INTRODUCTION

A frequently encountered problem in combined sewage overflow is limiting the rise of water surface level. The amount of water backing up at peak flow is often limited, for example, by overflow weirs.

This simple control may be improved by use of a hinged gate, activated by a mechanism controlled by a float placed upstream and arranged to move the gate at particular levels. The maximum overflow rate may then exceed the peak inflow rate by a considerable amount.

However, adequate control of this type of gate requires very precise instrumentation and an auxiliary power supply. Because the system depends on:

- Instrumentation
- Auxiliary power supply
- Numerous moving parts
- A long and delicate seal

its reliability and lifetime is questionable.

The Hydrovex® ARS Air Regulated Siphon offers an excellent alternative to conventional overflow weirs. Storm overflow outfalls, using air-regulated siphons, are much smaller in size than those using conventional weirs, thereby providing a considerable saving in costs. They have the following advantages:

- No moving parts
- No requirement for auxiliary power
- Minimum maintenance cost
- Flow rates up to 11 times greater than an overflow weir of the same construction width
- Linear flow characteristics without hysteresis
- The unit can accept submergence at the outlet and overtopping at the inlet
- Rigid construction with vertical downstream leg
- Inlet shaped to retain floating solids in the storm water chamber
- All models and sizes have been tested and their flow characteristics are known
- Civil works reduced to a minimum
- May easily be installed over existing weirs to enhance their capacity
- All stainless steel construction

In the standard siphon shown in Figure 1, air entry is prevented by placing the water inlet much lower than the crest. Air suction can lead to unstable behavior of the siphon to the point where it could lose its prime.

The price of stability, with the classical siphon, is a considerable hysteresis in the discharge curve. That is to say, on rising flow, the siphon produces a discharge similar to that of the hinged gate, but when the water level subsequently falls, the standard siphon produces a loss of stored volume ($\delta V$), which can be quite significant.

![Figure 1: A standard siphon](image-url)
The **Hydrovex® ARS** Air Regulated Siphon has flow characteristics that are much more complex than those of the standard siphon. This siphon has no hysteresis and is much more effective than a standard overflow weir. The siphon shown in Figure 2 has a vertical downstream leg (1), a specially designed inlet, and a U-shaped outlet. This siphon is very compact and can be mounted above an existing overflow weir by placing it over the crest.

The unit is fitted with a special air intake. The air intake pipe (7), slightly inclined to the horizontal, runs from the upstream chamber through the upper part of the siphon and into the downstream leg. This pipe supplies air to two openings, one at its end in the downstream vertical leg (8) and the other near the crest in the upstream leg (9). An air intake cap (10) controls the hydraulic characteristics. The level of the siphon crest (11) is the reference or retention level at which overflow starts.

There will be no flow as long as the water level remains below the retention level, as shown in Figure 2. If the water level rises slightly above this level, water will start to run over the crest (refer to Figure 3a).

If the water level rises further by only a slight amount, as in Figure 3b, the flow rate increases sufficiently for the water jet to form at the flow deflector, together with the pool formed at the outlet bend, to entrain air from the siphon in the manner of an air ejector. This produces a reduction of pressure in the siphon, which raises the water level over the crest. This pressure reduction is however regulated at the air inlet cap. A mixture of air and water is fed to both the underside and the upper side of the discharging water stream.

If the water level continues to rise above the crest to a level of 55% of the reference siphon size, the air intake becomes completely submerged, and so can admit only water. All the air is evacuated at the outlet from the siphon, which then runs at full capacity as shown in Figure 3c.

With decreasing water level, partial aeration takes place, thus relieving the reduction of pressure in the siphon. When the water again reaches the retention level, flow ceases and the vertical leg empties itself through the outlet.
Backwater flow starts when h/D is 0.55. So for a siphon of 200 mm (8 in) nominal size, only 110 mm (4.3 in) is required to attain the full flow condition. The remaining 50 mm (3.7 in) is used as freeboard. The flow rate for the long siphon would then be 713 L/s (25.2 cfs), as shown in Table 1.

![Figure 3: Operation of the Hydrovex® ARS Air Regulated Siphon](image)

As the intake to the siphon is well below the water level, floating solids do not enter and thus are not discharged to the storm water outfall. The air inlet may also be modified to eliminate clogging, as shown in Figure 4. The siphon is constructed with smooth surfaces without burrs or weld spatter.

![Figure 4: Various kinds of air inlets.](image)

**FLOW CHARACTERISTICS**

*Figure 5* shows the head discharge curve of the Hydrovex® ARS Air Regulated Siphon. For comparison, the curve for a simple weir of 7 to 11 times the width, is also shown. The siphon characteristic rises almost linearly up to the full flow or ‘’backwater’’ point shown as (h_b, Q_b). From this point, up to the condition of overtopping of the siphon, the increase of flow is very small.

**ENHANCED STORAGE CAPACITY**

Where siphons are installed at existing outfalls, they may, because of their high effectiveness, be set at higher levels than the existing sills. If we suppose that the quantity to be discharged is unaltered, and that the maximum permitted water level in the stormwater chamber is also not to be changed, the crest level of the siphon may be higher than that of the existing sill by an amount of dh, the value of which depends on the nominal size of siphon and whether it is of long type. The increase in water level gives an increase of storage capacity, within the storm water chamber, which ranges from 18 to 28%. If the additional storage capacity in the sewer is taken into account, the increase in total storage capacity may be up to 50%.
OUTLET CONDITIONS

The bend at the siphon outlet is designed to give good priming when discharging to atmosphere. Once primed, the downstream water level may be permitted to rise sufficiently to submerge the outlet without interfering with the operation of the siphon. However, the full flow or “backwater” flow rate will be reduced because of the reduction in effective head across the siphon. To restrict this reduction of full flow rate to about 15% and to ensure correct air-partialized behavior, it is recommended that the submergence of the outlet should not exceed H/3.

Figure 5: Typical discharge rating curve for Hydrovex® ARS Air Regulated Siphon

Table 1: Sizes and discharge rates of regulated air