On-site Underground Detention Storage Orifice Plate Sizing for Deemed-to-comply Detention

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This fact sheet describes the steps that should be taken to size an orifice plate for on-site underground detention when using deemed to comply detention storage. The standardised orifice plate design will help to ensure post-development flows match pre-development conditions for a range of storm events.

An orifice plate is required to ensure that peak flows being discharged from an underground storage tank can be attenuated for a range of storm events. Without an orifice plate, outflows would be controlled by the capacity of the outlet pipe. As the outlet pipe will typically be sized to convey the 10% Annual Exceedance Probability (AEP) event (at 2100) peak flows, the post-development discharges will likely exceed pre-development peak flows for smaller AEPs if an orifice plate or another form of staged discharge control is not installed.

Existing drainage networks, particularly in older established urban areas, were generally sized to convey the 39% AEP peak flows. Therefore discharging at higher than pre-development rates during smaller storm events could cause local flooding issues for surrounding areas. Control of peak flows during smaller events is also necessary in order to reduce the risk of increased scour and erosion in receiving waterways.

Having an outlet pipe sized to convey the smaller 39% AEP peak flow, without an orifice plate, so that outflows would be restricted for all storm events, would require more detention storage volume than proposed by Table 2 of the *Flooding and Stormwater Management Guidelines* (SCC, 2018).

Table 2 Deemed-to-comply detention storage volumes (m^3/Ha)

Pre-development condition	Post-development condition	
	Low Density (fi<60%)	Medium density (fi>60%)
Rural/grassed	330	420
Urban	NA	90

The outlet pipe to which the orifice plate is installed should be sized to convey the 10% AEP (at 2100) peak flows. This is to allow for potential future upgrade of the receiving drainage network. Allowance for blockage of the underground stormwater network and surcharge of the underground storage should be considered in the siting and design of the underground detention storage. The overland flow path is required to have sufficient capacity so that surrounding floor levels will not be inundated if there is complete blockage of the underground stormwater drainage network during the 1 in 100 AEP (at 2100) event.

The stormwater drainage upstream of the detention storage should be designed so that the 1 in 100 AEP peak flow can be conveyed to the underground detention storage.

To the maximum degree practical, the entire site should be drained to the detention storage. Where this is not possible, the equivalent storage for the entire site should be provided and the outlet should be reduced in size to achieve the same overall site discharge. A maximum of 20% of the developed portion of the site is allowed to bypass the detention storage.

The depth of the required underground detention storage is flexible in order to allow for a range of proprietary detention storage products to be utilised. Pre-treatment of flows entering the tank should be provided by a Gross Pollutant Trap (GPT) or gully pit baskets.

A removable debris screen, in accordance with the Section BN5.5.2(p) of QUDM (2017) should be provided upstream of the orifice plate. A sump pit, which houses the outlet orifice, will also be necessary. The access chamber to the underground storage should be adequately sized to enable the debris screen to be removed from the tank.

The orifice plate should be made from a corrosion resistant 5mm thick stainless steel. The orifice plate will have numerous holes at specified levels and diameters cut out of it. The minimum acceptable orifice plate hole diameter is 25mm.

Orifice Plate Sizing Process

The orifice plate should be designed using the following steps:

Step 1. Size the outlet pipe to which the orifice plate will attach so that it has a diameter half the depth of the underground tank, as shown in Figure 1. Multiple pipes can be used to achieve the required total depth, in order to allow smaller outlet pipes to be used.

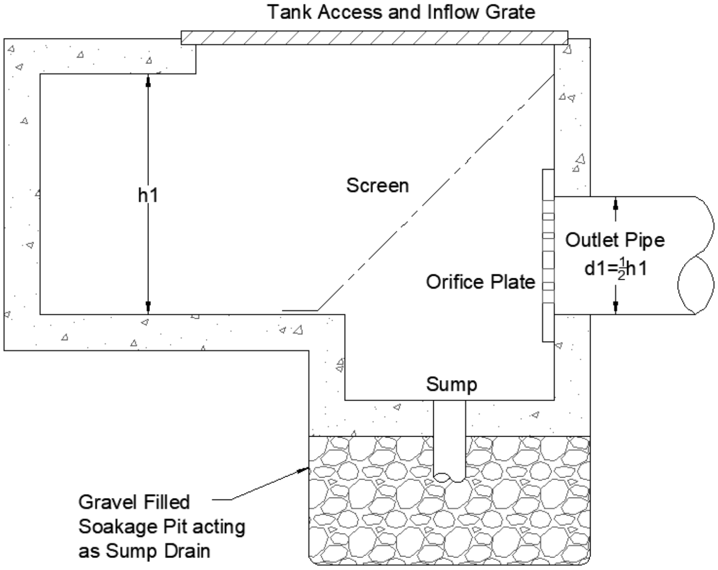

Figure 1 On-site Detention Storage Outlet Pipe Size

Step 2. Determine the current climate pre-development 10% AEP peak flow based on *A Review of Simple Peak Flow Estimation Methods for use on the Sunshine Coast following the release of ARR 2016* (SCC, 2017). This will be the target Q_o.

Step 3. Size the required orifice plate holes based on the following equation:

$Q_o = C\ A\ (2gH)^{1/2}$

Where:

C = 0.6 (unless otherwise justified)

A = total orifice area (m^2)

g = acceleration due to gravity (m^2/s)

H = depth of water above the centroid of orifice plate hole (m)

The orifice plate holes should be spaced so that the:

i. bottom third of the plate can convey 5/12 of Q_0 when H is 2/3 of the tank depth

ii. middle third of the plate can convey 1/2 of Q_0 when H is 2/3 of the tank depth

iii. the top third of the plate can convey 1/12 of Q_0 when H is 2/3 of the tank depth

An example of how H is calculated for the bottom third of the orifice plate is shown in Figure 2; $H = 2/3h_1 - 1/6d_1$. For the middle third of the plate $H = 2/3h_1 - 1/2d_1$. For the top third of the orifice plate $H = 2/3h_1 - 5/6d_1$.

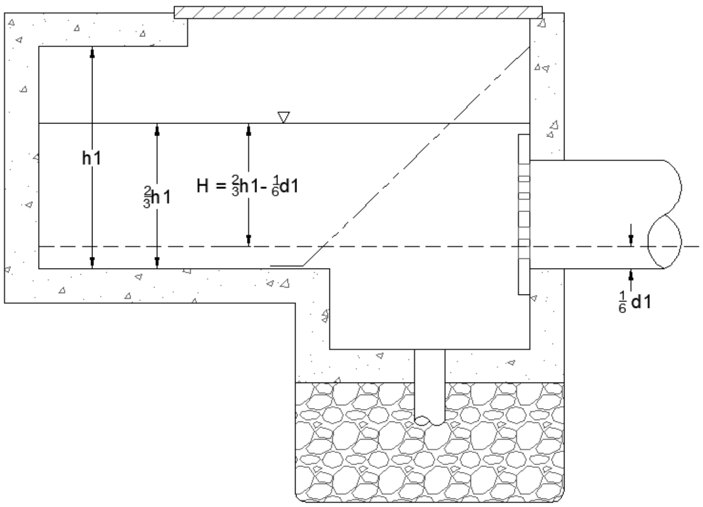

Figure 2 Example of H Calculation for Bottom Third of Orifice Plate

Step 4. Multiple holes will be required in each section of the orifice plate. The minimum acceptable orifice plate hole diameter is 25mm. Check that the proposed number of holes can fit within the available orifice plate area over the outlet pipe. In order to accommodate the required number of holes, multiple outlet pipes or a box culvert may be required. The procedure to size the orifice plate holes will not be modified, the holes will just be spread over a greater area.

Step 5. Check that the outlet pipe/s has sufficient capacity (based on Colebrook-White equation) to convey the 10% AEP (at 2100) peak pre-development flows.

Step 6. Size the removable debris screen so that the area (including blocked area) is at least 20 times the total orifice area. A grid mesh should be used (e.g. Weldlok A40/203 or similar).

An example of an orifice plate arrangement is provided in Figure 3.

The proposed outlet design should help to ensure that post-development peak flows from the site are attenuated to pre-development levels for all storm events, up to and including the 1 in 100 AEP (at 2100).

The depth of water (H) used to size the orifice plate is limited to two thirds of the depth of the tank. During major storms, additional storage above this level will be therefore be available.

In some instances, multiple small outlets may be able to be used instead of an orifice plate. The capacity of the outlet pipes (which is dependent on factors such as grade and materials) should be verified to ensure that they do not become the hydraulic control. The multiple pipes should drain to a single pit before connecting to Council’s underground drainage network.

Orifice Plate Sizing Example

An example of the orifice plate sizing is provided below for an example of a 0.5ha rural-residential block being developed into a medium density development. The volume of storage required is 210m^3. The pre-development 10% AEP peak flow is 0.15m^3/s (current day) and 0.18m^3/s (at 2100). The depth of the proposed tank is 1.2m.

Step 1. The outlet pipe will be required to have a diameter of half of 1.2m, i.e. 600mm.

Step 2. The target Q_o is 0.15m^3/s.

Step 3. The following orifice plate holes will be required:

i. The centroid of the bottom third is at 0.1m. The average depth of water above the centre of the holes at 2/3 of the tank depth is therefore 0.7m. The orifice plate holes are required to convey 5/12 of 0.15m^3/s, i.e. 0.0625 m^3/s. 4/95mm holes (or equivalent) are therefore required in the bottom third of the orifice plate.

ii. In the middle third of the plate, the average depth of water above the centroid is 0.5m, and it will be required to convey 1/2 of 0.15m^3/s, i.e. 0.075 m^3/s. 7/85mm orifice plate holes (or equivalent) are therefore required in the middle third of the orifice plate.

iii. In the top third of the plate, the average depth of water above the centroid is 0.3m, and it will be required to convey 1/12 of 0.15m^3/s, i.e. 0.0125 m^3/s. 1/105mm orifice plate hole (or equivalent) is therefore required in the top third of the orifice plate.

Step 4. The orifice plate holes are able to physically fit onto the 600mm diameter orifice plate, as shown in Figure 3, and so multiple outlet pipes will not be required.

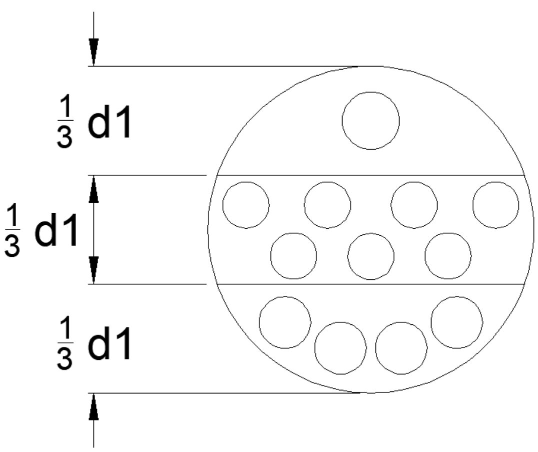

Figure 3 Orifice Plate Set Out Example

Step 5. The 600mm RCP outlet at a minimum grade of 0.2% will have a capacity of 0.27m^3/s, and so will have sufficient capacity to convey the future climate 10% AEP peak flow of 0.18m^3/s.

Step 6. The minimum debris screen area is 20 times the total orifice plate hole area, i.e 1.53m^2.