Culvert and Drainage Inlet/Outlet Safety Guidelines

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A1.0 Preface

1.1 The purpose of these standards is to identify general and specific requirements for the design of stormwater management systems within the City of Winnipeg to improve the safety of these systems and eliminate hazards that may expose the public to an unnecessary level of risk.

1.2 These standards cannot anticipate all of the situations that will arise in the design and operation of drainage systems and it is incumbent upon the individual designer to consider thoroughly, all aspects of public and operations personnel safety throughout the planning, design, and construction process. It is imperative that consideration not only be given in design to satisfying the requirements of a design event but logically to extreme events that could reasonably be anticipated to occur.

1.3 As a basic concept in design, the design professional should consider that drainage facilities that are normally accessible to the public should not present a hazard, particularly to children. Ditch flows should neither be excessively deep nor at excessively high velocities. Access to potential hazards should be restricted, where possible, by fencing or other suitable means. Inlet gratings and openings should not present hazards to cyclists, pedestrians, or operational personnel.

1.4 In terms of their duty to the public, the designer should be guided by the principle that it is not enough to react to a dangerous situation after the fact of a major accident. It is the professionals' duty to be aware of the different kinds of hazards, both man-made and natural and of the treatments which will reduce the magnitude of the hazard or protect the public from that hazard.

A2.0 Definitions

2.1 *Culverts* are relatively short sections of drainage pipe that facilitate drainage between open channel drainage courses (e.g. ditches) under roads or railway embankments, etc. A culvert, by definition, cannot be connected to a closed conduit drainage system.

2.2 *Ditch inlets* are catch basins or other suitably engineered inlet devices that facilitate the safe drainage of a ditch or major drainage channel to a closed conduit drainage system or an outfall pipe.

2.3 *Hazard exposure classifications* are a measure of the public's exposure to a particular drainage system component and are defined consistent with Chapter IX of the USBR publication *"Design of Small Canal Structures"*[(8)] as follows:

Class A Drainage courses and structures adjacent to schools and recreational areas, such as playgrounds, subject to frequent visits by children.

Class B Drainage courses and structures nearby or adjacent urban areas or highways and subject to frequent visits by the public.

Class C Drainage courses and structures nearby or adjacent rural development or highways which could be subject to visits by children seeking recreation such as swimming.

Class D Drainage courses and structures that are far removed from any dwelling, subject to infrequent visits by operating personnel.

2.4 Street classifications are as defined by the Transportation Association of Canada (TAC) as follows:

1.) Local - A local street is a minor traffic carrier within a neighborhood characterized by one or more moving lanes and parking along curbs, with no through traffic moving from one neighborhood to another. Traffic control may be by use of stop or yield signs.

2.) Collector - A collector street collects and distributes traffic between arterial and local streets. There may be from two to four moving traffic lanes and parking may be allowed adjacent to curbs. Traffic on collectors has right-of-way over traffic from adjacent local streets.

3.) Arterial - An arterial street permits rapid and relatively unimpeded traffic movement. There may be from four to six lanes of traffic, and parking adjacent to curbs may be prohibited. The arterial traffic normally has right-of-way over collector streets. Construction of an arterial street will often include a median strip with traffic channelization and signals at numerous intersections.

4.) Freeway - Freeways permit rapid and unimpeded movement of traffic through and around a city. Access is normally controlled by interchanges at major arterial streets. There may be four or more traffic lanes frequently separated by a median strip. Parking is not normally permitted within the freeway right-of-way.

A3.0 System Access Guidelines

3.1 The inlets and outlets of all closed conduit systems shall be provided with protective devices to preclude unauthorized or inadvertent entry to the system. All outfalls shall have debris grates conforming to the requirements of Section A4.0 of these guidelines.

3.2 Ditches that outlet to closed conduit sewers, shall do so through a suitably designed ditch inlet device. Ditch inlets shall conform to the technical requirements of Section A6.0 of these guidelines.

3.3 Culverts, 400 mm diameter and larger in Class A hazard exposure classification areas shall be provided with protective inlet grating devices to prevent small children from gaining access in accordance with the technical requirements of Section A7.0 of these guidelines. Culverts less than 400 mm diameter in Class A hazard exposure classification areas shall be reviewed on a case-by-case basis to determine the advantages and disadvantages of debris/safety racks and the designer shall make a recommendation to the Approving Authority accordingly.

Culverts of all diameters in Class B to E exposure classification areas shall be reviewed on a case-by-case basis to determine the advantages and disadvantages of debris/safety racks and the designer shall make a recommendation to the Approving Authority accordingly. The designer's review shall, as a minimum, address the advantage and disadvantage considerations outlined in Section A7.0 and where inlet devices are deemed to be required, they shall conform to the technical requirements, outlined therein.

A4.0 Outfalls and Outfall Structures

4.1 Outfalls debris/safety grates shall generally consist of horizontally placed bars with a maximum clear space of 150 mm between bars. The use of cage type racks is discouraged due to their poor debris handling characteristics. Where vertical reinforcement is required based on structural considerations it shall be kept to a minimum.

4.2 Outfall grating for up to 1800 mm diameter shall be designed such that the full diameter of the outfall pipe can be accessed for periodic maintenance. Gratings shall be secured with "tamper-proof" bolts, a locking device, or other means as may be determined by the Approving Authority. Conceptual configurations for outfall grates are presented in Appendix B. Outfall gratings for outfalls greater than 1800 mm shall require site specific designs addressing the general design concepts presented herein.

4.3 Debris grating must have sufficient clear space to minimize the impact of clogging on hydraulic capacity and the horizontal bars shall be designed to minimize the occurrence of clogging. For non-symmetrical bars, the thinnest portion of the bar, shall be pointed at the direction of flow.

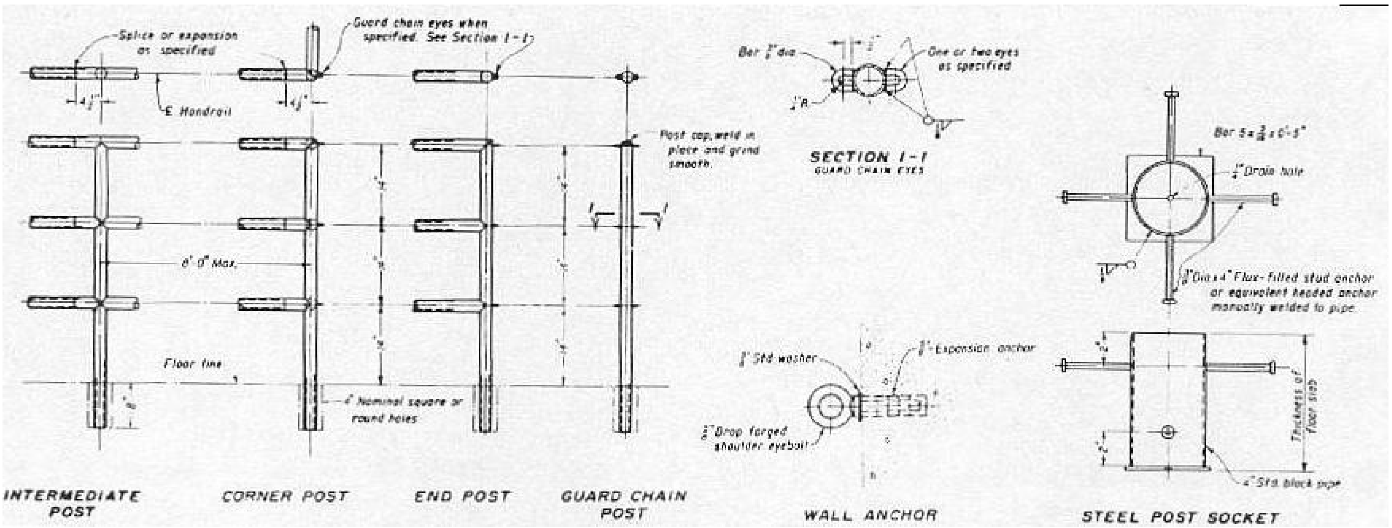
4.4 Debris grating shall be structurally designed with a break away feature such that the the grating will break open under the design condition of a 40% reduction in cross sectional area AND the anticipated velocities from a 10 year synthetic storm event. The outfall grating shall be designed such that the grating is not lost when the break-away feature is utilized. This may be accomplished by the use of hinges with one break-away side, a chain, or by other suitable means as may be determined by the designer.

4.5 Non-submerged outfalls and outfall structures shall be fenced or equipped with handrails to prevent accidental access to the receiving water course. Fencing and handrails shall conform to the requirements of Chapter IX of USBR publication *"Design of Small Canal Structures"*[(8)] based on the appropriate hazard exposure classification.

Handrails shall be a minimum of 1050 mm high with a three rail configuration (see typical in Figure A-1) in Class A to Class C exposure areas and a two rail configuration in Class D and E exposure areas as per Figures 9-11 and 9-10, respectively, in the USBR manual.

Handrails that will be subject to exposure to ice break-up on the river shall have removable posts and rails to facilitate their removal and temporary replacement with snow fencing during the spring break-up of the river. The designer shall advise the Approving Authority requirements accordingly during the design process.

Figure A-1
<u>Typical Three Rail Handrail</u>



4.6 Site grading adjacent to outfall structures that are exposed under normal summer water level conditions shall consist of mild slopes, 7H:1V or flatter, or have provision for a 1.50 m wide safety ledge on all sides exposed to the public, to eliminate the risk associated with the public or operations personnel accidentally falling into the receiving course. Where site geometry precludes the provision of safe slopes or a safety ledge, these areas shall be fenced off to preclude access and warning signs should be posted accordingly.

4.7 End treatment at outfall works shall provide sufficient protection against erosion, both due to the outlet velocities associated with the stormwater discharge and natural flow of the receiving course. The erosion protection due to the stormwater discharge shall be based on anticipated exit velocities for a 25 year synthetic rain storm.

A5.0 Inlet Design for Traffic Safety

5.1 Design location and spacing of inlets for pavement drainage according to the following general rules:

Intersections - Provide inlets at intersections to intercept 100% of runoff and prevent cross street flow which could cause a traffic hazard. Inlets should generally be placed on tangent curb sections and near corners.

Superelevation transitions - Provide inlets where street cross slopes begin to superelevate to reduce the traffic hazard of street cross flow to the opposite side of the street.

Side drainage - Place inlets immediately downstream from where side drainage enters streets (e.g. drainage from parking lots or other major runoff sites) to prevent overloading gutter capacity. Developments greater that 1000 m^2 shall have internal drainage systems to preclude side drainage from entering the street or limit it to an acceptable level at the discretion of the Approving Authority.

5.2 Do not generally locate inlets in driveways or directly in front of commercial/industrial doorways in areas where those doorways are in close proximity to the street.

Ensure there is an adequate number of inlets to utilize the *intended* land drainage or combined sewer capacity. Note that the intended land drainage or combined sewer capacity may utilize inlet restriction devices to intentionally limit capacity. The designer should familiarize himself/herself these requirements prior to carrying out design modifications in an existing area.

5.3 In inlet selection consider hydraulics, potential for clogging, nuisance to traffic, safety, and cost. Consider the following in inlet selection:

- Likelihood of clogging
- Traffic considerations
- Safety of pedestrian and vehicular traffic
- The requirement for inlet restriction to limit peak runoff capacity

5.4 Provide recognized allowances in flow capacity for interception capability of inlets and to account for a minimum amount of debris being present at the inlet grate during design events. Suitable design procedures are presented in RTAC, Drainage Manual - Volume 2, 1987, pp. 5.21-5.25(35) and the Urban Drainage Criteria Manual - Volume 1(3). Consider relevant site specific conditions in design.

5.5 Maximum gutter flow or ponding intrusion into traffic under minor and major storms shall not exceed the performance standards noted in Tables A-1 and A-2.

Table A-1
Maximum Combination of Gutter Flow Depth and Velocity

Water Velocity (m/s)	***Maximum Permissible Depth (m)***
0.50	0.80
1.00	0.32
2.00	0.21
3.00	0.09

Table A-2
Inlet Design Requirements for Traffic Safety

Roadway Classification	***Local***	***Collector***	***Arterial***	***Freeway***
Design Speeds in km/h				
Urban	30 to 50	60 to 100	80 to 130	100 to 130
Rural	50 to 100	50 to 80	50 to 100	80 to 120
Traffic Volume (vehicles per day)				
Urban	< 1,000	< 5,000	< 12,000	> 8,000
Rural	< 3,000	1,000 to 12,000	5,000 to 30,000	> 20,000
Design Criteria				
Minor Storms	***5 year***	***5 year***	***10 year, 25 year for depressed roadway***	***25 year or greater***
Concept	Ponding and Street Storage permitted.	Ponding permitted. Road must remain passable.	Ponding not permitted.	Ponding not permitted.
Pavement Encroachment	Flow may spread to crown.	One travel lane open.	One travel lane open in each direction.	No encroachment into travel lanes.
Flow Depth	Curb overtopping permitted.	No curb overtopping.	No curb overtopping.	No curb overtopping.
Cross-flow	150 mm maximum.	Controlled cross-flow permitted.	Not permitted.	Not permitted.
Major Storms	***25 year or greater***	***25 year or greater***	***50 year***	***50 year or greater***
Concept	Ponding permitted.	Ponding permitted. Pavement must remain passable to emergency vehicles.	Pavement must remain passable.	Pavement must remain passable.
Pavement Encroachment	Flow may spread over crown.	Flow may spread over crown.	Flow may spread over crown.	One travel lane open.
Ponding Depth	Flow depth not to encroach on private property (see Note 3)	300 mm maximum over gutter.	150 mm maximum over crown.	150 mm maximum over crown during storm peak..
Cross-flow	300 mm maximum.	300 mm maximum.	150 mm maximum over crown or centreline.	150 mm maximum over crown or centreline.
Other Issues				
Note 1 *- Maximum permissible gutter velocity for pedestrian safety as per Table A-1.*				
Note 2 *- Preferable to divert drainage away from intersections rather than permit cross-flow.*				
Note 3 *- Where retrofitting with inlet restriction, ensure that any intrusion onto private property is minor and precludes the possibility of property damage.*				

A6.0 Ditch Inlets

6.1 Inlet grating protection is **mandatory** for all ditch inlets to closed conduit drainage systems or systems where the point of egress is restricted or undesirable. Ditch inlets shall be designed as either “beehive” type grates, inclined catch basin type grating structures, inclined inlet grates on flared inlet sections, or inclined inlet grate structures as per the conceptual ditch grating options depicted in Appendix B.

6.2 Ditch inlet grating selection requires that the designer carry out site specific design. Without limiting this requirement, the ditch inlet types identified in 6.1 are generally applicable to the diameter ranges listed in Table A-3.

Table A-3
Ditch Inlet Type Guidelines

Type	Ditch Inlet Type	Diameter Range of Outlet Pipe
Type I	Beehive grates	up to 600
Type II	Inclined catch basin type	up to 1200
Type III	Inclined inlet grates on flared inlet section	500 to 1200
Type IV	Inlet structures	greater than 1200

6.3 Inlet grate bars for Type II-IV grates shall generally be parallel to each other and aligned vertically, for safety and to facilitate ease of maintenance, with no exposed horizontal bars. Where horizontal bars are required as a structural consideration, it is preferable to recess the bars from the surface of the grate such that they do not impede the efforts of a person trying to remove themselves from the grating. Recessed bar are mandatory for Type IV inlet structures.

The maximum clear space between vertical bars shall be 140 mm as a safety consideration to children.

Where Type II or III grates are to placed in areas that are subject to vehicular or pedestrian traffic, a special grating design will be required to make the inlet grating “vehicle” and/or “pedestrian” safe. This may include the use of “honeycomb” type grates, conventional bicycle safe type grates or other designs that are suitable appropriate for the specific location. The designer shall carefully consider all aspects of public and operational staff safety in the design of specialized grates as well as the maintenance aspects of the grate design. Preference for all inclined inlet grate type designs are the features that minimize pinning forces, incorporate the concept of self cleaning, and do not present a hazard in terms of human limbs becoming caught up in the grating structure itself.

6.4 Where inlets are placed across a ditch or major drainage channel and are accessible by vehicular traffic, they shall be inclined such that they do not protrude from the ditch slope. The most desirable slopes, from the perspective of traffic safety, are slopes of 6H:1V or flatter. Inlet structures should not pose a risk to vehicular traffic that may inadvertently leave the road surface. The designer’s attention is drawn to the TAC manual *Treatment of Roadside Hazards*[(16)] for guidance.

6.5 In selecting the type of inlet that is applicable to each location the designer shall consider:

- The debris potential of the drainage course.

- Whether a sump would be appropriate or not, based on the debris potential of the drainage course and the Approving Authority's stated frequency for catch basin sump cleaning.
- The hydraulics of the inlet, the impact it would have on safety, and the significance of debris blockage in terms of flooding adjacent properties.
- The anticipated pinning forces associated with the inlet when operating under its design condition.
- In addition to the design event utilized to size the inlet, the designer shall review the performance of the inlet under spring snowmelt conditions and the assumption of utilizing all available headwater in the ditch with no backwater effect from the closed conduit drainage system.

6.6 Where Type III or IV inlet structures are used on inlets 900 mm diameter and larger, the design shall conform to the following general requirements:

6.6.1 Debris/safety racks should have a removable feature to permit access to to the inlet pipe for cleaning, and should slope at 3:1 to 5:1 (horizontal to vertical) to permit debris to "ride up" as the water level rises and to facilitate egress from the structure.

6.6.2 The debris/safety racks should be located a considerable distance out from the entrance to the pipe to ensure that entrance velocities will be low enough that a person will be able to lift himself/herself off the grating. The required velocity will vary with design flow depth, however, velocities less than or equal to 1.00 m/sec are not likely to pose any significant risk to the public.

6.6.3 Bar spacing should be such that a child will not be able to pass between the bars (maximum 140 mm clear spacing).

6.6.4 The net open surface area of the debris/safety racks should be at least four times the cross sectional area of the pipe.

6.7 Where Type IV inlet structures are utilized on inlets larger than 2000 mm (height, width, or diameter), parabolic grates shall be utilized and the design shall also conform the following geometric and structural requirements:

6.7.1 Geometric guidelines for the grate include:

Width of pipe or culvert = b

Average width of channel = B, and $\frac{b}{B} \leq 0.4$

Distance of grate from edge of pipe along headwall

= d, and $\frac{d}{B} \geq 0.5$

Length of vertical parabola = L, and $\frac{L}{H} = \frac{H}{2h}$

where,

H = height of the pipe

h = 0.4 m for $H \leq$ 3 m, and

h = 1.2 m for $H > 3$ m

Length of flat top of grate = l, and $\frac{l}{b} \geq 1.0$

Review the design flow water surface profile to ensure that the length of the flat top of the grate (l) equals the distance from the headwall to the onset of the drop in water surface profile approach the pipe entrance (e.g. ensure that the localized increase in velocity near the pipe inlet occurs within the grating).

The vertical parabola (see Figure A-2) geometry should be,

$$y^2 = 2hx$$
$$0 \leq x \leq L$$
$$0 \leq y \leq H$$

6.7.2 Bars may be used in the horizontal plane up to a height of 500 mm.

6.7.3 All remaining bars should be parallel and in the vertical plane.

6.7.4 Horizontal strutting must be recessed behind the vertical bars to avoid catching any protruding human limbs.

6.7.5 Any drops in channel invert or other energy dissipating device must be behind the grating.

The designers attention is drawn to the references provided in Section A7.3.5 in terms of additional requirements which should be addressed as design considerations to minimize potential operational problems and improve public safety relative to the design of large inlet structures.

A7.0 Culvert Inlets/Outlets

7.1 Culverts shall be reviewed for safety based on the following primary considerations:

7.1.1 Culverts and culvert drainage structures shall be adequate to avoid hazardous flooding and failures of road or embankment structures. The required level of protection to prevent road flooding shall be consistent with the design requirements of Table A-2. The level of protection required for other embankment structures shall be reviewed on a case-by-basis and the designer shall advise the Approval Authority accordingly.

7.1.2 In determining the required hydraulic capacity of the culvert the designer shall review the debris potential of the drainage course, the Approving Authority's stated frequency of maintenance and make an allowance in design capacity to account for anticipated debris blockage. The designer's attention is drawn to *"Design and Construction of Urban Stormwater Management Systems, ASCE Manuals and reports of Engineering Practice No. 77, WEF Manual of Practice FD-20"*[(15)] for guidance.

7.1.3 Culvert end sections and their associated drainage structures shall be located or configured such that they do not pose a hazard to traffic. The designer's attention is drawn to the TAC manual *Treatment of Roadside Hazards*[(16)] for guidance.

7.1.4 Adjacent site geometry in the vicinity of the culvert entrance and exit shall be designed or modified to minimize the possibility of someone inadvertently falling into the drainage course. While this should be evaluated for all sites, it becomes an increasingly critical factor to consider at ditch depths and culvert diameters of 900 mm and greater.

Where due to site constraints, undesirable entrance geometry must be constructed, the area shall be fenced off based on the prevailing exposure classification of the site to ensure that the culvert entrance/exit does not pose an undo risk to vehicles or pedestrians. The designer attention is drawn to Chapter IX of USBR publication *"Design of Small Canal Structures"*[(8] for guidance on recommended entrance geometry and specific methods to discourage access based on the degree of risk and exposure classification.

7.1.5 When assessing the prevailing exposure classification the designer shall, to as great a degree as is practicable, anticipate future conditions with respect to adjacent land use, etc.

7.1.6 In sizing the culvert the designer shall make a thorough review of entrance and exit velocities versus the culvert diameter and recognize the balance that must be achieved in terms of minimizing entrance velocities to reduce risk exposure and erosion potential, yet achieving sufficient velocities to minimize maintenance requirements. Where site constraints or other conditions dictate that an undesirable combination of flow depth and entrance velocity must prevail, the designer shall recommend suitable warning signing and restrict access to the culvert entrance/exit for a suitable distance by fencing or other means that may be satisfactory to the Approving Authority. The designer may use Table A-1 as a guideline with respect to undesirable combinations of design flow depth and entrance velocity.

7.1.7 When analyzing conditions of safe entrance velocities the designer shall give consideration to spring runoff conditions as well as the governing design event.

7.1.8 In Class A exposure areas, all culverts 400 mm and larger shall be provided with inlet and outlet protection devices to prevent children from accessing the system in accordance with 7.3. For all other culverts, in all other exposure classifications the designer shall consider the advantages and disadvantages of providing inlet/outlet protection devices as outlined in 7.2.

7.2 Where the designer carries out a review of the requirement for inlet/outlet debris/safety racks, they shall consider the following:

7.2.1 Carry out a thorough review of the drainage course to acquire the necessary information on design flows, debris potential, public exposure, existing and future land use, and other relevant conditions.

7.2.2 Based on the above information, examine the risks associated with inadvertent access (e.g. generally a function of existing and future land use), the hazards associated with a person(s) entering the drainage course (e.g. generally a function of flow depth, velocity, culvert size, culvert length, available free space in the culvert under the design flow condition, and the suitability of the point of egress), and the risks associated with installing debris or safety grating at that particular location (e.g. flooding potential, icing problems, debris accumulation, etc.).

7.2.3 Based on the above review, the designer shall make a recommendation to the Approving Authority on whether debris/safety grates would be recommended on a case-by-case basis. The rationale for this review shall be a recommendation on how the interests of the public would best be served given what is often a conflicting set of objectives in terms of maintaining sufficient hydraulic capacity for the culvert while minimizing the public exposure to drainage hazards. The designer shall clearly advise in their recommendation of the assumptions utilized in analysis, the ramifications of installing or not installing debris/safety grates in each case, and any additional design features that should be employed to address safety issues.

7.3 Where safety/debris grates on culverts are required by this standard to be utilized or deemed to be required based on the design professional’s review, the following guidelines shall apply:

7.3.1 Any culvert that is provided with inlet protection shall be provided with outlet protection and vice versa.

7.3.2 For inlet grates for use on culverts up to and including 600 mm diameter (or the largest dimension of a box, arch, or elliptical cross section culvert), inlet grates can be vertical grates. The basic design must incorporate a hinge or other device to permit periodic access for maintenance. They shall be provided with a suitable security device to prevent unauthorized access as detailed in A4.2. The general design shall conform to Figure B1 in Appendix B except that that bars shall be orientated vertically rather than horizontally to maximize hydraulic efficiency. The maximum clear spacing between grates shall be 140 mm, such that a child will not be able to pass between the bars.

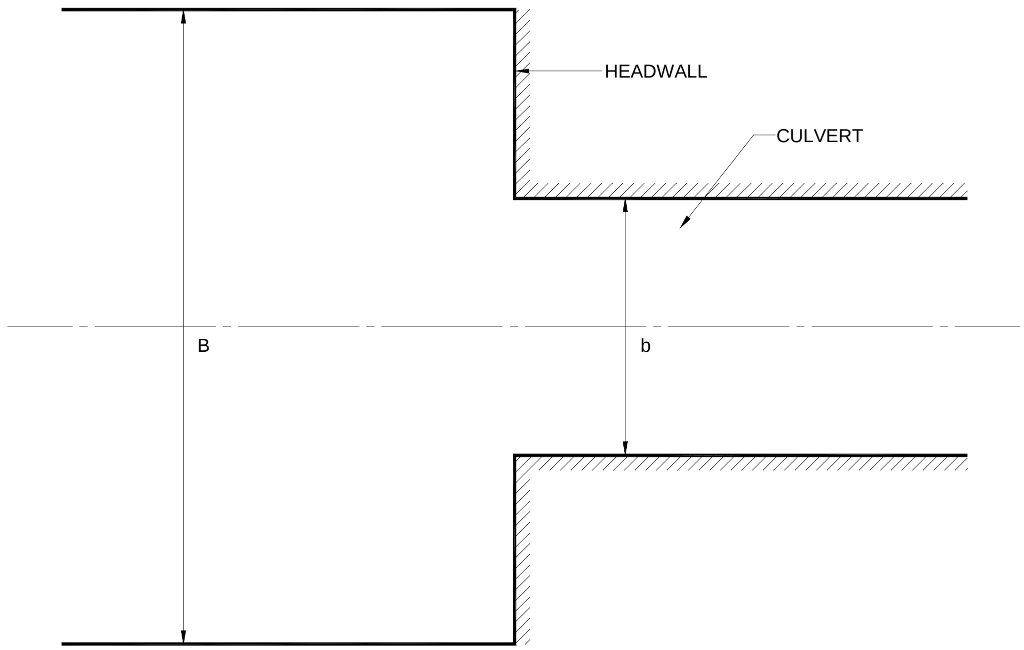
7.3.3 For inlets larger than 600 mm diameter (or the largest dimension of a box, arch, or elliptical cross section culvert) up to and including 2000 mm diameter Type III or Type IV inlet structures shall be provided as outlined in the appropriate sections of A6 for Ditch Inlets.

7.3.4 For inlets larger than 2000 mm diameter (or the largest dimension of a box, arch, or elliptical cross section culvert) Type IV inlet structures shall be provided as outlined in the appropriate sections of A6 for Ditch Inlets.

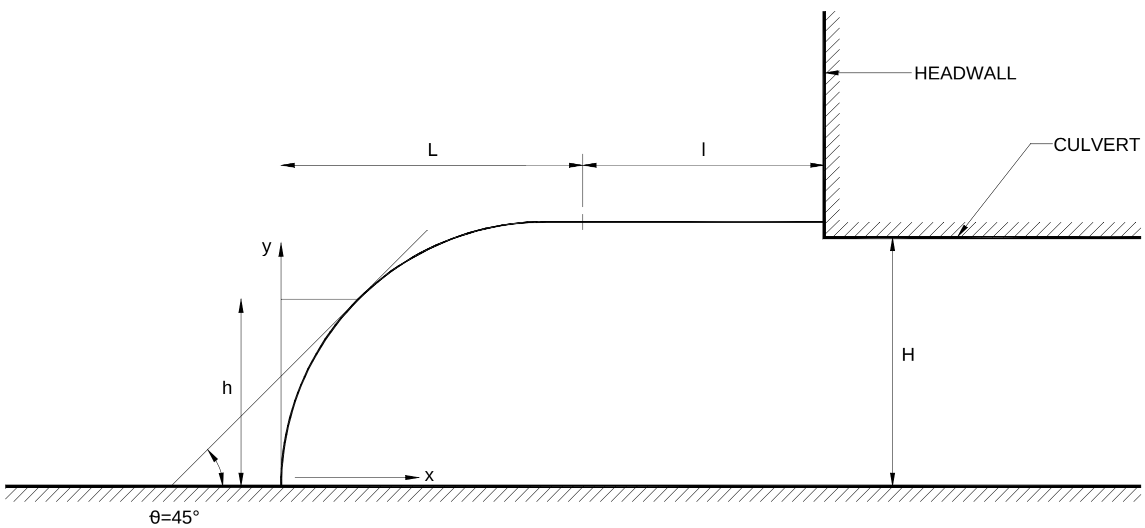
7.3.5 The designer’s attention is drawn to the following references regarding safe design procedures for inclined inlet gratings on large inlet structures :

- Metropolitan Toronto Task Force on Storm Inlet Grating Design, *"Study of Culvert Inlet Gratings"*, Metropolitan Toronto Task Force, Toronto, ON, May, 1981.
- Weisman, R.N., *"Model Study of Safety Grating for Culvert Inlet",* Journal of Transportation Engineering, Vol.115, No. 2, published by the ASCE, March 1989.
- Abt, S.R., Brisbane, T.E. , et al, *"Trash Blockage in Supercritical Flow",* Journal of Hydraulic Engineering, Vol. 118, No.12, published by the ASCE, December, 1992.
- Allred-Coonrod, J.E., *"Safety Grates in Supercritical Channels"*, Journal of Irrigation and Drainage Engineering, Vol. 120, No. 1, published by the ASCE, January/February 1994.

Figure A-2
Standard Geometry for Type IV Inlets > 2000 mm



PLAN



ELEVATION

Conceptual Representations of Ditch/Culvert Inlet and Outlet Grating Options

Conceptual Representations of Ditch/Culvert Inlet and Outlet Grating Options

Figure B-1 Typical Outfall Debris Grating Detail

Figure B-2 *Neenah Foundry* - Typical “Beehive” Grate and Frame (Type I Ditch Inlet)

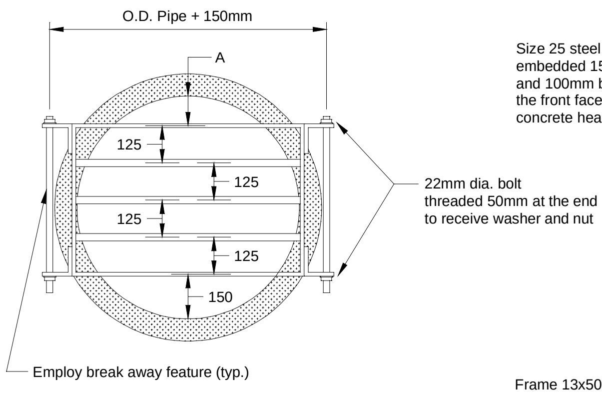
Figure B-3 Typical Type II Ditch Inlet - Inclined Catch Basin Type (up to 400 mm diameter pipe, high debris potential ditch)

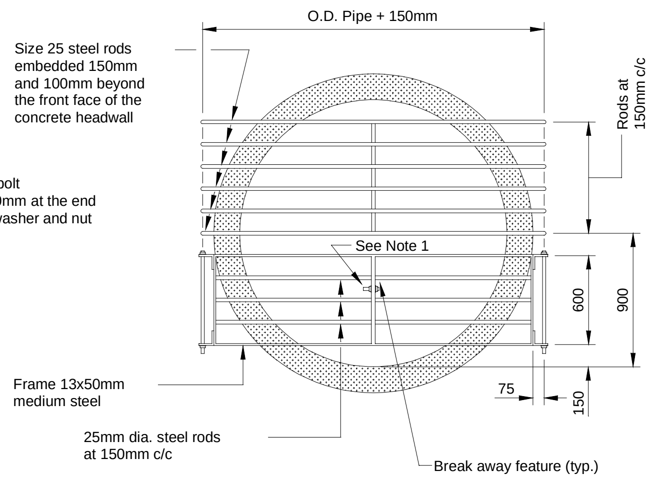
Figure B-4 Typical Type II Ditch Inlet - Inclined Catch Basin Type (up to 400 mm diameter pipe, low debris potential ditch)

Figure B-5 Typical Type II Inclined Catch Basin Type (up to 1200 mm diameter pipe, high debris potential)

Figure B-6 Typical Type III Flared End Section Inlet (up to 1200 mm diameter pipe, low to no debris potential or alternate means of debris control)

Figure B-7 Typical Type IV Inlet Structure (> 2000 mm diameter or height)



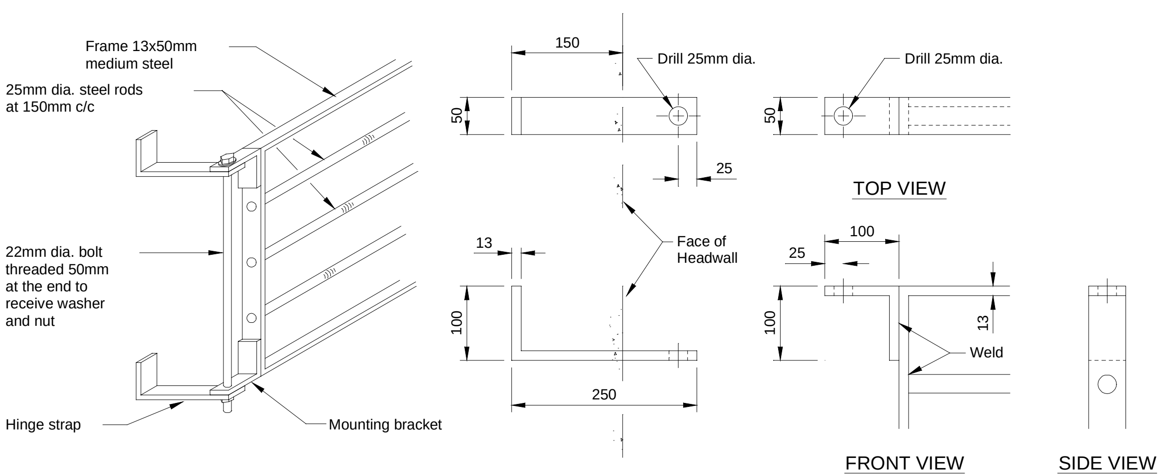


PIPE DIA.			450	525	600	675
A			50	125	75	25
No. of RODS IN FRAME			1	1	3	3
PIPE DIA.	750	825	900	975	1050	1200
A	100	50	125	75	25	50
No. of RODS IN FRAME	3	4	4	5	6	7

NUMBER OF FIXED RODS				
PIPE DIA.	1350	1500	1650	1800
No. of RODS	3	4	5	6

TYPE A - PIPE DIA. up to 1200mm

TYPE B - PIPE DIA. 1350 to 1800mm



ASSEMBLY

HINGE STRAP (4 Req'd)

MOUNTING BRACKET (4 Req'd)

ASSEMBLY AND HINGE STRAP DETAILS FOR TYPE A & B

NOTES:
1. Grate to be secured by either a bolt and nut or locking device as specified.
2. All dimensions are in millimetres unless otherwise shown.

Figure B-1
Typical Outfall Debris Grating
CONCEPTUAL (not to be used for construction)

R-2560 Series
Beehive Grates with Frames

Suitable for drainage in circumstances where clogging of a flat grating is a problem. Excellent for roadside or earth ditch catch basins.

Catalog No.	Dimensions in inches							Wt. Lbs.
	A	B	C	D	E	F	G	
R-2560-A	12	1	11	12½	19	4	4	80
R-2560-B	15½	1¼	15	15	21	5	3	120
R-2560-C	18	1¼	16½	20½	30	8	4	190
R-2560-C1	22	1½	20	23	28	4	4½	195
R-2560-C2	22	1½	20½	24	28¼	6	4½	270
R-2560-D	22	1½	20	24½	35	9	4½	315
R-2560-D1	22	1½	20	23	28	4	7	210
R-2560-D2	22	1½	20⅝	24	28⅜	6	7	285
R-2560-D3	22	1½	20	24½	35	9	7	345
R-2560-E	23	1½	21	25½	36	9	7	340
R-2560-EA	25¾	⅞	24⅛	26½	35½	4	6	265
R-2560-EB	25¾	⅞	24⅛	26½	35½	4	9	285
R-2560-E1	25¾	⅞	24⅛	26½	35½	7	6	285
R-2560-E2	25¾	⅞	24⅛	26½	35½	7	9	300
R-2560-E5	25¾	⅞	24⅛	26½	35½	8	6	345
R-2560-E6	25¾	⅞	24⅛	26½	35½	8	9	365
R-2560-E7	25¾	⅞	24⅛	26½	35½	9	6	350
R-2560-E8	25¾	⅞	24⅛	26½	35½	9	9	365
R-2560-E9	25¾	⅞	24⅛	26½	35½	10	6	360
R-2560-E10	25¾	⅞	24⅛	26½	35½	10	9	385
R-2560-F	29	1⅜	27	38	46	10	6	520
R-2560-G	32	1½	30	36	46	7	4	535

Illustrating
R-2560-E

Furnished standard with ground bearing surfaces.

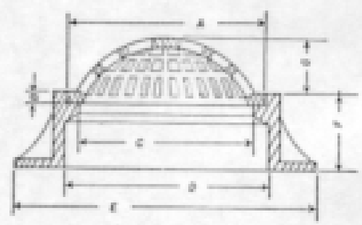
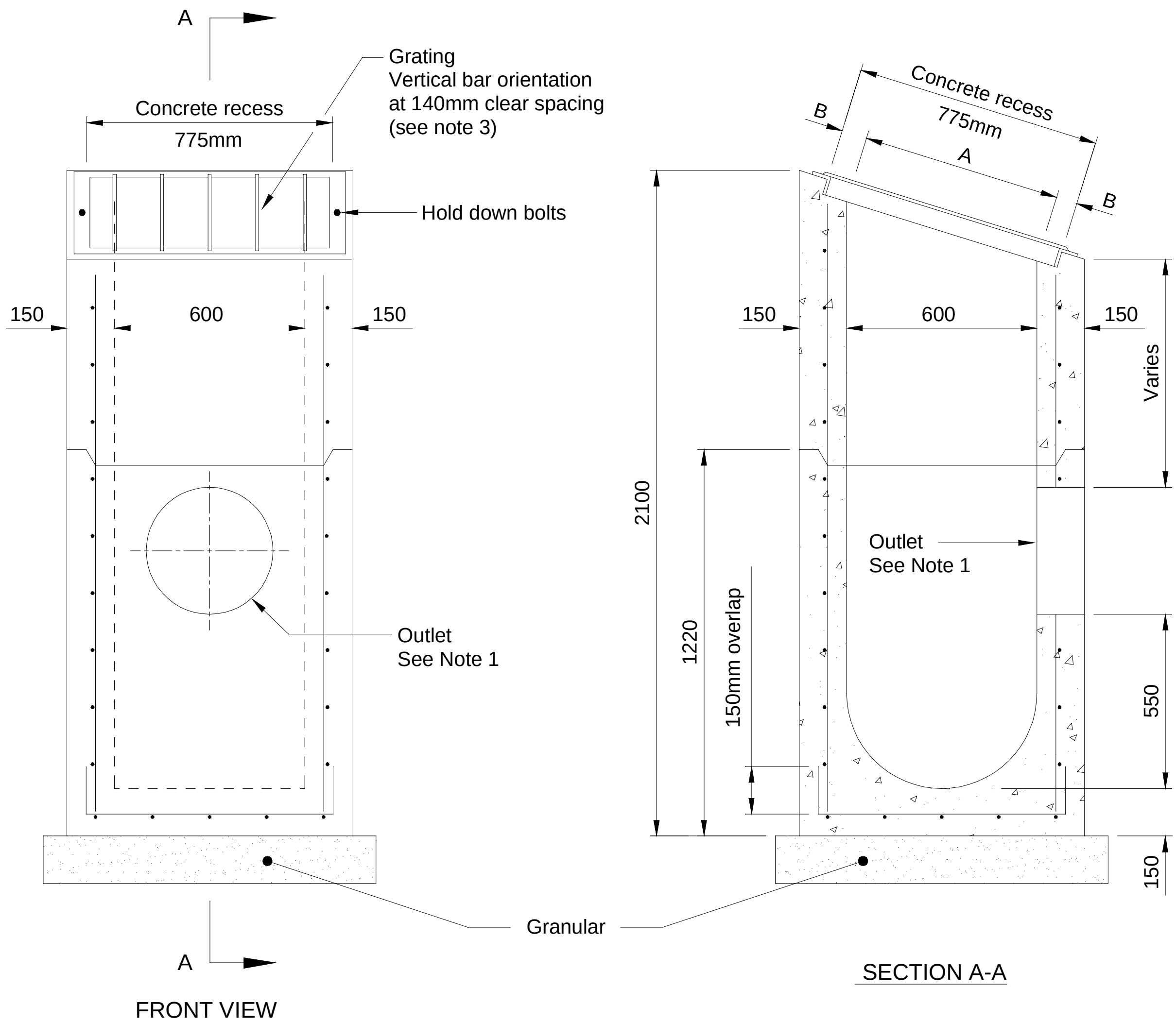


Figure B-2
Neenah Foundry - Typical "Beehive" Grate and Frame (Type I Ditch Inlet)

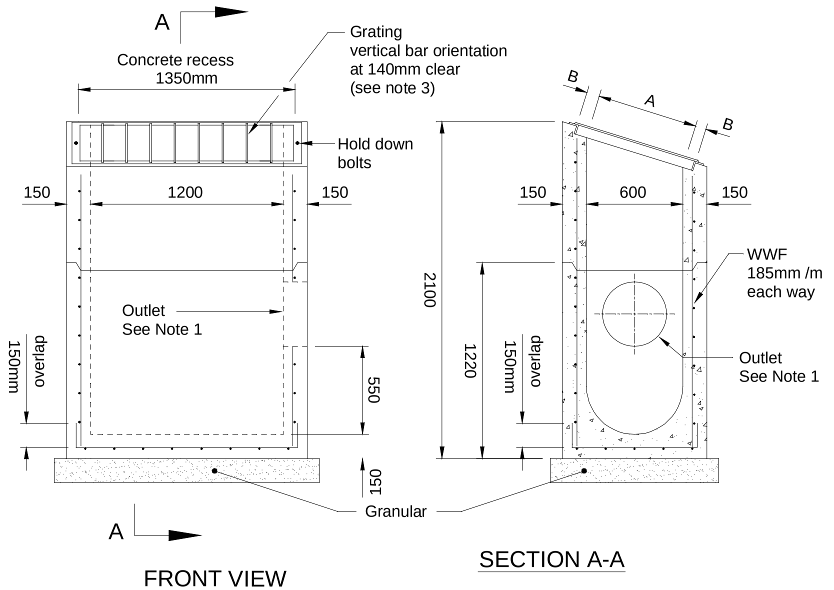


NOTES:
1. Maximum outlet hole size 400mm diameter, location as required.
2. Where inlet is placed across ditch and is accessible to vehicular traffic, grating slope should match existing side slope.
3. Where inlet likely to be accessed by vehicular or pedestrian traffic, special grating design required as per A6.3.
4. All dimensions are in millimeters unless otherwise shown.

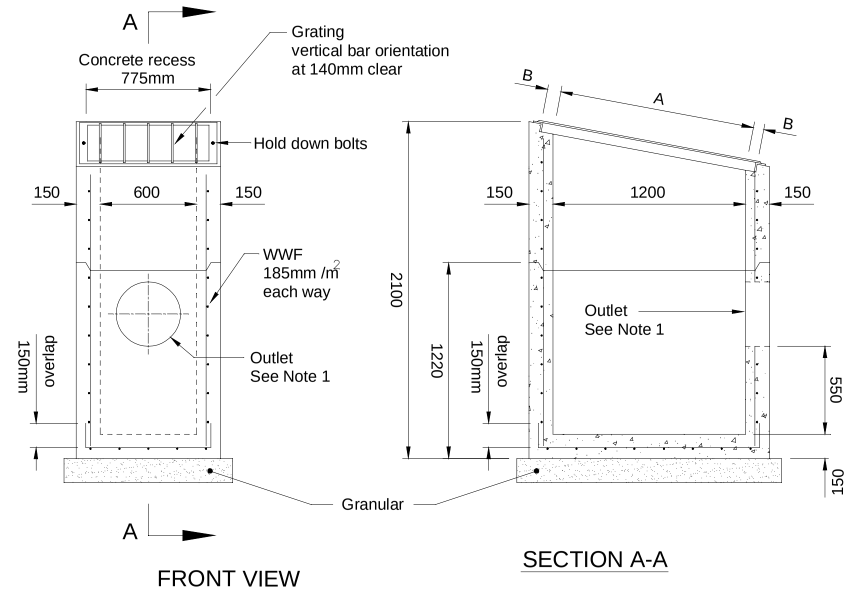
Slope of Grating	Dimensions	
	A	B
2:1	675	50
3:1	645	65
4:1	625	75
6:1	605	85
8:1	605	85
10:1	605	85

Figure B-3
Typical Type II Inlet Grate
(up to 400 LDS outlet
low debris potential)

CONCEPTUAL (not to be used for construction)



TYPE A



TYPE B

Slope of Grating	Dimensions	
	A	B
2:1	675	50
3:1	645	65
4:1	625	75

Slope of Grating	Dimensions	
	A	B
2:1	1365	55
3:1	1285	95
4:1	1260	110
6:1	1240	55
8:1	1230	60
10:1	1225	60
Horizontal	1220	65

NOTES:
1. Maximum outlet hole size 400mm diameter, location as required.
2. Where inlet is placed across ditch and is accessible to vehicular traffic, grating slope should match existing side slope.
3. Where inlet likely to be accessed by vehicular or pedestrian traffic, special grating design required as per A6.3.
4. All dimensions are in millimeters unless otherwise shown.

Figure B-4
Typical Type II Inlet Grate
(up to 400 LDS outlet
high debris potential)
CONCEPTUAL (not to be used for construction)

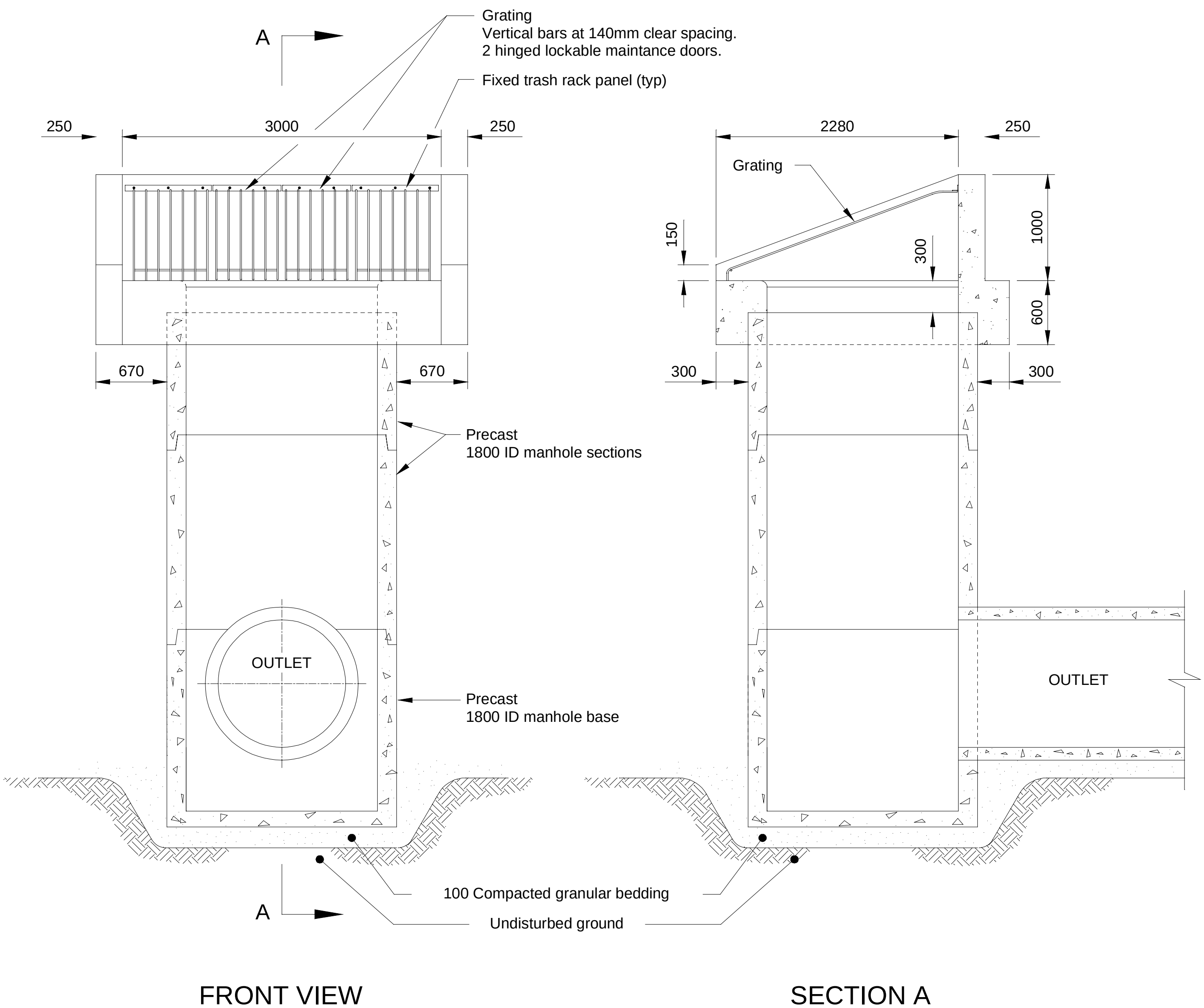


Figure B-5
Typical Type II Inlet Grate
(up to 1200 LDS outlet)
CONCEPTUAL (not to be used for construction)

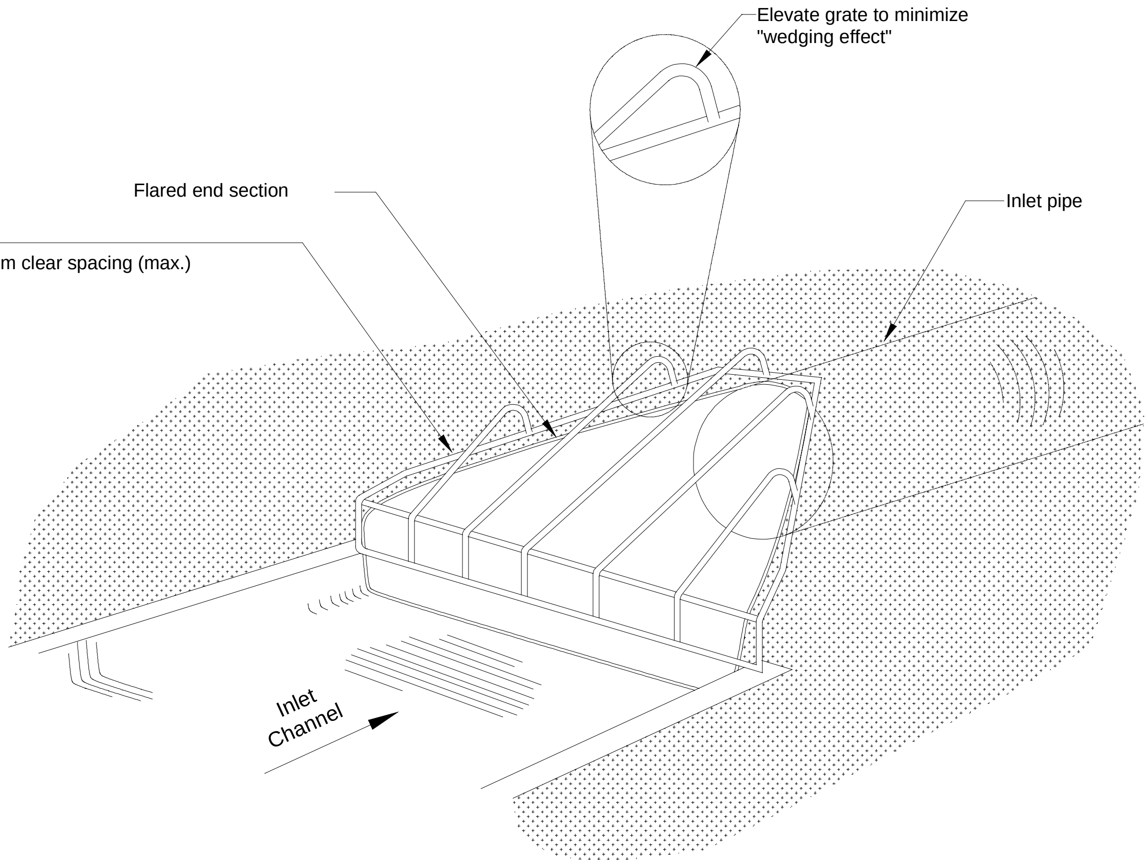


Figure B-6
Typical Inclined Grates on
Flared End Section
(500 to 1200 LDS outlet)

CONCEPTUAL (not to be used for construction)

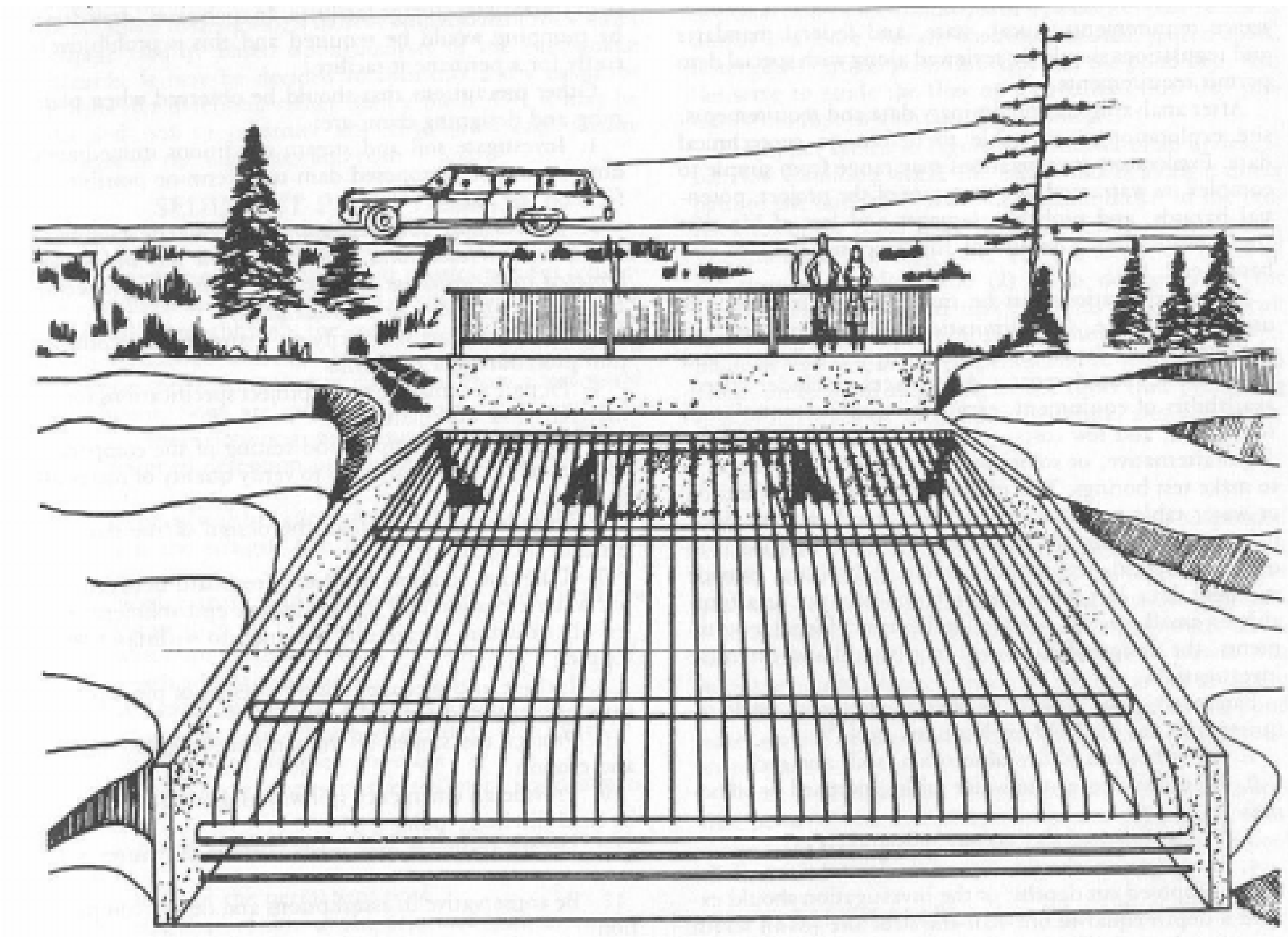


Figure B-7
Typical Type IV Inlet Structure
(> 2000 mm diameter or height)