Discharge measurement structures

Third revised edition

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3.3 Properties and limits of application of structures

3.3.1 General

In Section 3.2 the most common demands made upon discharge measuring or regulating structures are described. In Chapters 4 to 9, the properties and limits of application of each separate structure are given in the sections entitled Description and Limits of application. To aid the design engineer in selecting a suitable structure, we have tabulated the most relevant data.

3.3.2 Tabulation of data

Table 3.1 consists of 18 columns giving data on the following subjects

Column 1 – Name of the standard discharge measuring or regulating device. In brackets is the section number in which the device is discussed. Each section generally consists of sub-sections entitled: Description, Evaluation of discharge, Modular limit, Limits of application.

Column 2 – A three-dimensional sketch of the structure.

Column 3 – Shape of the control section perpendicular to the direction of flow and the related power u to which the head or differential head appears in the head-discharge equation.

Column 4 – Possible function of the structure. If the area of the control section cannot be changed, the structure can only be used to measure discharges; this is indicated by the letter M in the column. If the weir crest can be made movable by use of a gate arrangement as shown in Section 4.2, or if the area of an orifice is variable, the structure can be used to measure and regulate discharges and has the letters MR in the column. The Dethridge and propeller meters can measure a flow rate in m^3/s and totalize the volume in m^3. The discharge can be regulated by a separate gate, which is, however, incorporated in the standard design. These two devices have the letters MRV in the column.

Column 5 – Minimum value of H_1 or Δh in metres or in terms of structural dimensions.

Column 6 – As Column 5, but giving maximum values.

Column 7 – Minimum height of weir crest or invert of orifice above approach channel bottom; in metres or in terms of structural dimensions.

Column 8 – Minimum dimensions of control section; b_c, B_c, w, and D_p.

Column 9 – Range of notch angle θ for triangular control sections.

Column 10 – Minimum discharge (Q_{min}) in $m^3/s \times 10^{-3}$ or l/s of the smallest possible structure of the relevant type, being determined by the minima given in Columns 5, 8, and 9.

Column 11 – Maximum discharge: q in m^2/s, being the discharge per metre crest width if this width is not limited to a maximum value, or Q in m^3/s if both the head (differential) and control section dimensions are limited to a maximum. No maximum discharge value is shown if neither the head (differential) nor the control dimensions are limited by a theoretical maximum. Obviously, in such cases, the discharge is limited because of various practical and constructional reasons.

Column 12 – Value of $\gamma = Q_{max}/Q_{min}$ of the structure. If Q_{max} cannot be calculated directly, the γ-value can usually be determined by substituting the limitations on head (differential) in the head-discharge equation, as shown in Section 3.2.3.

Column 13 – Modular limit H_2/H_1 or required total head loss over the structure. The modular limit is defined as that submergence ratio H_2/H_1 whereby the modular discharge is reduced by 1% due to an increasing tailwater level.

Column 14 – Error in the product C_dC_v or in the coefficient C_e.

Column 15 Maximum value of the sensitivity of the structure times 100, being

$$100\,S = \frac{u}{h_1}\,\Delta h_1\,100$$

where the minimum absolute value of h_1 is used with the assumption $\Delta h_1 = 0.01$ m. The figures shown give a percentage error in the minimum discharge if an error in the determination of h_1 equal to 0.01 m is made. The actual error Δh obviously depends on the method by which the head is determined.

Column 16 – Classifies the structures as to the ease with which they pass floating and suspended debris.

Column 17 – Classifies the structures as to the ease with which they pass bed-load and suspended load.

Column 18 – Remarks.

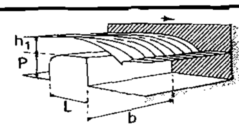
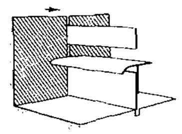
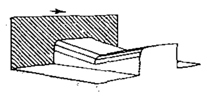
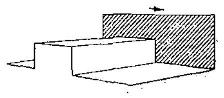
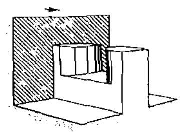
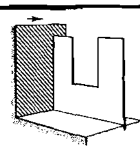
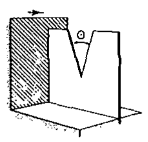
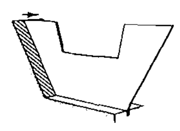
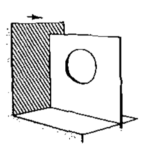
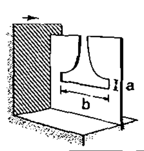
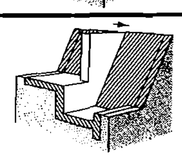
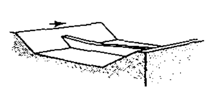
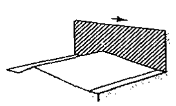
3.4 Selecting the structure

Although it is possible to select a suitable structure by using Table 3.1, an engineer may need some assistance in selecting the most appropriate one. To help him in this task, we will try to illustrate the process of selection. To indicate the different stages in this process we shall use differently shaped blocks, with connecting lines between them. A set of blocks convenient for this purpose is defined in Figure 3.7.
All blocks except the terminal block, which has no exit, and logical decision blocks, which have two or more exits, may have any number of entry paths but only one exit path. A test for a logical decision is usually framed as a question to which the answer is 'Yes' or 'No', each exit from the Lozenge block being marked by the appropriate answer.

A block diagram showing the selection process is shown in Figure 3.8. The most important parts of this process are:
- The weighing of the hydraulic properties of the structure against the actual situation or environment in which the structure should function (boundary conditions);
- The period of reflection, being the period during which the engineer tests the type of structure and decides whether it is acceptable.

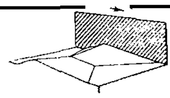
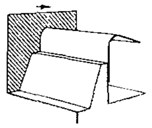
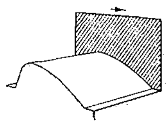
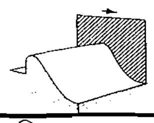
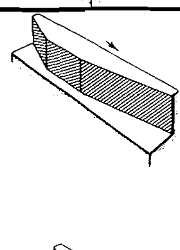
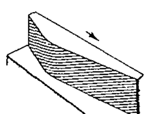
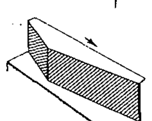
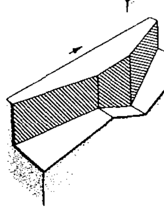
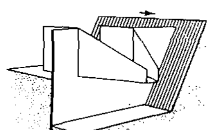
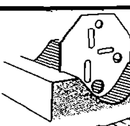
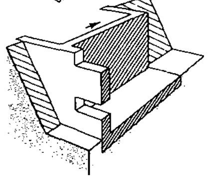
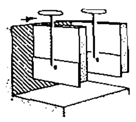
Both parts of the selection process should preferably be passed through several times to obtain a better understanding of the problem.
To assist the engineer to find the most appropriate type of structure, and thus the

TABLE 3.1. OATA ON VARIOUS STRUCTURES

1 Name of structure and section number in which structure is described	2 Sketch of structure	3 Shape of control section perpendicular to flow and u-value	4 M = measuring MR = measuring & regulating	5 H_1 min or Δh min	6 H_1 max or Δh max	7 minimum crest height above approach channel bottom p	8 minimum size of control b or B, w and D_p	9 range of notch angle θ degrees
Round-nose horizontal broad-crested weir (4.1)		rectangular u = 1.5	MR	0.06 m 0.05 L	0.5 L	0.15 m 0.33 H_1	0.30 m H_1 max 0.2 L	-
Romijn movable measuring/ regulating weir (4.2)		rectangular u = 1.5	MR	0.05 m 0.12 L	0.78 L	0.15 m 0.33 H_1	0.30 m H_1 max	-
Triangular broad-crested weir (4.3)		(truncated) triangular u=1.7 to 2.5	MR	0.06 m 0.05 L	0.5 L to 0.7 L	0.15 m 0.33 H_1	0.30 m H_1 max 0.2 L	30 to 180
Broad-crested rectangular profile weir (4.4)		rectangular u = 1.5	MR	0.06 m 0.08 L	0.85 L* → 1.50 L →	0.15 m if 0.4 h_1 if 0.65 h_1	0.30 m h_1 max 0.2 L	-
Faiyum weir (4.5)		rectangular u = 1.6	M	0.06 m 0.08 L	1.6 L	0.15 m	0.05 m $3h_1/A_1$	-
Rectangular sharp-crested weirs (5.1)		rectangular u = 1.5	M → or MR →	0.07 m 0.03 m	0.60 m 0.5 b 2.4 p	0.30 m 2 h_1 0.10 m 0.5 h_1	0.30 m B-b>4 h_1 0.15 m	-
V-notch sharp-crested weirs (5.2)		triangular u = 2.5	M M	0.05 m 0.05 m	0.60 m 1.2 p 0.38 m 0.4 p	0.10 m 0.45 m	$B_1 \geq 2.5\ h_1$ $B_1 \geq 5.0\ h_1$	90 25 to 100
Cipoletti weir (5.3)		trapezoidal u = 1.5	MR	0.06 m	0.60 m	0.30 m 2 h_1	b≥0.30 m 0.5 h_1	-
Circular weir (5.4)		circular u is variable but ≤ 2.0	M	0.03 m 0.1 d	0.9 d	0.10 m 0.5 d	d≥0.20 m	-
Proportional weir (5.5)		proportional u = 1.0	M	0.03 m 2 a	such that x≤0.005 m	p = 0 or p≥0.15 m	0.15 m	-
Weir sill with rectangular control section (6.1)		rectangular u = 1.5	M	0.09 m 0.75 L	0.90 m 0.5 b	0	0.30 m b≥1.25 b_1	-
V-notch weir sill (6.2)		triangular u = 2.5	M	h_1=0.03m	h_1=1.83 m	0.15 m	-	126°52'* 143°08' 157°22'
Triangular profile two-dimensional weir (6.3)		rectangular u = 1.5	M	0.03 m* steel 0.06 m concrete	3.00 m 3.0 p	0.06 m 0.33 H_1	0.30 m 2 H_1	-

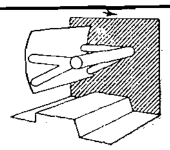
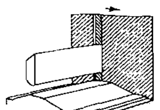
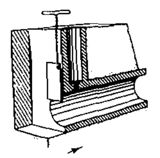
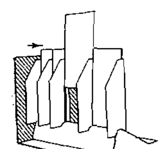
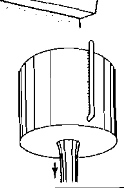
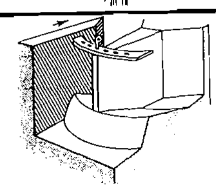
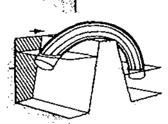
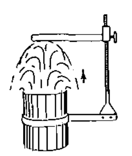
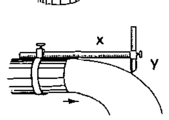
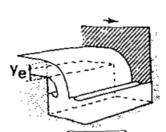
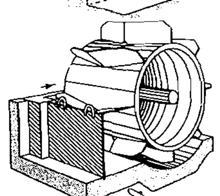
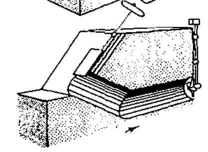
1 Name of structure	10 Q_{min} m^3/s	11 Q_{max} in m^3/s or q max in m^2/s	12 $\gamma = \frac{Q_{max}}{Q_{min}}$	13 modular limit H_2/H_1 or head loss	14 error in C_dC_v or C_e (%)	15 sensitiveness at minimum head % per 0.01 m	16 debris passing capacity	17 sediment passing capacity	18 Remarks
							+ + very good; + good; □ fair; - poor; - - very poor		
Round-nose horizontal broad-crested weir (4.1)	0.0066 b = 0.30 m	q = 4.7 H_1=2.0 m	35	0.70 to* 0.95	2(21-20 C_d)	25	+	□	* value depends on slope backface and on ratio p_2/H_2
Romijn movable measuring/ regulating weir (4.2)	0.0057* b=0.30 m	Q=0.860* b=1.50 m	30	0.30	3	30	+	+	* values refer to standard weir with L = 0.60 m
Triangular broad-crested weir (4.3)	0.0026 at θ=30°	variable	830*	0.80 to 0.95	2(21-20 C_d)	42	+ to □ depending on θ	□	* triangular control 0.05 L≤H_1≤0.7 L
Broad-crested rectangular profile weir (4.4)	0.0064	q=5.07 H_1=2.0 m	35* 81	0.66 to 0.38	10F-8 1≤F≤1.24	25	□	□	* depending on weir height p
Faiyum weir (4.5)	0.0011	q=5.1 H_1=2.0 m	90	0.66*	5	25	□	-	*usually lower
Rectangular sharp-crested weirs (5.1)	0.00997 0.00137	q=0.813 variable	24.5 if b≥1.2 m about 30	head loss= H_1 +0.05 m head loss= H_1 +0.05 m	1 1	25 25	- - -	- - - -	Fully contracted weir Full width & partially contracted weirs
V-notch sharp-crested weirs (5.2)	0.0008 about 0.0002 if θ=28°4'	Q=0.390 about Q=0.145 if θ=100°	about 500 about 150	head loss ≥ H_1 head loss ≥ H_1	2 1	50 50	- - - -	- - - -	partially contracted fully contracted
Cipoletti weir (5.3)	Q=0.0082 b=0.30 m	q=0.864	36.4	head loss H_1+0.05 m	5	25	- -	- -	
Circular weir (5.4)	0.00091 d=0.20 m	variable	55.9 if d≥0.30 m	head loss H_1+0.05 m	2	67	- -	- -	
Proportional weir (5.5)	0.0058 a=0.006 m b=0.15 m	variable	small,but depends on a-value	head loss H_1+0.05 m	2	33	- -	- - good if p = 0	a ≥ 0.005 m
Weir sill with rectangular control section (6.1)	0.013 b=0.30 m	q=1.366	32	0.20	5	17	+	+	
V-notch weir sill (6.2)	0.0005 0.0007 0.0010	Q=25.4** Q=30.6 Q=49.4	50000 * 43000 49000	0.30	3	83	□	-	*three notch angles only **depending on A_1-values
Triangular profile two-dimensional weir (6.3)	0.0031 h_1=0.03m 0.0088 b=0.30 m h_1=0.06m	q=10,18	1000* or 350	0.75	10 C_v-9	50 or 25	+ +	+	*depends on crest material. Applies to 1-to-5 back face

TABLE 3.1. DATA ON VARIOUS STRUCTURES (cont.)

1 Name of structure and section number in which structure is described	2 Sketch of structure	3 Shape of control section perpendicular to flow and u-value	4 M = measuring MR = measuring & regulating	5 H_1 min or Δh min	6 H_1 max or Δh max	7 minimum crest height above approach channel bottom p	8 minimum size of control b or B, w and D_p	9 range of notch angle θ degrees
Triangular profile flat-vee weir (6.4)		(truncated) triangular u = 1.7 to 2.5	M	0.03 m steel 0.06 m concrete	3.00 m 3.0 p	0.06 m 0.33 H_1	0.30 m 2 H_1	168°34' 174°16'
Butcher's movable standing wave weir (6.5)		rectangular u = 1.6	MR	0.05 m	1.00 m	1.4 $h_1$max	0.30 m 2 h_1	-
WES-Standard spillway (6.6)		rectangular u = 1.5	M	0.06 m	depends* on h_d 5.0 p	0.15 m 0.2 h_1	0.30 m 2 H_1	-
Cylindrical crested weir (6.7)		rectangular u = 1.5	MR	0.06 m 0.1 r	depends* on r 3.0 p	0.15 m 0.33 h_1	0.30 m 2 H_1	-
Long-throated flumes (5 basic shapes) (7.1)		rectangular u = 1.5	M	0.06 m 0.1 L	1.0 L 1.0 B	0 but Fr≤0.5	0.30 m*	-
		(truncated) triangular u=1.7 to 2.5	M	for all flumes	for all flumes	for all flumes	B≥0.10 m*	30 to 180
		trapezoidal u=1.6 to 2.4	M		*Note: in general H_1≤3.0 m*		B≥0.30 m*	side slope variable**
		parabolic u = 2.0	M				f ≥0.10 m*	-
		(semi)-circular u is variable but ≤ 2.0	M				d ≥ 0.20 m*	-
Throatless flumes with rounded transition (7.2)		rectangular u = 1.5	M	0.06 m	2.00 m 1.5 R	0	0.20 m H_1 max	-
Throatless flumes with broken plane transition (7.3)		rectangular u = 1.5	M	0.06 m	1.80 m	0	0.305 m only	-
Parshall flumes (22 types) (7.4)		rectangular u = 1.55	M	0.015 m and 0.03 m	0.21 m to 0.33 m	0 level floor	0.0254 m to 0.0762 m	-
		u = 1.522 to u = 1.607	M	0.03 m, 0.045 m, and 0.076 m	0.45 m to 0.76 m		0.1524 m to 2.438 m	-
		u = 1.60	M	0.09 m	1.07 m to 1.83 m		3.048 m to 15.24 m	-
H-flumes (3 types) (7.5)		sloping trapezium u = 2.0 to 2.4	M	0.01 m to 0.04 m	0.11 m to 0.30 m	0	see Figure 7.21	-
				0.01 m to 0.03 m	0.14 m to 1.36 m			
				0.03 m	1.06 m and 1.21 m			
Circular sharp-edged orifice (8.1)		circular u = 0.5	M	Δh≥0.03 m h_1 ≥ d	-	0.5 d	A ≤ 10 A_1 d ≥ 0.02 m	-
Rectangular sharp-edged orifice (8.2)		rectangular u = 0.5	M but MR if suppressed	Δh≥0.03 m y_1≥0.15 m	-	0	b≥0.30 m w≥0.02 m	-
Constant head orifice (8.3)		rectangular u = 0.5	MR	Δh≡0.06 m y_1 ≥ 2.5 w	Δh=0.06 m	0	usually* b=0.60 m and b=0.75 m	-

1 Name of structure	10 Q_{min} m³/s	11 Q_{max} in m³/s or q max in m²/s	12 γ = Q_{max}/Q_{min}	13 modular limit H_2/H_1 or head loss	14 error in C_dC_v or C_e (%)	15 sensitiveness at minimum head % per 0.01 m	16 debris passing capacity	17 sediment passing capacity	18 Remarks
							+ + very good; + good; □ fair; - poor; - - very poor		
Triangular profile flat-vee weir (6.4)	0.0137 h=0.03 m 0.0275 h_1=0.06 m b=0.30 m	depends on degree of truncation	100,000* h_1≥0.03 m 17,500 h_1≥0.06 m	0.67	10 C_v-8	83 if h_1=0.03 m 42 if h_1=0.06 m	+ +	+	Applies to 1-to-5 back face only. *γ-values decrease if control is more truncated
Butcher's movable standing wave weir (6.5)	0.0077 b=0.30 m	q=2.30	120	0.70	3	32	+	-*	* good if gate arrangement as in Section 4.2
WES-Standard spillway (6.6)	0.025 b=1.0 m	variable*	about 1000 but depends on h_d-value	0.30	5	25	+ +	+	* minimum pressure on crest limited to -4.0 m water column (see Fig.6.17)
Cylindrical crested weir (6.7)	0.0064 b=0.30 m	variable*	about 750, but depends on ratio H_1/r	0.33	5	25	+ +	+	* minimum pressure on crest limited to -4.0 m water column (see Fig.6.23)
Long-throated flumes (7.1): rectangular	0.0066 b=0.30 m	variable with throat length	35	0.70 to 0.95 depending on downstream transition	2(21-20C_d) for all flumes	25	+ +	+	* for all flumes; at maximum stage: B > 0.30 m B > H_1max B > L/5
(truncated) triangular	0.00098 θ=90°		≤315			28 to 42	+ +	+ +	**side slope ratio horz : vert. varies between ¼:1 to 4:1
trapezoidal	0.0036 b=0.08 m slope 1:2		≤250			27 to 40	+ +	+ +	
parabolic	0.0027 f=0.10 m		100			33	+ +	+ +	
(semi)-circular	0.0026 d=0.20 m		100 if d≥0.60 m			≤ 33	+ +	+ +	
Throatless flumes with rounded transition (7.2)	0.0050 b=0.20 m	q=4.82 H_1=2.00 m	190	about* 0.50	8	25	+ +	+	* if radii of rounding and if downstream transition comply with Section 7.2.2
Throatless flumes with broken plane transition (7.3)	-	-	-	-	-	25	+ +	+	not recommended to be constructed due to lack of data
Parshall flumes (7.4): u = 1.55	0.00009 to 0.00077	0.0054 to 0.0321	about 55	0.50	3	103 to 52	+ +	+	very small flumes; 1,2, and 3 inch wide
u = 1.522 to 1.607	0.0015 to 0.0972	0.111 to 3,949	about 75	0.60 and 0.70	3	53 to 21	+ +	+	small flumes; 0.5,0.75, 1.0, 1.5, 2,3 to 8 feet wide
u = 1.60	0.16 to 0.75 m³/s	8.28 to 93.04 m³/s	about 105	0.80	3	18	+ +	+	large flumes; 10 to 50 feet wide
H-flumes (7.5)	0.000012 to 0.00034	0.0003 to 0.0223	about 100	0.25	3	≤240	-		HS-flumes, D=0.4, 0.6, 0.8 and 1.0 ft
	0.000031 to 0.0014	0.009 to 2.336	about 750	0.25	3	≤240			**H-flumes**,D=0.5, 0.75, 1.0, 1.5, 2.0, 2.5, 3.0, and 4.5 ft
	0.0018 and 0.0020	2.369 and 3.326	about 1500	0.25	3	≤ 80	+		HL-flumes, D=3.5 and 4.0 ft
Circular sharp-edged orifice (8.1)	0.00014 d=0.02 m	variable	5.8*	submerged	1	17	- -	- -	*0.03 m ≤ Δh ≤ 1.0 m
Rectangular sharp-edged orifice (8.2)	0.0028	variable	5.8*	submerged	2 to 3	17	- -	□ if p=0	* 0.03 m ≤Δ h ≤ 1.0 m and A = constant
Constant head orifice (8.3)	0.0086* 0.0107	Q=0.140* Q=0.280	16** 26	submerged, but usually $ΔH_t$≥0.30 m	≥ 7	8	- -	-	* Two sizes of orifice gates,0.60×0.45 m & 0.75 ×0.60 m are com.used ** If A varies

TABLE 3.1. DATA ON VARIOUS STRUCTURES (cont.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Name of structure and section number in which structure is described	Sketch of structure	Shape of control section perpendicular to flow and u-value	M = measuring MR = measuring & regulating	H_1 min or Δh min	H_1 max or Δh max	minimum crest height above approach channel bottom p	minimum size of control b or B, w and D_p	range of notch angle θ degrees	Q_{min} m^3/s	Q_{max} in m^3/s or q max in m^2/s	$\gamma = \frac{Q_{max}}{Q_{min}}$	modular limit H_2/H_1 or head loss	error in C_dC_v or C_e (%)	sensitiveness at minimum head % per 0.01 m	debris passing capacity	sediment passing capacity + + very good; + good; □ fair; - poor; - - very poor	Remarks
Radial or Tainter gate (8.4)		rectangular u = 0.5	MR	$y_1 \geq 0.15$ m $y_1 \geq 1.25$ w $y_1 \geq 0.1$ r	$y_1 < 1.2$ r	0	b≥0.30 m w≥0.02 m	-	0.005 y_1=0.15 m	variable	about* 35	variable	5	8	-	+ +	* If A varies γ is greater if gate is lifted entirely
Crump-de Gruyter adjustable orifice (8.5)		rectangular u = 0.5	MR	0.03 m 1.58 w	0.60 m	0.20 m p = b	b≥0.20 m 0.02 m ≤ w ≤ 0.38 m w≤0.63 h_1	-	0.0088	q=0.742	10	up to* 0.25	3	8	-	-	*If w/h_1 is small
Meter gate (8.6)		Section of circle u=0.5	MR	h_1≥1.0 D_p Δh≥0.05 m	Δh≤0.45 m	0.17 D_p	D_p≥0.30 m w≤0.75 D_p w≥0.02 m	-	0.0076 D_p=0.30 m	Q=2.10 D_p=1.22 m	7 to 45	h_2 ≥ 0.15 m ΔH_c ≥ 0.30 m	3 to 6	8	-	-	Usually 0.20 m ≤ D_p ≤ 1.22 m
Neyrpic modules (8.7)		rectangular u = 0.5	MR	h_d=0.17m h_d=0.28m	h_d ≤ P and h_d≤0.35 P_2	0.16 m 0.26 m	0.05 m 0.05 m	- -	0.0005 0.0010	q=0.100 q=0.200	1* 1	0.60 0.60	5 5	3 1.8	- - - -	□ □	Type X 1 Type XX 2 * Discharge is regulated by opening/closing gates
Danaidean tub (8.8)		circular or rectangular u = 0.5	M	approx. 0.10 m	approx. 5.0 m	-	d≥0.02 m b≥0.02 m	0°≤β≤180°	0.00027 d=0.02 m h_1=0.10 m	variable	7	h_1+δd*	2	5	- -	□	*δ = contraction coefficient
Divisors (9.1)		rectangular u = 1.5	MR	0.06 m 0.50 r	1.0 p 0.35 P_2 4.0 r	0.15 m 0.33 H_1	0.30 m 2.0 H_1	-	0.0075 b=0.30 m	q=5.69 H_1=2.00 m	30*	0.60	5	25	- -	+	* Other weir profiles are possible
Pipes and small siphons (9.2)		circular u = 0.5	M	0.03 m	1.20 m	1.0 D_p	D_p≥0.015 m D_p≥0.03 m	-	0.00006 0.00037	variable	6 6	usually submerged	10 10	17 17	- - - -	- - - -	L > 20 D_p 6 D_p ≤ L ≤ 20 D_p *
Fountain flow from vertical pipe (9.3)		circular u = 1.35 or u = 0.53	M	0.03 m	4.00 m	-	0.025 ≤ D_p D_p ≤ 0.609	-	0.00048 D_p=0.025 m	Q=2.45 D_p=0.609 m	237	pipe must discharge free into the air	15 to 20	50	- -	- -	
Flow from horizontal pipes (9.4)		circular 1.5 < u ≤ 2	M	y_e=0.02m 0.1 D_p	y_e ≤ 0.56 D_p	-	D_p≥0.05 m	-	0.00062 D_p=0.05 m	variable	42	pipe must discharge	3	100	- -	- -	Brink depth method
		u = 1.5 (versus Y)	M	y_e ≥ D_p Y≥0.025	Y ≤ 0.15 m*	-	0.05 ≤ D_p ≤ 0.15 m	-	0.0020 D_p=0.05 m	Q=0.100 D_p=0.15 m	2.5	free into the air	15	20	- -	- -	Trajectory method; X=0.152, 0.305 and 0.457 m
Brink depth method for rectangular canals (9.5)		rectangular u = 1.5	M	y_e≥0.03m	-*	p = 0	0.30 m 3 y_c	-	0.0081 b=0.30 m	q=4.82 H_1=2.0 m	about 175	head loss 2.1 H_1	3	25	+	+	y_e/y_c=0.715 * Approach canal length ≥ 12 y_c
Dethridge meters (9.6)		rectangular no u-value	MRV	y_1=0.30m y_1=0.38m	y_1=0.90m y_1=0.90m	- -	0.52 m 0.78 m	- -	0.015 0.040	Q=0.070 Q=0.140	4.6 3.5	head loss ≥ 0.08 m ≥ 0.09 m at y_1 min.	5 5	- -	+ +	+ +	Small meter Large meter
Propeller meters (9.7)		usually circular no u-value	MRV	v > 0.45 m/s	v < 5.0 m/s	-	0.05 m ≤D_p≤ 1.82 m	-	0.00088 D_p=0.05 m	Q=13.0 D_p=1.82 m	10	usually Δh ≥ 0.50 m	5*	-	□	+	* If propeller is maintained frequently