City of Perth

Design and Construction Note

Book 200

Drainage Design and Drainage Structures

Version 1.1

Book 200 - Amendments

Version 1.0		*29/06/2018*
V1.0	Book 200	29/06/2018
	Issued For Use	
Version 1.1		*16/08/2018*
V1.1	Book 200	16/08/2018
	Backdrafted & Re-issued For Use	

Drainage Design and Drainage Structures
Index

200.00 Drainage Design & Drainage Structures

201.00 Drainage Design

Drainage Design and Drainage Structures
Index

202.00 Drainage Structures

01 - Introduction to Drainage Design

01.1 Introduction

The planning, design and implementation of stormwater design must integrate the different components of stormwater management, including but not limited to the water quality and quantity. The stormwater drainage system must:

a) prevent or minimise adverse social, environmental, and flooding impacts on the city's waterways, overland flow, paths and constructed drainage networks.
b) achieve acceptable level of stormwater runoff quantity and quality by applying total water cycle management and water sensitive urban design.

Urban stormwater drainage system and planned designed and constructed in accordance with the current edition of the following:

1) City of Perth Policy on Stormwater Drainage Connections (Appendix)
2) City of Perth Guidelines for better management of Urban Stormwater for Commercial Properties (Appendix)
3) City of Perth Guidelines for better management of Urban Stormwater for Residential Properties (Appendix)
4) Australian Rainfall and Runoff (ARR-1997)
5) Stormwater Management Manual for Western Australia (WA 2004-2007)
6) AustRoads - Part 5: Drainage Design (AustRoads 2010)

These guidelines have been prepared to assist in the design of stormwater drainage systems within the City of Perth. The Guidelines are provided so that uniformity of standards and practices are maintained in the design of the municipal drainage systems.

The City may consider alternate storm water management options suitable for the built environment, provided they comply with the Stormwater Management Manual for Western Australia (Integrated Water Cycle Management)

01.2 - Asset Management Plan

To maintain the performance of all new and existing stormwater infrastructure, it is required to undergo ongoing maintenance. All proposals regarding new stormwater infrastructure should consider the stormwater systems ability to meet design objectives and the maintenance needs over the length of its design life.

Prior to Asset Handover the new drainage infrastructure must undergo an inspection using CCTV and the results provided to the City of Perth.

01.3 - Water Sensitive Urban Design (WSUB) & Water Sensitive Road Design (WSRD)

WSUB involves the intergration of urban stromwater, water supply and wastewater issues during the planning and design of urban developments with the objective that water is used in a resource sensitive and ecologically sustainable manner.

WSRD should focus on water sensitive stormwater management within parks and road reserves. These principles can be applied to urban roads when it is considered as an alternative drainage design. Basic design tools incorporated in to WSRD are:

- minimising the extent of impervious surfaces;
- stormwater detention and retention;
- stormwater treatment systems;
- pollution containment systems; and
- appropriate street landscaping.

01.4 - Stormwater Management Plan (SMP)

A Stormwater Management Plan (SMP) shall set out management activities within a catchment and should be provided for a proposals which are likely to:

- alter stormwater runoff volume, rate, duration and/or frequency; and/or
- adversely affect the environmental values of the area receiving the water, including groundwater, downstream water and waterways such as the river.

An SMP should identify the proposed protection, treatment and management of the identified water ways and water bodies within the catchments area with respect to:

- the impact of stormwater on the features of the environment and their ecosystems; and
- the impact on the features of the stormwater

The two forms of SMP that should be developed as part of a new development are:

1) Urban Stormwater Quality Management Plan
2) Site Based Stormwater Management Plan

It is also necessary to develop a risk assessment of the proposal and develop a Risk Management Strategy, in accordance with *"City of Perth Enterprise Risk Management Policy (COP Policy 19.1)"* and *"AS/NZS ISO 31000:2009 - Risk Management - Principles and Guidelines."*

01.5 - Referenced Documents

(ARR 2016)	*Australian Rainfall and Runoff – A Guide to Flood Estimation - Ed. 4*
(COP Policy 19.1)	*City of Perth Enterprise Risk Management Policy*
(DER 2015)	*Identification and investigation of acid sulfate soils and acidic landscapes*
(DER 2015)	*Treatment and management of soils and water in acid sulfate soil landscapes*
(WA 1986)	*Environmental Protection Act 1986*
(WA 2004)	*Environmental Protection (Unauthorised Discharges) Reg. 2004*
(AustRoads 2010)	*Guide to Road Design Part 5: Drainage – General and Hydrology Considerations*
(AustRoads 2010)	*Guide to Road Design Part 5A: Drainage – Road Surface, Networks, Basins and Subsurface*
(AustRoads 2010)	*Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways*
(WA 1911)	*Health Act 1911*
(WA 2004-2007)	*Stormwater Management Manual for Western Australia*

01.6 - Referenced Australian Standards

AS/NZS 1254:2010	*PVC-U Pipes and Fittings for Stormwater and Surface Water Applications*
AS/NZS 1260:2009	*PVC-U Pipes and Fittings for Drain, Waste and Vent Applications*
AS 1273-1991	*Unplasticised PVC (UPVC) Downpipe and Fittings for Rainwater*
AS 1597.1-2010	*Precast Reinforced Concrete Box Culverts*
AS 1646-2007	*Elastomeric Seals for Waterworks Purposes*
AS/NZS 2032:2006	*Installation of PVC pipe systems*
AS/NZS 2041.1:2011	*Buried corrugated metal structures - Design methods*
AS/NZS 2041.2:2011	*Buried corrugated metal structures - Installation*
AS/NZS 2041.4:2010	*Buried corrugated metal structures - Helically formed sinusoidal pipes*
AS/NZS 2566.1:1998	*Buried flexible pipelines - Structural design*
AS/NZS 2566.2:2002	*Buried flexible pipelines - Installation*
AS/NZS 3500.3:2015	*Plumbing and drainage - Stormwater drainage*
AS/NZS 3500.5:2012	*Plumbing and drainage - Housing Installations*
AS 3571-2009	*Plastics Piping Systems*
AS/NZS 3725:2007	*Design for installation of buried concrete pipes*
AS 3735-2001	*Concrete structures retaining liquids*
AS 3600-2009	*Concrete structures*

AS/NZS 4058:2007	*Precast Concrete Pipes (pressure and non-pressure)*
AS 5100.2-2004	*Bridge Design - Part 2: Design Loads*
AS/NZS 5065:2005	*Polyethylene and polypropylene pipes and fittings for drainage and sewer...*
AS 5100.2-2004	*Bridge Design - Design Loads*
AS/NZS ISO31000:2009	*Risk Management - Principles and Guidelines*

02 - Drainage Design Criteria

02.1 - Design Method

02.1.1 - The Guidelines as recommended in *"Australian Rainfall and Runoff, A guide to Flood Estimation"* (ARR) shall be used for the hydrological and hydraulic designs of the Council's drainage systems.

02.1.2 - The Rational Method as described in Book Eight - "Urban Stormwater Management" of the above publication (ARR) shall be used as the basis of design for the calculation of peak flows.

02.1.3 - Computerised Rational or Laurenson Formula based software for pipe system and analysis may be used. The Council presently utilises the XP-Storm software developed by WP Software which produce peak flow rate output files and hydraulic grade lines. The designer shall include information on the software used for the submitted design calculations.

02.2 - Design Average Recurrence Intervals

02.2.1 - The average recurrence intervals (ARI) for the design of piped drainage systems in a residential, commercial or industrial area will depend on the local circumstances of the catchment area.

02.2.2 - The Council may require designs to be based on storms of longer recurrence intervals where it is considered that the damage, danger or inconvenience likely to result from surcharging warrants such measures.

02.2.3 - As a guide the recurrence intervals adopted for typical catchments (property development) within the municipal boundary City of Perth are shown in the table below:

Type of Catchment
A) Central Business District
B) Commercial/Industrial Areas/High Rise /Multiple residential(outside CBD)
C) Residential Area
D) Street Drainage System

	Storage Tank	Drainage Network
A	100	20
B	50	10
C	20	10
D	20	10

ARI (years)

02.3 - Runoff Coefficients

02.3.1 - The runoff coefficient can be calculated as the average (weighted by area) of the coefficients chosen for the portions of differing permeability.

02.3.2 - The adopted range of runoff coefficients for the City of Perth are as shown below:

Paved Surfaces	1.0
Intensely developed commercial & industrial areas	0.9
Suburban commercial & industrial areas	0.3
Residential development	0.5

02.3.3 - The stormwater runoff from residential properties are required to be retained on site. If due to special circumstances such as multi-unit developments the water cannot be suitably retained on site, a connection to the Council's drainage system may be considered.

02.4 - Rainfall Intensity-Frequency-Duration

02.4.1 - The rainfall intensity-frequency-duration relationships are to be as set out in *"Australian Rainfall and Runoff, A Guide to Flood Estimation"*.
See Design & Construction Note 201.06 for the Rainfall Intensity Chart for Perth.

02.5 - Time of Concentration

02.5.1 - Travel times may be calculated from charts for overland flow and gutter flows contained in the Australian Rainfall and Runoff publication, together with pipe and channel flow charts.

02.5.2 - The minimum time of concentration shall be taken as 5.0 minutes.

02.6 - Flooding Hazards

02.6.1 - Tailwater Level Assumption
An allowance of 1200mm change to the sea level due to climate change must be assumed for the design of minor drainage systems, where the stormwater drainage discharges into tidal waterways such as the Swan River.
If tailwater is critical for managing major flows and setting flood immunity, a sensitive check must be undertaken to examine impacts of higher sea level in accordance with best climate change predictions at the time.

02.6.2 - Hazard Estimation
For pedestrian safety the following criteria apply:
The velocity x depth product in a roadway in the designed major storm event is not to exceed 0.6m²/s in the channel, kerb and footpath.

02.7 - Stormwater Pipes

02.7.1 - Each section of pipe or conduit shall be designed to flow full and operate under pressure.

02.7.2 - The hydraulic design of pipe size shall be based on the Colebrook-White formula using the charts for roughness coefficient K.
Reinforced Concrete Pipe.....K = 0.6
UPVC Plastic.....K = 0.015
Clay.....K = 0.15

02.7.3 - The maximum and minimum velocity for full pipe flow shall be 4.5 m/s and 0.75 m/s respectively.

02.7.4 - The pipe sizes shall have a minimum capacity designed for a storm event of average recurrence interval as outlined in 02.2.3.

02.7.5 - The pipe types and classes must comply with the following requirements:
a) Low density residential must be in accordance with *"AS1254:2010 PVC-U Pipes and Fittings for Stormwater and Surface Water Applications"*
b) Commercial, industrial, medium and high density residential applications must be in accordance with *"AS1260:2009 - PVC-U Pipes and Fittings for Drain, Waste and Vent Applications."*

02.7.6 - The minimum pipe class to be used is:
a) Steel reinforced concrete pipe, *Class 2*
b) Fibre reinforced concrete pipe, *Class 4*
c) Precast reinforced concrete pipe, Complying with *AS4058:2007*
d) U.V. plasticised polyvinyl chloride (UPVC) for roof drainage and sewer, *Class SN6*
e) Flexible stormwater pipe, *Class SN8 (AS5065:2005)*

Alternative pipe material subject to satisfactory demonstration that the proposed alternative material will meet the performance requirements with regard to the design, installation and maintenance for the design life.

02.7.7 - Depth of Cover to Pipes:
a) Minimum pipe cover for polyvinyl chloride (PVC) pipelines vary for different locations and loadings. Minimum covere is set out in the technical manual and must be in accordance with *"AS2032:2006 - Installation of PVC Pipe Systems."*
b) Pipe bedding and cover requirements for steel reinforced concrete pipe (RCP) or fibre reinforced concrete pipe (Fibre RCP) shall be determined from the Concrete Pipe Association or *"AS3725:1989 - Loads on buried Concrete Pipes."*

The required bedding and minimum cover to pipes shall be in accordance with the manufacturer's recommendations.

02.7.8 - The minimum pipe size for the main drainage system shall be 300mm in diameter.

02.7.9 - Pipe diameters along a main drain shall not decrease in the downstream direction irrespective of steeper grades.

02.7.10 - Loading & Overburden of Pipes:
Steel reinforced concrete pipes shall be designed for installation in accordance with *"AS/NZS 3725:2007 - Design for installation of buried concrete pipes."* with the following exceptions.
Clause 6.5 of AS/NZS 3725 shall be replaced by:

a) The defects of superimposed live loads shall be calculated in accordance with *AS5100.2-2004*
b) Distribution of live loads shall be in accordance with *AS5100.2-2004*
c) Dynamic load allowance shall be as follows:
    i) a value of 0.4 for zero height
    ii) a value of 0.1 for fill heights of 2m of higher
    iii) a linear interpolation between 0.4 and 0.1 for depths between zero and 2m depths respectively.

Construction load cases shall be considered in addition to load cases associated with compaction of fill material.

02.7.11 - Pit energy losses and pressure changes shall be taken into account for the hydraulic grade line analysis. For reliable values of energy losses and pressure changes for different types of pits and junctions, it's recommended that "Missouri Charts" are used.

02.7.12 - Pipe Capacity Assumptions:

1. Pipe capacity for trunk stormwater systems is to be estimated using hydraulic grade line analysis of the drainage system for the relevant design storm and using a suitable computer model.
2. For smaller pipelines, the capacity can be estimated using pipe flowing full at grade assumptions. The adopted pipe velocity when using this method must not be less than 3 m/s.

02.8 - Soakage Sump

02.8.1 - The sump for soakage purposes shall be designed to cope with the accumulated storage resulting from the runoff from a design storm of 1 in 10 years ARI to 1 in 50 years ARI depending on its location. A check shall also be made for a design storm of 1 in 100 years ARI in order to determine its impact on the surrounding land and installations.

02.8.2 - In estimating storage requirements a mass - curve technique may be used. An example of this procedure is given in Book Eight, Technical Note 1 of *ARR 1997*. The Council presently uses a simple inflow and outflow hydrograph relationship to analyse the storage capacity of soakwells.

02.8.3 - A soil investigation shall be carried out to determine the soil parameters required for the storage analysis of the sumps.

02.9 - Detention Systems

02.9.1 - On-site detention system may be designed to restrict peak outflows for selected design storms to either pre-development conditions, or to the maximum capacity of the existing downstream drainage network.

02.9.2 - If stormwater cannot be disposed of on-site due to adverse site conditions then connection to the City's street stormwater system may be considered. Approval of the proposed connection may require the installation of large on-site holding tanks to retain the critical storm. These on-site detention systems shall be designed to reduce the peak runoff from the developed sites for a once in a hundred (1:100) year storm to the runoff which would have occurred in a natural state of a once in twenty (1:20) storm of a duration equal to the natural time of concentration. The maximum allowable discharge to the City's system is 120litres/second/hectare of site and the minimum storage requirement is 185 cubic metres/hectare of site. In designing the storage tank allowance should be made for the additional area that may be created by high rise buildings on the site. A detailed design must be submitted to the City of Perth's Engineering Section before any drainage connection approval will be considered.

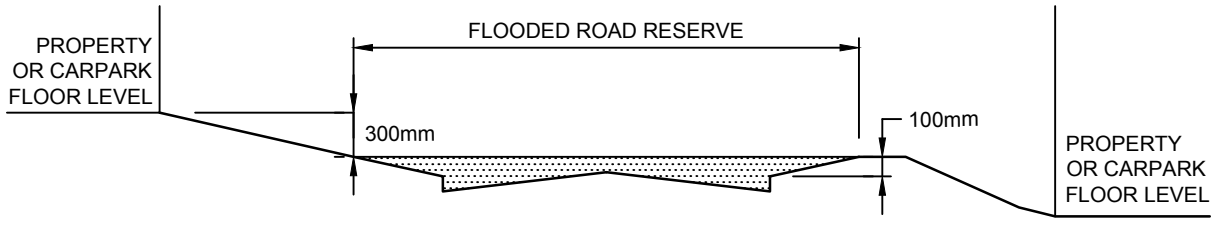
02.10 - Retention Systems

02.10.1 - Stormwater retention systems can be designed to reduce the total annual runoff volume and reduce the runoff volume from a specified design storm.

02.10.2 - Grassed and Vegetated Drainage Channels:
The application of ground channels is genuinely limited by the design standards and site conditions. Consideration should be given to the incorporation of the principles of natural channel design for the design of such drainage channels. All drainage channels of this design should have a natural appearance and fit with its surroundings.
Refer *Stormwater Management Manual for Western Australia* (WA 2004-2007).

02.11 - Free Board

The Free Board level required is 300mm, this is the level between a flooded road reserve and the floor level of commercial/residential properties or carparks. Where the level of a property or carpark is below the level of the top of kerb it is required that in between is a raised footpath that is 100mm higher than the top of kerb. This requirement minimises the risk of flooding to private properties and carparks. See drawing below.



02.12 - Non-Aggressive Ground Conditions

To install a pipe underground or above ground in ground conditions considered to be non-aggressive, the following must apply:

a) The pipe must not come in to contact with salt-water or salt spray
b) The pipe must not be subject to and tidal conditions or forces
c) Internal and external surfaces of pipes exposed only to fresh or brackish water
d) The soil and ground conditions are not contaminated with Acid Sulphate Soil, as per the Department of Environment Regulations guidelines. (DER 2015)

02.13 - Marine Environment

To install a pipe underground or above ground in ground conditions considered to be a Marine Environment, the following must apply:

a) Only the external pipe surface is to come in contact with salt water or salt spray
b) The soil and ground conditions are not contaminated with Acid Sulphate Soil, as per the Department of Environment Regulations guidelines. (DER 2015)

02.14 - Acid Sulphate Soils

Planning of stormwater drainage systems within potential acid sulphate soil zones must be undertaken with considerations for items such as, but not limited to:

- Highly acidic soils affect on the surrounding and downstream environment;
- The potential that groundwater is also highly acidic; and
- The acidic conditions affect on existing and new infrastructure.

The Department of Environment and Conservation has produced guidelines to assist with the identification, treatment and management of acid sulphate soils within Western Australia. Refer *Identification and investigation of acid sulfate soils and acidic landscapes* (DER 2015) and *Treatment and management of soils and water in acid sulfate soil landscapes* (DER 2015).

03 - Design of Pipe Network

03.1 - Location of Drainage Pipes

03.1.1 - The drainage pipes shall be located within the road reserves unless permission has been obtained to locate it in private property.

03.2.1 - When a drainpipe is located within a property not under control of the local government, a drainage easement in favour of the local government will be required along the alignment of the drainpipe.
If a developer seeks to use or encroach an existing easement of the local government stormwater system, the local government's consent will be required.
For typical easement dimensions refer *Design & Construction Note 202.10.*

03.2.1 - The proposed alignments of pipe networks shall be checked and confirmed by on-site inspections of the locality. Where possible, the alignment and cover to proposed piped systems shall comply with the requirements of the Public Utilities Information Manual for Western Australia.

03.1.3 - The proposed pipe network must be checked against the presence of all underground and above ground public utilities in the locality.

03.1.4 - Connection to stormwater drainage under building.
A connection to the stormwater drainage under a building is to be carried out in accordance with *"Section 7.2.9, AS/NZS3500.3:2003"*

03.2 Manholes and Access Chambers

03.2.1 - The standard manhole/access chamber should be used and the standard drawings for their installation have been made available (Water Corp Std & COP Std). However for the intersection of multiple pipes, large diameter pipes or to match the configuration of existing pipes, it may be necessary to design a special chamber.

03.2.2 - Manholes and access chambers should be provided on drainage lines to provide access for maintenance at critical points, they should be provided in a drainage system at:

a) lateral drainage inlets
b) changes of grade
c) changes of pipe diameter
d) changes of direction

Consideration should given to the placement of a manhole/access chamber at an obstruction or penetration by a conduit or service, to facilitate the removal of debris.

03.2.3 - The maximum allowable length of pipes between manholes shall not exceed 90 metres for pipes ranging from 225mm to 600mm in diameter. For pipe sizes greater than 600mm diameter, it is preferable to limit the maximum length of pipes between manholes to 120m.

03.2.4 - Placement of manholes and access chambers:

a) Placement of a manhole/access chamber in a carriageway with a paved surface should be level with the finished surface. When a manhole/access chamber is located within the carriageway, the chamber top, or access point, should be positioned to avoid wheel paths.
b) Elsewhere, access chambers should be finished 25mm above the natural surface level with the topsoil or grassed surface around the chamber graded gently away.

03.2.5 - Change in direction of Large Pipes.
Changes of direction for drainage lines of 1200mm or greater may be achieved by deflection of pipe joints, the use of splayed joints or fabricated bends.

03.3 - Gully Pits

03.3.1 - Gully pits shall be located to capture stormwater runoff in order:

a) to limit the inconvenience caused to pedestrians by the gutter flow;
b) to reduce traffic hazards and flood damage to adjacent properties;
c) to restrict the typical gutter flow width to 1.0m where possible, if not max 1.5m.
d) to restrict the gutter flow width at bus stops and pedestrian crossings to maximum 450mm.
e) to restrict the gutter flow width at intersections and kerb returns to max 1.0m.

03.3.2 - An example of the preferred approach to locating pits is given in Book 8, Technical Note 2 of *ARR 1997*.

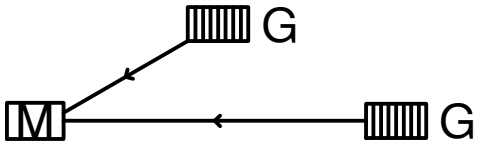
03.3.3 - All gully pits shall be trapped to minimise sand and other debris deposits in the pipe network.

03.3.4 - Complete reliance should not be placed on the capture of stormwater runoff by any one gully pit because of the possibility of blockage by debris.

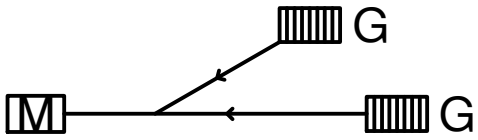
03.3.5 - For the safety of cyclists, gully grates shall have bars placed transversely to the direction of flow or installation of a cycle safe gully grate.

03.3.5 - The standard connection of gully pits and side entry pits located on road pavements shall be as follows:

Case (A): Preferred option



Case (B): In limited circumstances where Case (A) cannot be used.



03.4 - Recharging Ground water

03.4.1 - Systems which allow disposed of stormwater and recharged ground water, will be encouraged.

03.4.2 - Soakwells shall be located clear of all building structures with adequate site provisions to contain the stormwater if the soakwells are blocked. Minimum distance of 1.8m from any structural footings.

03.4.3 - All soakwells shall be interconnected with a piped system.

03.5 - Headwalls and Outfalls

03.5.1 - Any proposed headwall and outfall structures which discharge into the Swan River or lakes shall comply with the requirements of the Department of Water Western Australian Government.

03.5.2 - The use of approved check valves should be considered in the design of outfall pipes.

03.6 - Subsoil Drains

03.6.1 - Subsoil drains shall be provided where necessary to control ground water table and flow. Subsoil drainage systems are to be designed and constructed in accordance with *"AS/NZS3500.3:2003 - Plumbing and Drainage: Part 3 - Stormwater Drainage."*

03.6.2 - For subsoil drains, only approved perforated or slotted pipes and conduits shall be used.

03.6.3 - Drain cells or nylex strip drains shall be laid in a granular filter medium wrapped with an approved geotextile filter membrane.

04 - Drainage Connections

04.1 - General

04.1.1 - Reference shall be made to the Council's Procedural Manual for information relating to the regulations and policies on stormwater drainage connections.

04.1.2 - If there is to be no new manhole or connection pit at the connection point of new drainage lines that connect into a main drainage line, the joint shall be constructed as a saddled joint so that the new drainage pipe does not extend into the internal side of the main drainage line.

04.2 Private Connections

04.2.1 - Council approval shall be obtained and a fee paid for all drainage connections from private properties before any work can be carried out.

04.2.2 - The standard drainage connection application form can be found at: *www.perth.wa.gov.au/Planning-Development*

04.2.3 - The maximum pipe size for connection into the Council's drainage system shall not exceed 225mm in diameter unless otherwise approved.

04.2.4 - The manhole for connection shall incorporate an approved trap and be located within the private property, preferably not exceeding 2m from the boundary.

04.2.5 - An orifice must be provided inside the manhole to limit the stormwater discharge to the approved rate.

04.2.6 - In locations where there is risk that the stormwater from the City's drainage network will backflow into the private property, a backflow device shall be provided by the property owner.

04.2.7 - All reinstatements shall be as per the City's requirements.

04.2.8 - As a condition of handover, the contractor must submit compaction certificates and "As Constructed" drawings signed off by the contractor. As a minimum, the "As Constructed' drawings shall contain the following information: 1 pipe size. 2 pipe material. 3 pipe length. 4 pipe upstream invert level. 5 pipe downstream invert level. 6 existing ground level. 7 manhole lid level. 8 manhole type. 9 manhole size and depth. 10 manhole invert level

04.3 - Connections to Water Corporation's Main Drains

04.3.1 - All proposed drainage connections into the Water Corporation's Main Drain shall comply with the guidelines in the Water Corporation's Urban Drainage Manual.

05 - Drainage Drawings

05.1 - General

05.1.1 - The Council has drainage information, (including - guidelines, applications and the City of Perth's drainage data base), available for design purposes on the City of Perth website at: *www.perth.wa.gov.au/Planning-Development*

05.1.2 - Standard drawings on manholes, gully pits and outlet structures are available for reference in this document.

05.2 Design Drawings

05.2.1 - The design drawings shall be drawn on AutoCad and stored with the City of Perth's Engineering/Drafting Section.

05.2.2 - The proposed drainage design shall be clearly shown on plan drawings to a scale of 1:250, 1:500 or 1:1000 depending on the size of the project.

05.2.3 - Longitudinal sections of the proposed drainage pipe networks shall also be provided.

05.2.4 - All underground and above ground public utility services shall be clearly indicated on the plan drawings.

05.2.5 - Legends and symbols shall be clearly shown on the drawings, using standard notation wherever possible.

06 - Rainfall Intensity Charts for Perth

Rainfall Intensity (mm/h) for Perth

DURATION	Average Storm Recurrance Interval (years)							
	1	2	5	10	20	50	100	500
5m	59.35	78.17	102.62	119.02	142.65	177.59	207.44	290.89
6	55.19	72.60	95.01	110.00	131.62	163.54	190.77	266.70
7	51.74	67.99	88.74	102.57	122.56	152.02	177.10	246.93
8	48.82	64.08	83.44	96.31	114.92	142.32	165.62	230.37
9	46.30	60.72	78.88	90.92	108.37	134.01	155.79	216.21
10	44.09	57.77	74.90	86.23	102.66	126.78	147.25	203.94
11	42.13	55.16	71.38	82.08	97.63	120.42	139.74	193.17
12	40.38	52.83	68.24	78.39	93.15	114.76	133.07	183.63
13	38.81	50.73	65.42	75.08	89.13	109.70	127.10	175.09
14	37.38	48.83	62.87	72.08	85.50	105.13	121.71	167.41
15	36.07	47.10	60.55	69.36	82.21	100.97	116.82	160.45
16	34.88	45.51	58.42	66.87	79.19	97.18	112.37	154.11
17	33.77	44.04	56.47	64.58	76.43	93.71	108.28	148.31
18	32.75	42.69	54.66	62.46	73.87	90.50	104.52	142.97
20	30.93	40.26	51.43	58.69	69.32	84.79	97.81	133.48
25	27.27	35.43	45.02	51.21	60.32	73.53	84.62	114.87
30	24.52	31.80	40.22	45.63	53.62	65.17	74.85	101.16
35	22.36	28.95	36.47	41.28	48.41	58.70	67.29	90.59
40	20.61	26.64	33.45	37.79	44.23	53.51	61.25	82.18
45	19.15	24.73	30.96	34.90	40.79	49.25	56.29	75.30
50	17.93	23.11	28.86	32.48	37.90	45.68	52.15	69.56
55	16.87	21.73	27.06	30.42	35.44	42.65	48.63	64.70
60	15.96	20.53	25.51	28.63	33.32	40.03	45.60	60.53
75	13.85	17.80	22.06	24.72	28.73	34.47	39.21	51.92
90	12.32	15.82	19.56	21.89	25.42	30.45	34.60	45.73
2.0h	10.21	13.09	16.14	18.03	20.89	24.97	28.34	37.32
3.0	7.82	10.00	12.27	13.67	15.80	18.82	21.32	27.94
4.0	6.46	8.25	10.09	11.22	12.94	15.39	17.40	22.73
5.0	5.57	7.11	8.67	9.62	11.09	13.16	14.87	19.37
6.0	4.94	6.30	7.66	8.49	9.78	11.59	13.07	17.00
8.0	4.09	5.20	6.31	6.98	8.02	9.48	10.68	13.84
10.0	3.53	4.49	5.43	5.99	6.87	8.12	9.13	11.80
12.0	3.13	3.98	4.80	5.29	6.06	7.15	8.04	10.36
14.0	2.83	3.60	4.36	4.82	5.53	6.54	7.36	9.52
16.0	2.59	3.30	4.01	4.44	5.11	6.05	6.82	8.85
18.0	2.40	3.06	3.72	4.13	4.76	5.64	6.37	8.29
20.0	2.24	2.86	3.49	3.87	4.46	5.30	5.99	7.82
22.0	2.10	2.68	3.28	3.65	4.21	5.01	5.67	7.41
24.0	1.98	2.53	3.11	3.46	4.00	4.76	5.39	7.06
36.0	1.50	1.93	2.39	2.67	3.10	3.72	4.23	5.59
48.0	1.22	1.57	1.96	2.21	2.57	3.10	3.53	4.71
60.0	1.03	1.33	1.67	1.89	2.21	2.67	3.05	4.09
72.0	0.89	1.16	1.46	1.65	1.94	2.35	2.69	3.62

Note: Caution should be applied to intensities with an ARI>100 years, due to the possible shortness of rainfall records. Refer to Section 2.6 Volume 1 of AR&R, 1997 for more information.

POLICY ON STORMWATER DRAINAGE CONNECTIONS

"Disposal of storm-water generated on properties shall be as follows:-

1. *Stormwater to be retained on site;*
2. *Where part 1 is not possible, an approved on-site detention system must be provided prior to connection to the City's drainage system;*
   - 2.1. *If exceptional circumstances exist where stormwater cannot be detained on-site then direct disposal to the City's drainage system may be approved;*
   - 2.2. *If an adjoining street drainage system does not exist, or where the existing system is not capable of handling the flow from the property, an application may be made by the owner of the property for an extension or up-grading of the City's stormwater system;*
   - 2.3. *Water to be discharged to the City's drains must be adequately treated on site to comply with the requirements of the 'Manual for Managing Urban Stormwater Quality in Western Australia' as published by the Water and Rivers Commission, August 1998;*
   - 2.4. *The cost of connecting on-site drainage to the City's drainage system shall be the responsibility of the owner of the property being connected, including the cost of any necessary extensions or up-grading to the City's drainage system."*

Policy adopted by council 8th October 2002.

RKS File number 8361/05

BACKGROUND

In the past, the City's practice for single residential properties has been to retain stormwater on site and for commercial or industrial properties to connect to the street drainage system where possible. With the gradual increase in expectations of the community, there have been alterations in the criteria affecting the rate at which stormwater requires to be disposed of from properties. For example, in the period from 1970 to the present, the design criteria used for calculating the rate of discharge of stormwater from properties has progressively altered, restricting expected storm flooding from once in every 5 years to once in 50 or 100 years.

These changes require many of the City's street stormwater drainage systems and Water Corporation Mains into which the City's stormwater drains discharge, to be upgraded. The cost of up-grading the City's drains can be very expensive and even more so for the Water Corporation's main drains.

The Water Corporation have indicated that increases of discharges to their mains will not be allowed. As a result, upgrading of the City's drains to give increased capacity is often not possible.

The City's current policy is that disposal of stormwater generated on the following property categories shall be as indicated:

1. Commercial or Industrial Developments

Such properties shall be connected into the City's drainage system. However, if an adjoining drainage system does not exist, or where the existing system is not capable of handling the additional flow, stormwater is to be retained on-site or an application may be made by the owner of the property for an extension of the stormwater system. Where there is concern about possible pollution of the stormwater generated on such a property, the stormwater should be adequately treated and retained on site.

2. Residential Properties

Stormwater to be retained on-site. However, if circumstances exist where stormwater cannot be suitably retained on-site a connection to the City's drainage system may be approved.

The cost of connecting on-site drainage to the City's drainage system by the Council shall be the responsibility of the owner of the property being connected, this includes the cost of any necessary extensions to the City's drainage system. A connection of limited capacity only may be provided in some circumstances.

DETAILS

With the lack of desirable capacity in both the City's and the Water Corporation's drainage systems, in recent times developers have been requested to retain stormwater on site. Retention of the stormwater on site by the use of soakwells helps recharge the ground water table and places much of the responsibility for maintenance of the property's stormwater disposal system onto the property owners.

The use of a relief overflow from soakwell systems to the City's drains has been permitted to cater for exceptional storms. Where retention on site is not possible as in many inner city sites, an on-site detention system has been requested with a restriction on the outflow from the site to the City's drainage system. This method requires the construction of on-site holding tanks which release the stormwater to the City's drains, either by gravity flow or pumping, at a restricted rate and thus reducing the peak discharge from storms.

The use of these detention systems is in line with practices of other capital cities and will greatly relieve the pressure on both the City's and the Water Corporation's stormwater drainage systems. This practice also allows properties to connect to the City's drainage system where the existing system could not adequately cater for the full discharge.

The use of detention systems designed to limit the peak runoff to that which would have occurred during a once in 20 year storm on the original undeveloped site is a generally accepted practise. This restriction creates a volume of water which must be detained on site. An analysis has been carried out of catchments within the city area to determine the maximum allowable site discharge rate and the minimum detention storage volume required to comply with the criteria (refer Schedule 1). Some concessions have been adopted in the criteria used to allow for city conditions. Based on these calculations, it is considered that for each hectare of development, the rate of discharge should be limited to 120 litres per second and the minimum storage required is 185 cubic metres.

The adoption of this practice as policy for all developments would reduce the necessity for costly upgrades of existing systems to cope with the parameters set by modern standards and community expectations.

Appendix: COP Guidelines for management of Urban Stormwater for Commercial Properties

City of Perth - Guidelines for better management of Urban Stormwater for Commercial Properties

These guidelines provide information on simple practices that can be employed to prevent contamination of the stormwater system by commercial properties and businesses especially where storm water from the premises is discharged into Council's storm water drainage system. Only rainwater is allowed to enter the stormwater drainage system. Anything other than rainwater will pollute the receiving water bodies.

1. Used water from inside commercial businesses is wastewater. Wastewater must not be discharged into stormwater drains. This includes water from swimming pools, air conditioners, window washing and mop cleaning. Wastewater that meet Water Corporations requirement should be directed to the sewer. Businesses should make their staff aware of disposal points for wastewater.

2. Litter and sediment should be swept and disposed off in waste bins/or recycled and not washed into drains.

3. Bins should be washed in the designated bin wash area on the premises. Bin wash areas are required where bins are likely to be soiled or where businesses produce putrescibles waste. Waste bins should not be allowed to overflow. Unsecured wastes can be blown into the stormwater drains and cause local flooding.

4. Cardboard, paper, oil, drums, bottles and other materials that can be recycled should be recycled. Different bins to separate general waste from recyclables should be provided and identified.

5. Spillage from oil and liquid storage areas can block stormwater drains and contaminate the stormwater system. Spills should be picked up using absorbent materials and disposed off into commercial bins and not hosed away. Chemicals and liquids should be stored away from stormwater drains and pits.

6. Compliance with the Health Act 1911 and Environmental Protection Act 1986 with regards to Waste Management and discharges into the environment. (Further information can be obtained from Environmental Health Services on 9461 3218).

7. Environmental Protection (Unauthorised Discharges) Regulations 2009. Refer to Schedule 1 materials. A person who in the course of or in connection with a business or commercial activity causes or allows a material listed in Schedule 1 to be discharged into the environment commits an offence. (Penalty: $5,000)

Schedule 1 - Materials that must not be discharged into the environment:

- Acid with a pH less than 4
- Alkali with a pH more than 10
- Animal waste
- Animal oil, fat or grease
- Compounds or solutions of cyanide, chromium, cadmium, lead, arsenic, mercury, nickel, zinc or copper
- Degreaser
- Detergent
- Dust produced by a mechanical process as including cutting, grinding, sawing, sanding or polishing a material
- Dye
- Engine coolant or engine corrosion inhibitor
- Food waste
- Laundry waste
- Mineral oil
- Organic solvent
- Paint
- Petrol, diesel or other hydrocarbon
- Pesticide
- Sediment
- Sewage
- Vegetable oil, fat or grease

(Source: Environmental Protection (Unauthorised Discharges) Regulations 2004)

Appendix: COP Guidelines for management of Urban Stormwater for Residential Properties

City of Perth - Guidelines for better management of Urban Stormwater for Residential Properties

These guidelines provide information on simple practices that can be employed to prevent contamination of the stormwater system by residential properties especially where storm water from the premises is discharged into Council's storm water drainage system. Only rainwater is allowed to enter the stormwater drainage system. Anything other than rainwater will pollute the receiving water bodies.

1. Used water from inside residential properties is wastewater. Wastewater and must not be discharged into stormwater drains. This includes water from swimming pools, air conditioners, window washing, car washing and mop cleaning. Wastewater that meet Water Corporations requirement should be directed to the sewer.

2. Litter and sediment should be swept and disposed off in waste bins/or recycled and not washed into drains.

3. Bins should be washed in the designated bin wash area on the premises. Waste bins should not be allowed to overflow. Unsecured wastes can be blown into the stormwater drains and cause local flooding.

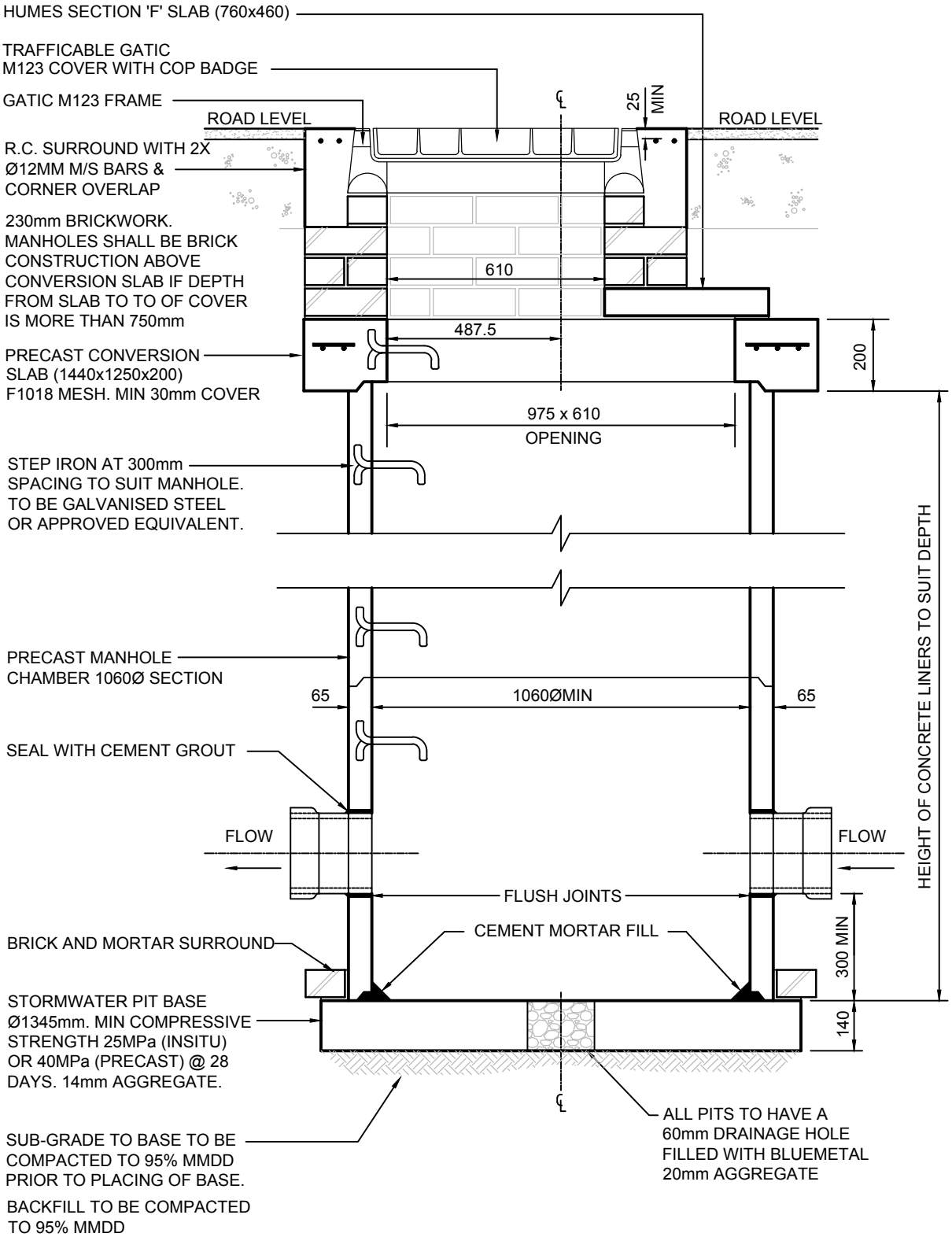
4. Cardboard, paper, bottles and other materials that can be recycled should be recycled.

5. Compliance with Health Act 1911 and Environmental Protection Act 1986 with regards to Waste Management and discharges into the environment. (Further information can be obtained from Environmental Health Services on 9461 3218).

City of Perth

Design and Construction Note
202.00
Drainage Structures
Standard Stormwater Manhole

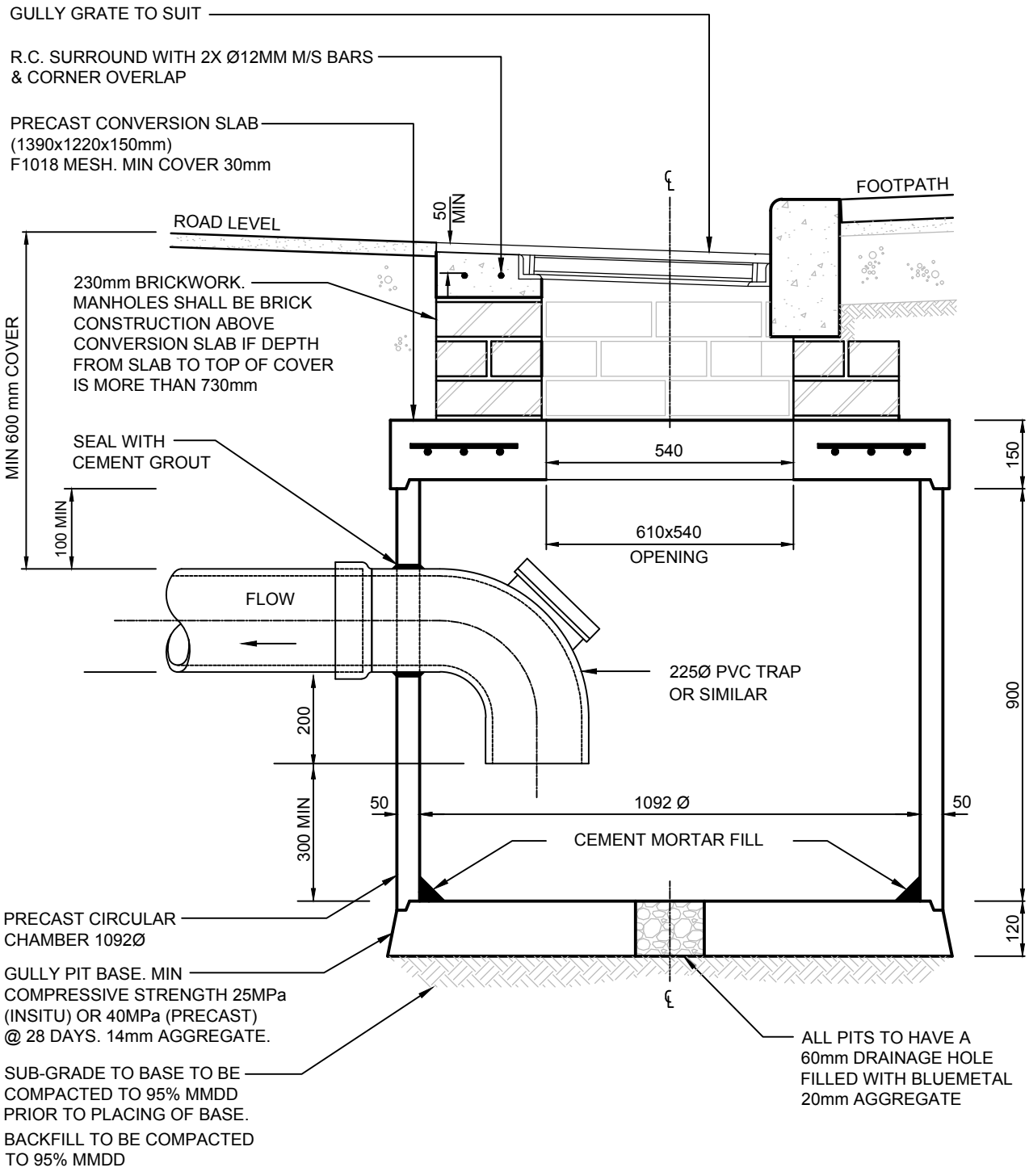
Reviewed: 16/08/2018



City of Perth

Design and Construction Note
202.01
Drainage Structures
Standard Trapped Gully

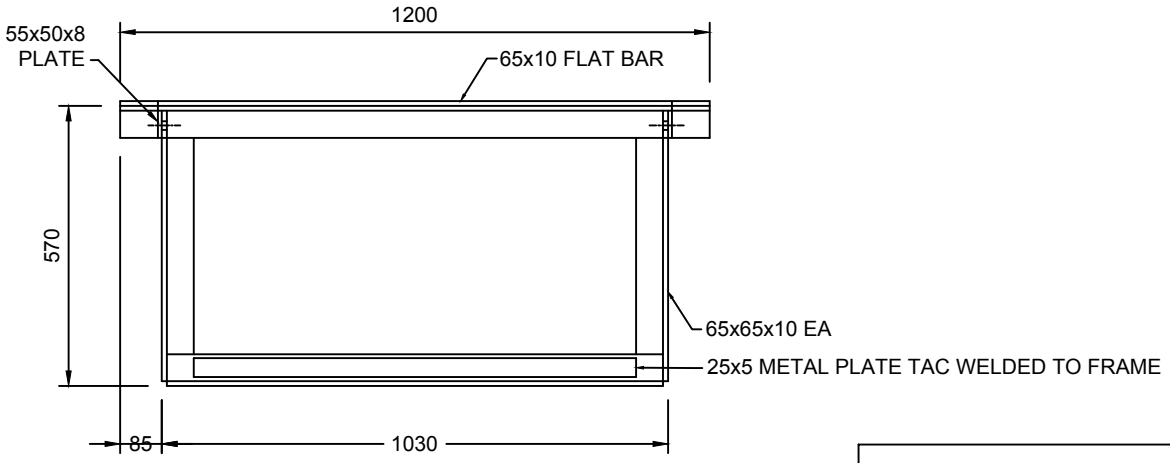
Reviewed: 16/08/2018



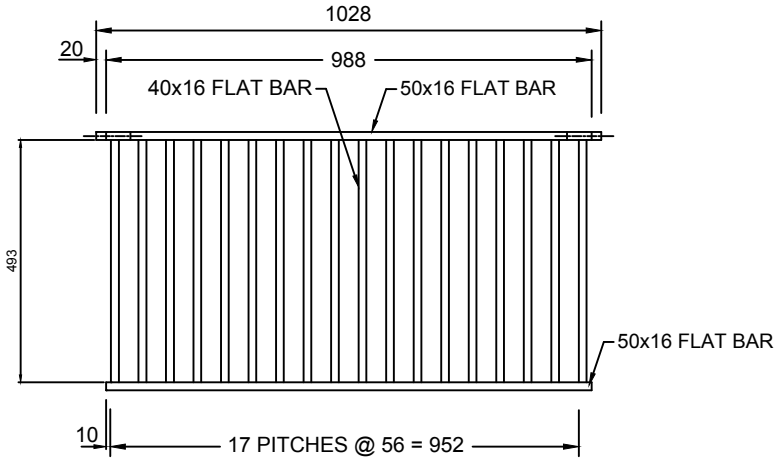
City of Perth

Design and Construction Note
202.02
Drainage Structures
Mild Steel Gully Grate - Large

Reviewed: 16/08/2018



GRATE MOUNTING FRAME



HINGED GRATE INSERT

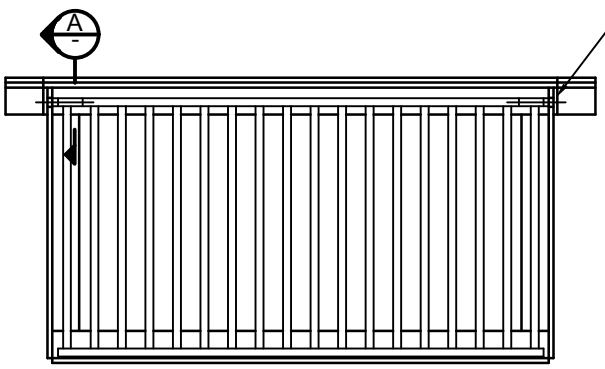
Note

Cycle-friendly gully grates should be used in place of the Standard Gully Grates:

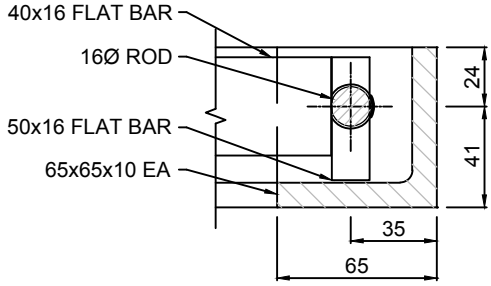
- on roadways alongside Bicycle Path routes, at pedestrian ramps, and where gullies are situated in footpaths and dual-use paths.

Refer to *Design & Construction Note 202.05* for Cycle-friendly Gully Grates.

Gully grate must be galvanized when soil type is classified as acidic soil or acid sulfate soil.



GRATE ASSEMBLY



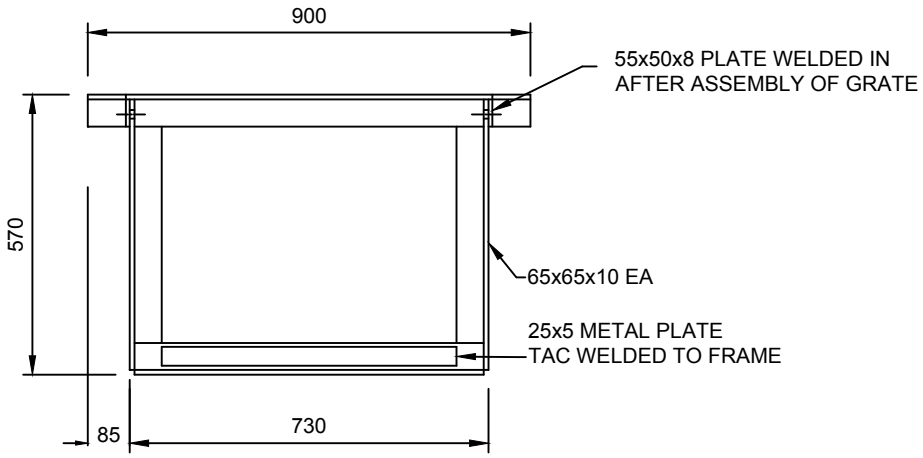
SECTION A
-

GRATE HINGE DETAIL

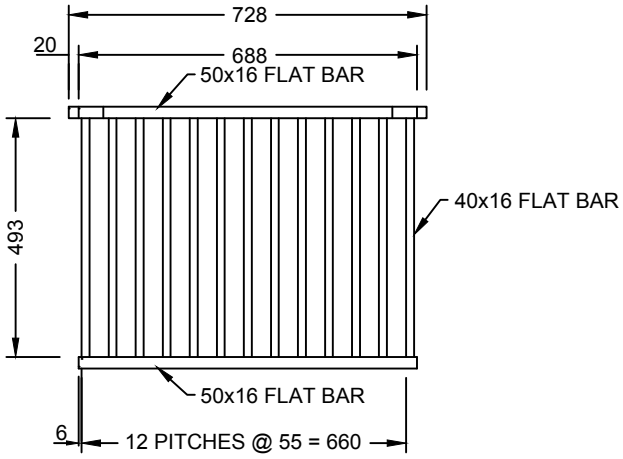
City of Perth

Design and Construction Note
202.03
Drainage Structures
Mild Steel Gully Grate - Medium

Reviewed: 16/08/2018



GRATE FRAME



GRATE

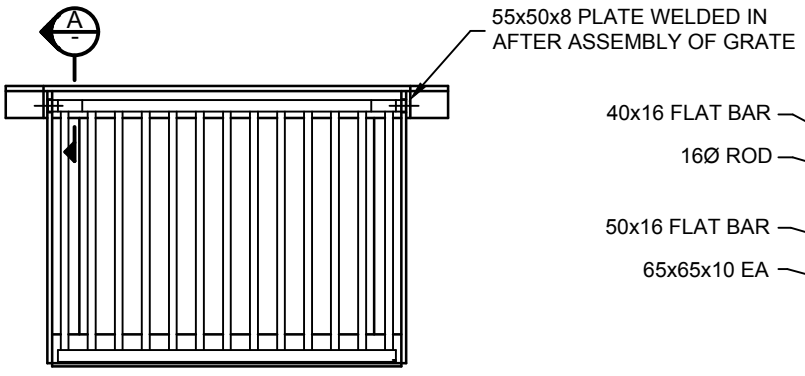
Note

Cycle-friendly gully grates should be used in place of the Standard Gully Grates:

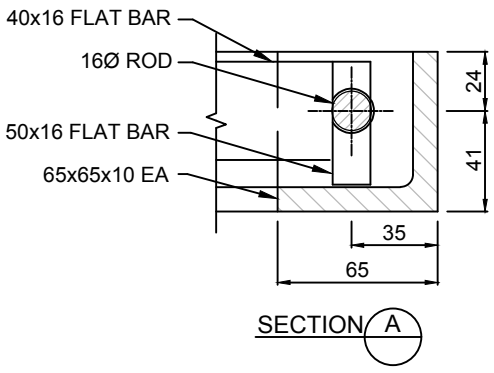
- on roadways alongside Bicycle Path routes, at pedestrian ramps, and where gullies are situated in footpaths and dual-use paths.

Refer to *Design & Construction Note 202.05* for Cycle-friendly Gully Grates.

Gully grate must be galvanized when soil type is classified as acidic soil or acid sulfate soil.



GRATE ASSEMBLY

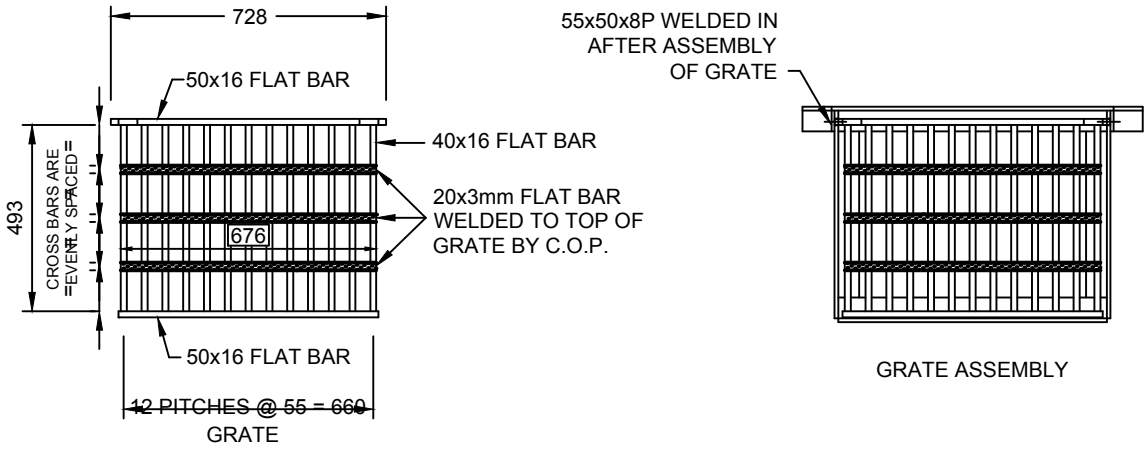


SECTION A

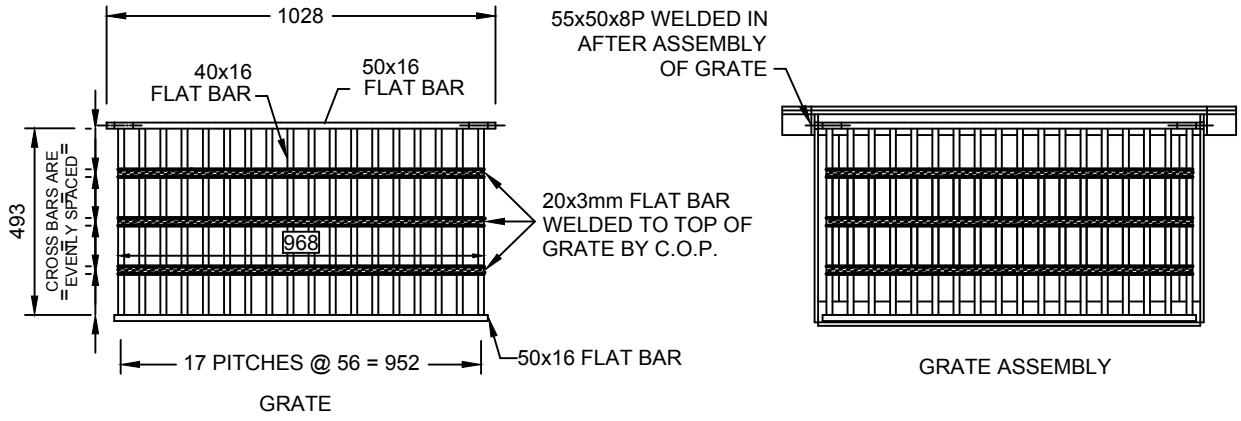
City of Perth

Design and Construction Note
202.04
Drainage Structures
Mild Steel Gully Grate - Cycle Friendly

Reviewed: 16/08/2018



GULLY GRATE - MEDIUM



GULLY GRATE - LARGE

Note

The Cycle-friendly gully grates used by the City of Perth are made 'in-house' by modifying the Standard Gully Grates.
Three transverse bars are welded onto the medium or large standard grates at equal distances to produce a grate that bicycle, wheelchair and/or pram wheels cannot get caught in.

Cycle-friendly gully grates should be used in place of the Standard Gully Grates:
on roadways alongside Bicycle Path routes, at pedestrian ramps, and where gullies are situated in footpaths and dual-use paths.

Gully grate must be galvanized when soil type is classified as acidic soil or acid sulfate soil.

City of Perth

Design and Construction Note

202.05

Drainage Structures

Cast Steel Gully Grate - Cycle Friendly

Reviewed: 16/08/2018

Note

The Cast Cycle-friendly gully grates shown need to be approved before use by the City of Perth representative.

Cycle-friendly gully grates should be used in place of the Standard Gully Grates:
on roadways alongside Bicycle Path routes, at pedestrian ramps, and where gullies are situated in footpaths and dual-use paths.

Gully grate must be galvanized when soil type is classified as acidic soil or acid sulfate soil.

City of Perth

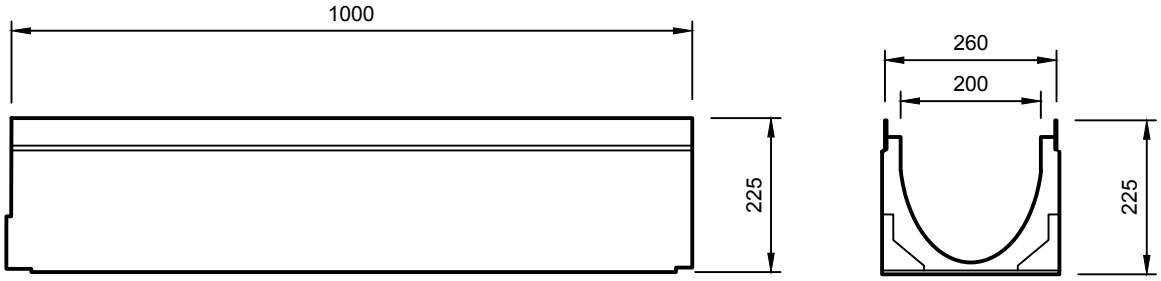
Design and Construction Note

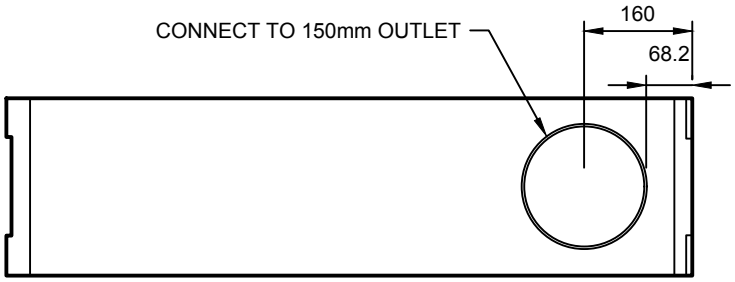
202.06

Drainage Structures

Standard Trench Drain

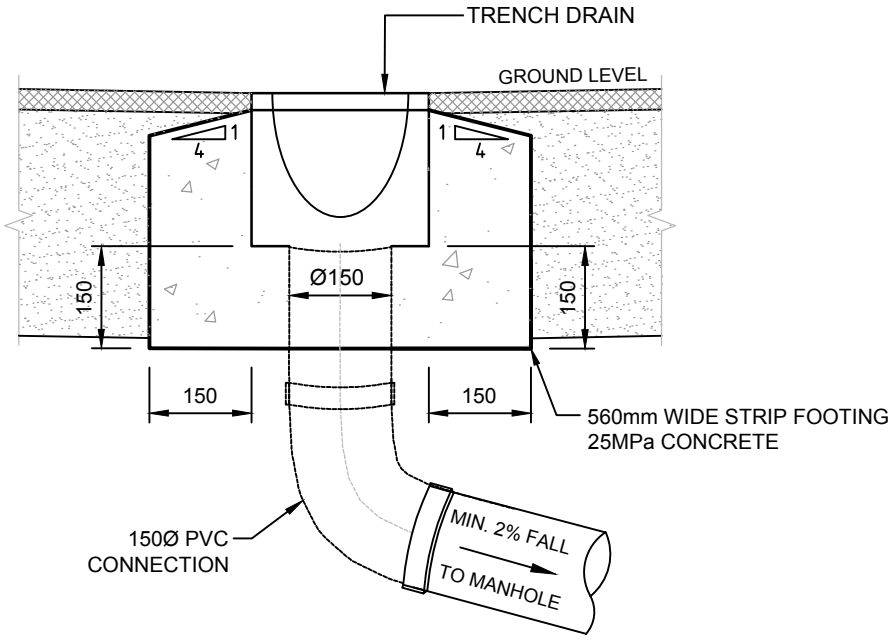
Reviewed: 16/08/2018





PREVIOUS USED PRODUCT:
ACO*drain:* KLASSIK DRAIN
K200 GALVANISED STEEL EDGE RAIL CHANNEL SYSTEM
PRODUCT: BOTTOM OUTLET K2-00
OUTLET SIZE: 150mm
INVERT DEPTH: 200mm
L/S: 21.8mm
GRATE: TYPE 678Q - IRON INTERCEPT
HEELSAFE, ANTISLIP
FOR K200 LOAD CLASS D

TRENCH DRAIN

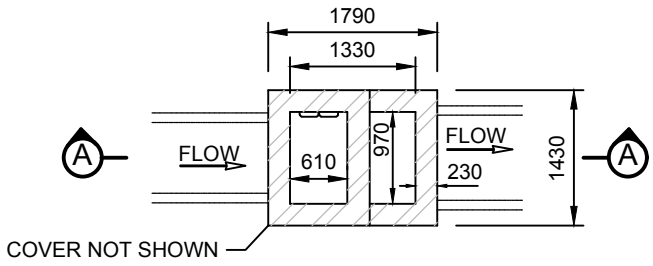


INSTALLATION DETAIL

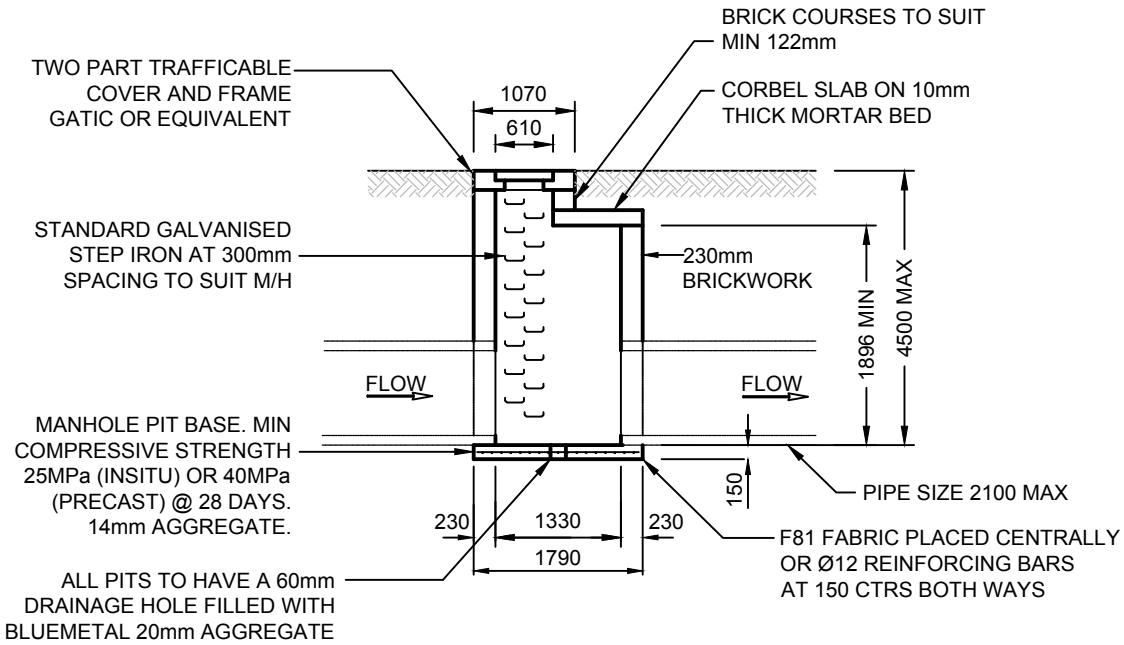
City of Perth

Design and Construction Note
202.07
Drainage Structures
Standard Brick Manhole

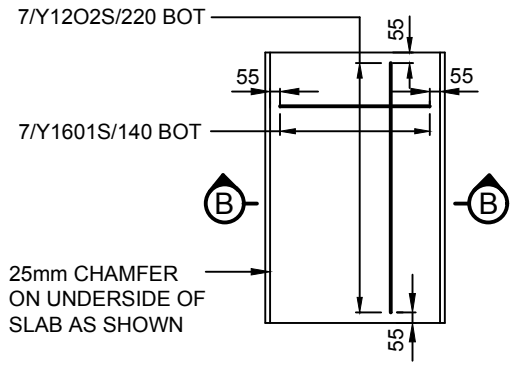
Reviewed: 16/08/2018



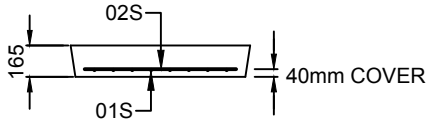
PLAN VIEW



SECTION A -



PLAN OF CORBEL SLAB



SECTION B -

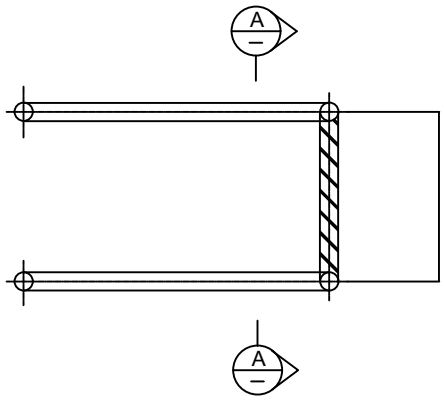
City of Perth

Design and Construction Note
202.08
Drainage Structures
Standard Brick Manhole

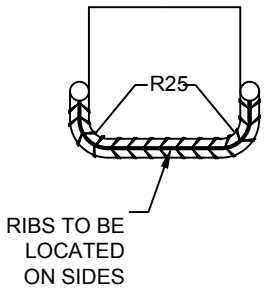
Reviewed: 16/08/2018

STEP IRON BENDING NOTES

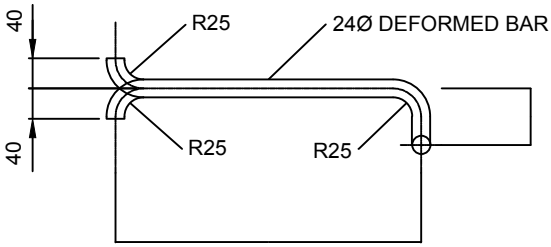
1. HEAT BAR TO 900°C
2. CARRY OUT BENDING REQUIREMENTS
3. NORMALISE STEP IRON BY HEATING TO 900°C AND ALLOWING TO COOL.



PLAN



SECTION A



ELEVATION

General Notes

1. Welding to comply with *AS1554 Part 1.*
2. Fabricated mild steelwork to be galvanised in accordance with *AS4680-2006.*
3. Stainless steel for landing panel brackets to be A.I.S.I. Grade T316L.
4. Step irons to be fabricated from structural grade 410Y reinforcing steel to *AS4671-2001.*

Alternative Materials

5. Alternative materials such as high strength plastics may be considered, and must be approved by a City of Perth representative.
6. Sufficient testing of a product must be provided and all relevant Australian Standards adhered to.

City of Perth

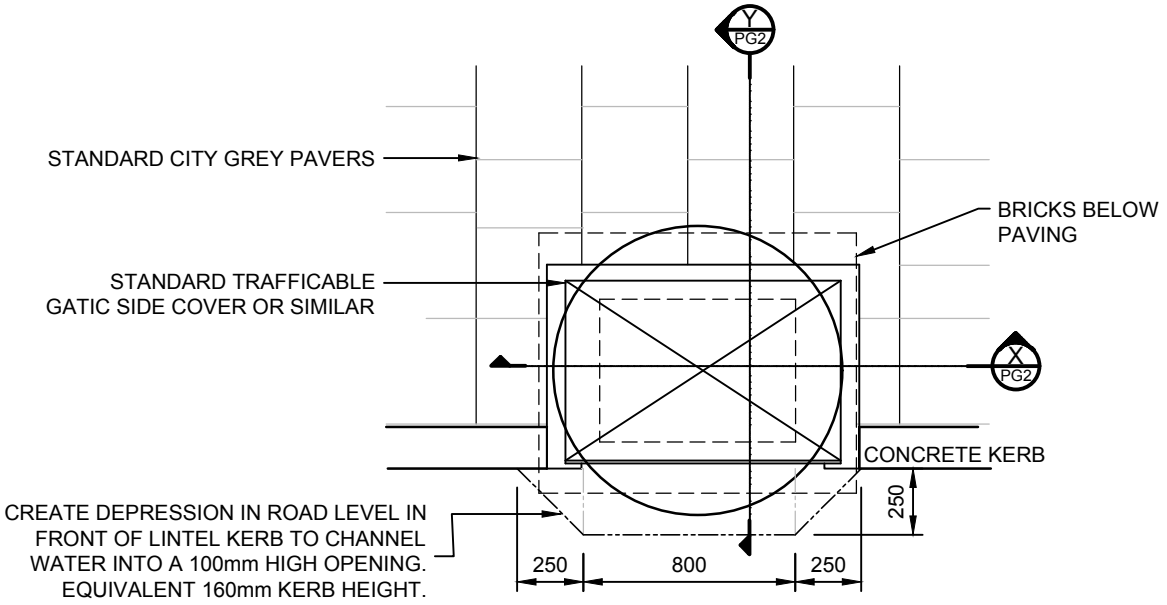
Design and Construction Note

202.09

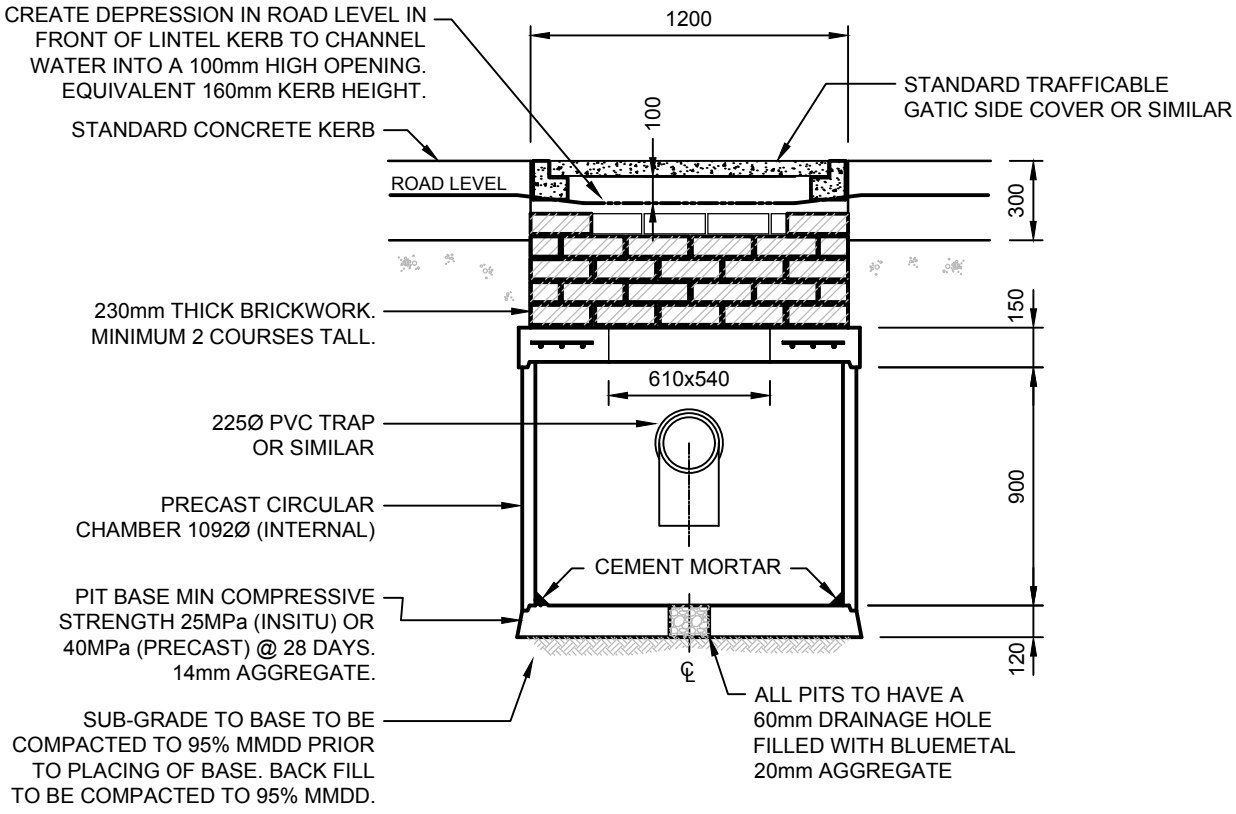
Drainage Structures

Standard Side Entry Pit
Concrete Kerb

Reviewed: 16/08/2018



PLAN VIEW



FRONT VIEW

City of Perth

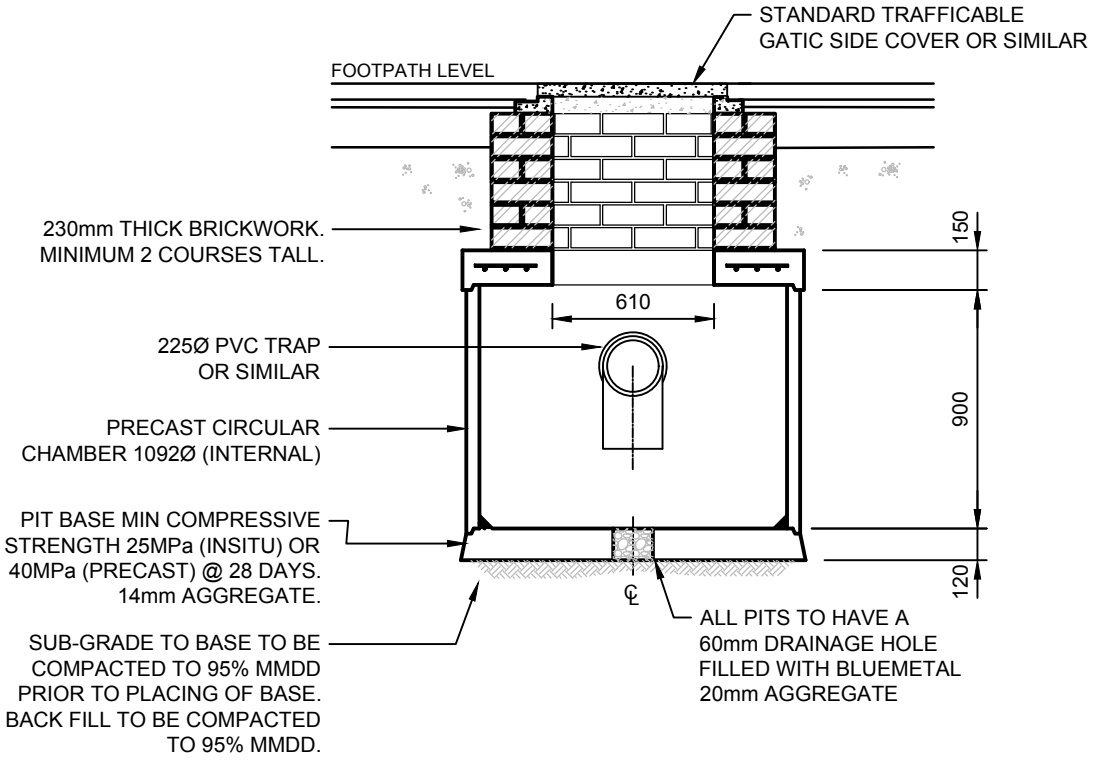
Design and Construction Note

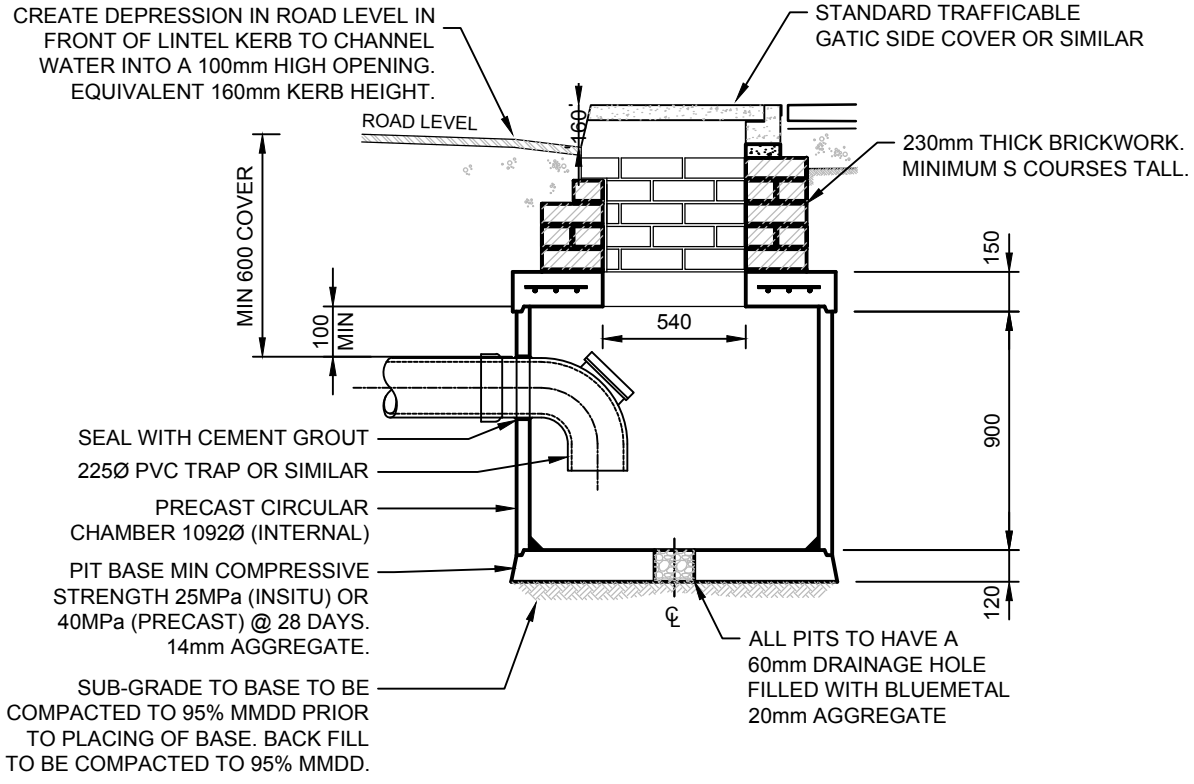
202.10

Drainage Structures

Standard Side Entry Pit
Concrete Kerb

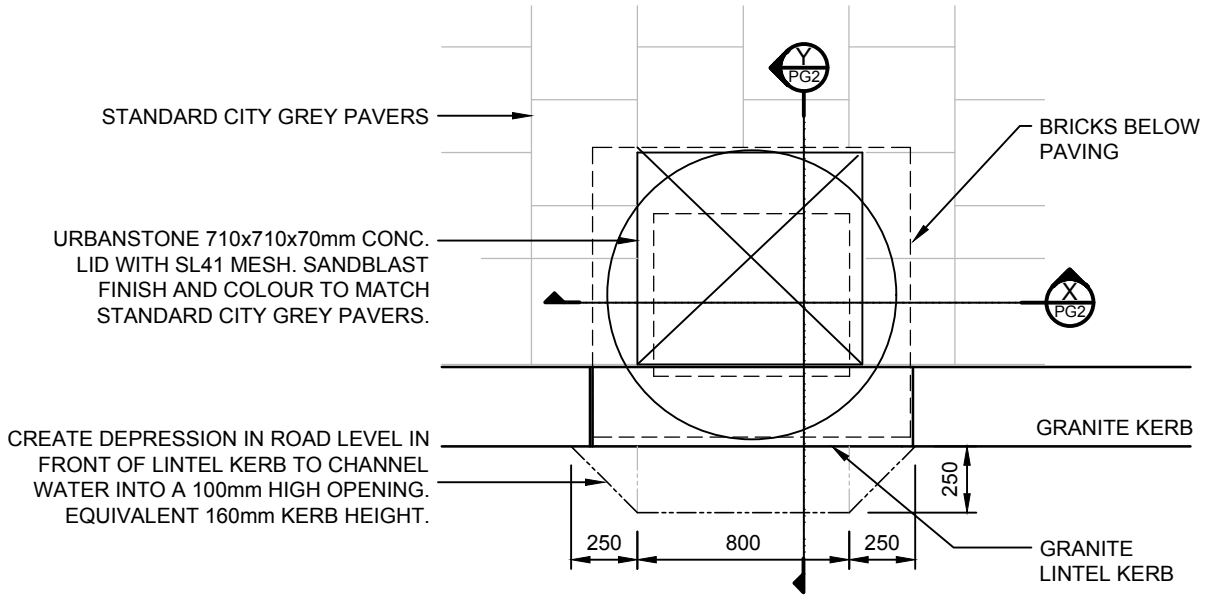
Reviewed: 16/08/2018



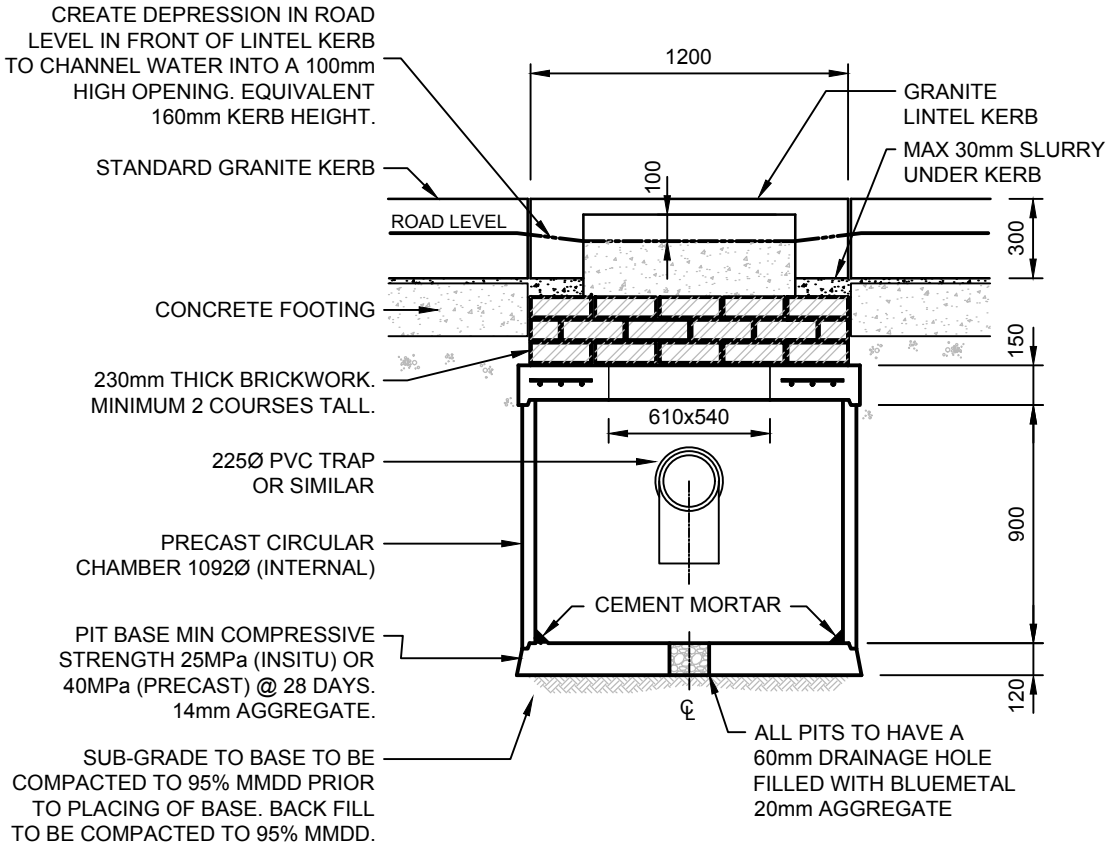


City of Perth

Design and Construction Note
202.11
Drainage Structures
Standard Side Entry Pit
Granite Kerb
Reviewed: 16/08/2018



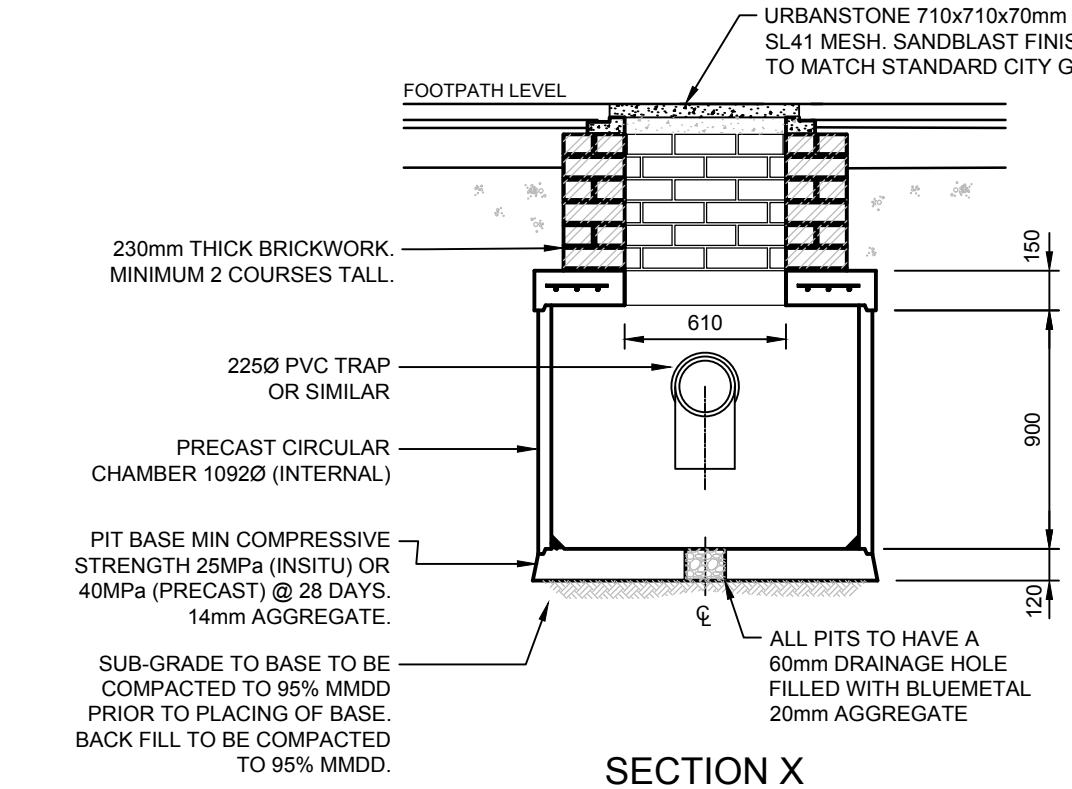
PLAN VIEW



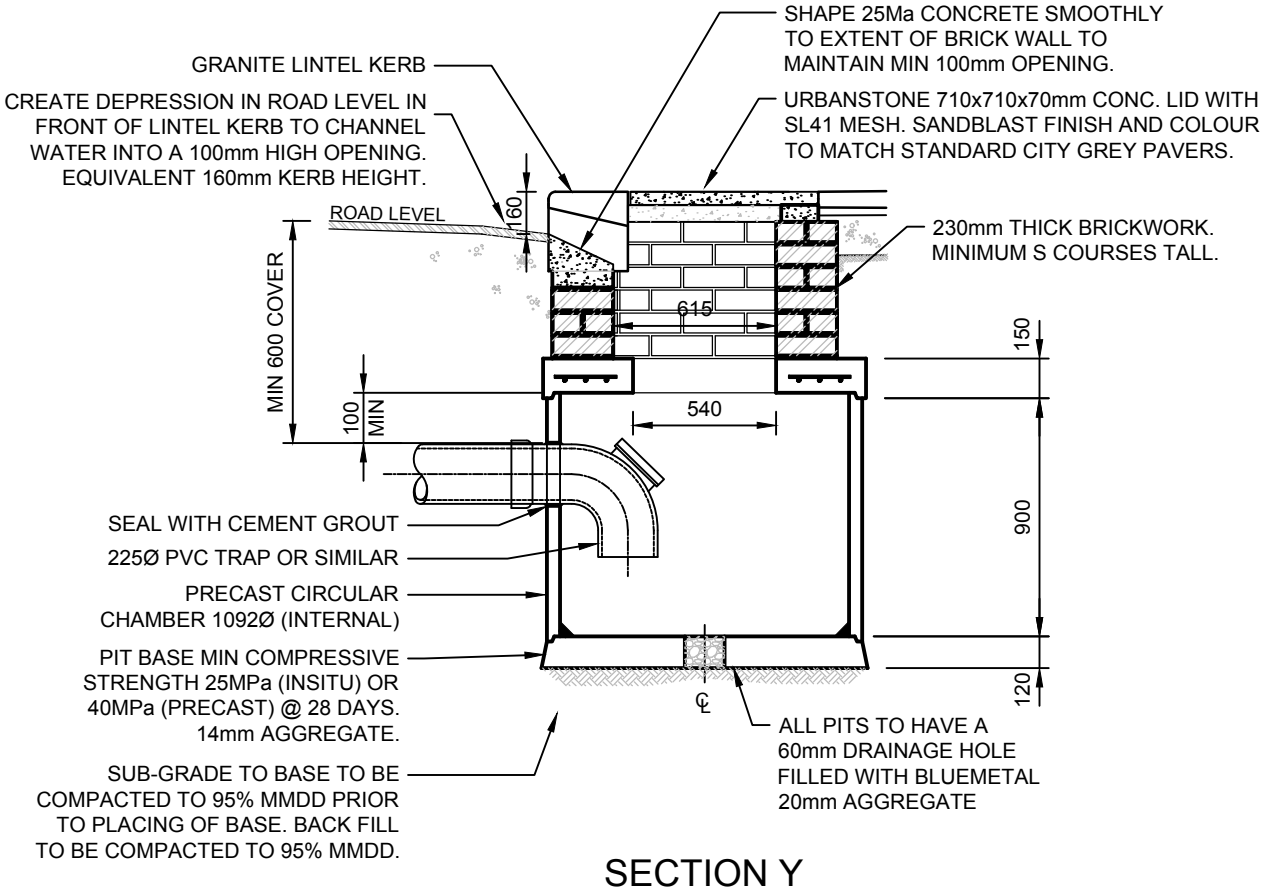
FRONT VIEW

City of Perth

Design and Construction Note
202.12
Drainage Structures
Standard Side Entry Pit
Granite Kerb
Reviewed: 16/08/2018



SECTION X

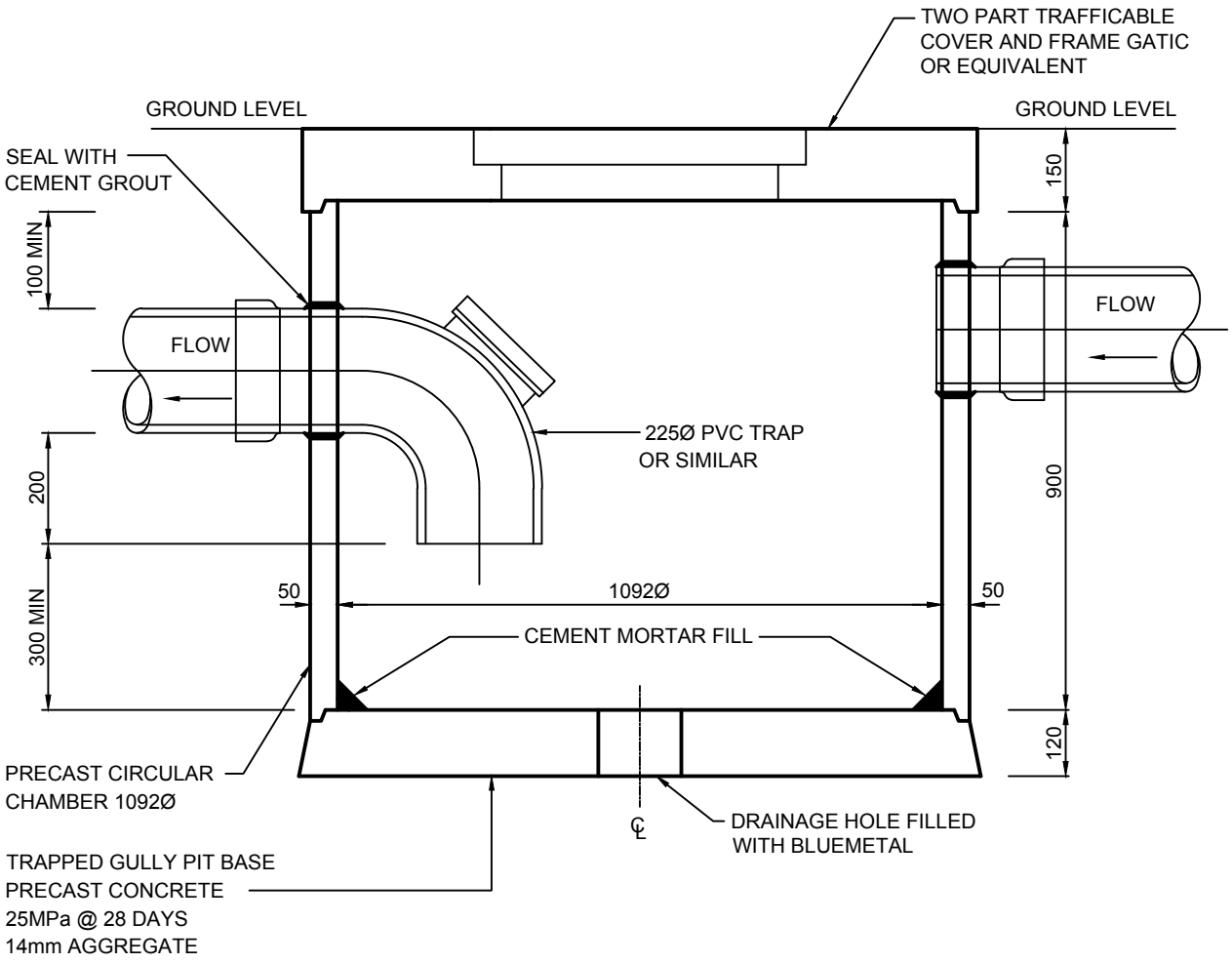


SECTION Y

City of Perth

Design and Construction Note
202.13
Drainage Structures
Standard Property Connection Pit

Reviewed: 16/08/2018

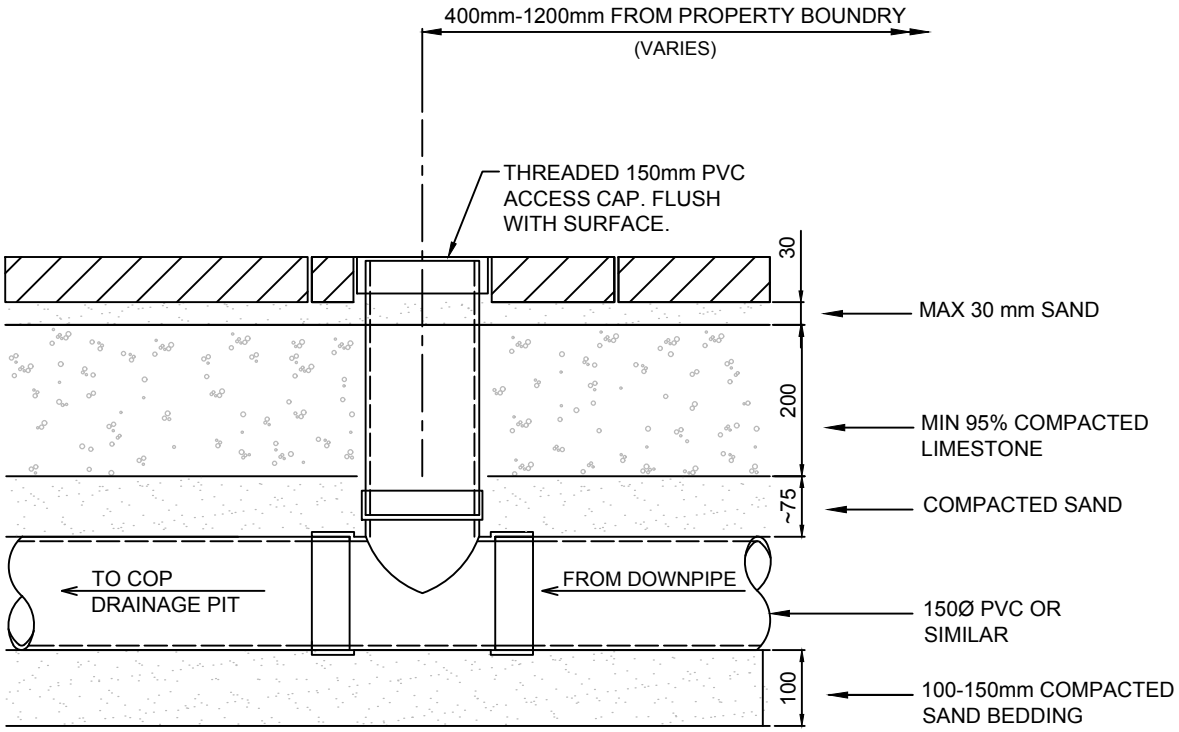


Note

In some cases it is acceptable that the Property Connection Pit is constructed within private property boundaries, on private land.

City of Perth

Design and Construction Note
202.14
Drainage Structures
Property Connection Inspection Access Point
Reviewed: 16/08/2018

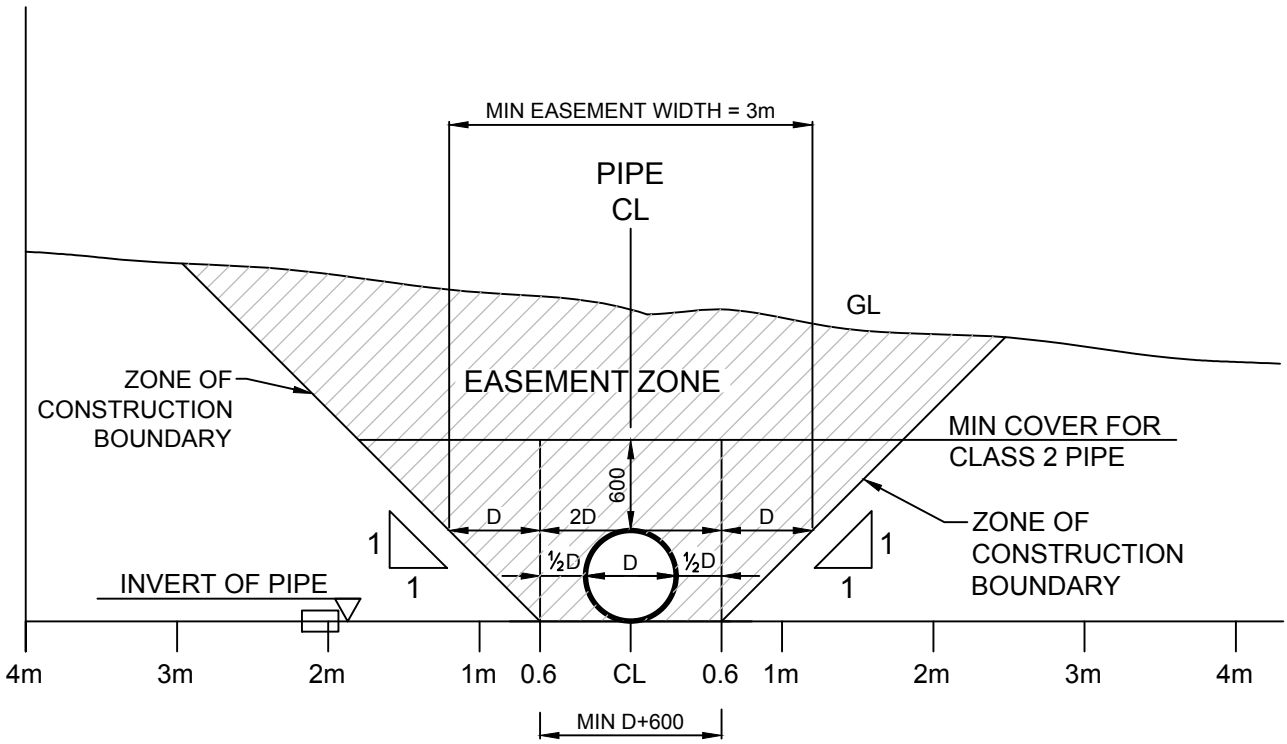


Note:
Inspection Access Point to be installed when replacing Overflow Pit.

City of Perth

Design and Construction Note
202.15
Drainage Structures
Stormwater Pipe Easement

Reviewed: 16/08/2018



NOTE

1. EXTENSIVE CUT OR FILL OVER DRAINS. WHEN THE COVER OVER THE PIPE IS INCREASED OR REDUCED THE DRAIN SHALL BE CHECKED FOR SATISFACTORY PIPE STRENGTH AS SET-OUT IN *AS3726-2007*
2. WHEN RETAINING WALLS ARE TO BE CONSTRUCTED WITHIN THE ZONE OF CONSTRUCTION BOUNDARY THEY SHALL BE SUPPORTED ON PILED FOOTINGS. THE PILES SHALL BE DRIVEN TO A MINIMUM OF 300mm BELOW THE ZONE OF CONSTRUCTION.
3. THE BUILDING FOOTINGS SHALL NOT BE CONSTRUCTED WITHIN THE ZONE OF CONSTRUCTION BOUNDARY.
4. D = EXTERNAL DIAMETER OF PIPE