the perimeter of the pond. The shelf shall be a minimum of four metres wide, extending for two metres above and below the normal water level of the pond (refer 4.5.2.3 below also).

4.5.2.2 Signage

Warning signs are required to be erected at all pond sites.

Signs shall be erected at all defined access points to the reserve.

Where there are existing park name signs, a running board shall be added to the bottom of the existing sign as detailed on SD 4.21.

Stand-alone signs, as detailed in SD 4.22 and 4.23 may be required.

The location, type and number of signs shall be determined in consultation with the Drainage Assets Engineer and the Service Manager, Parks and Green Assets.

4.5.2.3 Fencing

Fencing shall be installed where required for health and safety reasons as directed by the Drainage Assets Engineer in consultation with the Service Manager Parks and Green Assets.

The criteria used in the determination shall include the following:-

- Proximity to houses
- Proximity to schools
- Pond use
- Proximity to walkways
- Pond depth

Note: If the pond complies with 4.5.2 it is unlikely that there will be a requirement for permanent fencing. Council prefers such unfenced ponds to steeper ponds that require fencing and this should always be the first option investigated. Unfenced shallow edged ponds are also generally less costly.

Where the pond is in a reserve, the fencing shall be located in consultation with the Drainage Assets Engineer and the Service Manager, Parks and Green Assets.

Where the pond is located in a stand-alone drainage reserve, the fencing shall be erected on the boundary of the reserve.

Fencing of the pond shall be in accordance with SD4.24.

Gates are to be provided for access to the pond. The overall width of the gateway shall allow for access of maintenance vehicles and shall have a minimum opening width of three metres.

Fencing and gates shall be hot dipped galvanised and powder coated Waitakere Green (PMS 3302c).

Gates are to be fitted with hasp and latch and a standard EcoWater padlock.

4.5.2.4 Manhole outlets

Manhole outlets shall be located to allow safe access from the bank of the pond without need for boats.

The manholes shall be constructed as detailed on SD 4.03 except for the lid detail.

Manhole outlets shall have dome grates. Contact the Drainage Assets Engineer for preliminary standard details for dome grates.

4.5.2.5 Pond de-watering

Suitable measures shall be installed to allow the pond to be de-watered for maintenance using gravity through the outlet manholes.

Manholes shall, as a minimum, have de-watering outlets at 300mm and 600mm below the normal operating level and at the base of the pond. Where the base of the pond is at a point remote from the outlet manhole an inlet pipe shall be run from this point to the manhole. The inlet pipe shall be capable of being opened from within the manhole to allow draining of the pond.

De-watering pipes in the manhole shall comprise short lengths of SN 16 uPVC pipe with a puddle flange on the exterior of the manhole wall and a screwed cap on the inside of the manhole. The cap shall protrude no more than 150mm into the manhole. Construction shall be as set out in 4.3.10.

4.5.2.6 Planting

Site-specific planting plans and specifications are to be submitted to EcoWater for approval.

These shall be based on achieving planting requiring a minimum of long-term maintenance.

The plans and specifications are to include at least the following:

a) Timing of planting
b) Density
c) Planting and maintenance methodology
d) Plant replacement during maintenance period
e) Water level control for maintenance / establishment period
f) Protection of plants against pests
g) Weed control methodology.

The plants shall be eco sourced and shall be appropriate to and tolerant of each particular pond and particular site conditions.

All clay slopes are to be ripped to a depth of 300 mm prior to 150 mm of topsoil being applied.

Refer to SD 4.25 and SD 4.26 for Planting Guidelines and Pond Planting Zones.

Refer to Appendix A for Schedules of Native Plant Species for the various planting zones and reference L for the ARC guideline.

A variety of native plants are to be used in the planting plan. At least five different species are to be used in each of the margin, lower bank and upper bank zones. A minimum planting density of two plants per square metre is required in the margin zone and one plant per square metre in the lower and upper bank zones. No plant species used shall comprise more than 30% of the total plant mix in each zone.

The perimeter shelf of the pond is to be in dense wetland planting.

If a fence is used, 1 metre both sides of the fence are to be planted. Refer also to SD 4.26

For the duration of the planting maintenance period the pond shall be maintained at the cost of the developer and to the satisfaction of the Service Manager, Parks and Green Assets.

4.5.2.7 Maintenance access

Access shall be provided to the pond for maintenance, including the removal of sediment from the forebay.

The width and gradient of the vehicle access routes shall be adequate for maintenance vehicles and machinery to reach the pond and immediate environment including the outlet wingwall structure.

Vehicle access routes shall have adequate measures against vehicle erosion of the surfaces. This may be achieved by the use of appropriate erosion matting and or 200mm thick, GAP 20 gravel access. Access width shall be 3 metre minimum.

The construction plans shall detail the location of maintenance access points and routes. Whenever possible a concrete entry ramp to the forebay shall be provided unless there are other practicable options agreed by Council Asset Engineer.

4.5.2.8 Maintenance manual

A specific maintenance manual is required for each stormwater pond.

A draft maintenance manual is to be submitted to EcoWater with the final design for approval. The maintenance manual shall include at least the following:

a) Location Plan
   Site plan
   Construction plans
   Planting plan

b) General information:
   Pond data summary (refer to Appendix B for standard layout)
   Pond calculations summary (refer to Appendix B for standard layout)
   Resource consent and ARC approval
   Pond Survey designated to title plan status
   Geotechnical report from registered engineer specialising in geotechnics
   Fencing details
   Bonding information (terms and conditions) for pond maintenance
   Lists of any assets such as parks furniture and signs

c) Maintenance requirements:
   Proposed frequency of maintenance (refer to Appendix B for Maintenance Frequency Schedule layout)
   Maintenance log to be prepared (refer to Appendix B for maintenance log layout)
   Pond de-watering method
   Planting maintenance – timing and methods

Weed maintenance and control
Sediment removal timing and methods
Structural maintenance
Inlet and outlet maintenance
Pest inspections and control.

Note: In some circumstances EcoWater may accept an easement or a partial easement instead of vesting.

The approved final maintenance manual is to be submitted on completion of the pond construction and shall include As-Built details in addition to those items given above.

As-Built plans shall include pond contours at 200mm maximum spacings below normal water level.

4.5.2.9 Acceptance by EcoWater

The following checklist shall be used as part of the sign-off process for ponds.

a) Inspection after completion of earthworks

On completion of earthworks and prior to landscaping and the construction of any fences a site meeting between the developer's representative, Eco Water Solutions and Parks and Green Assets shall be arranged. The purpose of this meeting is to confirm adherence to the submitted landscaping plans and to agree on any amendments.

Note: This site meeting is vital because changes in the finished ground level can have a negative impact on visual amenity if not appropriately addressed.

b) On completion of construction

- On completion of construction, the land/pond shall vest with EcoWater. Prior to vesting with EcoWater, the following shall be confirmed/provided:
- Pond constructed in accordance with the construction plans and specifications
- Pond planting in accordance with plans and specifications, or planting plans submitted and approved with proposed planting time
- Geotechnical certification in the form of producer statements
- As-Built plans submitted\Maintenance manual submitted and approved
- Legal documentation of vesting complete where applicable
- Where planting has not been effected, a performance bond covering the work is to be lodged with EcoWater.

c) On completion of the maintenance period

The maintenance period shall be as shown in the Quality and Release Manual.

The following shall be confirmed/provided:

- Maintenance logs submitted for maintenance period
- Planting established in accordance with planting plants
- Details for consent sign-over confirmed where applicable
- ARC final approval.

4.5.3 OTHER TREATMENT DEVICES

The following stormwater devices are approved to be used in the city, provided they are designed to the ARC Technical Publication 10 and WCC requirements.

a) Sand filters
b) Hynds Up-Flo™ Filter
c) Stormwater360 – Storm Filter

4.5.3.1 Design Requirements

The design shall generally be in accordance with the requirements of the Auckland Regional Council (ARC) Technical Publication 'TP 10-Stormwater Treatment Devices' (reference K). The design shall incorporate all Health and Safety (H & S) requirements for the confined spaces.

Detail analysis of H & S requirements including the confined spaces shall be provided. Structural design details including all jointing details shall be provided.

4.5.3.2 Maintenance Manual

To ensure that stormwater quality and detention devices are adequately maintained, Operation and Maintenance Manuals shall be prepared and submitted to EcoWater.

Technical Details

1. Location - street address and plan
2. Year of completion
3. A detailed scale plan of the total contributing catchment
4. Construction detail plans or manufacturers brochure for the device
5. Copy of ARC resource consent if applicable
6. As-built plan, dated and showing truck maintenance access, machinery working pads and temporary working/storage areas
7. Copy of relevant design calculations
8. Geotechnical report from registered engineer specialising in geotechnics

Maintenance Requirements

Methodology for the on-going and long-term maintenance of the facility:

- Inspections required and frequency
- Maintenance needs and frequency
- Maintenance Log
- Methodology of cleaning and maintenance

4.6 REFERENCES

A. "Guidelines for stormwater run-off modelling in the Auckland Region", Auckland Regional Council Technical Publication 108, (1999)

B. Waitakere City District Plan (2003)

C. "Low impact design manual for the Auckland Region", Auckland Regional Council Technical Publication 124, (2000)

D. "Low Impact Urban Design – Code of Practice", Waitakere City Council, (2006), due October 2006.

E. "Greenfields Subdivision", Rule 4 of the Waitakere City District Plan (2003)

F. "Fish passage guidelines for the Auckland Region", Auckland Regional Council Technical Publication 131, (2000)

G. "Erosion and sediment control: guidelines for land disturbing activities in the Auckland Region" , Auckland Regional Council Technical Publication 90, (1999)

H. "Erosion and sediment control measures appendix", Waitakere City District Plan, (2003)

I. "Countryside and Foothills stormwater management Code of Practice", Waitakere City Council, (2005)

J. "Stormwater solutions for residential sites", Waitakere City Council, (2004)

K. "Design guideline manual: Stormwater treatment devices", Auckland Regional Council Technical Publication 10, (2003)

L. "Riparian management zones: a strategy for the Auckland Region", Auckland Regional Council Technical Publication 148, (2001)