TRAPEZOIDAL PROFILE WEIR "SANIIRI"

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1 INTRODUCTION

In the year 1977 the Indian Member Body of the International Standardization Organisation (ISO), working in sub-committee 2 of the technical committee 113 dealing with notches, weirs and flumes for measurement of liquid flow in open channels, proposed to standardize the trapezoidal profile weir, which is extensively used as a control structure on large and small rivers in India, Pakistan and many other countries. The trapezoidal weir to be standardized was to be constructed in a rectangular approach channel and could have several upstream or downstream slopes.
In 1983 the USSR Member Body proposed to include the trapezoidal profile weir "SANIIRI" in the future standard. This weir is constructed in a channel with a trapezoidal cross-section and furthermore their is a fixed relation between the crest length and the crest height.
In the same year it was decided by the department of Hydraulics & Catchment Hydrology of the Agricultural University to include this weir in their research program on the sediment transport capacity of discharge measuring structures and in addition to recalibrate the structure to accomplish more data. For several reasons the intended research was suspended, but nevertheless the recalibration was fulfilled in 1985.
This report describes the recalibration and discusses the results.

2 EXPERIMENTAL DESIGN

2.1 Laboratory equipment

The measurements necessary for the calibration of the SANIIRI weir, were performed in the hydraulic laboratory of the department of Hydraulics & Catchment Hydrology. The laboratory has the disposal of several flumes, with the inflow stabilized by a constant head tank in the water supply system. The discharge can be measured with an electromagnetic meter before the inflow takes place or volumetrically at the end of a return gutter, before the water is pumped to the constant head tank. Usual these two options are combined i.e. the readings of the flowmeter are related to the volumetric obtained values by fitting a regression line. The waterheights in a flume are measured in stilling wells by means of point gauges.

2.2 Description of the SANIIRI

The SANIIRI weir is characterized by a vertical downstream slope and a length of the crest of 0.8 times the height of the crest. The co-tangent of the upstream slope is either 3 or 4 and the co-tangent of the side-slopes of the channel varies from 1 to 1.5 (Figure 2.1). Once the crest height and upstream slope are chosen, all geometrical values are fixed within a certain channel. The following relations holds:

$$L = 0.8\ p$$
$$l = Z\ p + L$$
$$b_c = b + 2\ m\ p$$

where

L	= length of the crest	[L]
p	= heigth of the crest	[L]
l	= length of the weir	[L]
Z	= co-tangent upstream slope	[1]
b_c	= width of the crest	[L]
b	= width of the channel	[L]
m	= co-tangent side-slope	[1]

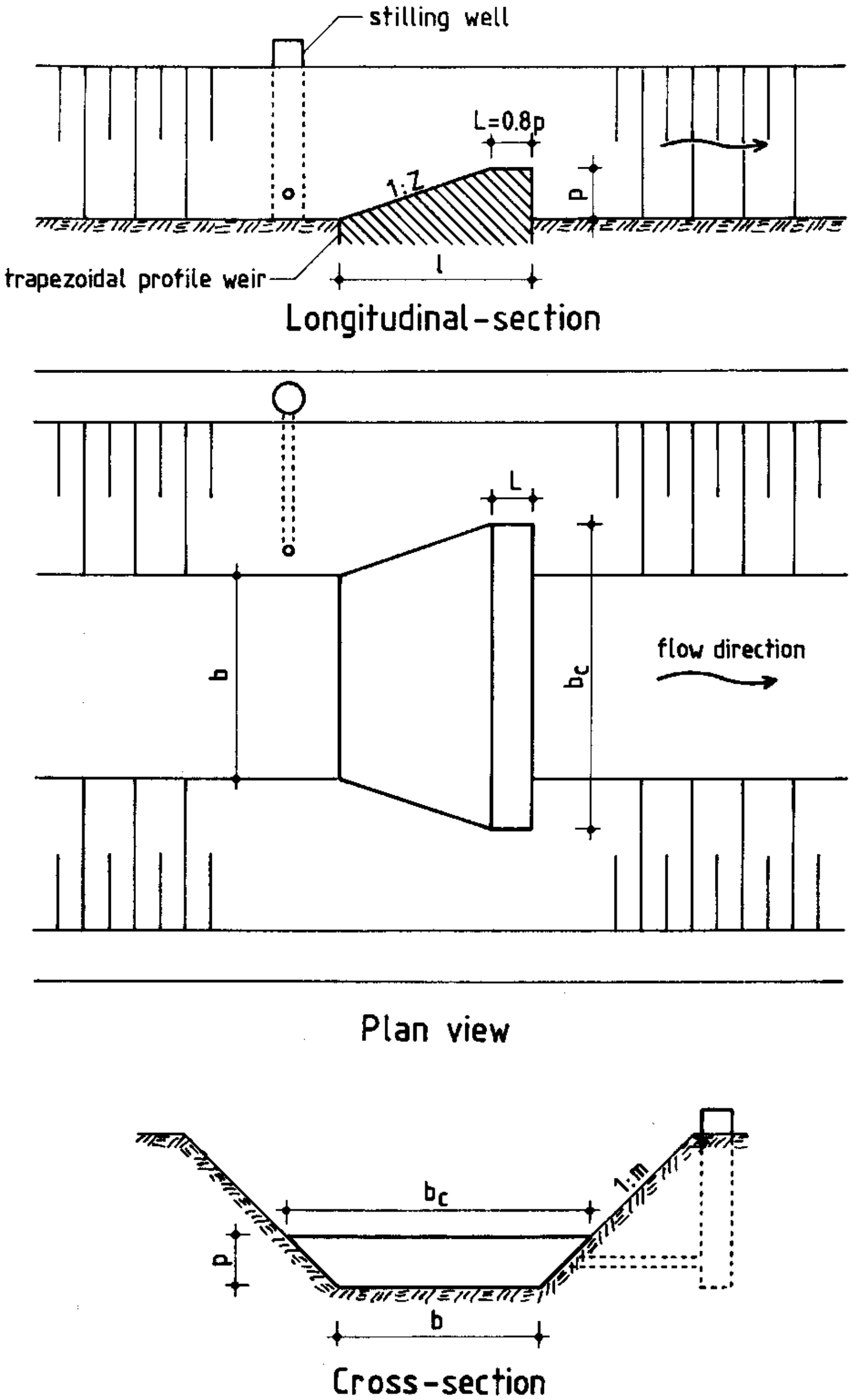


Figure 2.1 Trapezoidal profile weir SANIIRI

3 THEORETICAL DISCHARGE EQUATION

The theoretical discharge equation can be derived by determining the minimum **specific energy and using Bernouilli's law (Bos, 1978).**

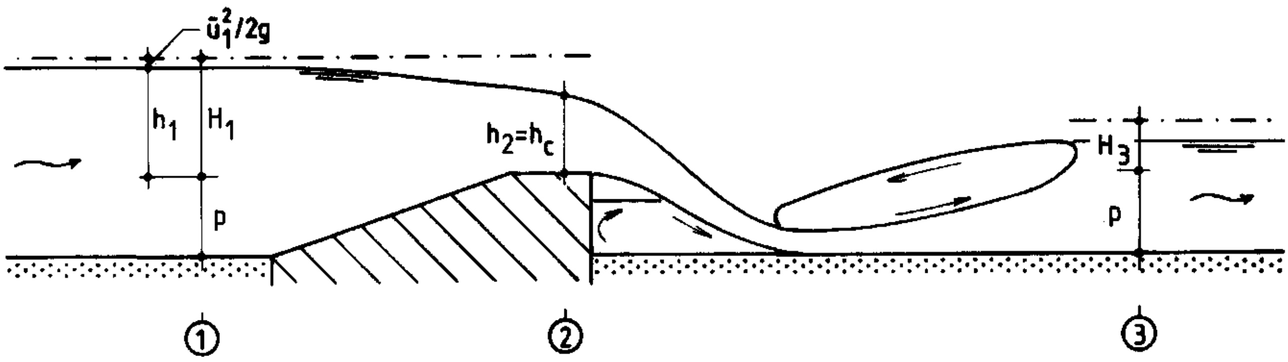


Figure 3.1 Definition sketch.

The relation between discharge and critical depth above the crest and the total head is given by:

$$H = H_1 = H_2 = h_c + \frac{Q^2}{2g\ A_c{}^2} \qquad (2.1)$$

where

H	=	total head	[L]
h	=	head opposite the weir crest	[L]
Q	=	discharge	$[L^3 \cdot T^{-2}]$
g	=	acceleration due to gravity	$[L \cdot T^{-2}]$
A	=	cross-sectional area	$[L^2]$

with the index c indicating the critical flow above the weir.

Equation 2.1 can be written as:

$$Q = (2g)^{1/2} \cdot A_c \cdot (H-h_c)^{1/2} \qquad (2.2)$$

Because of minimum specific energy above the crest, the relation between total head and critical depth yields:

$$H = h_c + \frac{1}{2}\frac{A_c}{B_c} = \left\{1 + \frac{1}{2}\frac{b_c + m\ h_c}{b_c + 2m\ h_c}\right\} h_c \tag{2.3}$$

This equation can be written as a second degree polynomial function:

$$5m\ h_c^2 + (3b - 4m)\ h_c - 2b\ H = 0 \tag{2.4}$$

Without dimensions Equation 2.4 becomes:

$$\left(\frac{h_c}{H}\right)^2 + 2\left(\frac{0.3\ b_c}{m\ H} - 0.4\right)\frac{h_c}{H}\frac{0.4\ b_c}{m\ H} = 0 \tag{2.5}$$

With the relevant solution:

$$\frac{h_c}{H} = -\left(\frac{0.3\ b_c}{m\ H} - 0.4\right) + \left\{\left(\frac{0.3\ b_c}{m\ H} - 0.4\right)^2 + \frac{0.4\ b_c}{m\ H}\right\}^{1/2} \tag{2.6}$$

For a known total head and given values of the width of the weir crest and the co-tangent of the side-slope of the channel, the discharge can be calculated using Equation 2.6 and 2.2 respectively.

The limit values of h_c/H can be derived from Equation 2.4. For a rectangular cross-section with $m = 0$ one obtains h_c/H equals 2/3 and in case of a triangular cross-section one obtains a value of 4/5. In Figure 3.2 a graphical representation is shown of h_c/H as a function of b_c/mH.

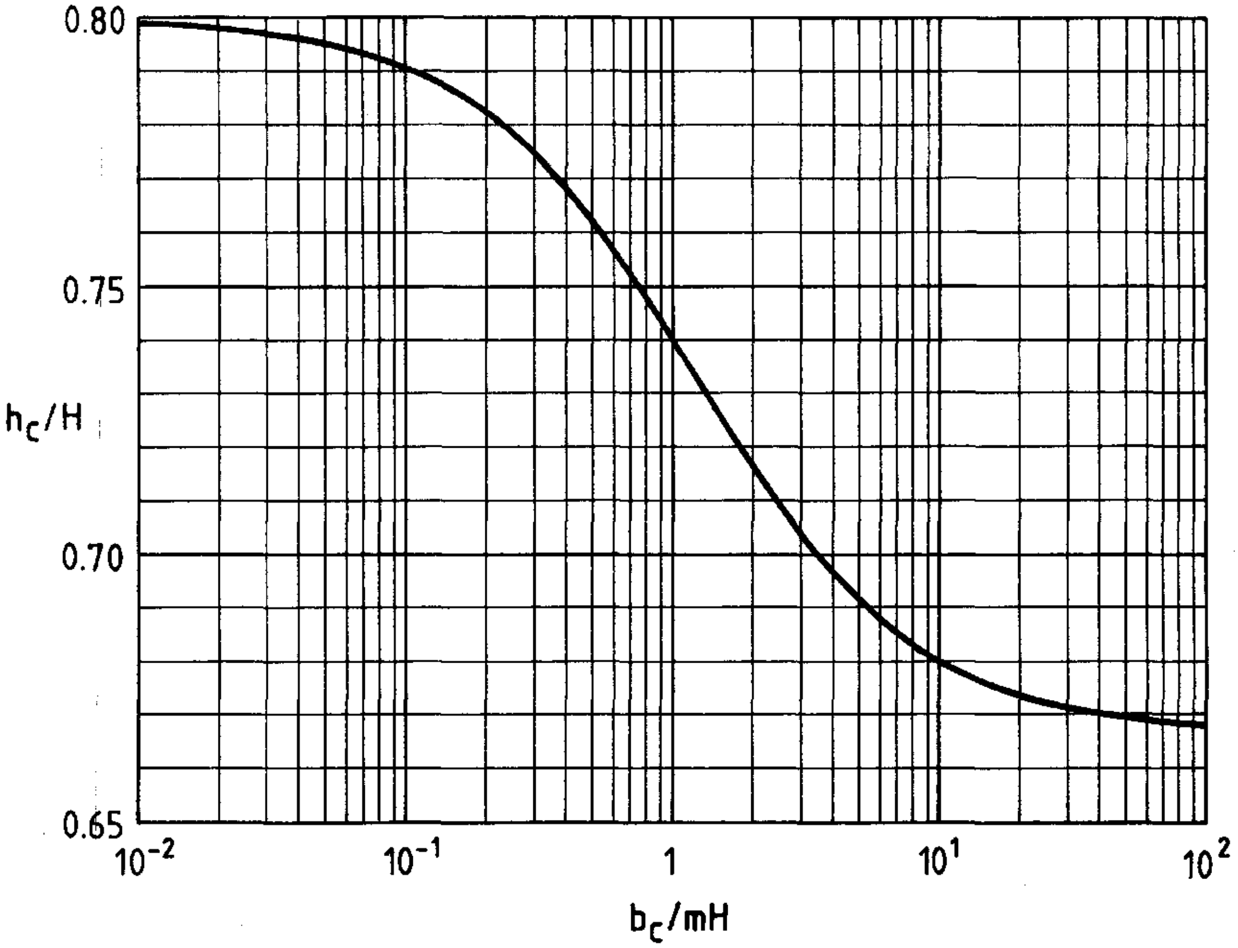


Figure 3.2 **Relation between critical depth and total head for a trapezoidal cross-section.**

4 RESULTS AND ANALYSIS

4.1 Free flow

The discrepancy between the theoretical discharge and the actual discharge can be expressed by

$$C_D = \frac{Q_m}{Q_t} \tag{4.1}$$

where

C_D	= discharge coefficient	[1]
Q_m	= measured discharge	$[L \cdot T^{-3}]$
Q_t	= theoretical discharge	$[L \cdot T^{-3}]$

The discharge coefficient can be related to the ratio of total head and length of the crest (H/L).

For all the runs the experimental data and calculated values of H/L and C_D are given in appendix I ... VI. The graphical representation of the relations between C_D and H/L accordingly are shown in appendix VII ... XII The regression curves in the figures are fifth degree polynomial equations determined with the method of least squares. The correlation coefficient r of the regression, the estimated standard deviation of the residuals σ, the mean value of the discharge coefficient μ and the ratio between σ and μ are shown in Table 4.1.

Run	r	σ 10^{-3}	μ	σ/μ 10^{-3}
01	0.997	3.8	1.000	3.8
02	0.999	2.5	1.007	2.5
03	0.996	4.8	1.023	4.6
04	0.996	4.5	1.028	4.4
05	0.997	3.5	1.034	3.4
06	0.985	8.2	1.036	7.9

Table 4.1 Parameters from regression analysis.

It can be concluded from Table 4.1 that the regression is quite satisfactory. The ratio of 2 σ/μ is less than 1.0% except for run 06 in which case a 1:2 scale model was use of the weir used at run 05.

All the results of run 01 ... 06 are shown in appendix XIII. No significant difference occurs in the discharge coefficients of run 01 ... 05 despite the different geometrical proportions and different values of p/L. A minor difference in C_D appears for the runs with a crest length of 0.200 m (01 and 02) and those with a length of 0.144 m (03, 04 and 05) in case of H/L between 0.6 and 0.8. The discharge coefficient of the 1.2 scale model is quite different, not only with regard to the values of C_D, but also the shape of the curve. Therefore these results can not be combined with the other ones. The combination of the discharge coefficients of run 01 ... 05 is shown in Figure 4.1.

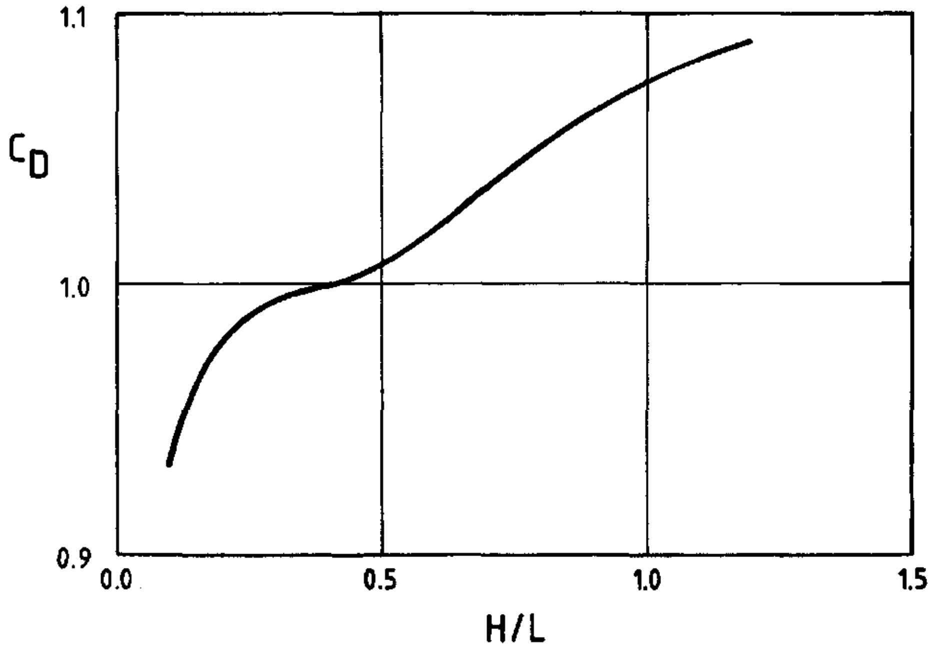


Figure 4.1 Discharge coefficient C_D as a function of the relative total head H/L for the SANIIRI trapezoidal weir.

A comparison can be made between the combined results of run 01 up to and including run 05, the results of run 06 and the results of the USSR (document ISO/TC 113/SC 2 N 330). Also the discharge characteristics of the trapezoidal profile weir in case of three-dimensional flow (SANIIRI) can be compared with those in case of two-dimensional flow (Boiten, 1983).

The experiments fulfilled by the USSR are summarized in Table 4.2

Run	b m	m m	p m	Z 1	Kind of investigation
N1	0.282	1.5	0.046	4	laboratory
N2	0.288	1.5	0.053	3	laboratory
N3	0.800	1.0	0.184	3	laboratory
N4	3.70	1.0	0.400	3	field

Table 4.2 Specification of experiments by the USSR (L/p = 0.8)

The calculated values of H/L and C_D are summarized in appendix XIV. In figure 4.2 the results of the USSR, Boiten and the present investigation are shown.

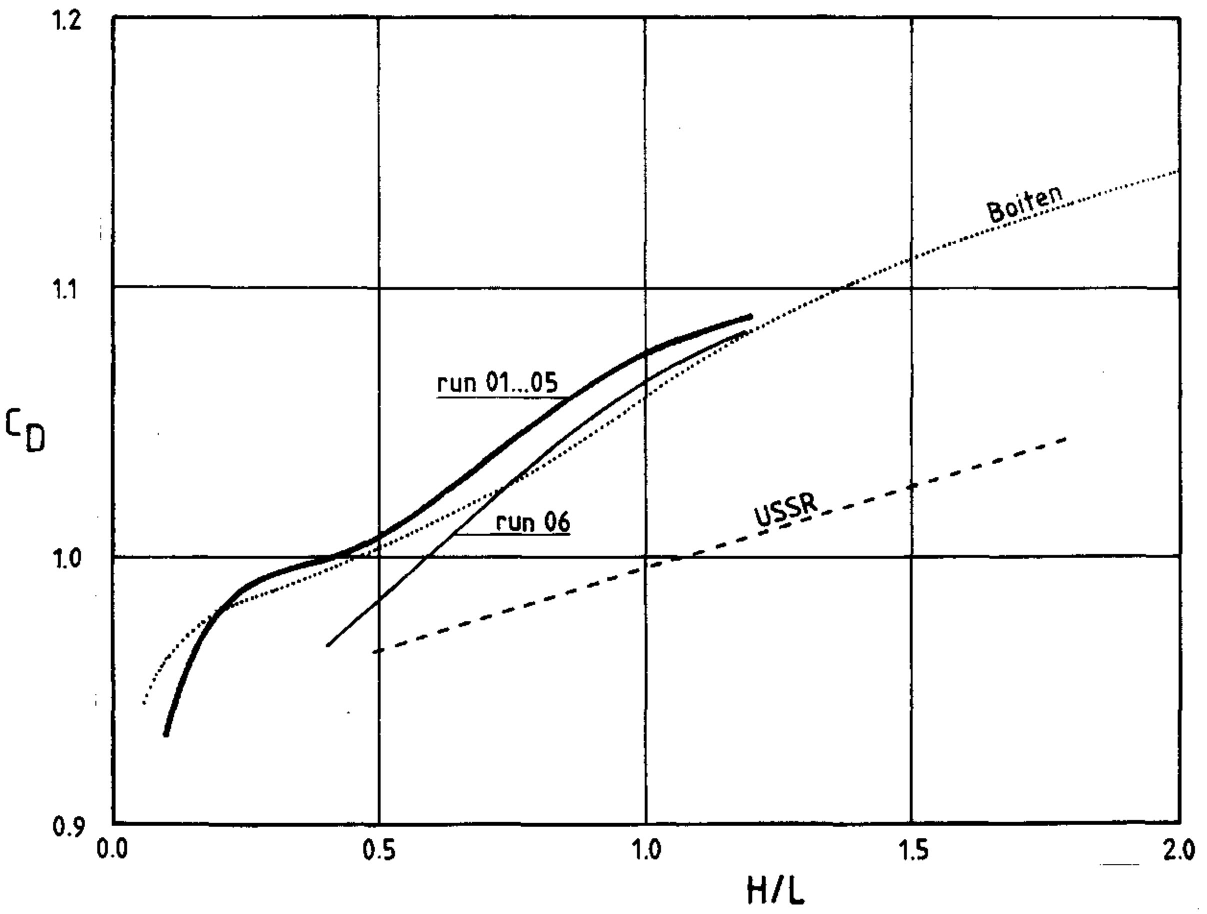


Figure 4.2 C_D as a function of H/L for several investigations.

It is obvious that the results of the present investigations don't agree with the result of the USSR but show a fairly good agreement with the results of Boiten. The reason for the disagreement is not quite clear.
Thinking at scale effects one should bear in mind that taking a crest height of 0.18 m as scale 1:1 the models used by the USSR were on scale 1:3.9, 1:3.4, 1:1 and 2.2:1 and the models used in the present investigation were on 1:2, 1:1 and 1.4:1. On the other hand the possibility of scale effects is not excluded at the investigations of Boiten with regard to this subject, because of limited range of H/L at big scale structures (appendix XV). The tendency however of a lower value of C_D at small scale models is present in both the present investigation and the investigation of Boiten.

4.2 Modular limit

In Figure 4.4 the results of the experiments on the modular limit are shown (see also appendix XVI and XVII). According to this the modular limit expressed as the ratio of downstream and upstream total head equals 0.60 ($H_1/H_0 < 1.01$).

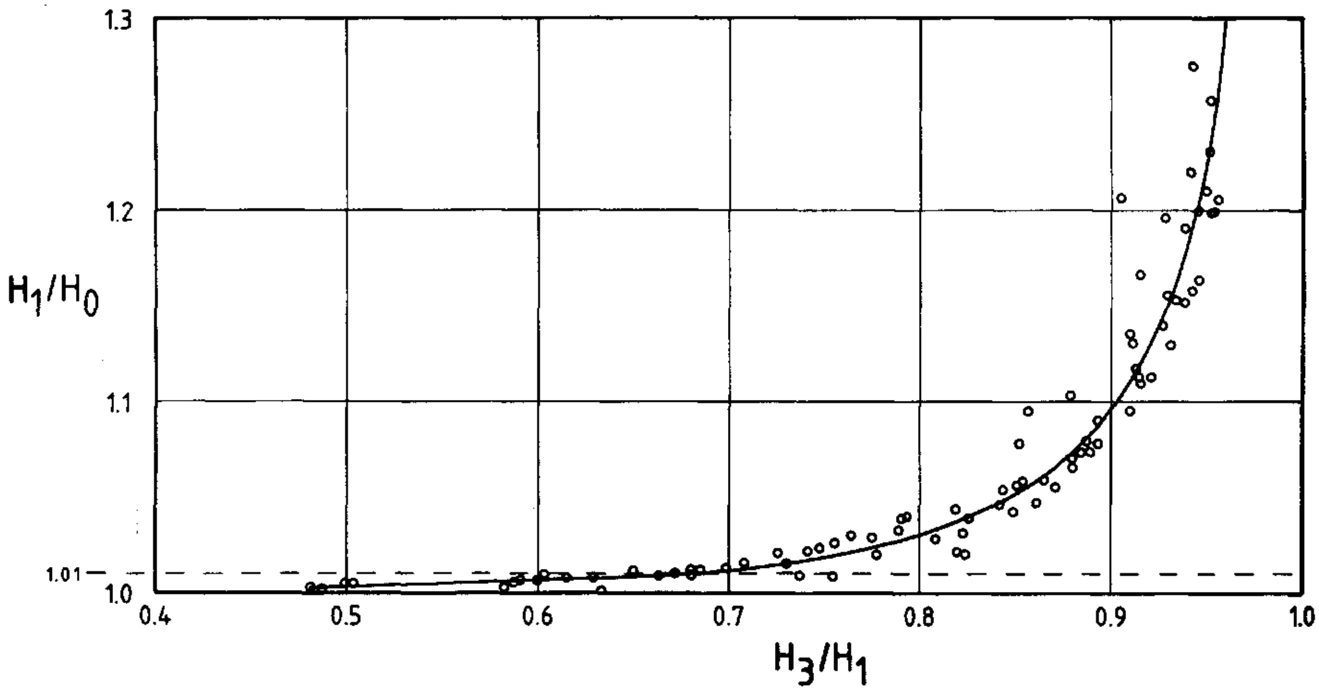


Figure 4.6 Relation between H_3/H_1 and H_1/H_0 combined results.

5 CONCLUDING REMARKS

The limited experiments on the SANIIRI as described in this report shows that before standardizing additional information on the 3-d trapezoidal profile weir is required. The scale effects should be investigated and the disagreement in different data should be eliminated.

The fixed ratio of L/p equal to 0.8 is not likely to be necessary. Also in case of the 2-d trapezoidal profile weir the discharge coefficient was a function of H/L only (Boiten, 1983).

The influence of the width of the weir crest is not investigated. Because of three dimensional flow a systematic research on this item is recommendable.

REFERENCES

Boiten, W. (1983) - The trapezoidal profile broad-crested weir, Report on basic research S170-XI, Delft Hydraulics Laboratory, Wageningen.

Bos, M.G. (1976) - Discharge measurement structures, Report no. 4, Laboratory of Hydraulics & Catchment Hydrology, Wageningen.

ISO/TC 113/SC 2 N330 (1983) - Information on the use of trapezoidal profile weirs in the USSR for flow measurement in open channels.

APPENDIX I: Data of run 01

Nr.	Q [m^3/s]	h [m]	H [m]	H/L [1]	Cd [1]	T [C]
1	2.060E-03	1.120E-02	1.120E-02	5.602E-02	8.811E-01	1.460E+01
2	3.000E-03	1.410E-02	1.411E-02	7.054E-02	8.979E-01	1.460E+01
3	4.020E-03	1.680E-02	1.681E-02	8.407E-02	9.233E-01	1.460E+01
4	4.100E-03	1.730E-02	1.731E-02	8.657E-02	9.009E-01	1.500E+01
5	5.240E-03	1.990E-02	1.992E-02	9.961E-02	9.315E-01	1.460E+01
6	5.920E-03	2.160E-02	2.163E-02	1.081E-01	9.294E-01	1.500E+01
7	6.670E-03	2.310E-02	2.313E-02	1.157E-01	9.457E-01	1.460E+01
8	8.220E-03	2.640E-02	2.645E-02	1.323E-01	9.515E-01	1.500E+01
9	8.340E-03	2.650E-02	2.655E-02	1.328E-01	9.599E-01	1.460E+01
10	1.001E-02	2.980E-02	2.987E-02	1.494E-01	9.636E-01	1.460E+01
11	1.072E-02	3.110E-02	3.118E-02	1.559E-01	9.669E-01	1.500E+01
12	1.205E-02	3.360E-02	3.370E-02	1.685E-01	9.659E-01	1.460E+01
13	1.306E-02	3.520E-02	3.532E-02	1.766E-01	9.749E-01	1.500E+01
14	1.452E-02	3.750E-02	3.764E-02	1.882E-01	9.837E-01	1.460E+01
15	1.598E-02	3.980E-02	3.997E-02	1.999E-01	9.882E-01	1.500E+01
16	1.703E-02	4.150E-02	4.169E-02	2.085E-01	9.877E-01	1.460E+01
17	1.954E-02	4.530E-02	4.554E-02	2.277E-01	9.904E-01	1.480E+01
18	2.083E-02	4.740E-02	4.767E-02	2.384E-01	9.847E-01	1.570E+01
19	2.225E-02	4.920E-02	4.951E-02	2.475E-01	9.929E-01	1.490E+01
20	2.378E-02	5.160E-02	5.194E-02	2.597E-01	9.860E-01	1.570E+01
21	2.520E-02	5.340E-02	5.378E-02	2.689E-01	9.908E-01	1.490E+01
22	2.693E-02	5.580E-02	5.622E-02	2.811E-01	9.892E-01	1.570E+01
23	2.816E-02	5.730E-02	5.776E-02	2.888E-01	9.926E-01	1.490E+01
24	3.047E-02	6.040E-02	6.092E-02	3.046E-01	9.897E-01	1.570E+01
25	3.156E-02	6.160E-02	6.215E-02	3.108E-01	9.940E-01	1.490E+01
26	3.501E-02	6.580E-02	6.646E-02	3.323E-01	9.949E-01	1.490E+01
27	3.548E-02	6.650E-02	6.717E-02	3.359E-01	9.919E-01	1.570E+01
28	3.899E-02	7.040E-02	7.119E-02	3.559E-01	9.969E-01	1.500E+01
29	4.049E-02	7.210E-02	7.293E-02	3.647E-01	9.972E-01	1.570E+01
30	4.284E-02	7.460E-02	7.552E-02	3.776E-01	1.000E+00	1.500E+01
31	4.492E-02	7.700E-02	7.799E-02	3.899E-01	9.978E-01	1.570E+01
32	4.665E-02	7.870E-02	7.975E-02	3.988E-01	1.002E+00	1.500E+01
33	5.022E-02	8.260E-02	8.378E-02	4.189E-01	9.966E-01	1.490E+01
34	5.396E-02	8.640E-02	8.772E-02	4.386E-01	9.993E-01	1.490E+01
35	5.750E-02	8.960E-02	9.106E-02	4.553E-01	1.005E+00	1.500E+01
36	6.133E-02	9.320E-02	9.482E-02	4.741E-01	1.007E+00	1.500E+01
37	6.507E-02	9.660E-02	9.837E-02	4.919E-01	1.009E+00	1.500E+01
38	6.890E-02	1.000E-01	1.019E-01	5.097E-01	1.011E+00	1.500E+01
39	7.303E-02	1.034E-01	1.055E-01	5.276E-01	1.015E+00	1.510E+01
40	7.716E-02	1.067E-01	1.090E-01	5.450E-01	1.019E+00	1.510E+01
41	8.109E-02	1.099E-01	1.124E-01	5.619E-01	1.022E+00	1.510E+01
42	8.492E-02	1.130E-01	1.157E-01	5.783E-01	1.023E+00	1.510E+01
43	8.935E-02	1.164E-01	1.193E-01	5.964E-01	1.026E+00	1.520E+01
44	9.397E-02	1.199E-01	1.230E-01	6.150E-01	1.028E+00	1.520E+01
45	9.878E-02	1.234E-01	1.267E-01	6.337E-01	1.031E+00	1.520E+01
46	1.039E-01	1.271E-01	1.307E-01	6.534E-01	1.032E+00	1.530E+01
47	1.089E-01	1.304E-01	1.343E-01	6.713E-01	1.038E+00	1.530E+01
48	1.138E-01	1.339E-01	1.380E-01	6.901E-01	1.039E+00	1.530E+01
49	1.192E-01	1.376E-01	1.420E-01	7.100E-01	1.041E+00	1.540E+01
50	1.259E-01	1.421E-01	1.468E-01	7.342E-01	1.042E+00	1.540E+01
51	1.328E-01	1.463E-01	1.514E-01	7.571E-01	1.047E+00	1.540E+01
52	1.396E-01	1.503E-01	1.558E-01	7.791E-01	1.052E+00	1.530E+01
53	1.467E-01	1.546E-01	1.605E-01	8.025E-01	1.054E+00	1.530E+01
54	1.528E-01	1.582E-01	1.645E-01	8.223E-01	1.057E+00	1.530E+01
55	1.595E-01	1.623E-01	1.689E-01	8.447E-01	1.057E+00	1.530E+01
56	1.666E-01	1.662E-01	1.733E-01	8.663E-01	1.061E+00	1.530E+01
57	1.740E-01	1.703E-01	1.778E-01	8.889E-01	1.063E+00	1.550E+01
58	1.801E-01	1.736E-01	1.814E-01	9.072E-01	1.065E+00	1.550E+01
59	1.873E-01	1.776E-01	1.859E-01	9.296E-01	1.069E+00	1.550E+01
60	1.950E-01	1.814E-01	1.901E-01	9.507E-01	1.070E+00	1.550E+01

APPENDIX II: Data of run 02

Nr.	Q [m^3/s]	h [m]	H [m]	H/L [1]	Cd [1]	T [C]
1	2.100E-03	1.130E-02	1.131E-02	5.653E-02	8.775E-01	1.910E+01
2	3.100E-03	1.440E-02	1.441E-02	7.207E-02	8.983E-01	1.910E+01
3	4.440E-03	1.800E-02	1.803E-02	9.013E-02	9.180E-01	1.910E+01
4	6.210E-03	2.210E-02	2.215E-02	1.107E-01	9.406E-01	1.910E+01
5	7.730E-03	2.540E-02	2.547E-02	1.274E-01	9.475E-01	1.910E+01
6	9.810E-03	2.940E-02	2.951E-02	1.475E-01	9.620E-01	1.910E+01
7	1.230E-02	3.410E-02	3.426E-02	1.713E-01	9.615E-01	1.910E+01
8	1.481E-02	3.810E-02	3.833E-02	1.916E-01	9.764E-01	1.910E+01
9	1.718E-02	4.170E-02	4.199E-02	2.100E-01	9.855E-01	1.920E+01
10	1.989E-02	4.590E-02	4.628E-02	2.314E-01	9.839E-01	1.920E+01
11	2.230E-02	4.940E-02	4.985E-02	2.493E-01	9.845E-01	1.920E+01
12	2.525E-02	5.340E-02	5.396E-02	2.698E-01	9.877E-01	1.920E+01
13	2.841E-02	5.760E-02	5.828E-02	2.914E-01	9.877E-01	1.920E+01
14	3.190E-02	6.200E-02	6.282E-02	3.141E-01	9.886E-01	1.920E+01
15	3.574E-02	6.640E-02	6.738E-02	3.369E-01	9.944E-01	1.920E+01
16	3.944E-02	7.070E-02	7.184E-02	3.592E-01	9.942E-01	1.920E+01
17	4.289E-02	7.450E-02	7.580E-02	3.790E-01	9.954E-01	1.920E+01
18	4.728E-02	7.920E-02	8.071E-02	4.036E-01	9.960E-01	1.890E+01
19	5.091E-02	8.300E-02	8.469E-02	4.234E-01	9.955E-01	1.890E+01
20	5.484E-02	8.680E-02	8.869E-02	4.435E-01	9.984E-01	1.900E+01
21	5.887E-02	9.050E-02	9.261E-02	4.630E-01	1.002E+00	1.900E+01
22	6.241E-02	9.370E-02	9.600E-02	4.800E-01	1.005E+00	1.900E+01
23	6.703E-02	9.770E-02	1.003E-01	5.013E-01	1.009E+00	1.900E+01
24	7.097E-02	1.011E-01	1.039E-01	5.194E-01	1.011E+00	1.920E+01
25	7.539E-02	1.047E-01	1.077E-01	5.387E-01	1.014E+00	1.920E+01
26	8.060E-02	1.088E-01	1.121E-01	5.607E-01	1.019E+00	1.920E+01
27	8.512E-02	1.124E-01	1.160E-01	5.801E-01	1.020E+00	1.920E+01
28	9.033E-02	1.162E-01	1.201E-01	6.007E-01	1.025E+00	1.940E+01
29	9.525E-02	1.199E-01	1.241E-01	6.207E-01	1.027E+00	1.940E+01
30	9.987E-02	1.232E-01	1.277E-01	6.387E-01	1.030E+00	1.940E+01
31	1.050E-01	1.267E-01	1.316E-01	6.579E-01	1.033E+00	1.970E+01
32	1.100E-01	1.304E-01	1.356E-01	6.780E-01	1.032E+00	1.970E+01
33	1.153E-01	1.339E-01	1.394E-01	6.972E-01	1.036E+00	1.990E+01
34	1.198E-01	1.367E-01	1.425E-01	7.127E-01	1.039E+00	1.970E+01
35	1.256E-01	1.403E-01	1.465E-01	7.327E-01	1.043E+00	1.970E+01
36	1.313E-01	1.439E-01	1.505E-01	7.526E-01	1.045E+00	1.980E+01
37	1.373E-01	1.475E-01	1.545E-01	7.727E-01	1.048E+00	1.980E+01
38	1.442E-01	1.516E-01	1.591E-01	7.956E-01	1.051E+00	1.980E+01
39	1.511E-01	1.555E-01	1.635E-01	8.176E-01	1.055E+00	2.000E+01
40	1.574E-01	1.590E-01	1.675E-01	8.373E-01	1.058E+00	2.000E+01
41	1.643E-01	1.627E-01	1.717E-01	8.584E-01	1.062E+00	2.020E+01
42	1.717E-01	1.668E-01	1.763E-01	8.815E-01	1.063E+00	2.020E+01
43	1.788E-01	1.704E-01	1.804E-01	9.021E-01	1.067E+00	2.040E+01
44	1.864E-01	1.742E-01	1.848E-01	9.240E-01	1.071E+00	2.040E+01
45	1.940E-01	1.783E-01	1.894E-01	9.472E-01	1.071E+00	2.040E+01

APPENDIX III: Data of run 03

Nr.	Q [m^3/s]	h [m]	H [m]	H/L [1]	Cd [1]	T [C]
1	2.220E-03	1.150E-02	1.151E-02	7.991E-02	9.033E-01	2.030E+01
2	3.210E-03	1.440E-02	1.441E-02	1.001E-01	9.301E-01	2.030E+01
3	4.410E-03	1.750E-02	1.753E-02	1.217E-01	9.514E-01	2.030E+01
4	5.350E-03	1.980E-02	1.984E-02	1.378E-01	9.572E-01	2.030E+01
5	6.620E-03	2.260E-02	2.265E-02	1.573E-01	9.690E-01	2.030E+01
6	8.070E-03	2.550E-02	2.558E-02	1.776E-01	9.829E-01	2.030E+01
7	8.490E-03	2.650E-02	2.659E-02	1.846E-01	9.753E-01	1.920E+01
8	9.510E-03	2.840E-02	2.850E-02	1.979E-01	9.830E-01	2.030E+01
9	1.107E-02	3.150E-02	3.164E-02	2.197E-01	9.768E-01	2.030E+01
10	1.200E-02	3.290E-02	3.306E-02	2.296E-01	9.905E-01	1.920E+01
11	1.299E-02	3.480E-02	3.498E-02	2.429E-01	9.840E-01	2.030E+01
12	1.511E-02	3.840E-02	3.864E-02	2.683E-01	9.841E-01	2.000E+01
13	1.594E-02	3.960E-02	3.986E-02	2.768E-01	9.900E-01	1.920E+01
14	1.757E-02	4.240E-02	4.270E-02	2.966E-01	9.824E-01	2.000E+01
15	1.960E-02	4.520E-02	4.557E-02	3.164E-01	9.927E-01	1.920E+01
16	2.028E-02	4.620E-02	4.659E-02	3.235E-01	9.929E-01	2.000E+01
17	2.289E-02	4.980E-02	5.028E-02	3.491E-01	9.976E-01	1.920E+01
18	2.323E-02	5.050E-02	5.099E-02	3.541E-01	9.910E-01	2.000E+01
19	2.668E-02	5.500E-02	5.561E-02	3.862E-01	9.965E-01	2.000E+01
20	3.018E-02	5.950E-02	6.025E-02	4.184E-01	9.971E-01	2.000E+01
21	3.358E-02	6.350E-02	6.439E-02	4.472E-01	1.002E+00	2.000E+01
22	3.727E-02	6.770E-02	6.875E-02	4.774E-01	1.005E+00	2.010E+01
23	4.077E-02	7.160E-02	7.281E-02	5.056E-01	1.007E+00	2.010E+01
24	4.505E-02	7.600E-02	7.742E-02	5.376E-01	1.012E+00	2.010E+01
25	4.948E-02	8.040E-02	8.204E-02	5.697E-01	1.016E+00	2.010E+01
26	5.376E-02	8.460E-02	8.646E-02	6.004E-01	1.018E+00	2.010E+01
27	5.838E-02	8.870E-02	9.081E-02	6.306E-01	1.025E+00	2.010E+01
28	6.369E-02	9.330E-02	9.570E-02	6.646E-01	1.030E+00	2.010E+01
29	6.841E-02	9.750E-02	1.002E-01	6.956E-01	1.031E+00	2.010E+01
30	7.352E-02	1.016E-01	1.046E-01	7.262E-01	1.036E+00	2.010E+01
31	7.903E-02	1.057E-01	1.090E-01	7.570E-01	1.044E+00	2.010E+01
32	8.453E-02	1.101E-01	1.137E-01	7.899E-01	1.045E+00	2.010E+01
33	9.023E-02	1.142E-01	1.182E-01	8.209E-01	1.050E+00	1.990E+01
34	9.652E-02	1.185E-01	1.229E-01	8.536E-01	1.057E+00	1.990E+01
35	1.020E-01	1.223E-01	1.271E-01	8.825E-01	1.060E+00	1.990E+01
36	1.079E-01	1.262E-01	1.314E-01	9.123E-01	1.064E+00	1.990E+01
37	1.138E-01	1.300E-01	1.356E-01	9.415E-01	1.068E+00	2.010E+01
38	1.192E-01	1.335E-01	1.394E-01	9.683E-01	1.071E+00	2.010E+01
39	1.249E-01	1.371E-01	1.434E-01	9.961E-01	1.073E+00	2.010E+01
40	1.313E-01	1.411E-01	1.479E-01	1.027E+00	1.075E+00	2.030E+01
41	1.374E-01	1.445E-01	1.517E-01	1.054E+00	1.080E+00	1.880E+01
42	1.439E-01	1.482E-01	1.559E-01	1.083E+00	1.084E+00	1.880E+01
43	1.513E-01	1.524E-01	1.606E-01	1.116E+00	1.087E+00	1.880E+01
44	1.579E-01	1.560E-01	1.647E-01	1.144E+00	1.090E+00	1.900E+01
45	1.647E-01	1.597E-01	1.689E-01	1.173E+00	1.092E+00	1.900E+01
46	1.724E-01	1.636E-01	1.734E-01	1.204E+00	1.096E+00	1.920E+01
47	1.798E-01	1.674E-01	1.778E-01	1.235E+00	1.099E+00	1.920E+01
48	1.873E-01	1.713E-01	1.822E-01	1.265E+00	1.100E+00	1.920E+01
49	1.948E-01	1.748E-01	1.863E-01	1.294E+00	1.104E+00	1.920E+01

APPENDIX IV: Data of run 04

Nr.	Q [m^3/s]	h [m]	H [m]	H/L [1]	Cd [1]	T [C]
1	2.210E-03	1.140E-02	1.140E-02	7.920E-02	9.115E-01	1.890E+01
2	3.240E-03	1.430E-02	1.431E-02	9.937E-02	9.492E-01	1.890E+01
3	4.480E-03	1.760E-02	1.762E-02	1.223E-01	9.590E-01	1.890E+01
4	5.890E-03	2.100E-02	2.103E-02	1.460E-01	9.649E-01	1.890E+01
5	7.480E-03	2.440E-02	2.444E-02	1.697E-01	9.759E-01	1.890E+01
6	8.860E-03	2.710E-02	2.716E-02	1.886E-01	9.854E-01	1.890E+01
7	1.053E-02	3.040E-02	3.048E-02	2.117E-01	9.831E-01	1.890E+01
8	1.176E-02	3.270E-02	3.280E-02	2.278E-01	9.824E-01	1.890E+01
9	1.383E-02	3.630E-02	3.643E-02	2.530E-01	9.848E-01	1.890E+01
10	1.580E-02	3.960E-02	3.977E-02	2.762E-01	9.847E-01	1.890E+01
11	1.821E-02	4.320E-02	4.342E-02	3.015E-01	9.929E-01	1.850E+01
12	2.087E-02	4.720E-02	4.747E-02	3.297E-01	9.929E-01	1.850E+01
13	2.363E-02	5.110E-02	5.144E-02	3.572E-01	9.945E-01	1.850E+01
14	2.688E-02	5.530E-02	5.572E-02	3.870E-01	1.001E+00	1.850E+01
15	3.043E-02	5.980E-02	6.032E-02	4.189E-01	1.003E+00	1.850E+01
16	3.412E-02	6.430E-02	6.493E-02	4.509E-01	1.005E+00	1.850E+01
17	3.762E-02	6.830E-02	6.904E-02	4.795E-01	1.008E+00	1.850E+01
18	4.151E-02	7.260E-02	7.347E-02	5.102E-01	1.011E+00	1.850E+01
19	4.535E-02	7.660E-02	7.761E-02	5.390E-01	1.015E+00	1.870E+01
20	4.973E-02	8.110E-02	8.227E-02	5.713E-01	1.017E+00	1.870E+01
21	5.386E-02	8.510E-02	8.643E-02	6.002E-01	1.021E+00	1.870E+01
22	5.887E-02	8.980E-02	9.133E-02	6.342E-01	1.024E+00	1.870E+01
23	6.418E-02	9.460E-02	9.635E-02	6.691E-01	1.028E+00	1.840E+01
24	6.929E-02	9.890E-02	1.009E-01	7.005E-01	1.033E+00	1.840E+01
25	7.470E-02	1.032E-01	1.054E-01	7.321E-01	1.040E+00	1.840E+01
26	8.060E-02	1.080E-01	1.105E-01	7.673E-01	1.043E+00	1.840E+01
27	8.650E-02	1.124E-01	1.152E-01	7.998E-01	1.049E+00	1.840E+01
28	9.308E-02	1.173E-01	1.204E-01	8.361E-01	1.053E+00	1.850E+01
29	9.937E-02	1.218E-01	1.252E-01	8.696E-01	1.057E+00	1.850E+01
30	1.060E-01	1.264E-01	1.302E-01	9.039E-01	1.061E+00	1.860E+01
31	1.129E-01	1.311E-01	1.352E-01	9.391E-01	1.064E+00	1.860E+01
32	1.187E-01	1.351E-01	1.395E-01	9.690E-01	1.065E+00	1.860E+01
33	1.254E-01	1.392E-01	1.440E-01	1.000E+00	1.070E+00	1.860E+01
34	1.326E-01	1.438E-01	1.490E-01	1.035E+00	1.073E+00	1.860E+01
35	1.398E-01	1.481E-01	1.537E-01	1.067E+00	1.076E+00	1.860E+01
36	1.470E-01	1.521E-01	1.581E-01	1.098E+00	1.082E+00	1.860E+01
37	1.544E-01	1.565E-01	1.630E-01	1.132E+00	1.084E+00	1.860E+01
38	1.615E-01	1.604E-01	1.673E-01	1.162E+00	1.087E+00	1.860E+01
39	1.690E-01	1.646E-01	1.719E-01	1.194E+00	1.089E+00	1.860E+01
40	1.757E-01	1.681E-01	1.758E-01	1.221E+00	1.093E+00	1.860E+01
41	1.824E-01	1.718E-01	1.799E-01	1.250E+00	1.093E+00	1.900E+01
42	1.884E-01	1.748E-01	1.833E-01	1.273E+00	1.096E+00	1.900E+01
43	1.954E-01	1.783E-01	1.873E-01	1.300E+00	1.099E+00	1.900E+01

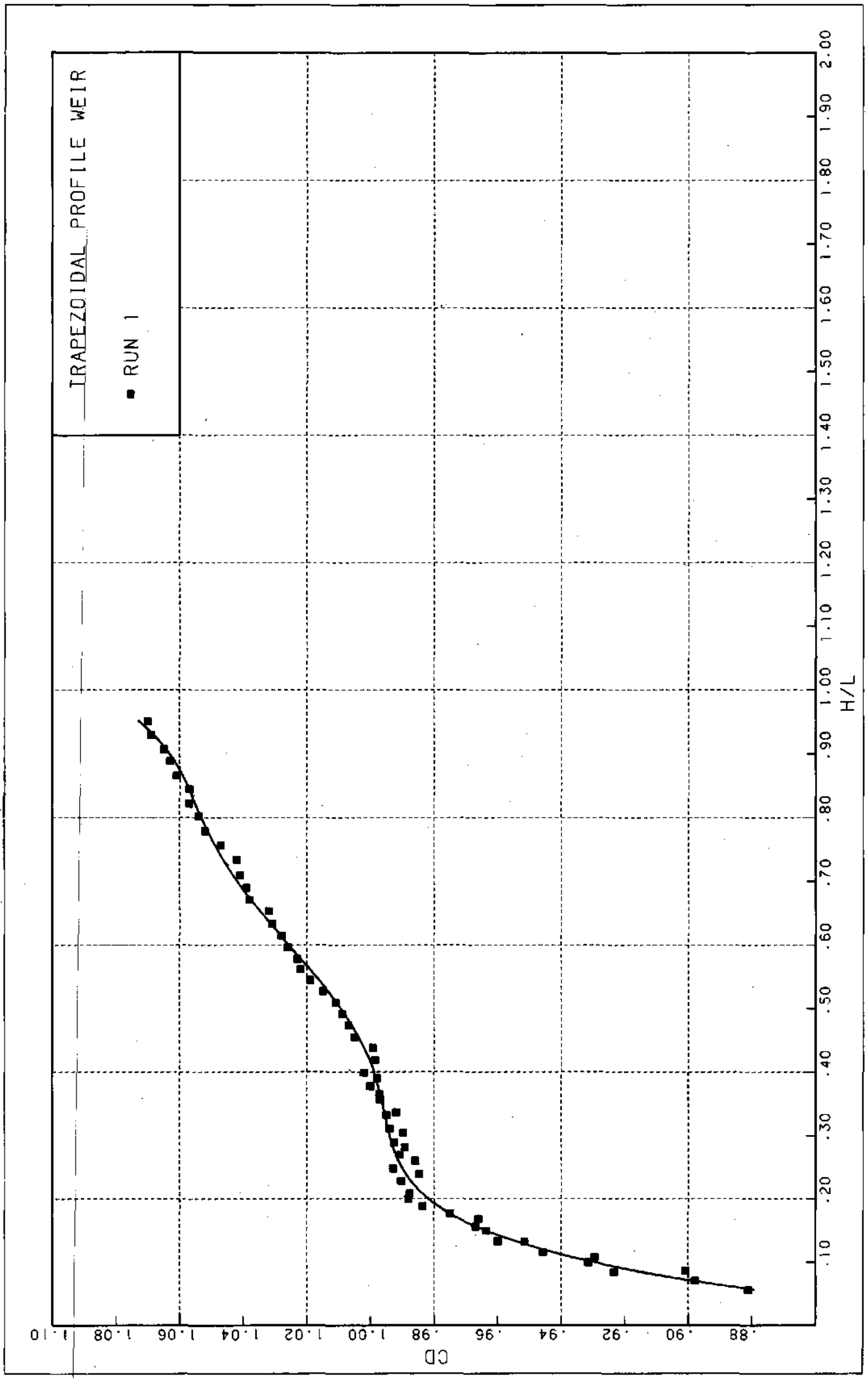
APPENDIX V: Data of run 05

Nr.	Q [m^3/s]	h [m]	H [m]	H/L [1]	Cd [1]	T [C]
1	2.260E-03	1.150E-02	1.151E-02	7.991E-02	9.196E-01	1.860E+01
2	3.350E-03	1.470E-02	1.472E-02	1.022E-01	9.409E-01	1.860E+01
3	4.580E-03	1.790E-02	1.793E-02	1.245E-01	9.543E-01	1.860E+01
4	6.050E-03	2.130E-02	2.135E-02	1.482E-01	9.689E-01	1.820E+01
5	7.400E-03	2.430E-02	2.437E-02	1.692E-01	9.701E-01	1.860E+01
6	8.950E-03	2.740E-02	2.749E-02	1.909E-01	9.771E-01	1.860E+01
7	1.087E-02	3.090E-02	3.103E-02	2.155E-01	9.877E-01	1.820E+01
8	1.181E-02	3.270E-02	3.285E-02	2.281E-01	9.841E-01	1.870E+01
9	1.450E-02	3.730E-02	3.752E-02	2.606E-01	9.874E-01	1.820E+01
10	1.988E-02	4.550E-02	4.588E-02	3.186E-01	9.965E-01	1.820E+01
11	2.471E-02	5.230E-02	5.284E-02	3.670E-01	9.981E-01	1.820E+01
12	2.900E-02	5.790E-02	5.860E-02	4.070E-01	9.997E-01	1.820E+01
13	3.348E-02	6.340E-02	6.429E-02	4.464E-01	1.001E+00	1.820E+01
14	3.775E-02	6.840E-02	6.947E-02	4.824E-01	1.002E+00	1.760E+01
15	3.806E-02	6.860E-02	6.969E-02	4.839E-01	1.006E+00	1.820E+01
16	4.259E-02	7.340E-02	7.470E-02	5.187E-01	1.011E+00	1.820E+01
17	4.257E-02	7.350E-02	7.479E-02	5.194E-01	1.009E+00	1.760E+01
18	4.683E-02	7.790E-02	7.940E-02	5.514E-01	1.012E+00	1.770E+01
19	4.739E-02	7.840E-02	7.993E-02	5.551E-01	1.013E+00	1.760E+01
20	5.093E-02	8.190E-02	8.361E-02	5.806E-01	1.016E+00	1.760E+01
21	5.131E-02	8.230E-02	8.403E-02	5.835E-01	1.016E+00	1.770E+01
22	5.549E-02	8.620E-02	8.815E-02	6.121E-01	1.020E+00	1.770E+01
23	5.555E-02	8.630E-02	8.825E-02	6.128E-01	1.019E+00	1.770E+01
24	5.983E-02	9.010E-02	9.228E-02	6.409E-01	1.024E+00	1.770E+01
25	5.997E-02	9.020E-02	9.239E-02	6.416E-01	1.025E+00	1.770E+01
26	6.460E-02	9.420E-02	9.665E-02	6.712E-01	1.029E+00	1.770E+01
27	6.853E-02	9.750E-02	1.002E-01	6.957E-01	1.033E+00	1.770E+01
28	7.286E-02	1.010E-01	1.039E-01	7.217E-01	1.037E+00	1.770E+01
29	7.728E-02	1.046E-01	1.078E-01	7.486E-01	1.039E+00	1.770E+01
30	8.200E-02	1.080E-01	1.115E-01	7.742E-01	1.046E+00	1.770E+01
31	8.633E-02	1.116E-01	1.153E-01	8.010E-01	1.044E+00	1.770E+01
32	9.056E-02	1.142E-01	1.182E-01	8.211E-01	1.054E+00	1.770E+01
33	9.498E-02	1.176E-01	1.219E-01	8.466E-01	1.054E+00	1.780E+01
34	9.950E-02	1.206E-01	1.252E-01	8.695E-01	1.058E+00	1.780E+01
35	1.036E-01	1.236E-01	1.285E-01	8.922E-01	1.059E+00	1.780E+01
36	1.081E-01	1.265E-01	1.317E-01	9.144E-01	1.062E+00	1.780E+01
37	1.127E-01	1.293E-01	1.348E-01	9.361E-01	1.067E+00	1.780E+01
38	1.170E-01	1.321E-01	1.379E-01	9.576E-01	1.070E+00	1.780E+01
39	1.176E-01	1.322E-01	1.380E-01	9.586E-01	1.073E+00	1.780E+01
40	1.219E-01	1.348E-01	1.410E-01	9.788E-01	1.077E+00	1.780E+01
41	1.265E-01	1.379E-01	1.444E-01	1.002E+00	1.075E+00	1.780E+01
42	1.306E-01	1.405E-01	1.472E-01	1.022E+00	1.076E+00	1.790E+01
43	1.343E-01	1.427E-01	1.497E-01	1.040E+00	1.078E+00	1.790E+01
44	1.383E-01	1.451E-01	1.524E-01	1.058E+00	1.079E+00	1.790E+01
45	1.443E-01	1.486E-01	1.563E-01	1.086E+00	1.082E+00	1.800E+01
46	1.487E-01	1.512E-01	1.592E-01	1.106E+00	1.083E+00	1.800E+01
47	1.531E-01	1.538E-01	1.621E-01	1.126E+00	1.083E+00	1.800E+01
48	1.574E-01	1.564E-01	1.650E-01	1.146E+00	1.083E+00	1.970E+01
49	1.625E-01	1.592E-01	1.682E-01	1.168E+00	1.085E+00	1.970E+01
50	1.671E-01	1.616E-01	1.710E-01	1.187E+00	1.087E+00	1.970E+01
51	1.711E-01	1.638E-01	1.734E-01	1.204E+00	1.088E+00	1.970E+01
52	1.770E-01	1.668E-01	1.769E-01	1.228E+00	1.090E+00	1.970E+01
53	1.815E-01	1.694E-01	1.798E-01	1.249E+00	1.089E+00	1.970E+01
54	1.858E-01	1.713E-01	1.821E-01	1.264E+00	1.093E+00	1.970E+01
55	1.905E-01	1.737E-01	1.848E-01	1.283E+00	1.094E+00	1.980E+01
56	1.956E-01	1.764E-01	1.879E-01	1.305E+00	1.094E+00	1.980E+01

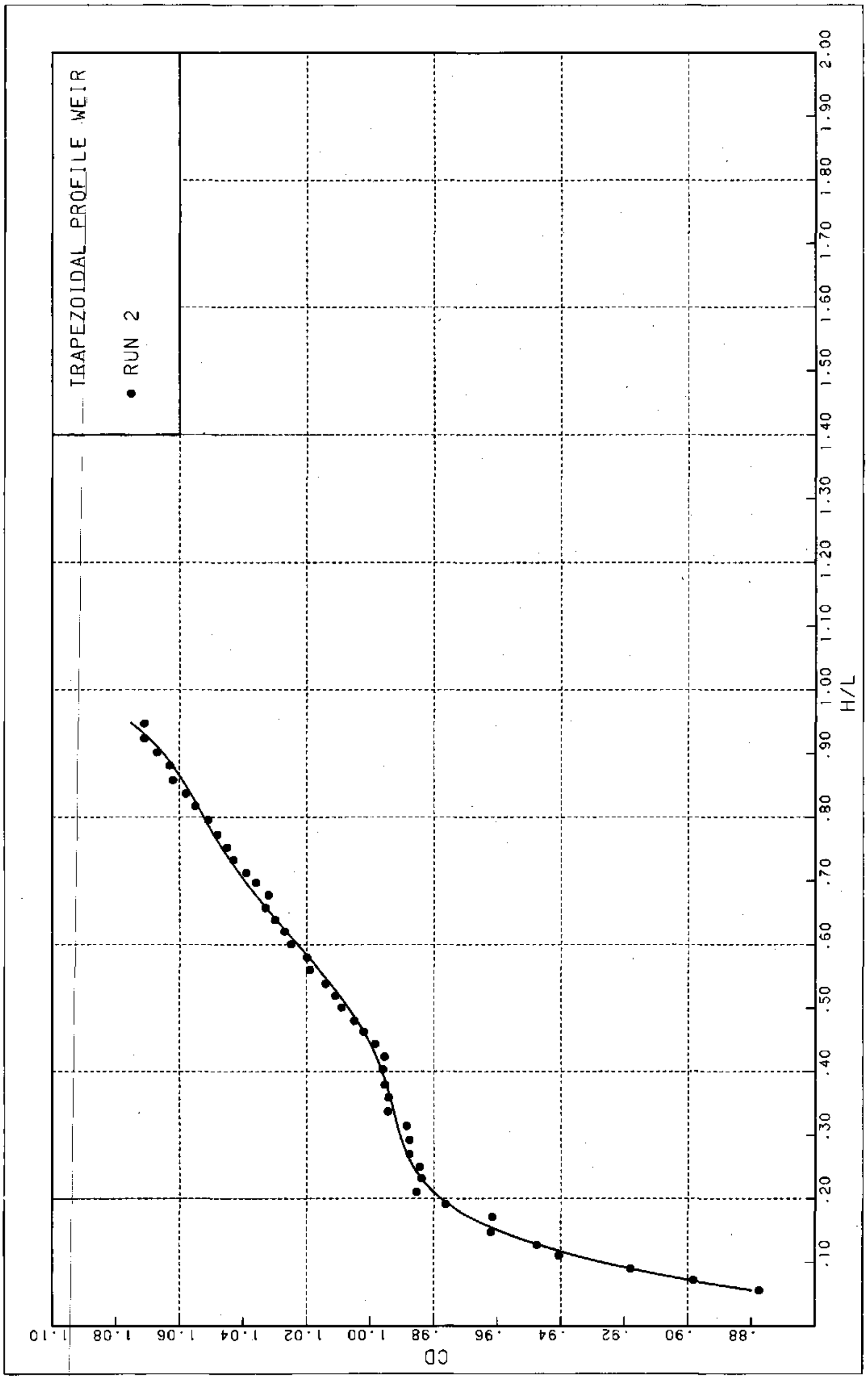
APPENDIX VI: Data of run 06

Nr.	Q [m^3/s]	h [m]	H [m]	H/L [1]	Cd [1]	T [C]
1	3.250E-03	2.220E-02	2.236E-02	3.106E-01	9.580E-01	1.740E+01
2	3.540E-03	2.380E-02	2.399E-02	3.331E-01	9.376E-01	1.820E+01
3	3.980E-03	2.510E-02	2.533E-02	3.518E-01	9.699E-01	1.740E+01
4	4.360E-03	2.690E-02	2.717E-02	3.773E-01	9.547E-01	1.820E+01
5	4.670E-03	2.790E-02	2.820E-02	3.916E-01	9.658E-01	1.740E+01
6	5.300E-03	3.020E-02	3.057E-02	4.245E-01	9.686E-01	1.820E+01
7	5.410E-03	3.060E-02	3.098E-02	4.303E-01	9.686E-01	1.740E+01
8	6.080E-03	3.280E-02	3.326E-02	4.619E-01	9.762E-01	1.820E+01
9	6.140E-03	3.300E-02	3.346E-02	4.648E-01	9.764E-01	1.740E+01
10	6.850E-03	3.510E-02	3.565E-02	4.952E-01	9.881E-01	1.740E+01
11	6.880E-03	3.540E-02	3.596E-02	4.994E-01	9.796E-01	1.820E+01
12	7.630E-03	3.740E-02	3.806E-02	5.286E-01	9.954E-01	1.740E+01
13	7.590E-03	3.750E-02	3.815E-02	5.298E-01	9.865E-01	1.820E+01
14	8.360E-03	3.950E-02	4.026E-02	5.591E-01	1.000E+00	1.770E+01
15	8.370E-03	3.970E-02	4.046E-02	5.619E-01	9.936E-01	1.820E+01
16	9.050E-03	4.150E-02	4.235E-02	5.883E-01	1.001E+00	1.770E+01
17	9.130E-03	4.180E-02	4.266E-02	5.926E-01	9.983E-01	1.820E+01
18	9.780E-03	4.330E-02	4.426E-02	6.148E-01	1.010E+00	1.770E+01
19	9.840E-03	4.360E-02	4.457E-02	6.190E-01	1.005E+00	1.820E+01
20	1.046E-02	4.540E-02	4.646E-02	6.453E-01	1.002E+00	1.770E+01
21	1.072E-02	4.570E-02	4.681E-02	6.501E-01	1.015E+00	1.820E+01
22	1.134E-02	4.750E-02	4.870E-02	6.764E-01	1.010E+00	1.770E+01
23	1.144E-02	4.750E-02	4.872E-02	6.767E-01	1.018E+00	1.820E+01
24	1.220E-02	4.920E-02	5.055E-02	7.020E-01	1.025E+00	1.820E+01
25	1.212E-02	4.940E-02	5.072E-02	7.045E-01	1.013E+00	1.770E+01
26	1.299E-02	5.110E-02	5.258E-02	7.302E-01	1.027E+00	1.820E+01
27	1.290E-02	5.130E-02	5.275E-02	7.326E-01	1.015E+00	1.770E+01
28	1.359E-02	5.270E-02	5.427E-02	7.537E-01	1.023E+00	1.770E+01
29	1.445E-02	5.440E-02	5.612E-02	7.795E-01	1.032E+00	1.770E+01
30	1.584E-02	5.740E-02	5.936E-02	8.245E-01	1.036E+00	1.780E+01
31	1.678E-02	5.910E-02	6.124E-02	8.506E-01	1.045E+00	1.780E+01
32	1.839E-02	6.220E-02	6.464E-02	8.978E-01	1.052E+00	1.780E+01
33	1.905E-02	6.350E-02	6.606E-02	9.175E-01	1.054E+00	1.780E+01
34	1.989E-02	6.510E-02	6.782E-02	9.419E-01	1.056E+00	1.780E+01
35	2.074E-02	6.650E-02	6.939E-02	9.637E-01	1.062E+00	1.780E+01
36	2.148E-02	6.780E-02	7.083E-02	9.838E-01	1.064E+00	1.790E+01
37	2.226E-02	6.900E-02	7.220E-02	1.003E+00	1.070E+00	1.790E+01
38	2.295E-02	7.030E-02	7.363E-02	1.023E+00	1.070E+00	1.790E+01
39	2.383E-02	7.170E-02	7.521E-02	1.045E+00	1.074E+00	1.790E+01
40	2.461E-02	7.300E-02	7.666E-02	1.065E+00	1.076E+00	1.790E+01
41	2.532E-02	7.430E-02	7.810E-02	1.085E+00	1.075E+00	1.800E+01
42	2.616E-02	7.570E-02	7.967E-02	1.107E+00	1.076E+00	1.800E+01
43	2.709E-02	7.710E-02	8.126E-02	1.129E+00	1.080E+00	1.800E+01
44	2.763E-02	7.820E-02	8.246E-02	1.145E+00	1.076E+00	1.800E+01
45	2.836E-02	7.930E-02	8.371E-02	1.163E+00	1.079E+00	1.800E+01
46	2.915E-02	8.050E-02	8.508E-02	1.182E+00	1.081E+00	1.800E+01
47	3.008E-02	8.180E-02	8.658E-02	1.202E+00	1.084E+00	1.800E+01
48	3.084E-02	8.300E-02	8.793E-02	1.221E+00	1.085E+00	1.810E+01
49	3.177E-02	8.420E-02	8.934E-02	1.241E+00	1.089E+00	1.810E+01
50	3.270E-02	8.550E-02	9.084E-02	1.262E+00	1.092E+00	1.810E+01
51	3.353E-02	8.660E-02	9.213E-02	1.280E+00	1.095E+00	1.810E+01
52	3.434E-02	8.790E-02	9.359E-02	1.300E+00	1.093E+00	1.820E+01
53	3.502E-02	8.890E-02	9.473E-02	1.316E+00	1.094E+00	1.830E+01
54	3.600E-02	9.030E-02	9.633E-02	1.338E+00	1.094E+00	1.830E+01
55	3.669E-02	9.120E-02	9.739E-02	1.353E+00	1.096E+00	1.840E+01
56	3.752E-02	9.220E-02	9.858E-02	1.369E+00	1.099E+00	1.840E+01
57	3.840E-02	9.340E-02	9.996E-02	1.388E+00	1.100E+00	1.840E+01

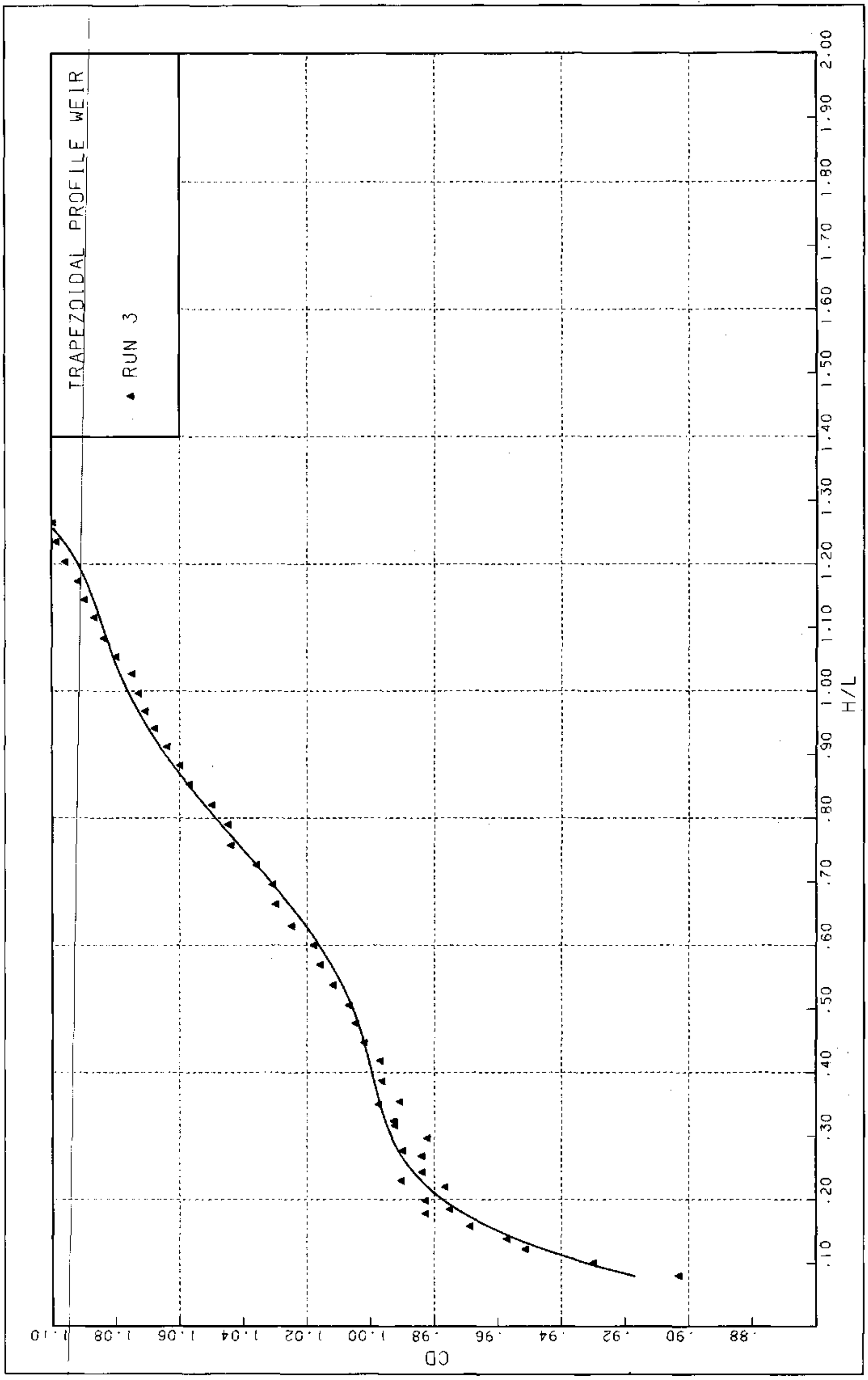
APPENDIX VII: Discharge coefficient as a function of the relative total head: run 01



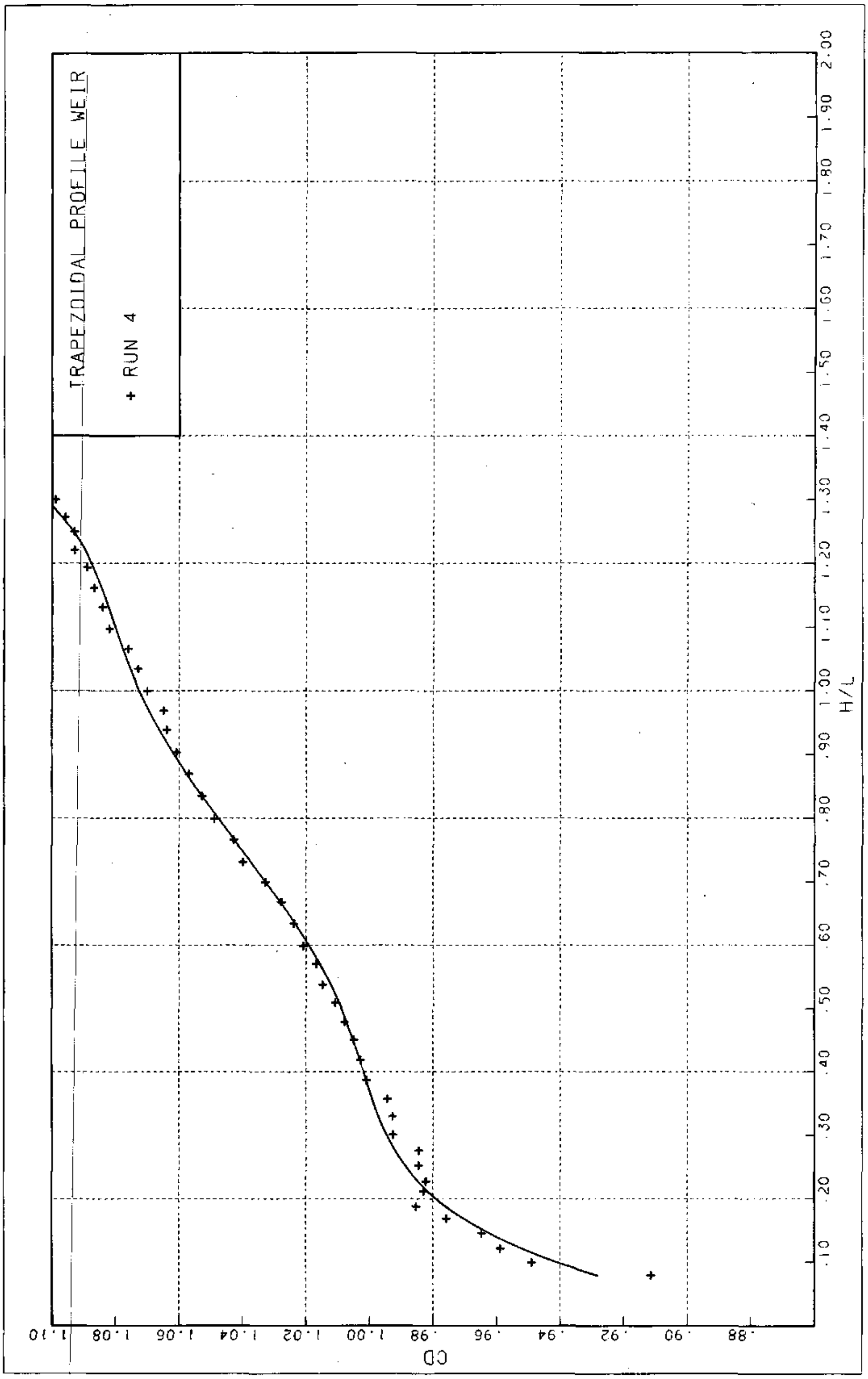
APPENDIX VIII: Discharge coefficient as a function of the relative total head: run 02



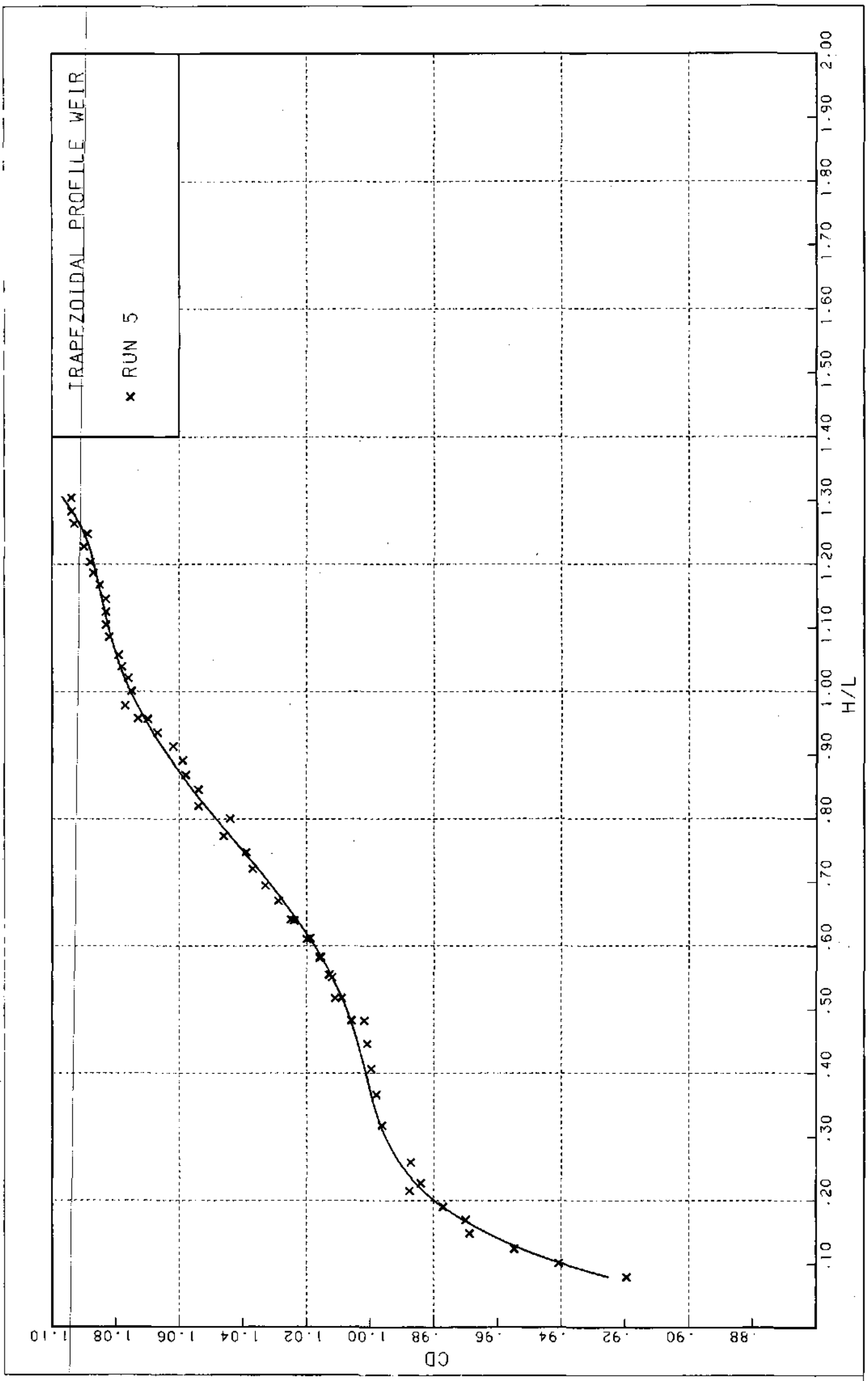
APPENDIX IX: Discharge coefficient as a function of the relative total head: run 03



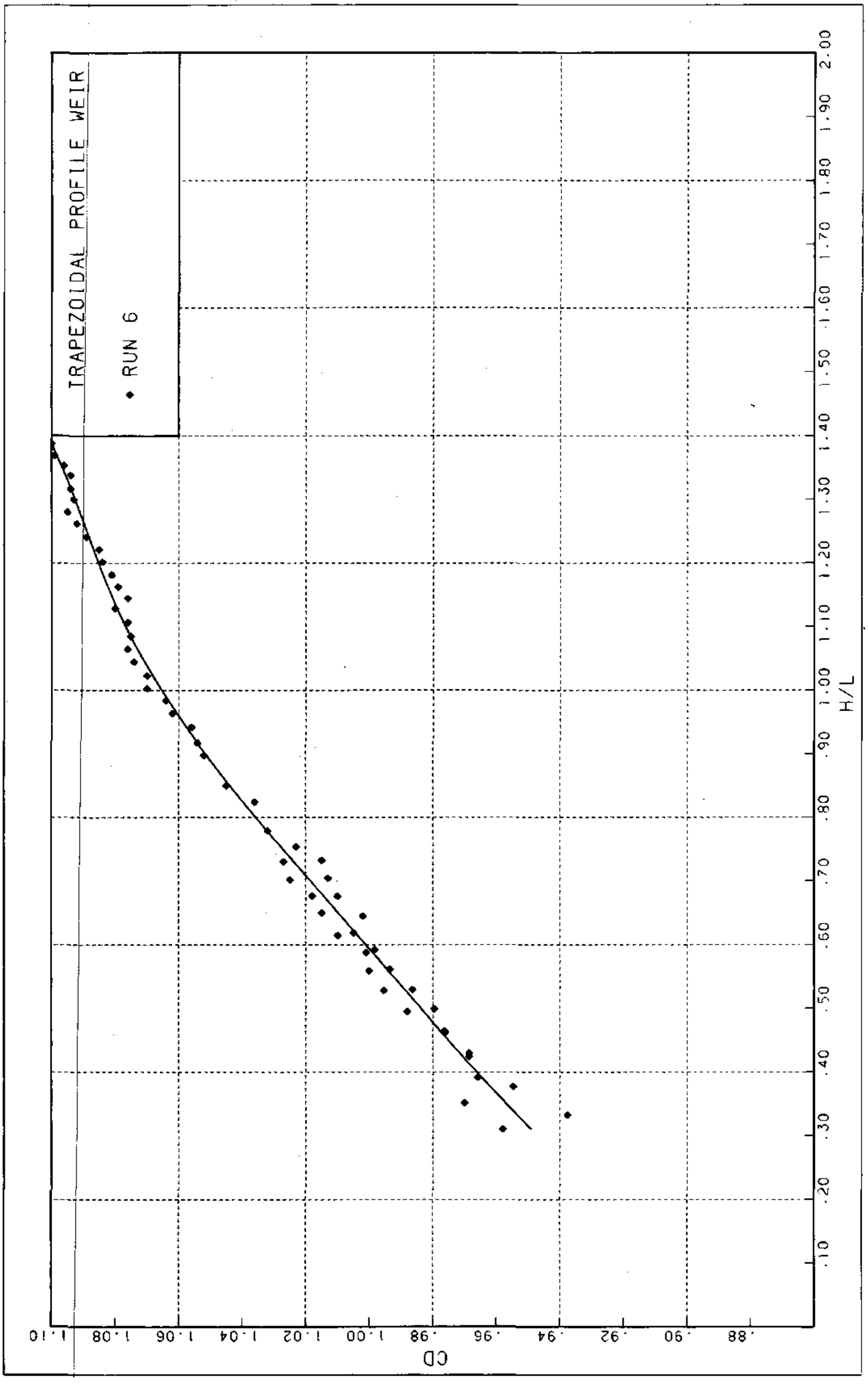
APPENDIX X: Discharge coefficient as a function of the relative total head: run 04



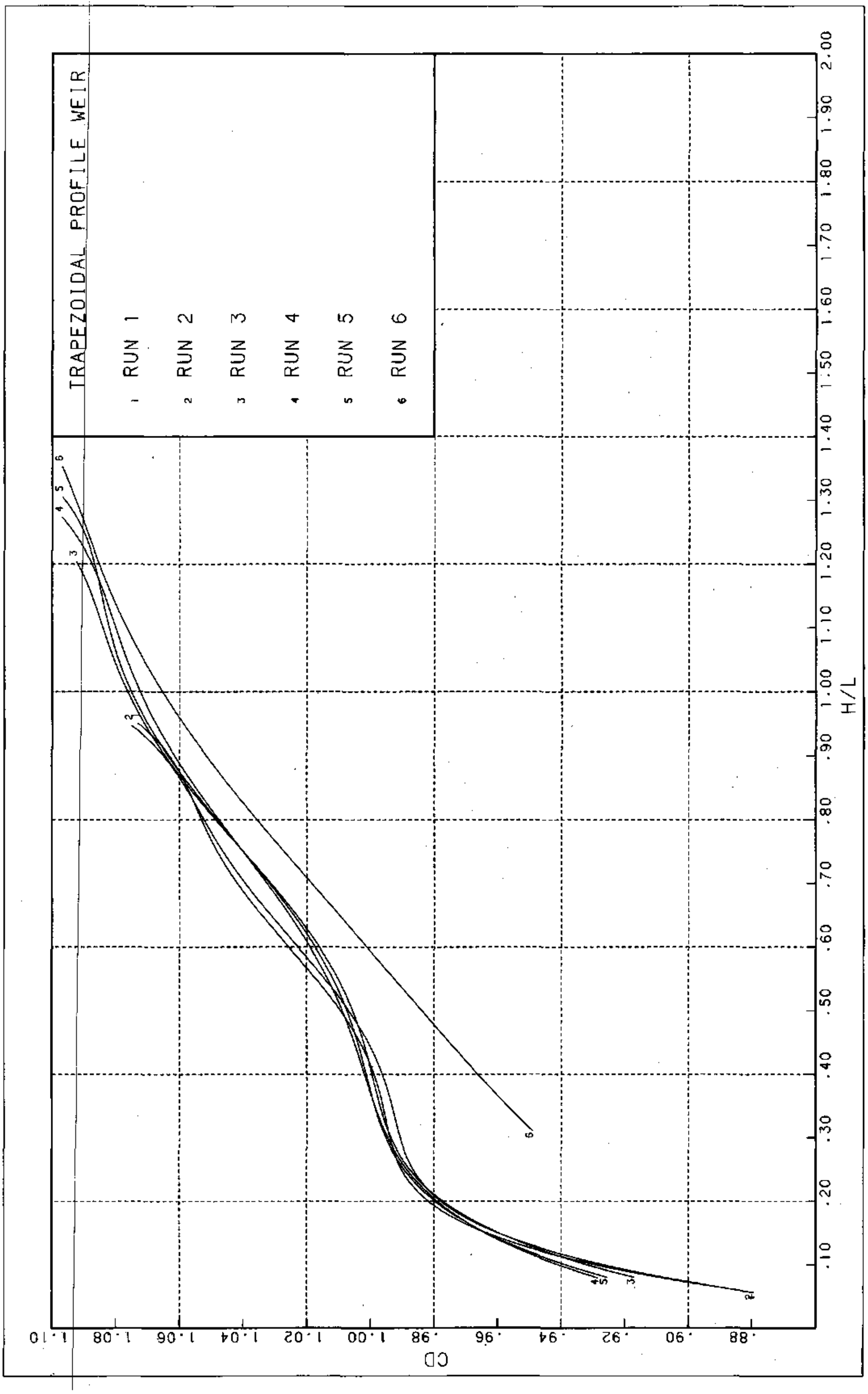
APPENDIX XI: Discharge coefficient as a function of the relative total head: run 05



APPENDIX XII: Discharge coefficient as a function of the relative total head: run 06



APPENDIX XIII: Discharge coefficient as a function of the relative



APPENDIX XIV: Data of the USSR

Run	Q m^3/s	h m	H/L 1	C_D 1
N1	0.0068	0.0410	1.16	0.971
	0.00845	0.0450	1.29	1.022
	0.0093	0.0485	1.39	0.996
	0.0105	0.0510	1.47	1.025
	0.0119	0.0555	1.61	1.008
	0.0130	0.0570	1.66	1.042
	0.0139	0.0590	1.73	1.047
	0.0149	0.0605	1.78	1.068
N2	0.00540	0.0350	0.85	0.955
	0.00805	0.0430	1.06	1.007
	0.0114	0.0520	1.30	1.030
	0.01215	0.0545	1.36	1.016
	0.01445	0.0597	1.50	1.029
N3	0.0392	0.070	0.484	1.013
	0.0451	0.079	0.546	0.965
	0.0597	0.094	0.653	0.969
	0.0621	0.096	0.668	0.974
	0.0717	0.104	0.726	0.988
	0.0878	0.117	0.820	0.999
N4	1.25	0.28	0.903	1.005
	2.00	0.37	1.21	1.023
	2.48	0.42	1.38	1.029
	3.16	0.49	1.63	1.017

APPENDIX XV: Data of Boiten, 1983

run	75	74	76	73	70	71	72	mean value C_D
L (m)	0.058	0.120	0.060	0.180	0.450	0.450	0.450	
P_1 (m)	0.479	0.465	0.155	0.453	0.453	0.220	0.110	
L/P_1	0.121	0.258	0.387	0.397	0.99	2.05	4.09	
H_1/L								
0.04					0.931			
0.05					0.936		0.937	0.936
0.06					0.940		0.947	0.943
0.07					0.944	0.950	0.954	0.949
0.08					0.947	0.955	0.960	0.954
0.09					0.951	0.959	0.965	0.958
0.10					0.953	0.963	0.968	0.962
0.12					0.958	0.969	0.973	0.967
0.14					0.963	0.975	0.977	0.971
0.16					0.967	0.979	0.980	0.975
0.18		0.928			0.971	0.983	0.981	0.978
0.20		0.932		0.948	0.974	0.986	0.982	0.980
0.25		0.942		0.956	0.982	0.987	0.983	0.984
0.30		0.952		0.963	0.988	0.988	0.985	0.987
0.35	0.927	0.962		0.969	0.994	0.990	0.988	0.991
0.40	0.941	0.971	0.954	0.975	0.999	0.992	0.991	0.995
0.45	0.956	0.980	0.965	0.981	1.004	0.996	0.996	0.999
0.50	0.968	0.989	0.978	0.989	1.009	1.001	1.002	1.003
0.55	0.979	0.998	0.985	0.996	1.017	1.005	1.009	1.007
0.60	0.989	1.007	0.995	1.005	1.030	1.011	1.016	1.012
0.70	1.007	1.022	1.013	1.021				1.022
0.80	1.022	1.036	1.029	1.037				1.032
0.90	1.036	1.050	1.045	1.053				1.045
1.00	1.048	1.061	1.059	1.068				1.059
1.20	1.074	1.084	1.083	1.096				1.084
1.40	1.095	1.104	1.100	1.120				1.102
1.60	1.116	1.123	1.115					1.118
1.80	1.130	1.141	1.127					1.131
2.00	1.144	1.160	1.138					1.143
2.50	1.167		1.158					1.163
3.00	1.187		1.173					1.180
3.50	1.204							
4.00	1.219							

The outlined C_D-values are free from scaling effects.

The outlined C_D-values are expected to be free from scaling effects ($Re > 3 * 10^5$).

Determination of the mean value of the characteristic discharge coefficient C_D.

APPENDIX XVI: Data of experiments on the modular limit

Q m^3/s	h_1 m	H_1 m	h_3 m	H_3 m	H_3/H_1 1	H_1/H_0 1
0.01035	0.0305	0.0306				1.000
	0.0307	0.0308	0.0181	0.0182	0.591	1.007
	0.0314	0.0315	0.0240	0.0241	0.765	1.029
	0.0334	0.0335	0.0286	0.0287	0.857	1.095
	0.0368	0.0369	0.0333	0.0334	0.905	1.206
	0.0418	0.0419	0.0395	0.0396	0.945	1.369
0.01978	0.0456	0.0459				1.000
	0.0457	0.0460	0.0221	0.0224	0.487	1.002
	0.0460	0.0463	0.0312	0.0315	0.680	1.009
	0.0474	0.0477	0.0374	0.0377	0.790	1.039
	0.0493	0.0495	0.0419	0.0422	0.852	1.078
	0.0518	0.0520	0.0470	0.0473	0.910	1.133
	0.0578	0.0580	0.0538	0.0540	0.931	1.264
	0.0621	0.0623	0.0589	0.0591	0.949	1.357
0.03469	0.0656	0.0663				1.000
	0.0658	0.0665	0.0379	0.0387	0.582	1.003
	0.0663	0.0669	0.0485	0.0493	0.737	1.009
	0.0671	0.0677	0.0548	0.0555	0.820	1.021
	0.0694	0.0700	0.0589	0.0596	0.851	1.056
	0.0725	0.0731	0.0643	0.0650	0.889	1.103
	0.0767	0.0773	0.0701	0.0707	0.915	1.166
	0.0787	0.0793	0.0730	0.0736	0.928	1.196
	0.0839	0.0845	0.0791	0.0797	0.943	1.275
	0.1024	0.1029	0.0998	0.1003	0.973	1.555
0.04973	0.0824	0.0836				1.000
	0.0825	0.0837	0.0515	0.0530	0.633	1.001
	0.0831	0.0843	0.0622	0.0636	0.754	1.008
	0.0842	0.0853	0.0690	0.0703	0.824	1.020
	0.0857	0.0868	0.0728	0.0741	0.854	1.038
	0.0891	0.0902	0.0788	0.0800	0.887	1.079
	0.0934	0.0945	0.0850	0.0861	0.911	1.130
	0.1010	0.1020	0.0949	0.0960	0.941	1.220
0.06949	0.1004	0.1024				1.000
	0.1009	0.1029	0.0483	0.0513	0.499	1.005
	0.1011	0.1031	0.0592	0.0619	0.600	1.007
	0.1017	0.1036	0.0685	0.0710	0.685	1.012
	0.1025	0.1044	0.0788	0.0811	0.777	1.020
	0.1037	0.1056	0.0851	0.0873	0.823	1.031
	0.1053	0.1072	0.0902	0.0923	0.861	1.047
	0.1080	0.1099	0.0951	0.0972	0.884	1.073
	0.1126	0.1144	0.1025	0.1044	0.913	1.117
	0.1166	0.1183	0.1079	0.1098	0.929	1.155
	0.1202	0.1219	0.1125	0.1143	0.938	1.190
	0.1271	0.1287	0.1208	0.1225	0.952	1.257

Q m^3/s	h_1 m	H_1 m	h_3 m	H_3 m	H_3/H_1 1	H_1/H_0 1
0.08994	0.1170	0.1199				1.000
	0.1177	0.1206	0.0665	0.0708	0.587	1.006
	0.1180	0.1209	0.0719	0.0760	0.629	1.008
	0.1181	0.1210	0.0762	0.0802	0.663	1.009
	0.1188	0.1217	0.0852	0.0889	0.730	1.015
	0.1205	0.1233	0.0962	0.0996	0.808	1.028
	0.1221	0.1249	0.1027	0.1060	0.849	1.042
	0.1237	0.1265	0.1071	0.1102	0.871	1.055
	0.1265	0.1292	0.1127	0.1157	0.896	1.078
	0.1307	0.1333	0.1190	0.1219	0.914	1.112
	0.1346	0.1372	0.1245	0.1273	0.928	1.144
	0.1414	0.1438	0.1333	0.1359	0.945	1.199
	0.1451	0.1475	0.1377	0.1402	0.951	1.230
0.11618	0.1356	0.1398				1.000
	0.1360	0.1402	0.0599	0.0675	0.481	1.003
	0.1370	0.1412	0.0888	0.0948	0.671	1.010
	0.1379	0.1421	0.0949	0.1006	0.708	1.016
	0.1389	0.1430	0.1013	0.1068	0.747	1.023
	0.1411	0.1452	0.1149	0.1198	0.825	1.039
	0.1449	0.1489	0.1265	0.1310	0.880	1.065
	0.1513	0.1551	0.1379	0.1421	0.916	1.109
	0.1575	0.1611	0.1466	0.1505	0.934	1.152
	0.1656	0.1690	0.1570	0.1606	0.950	1.209
0.13909	0.1501	0.1556				1.000
	0.1510	0.1564	0.0685	0.0787	0.503	1.005
	0.1521	0.1575	0.0992	0.1071	0.680	1.012
	0.1514	0.1568	0.0877	0.0964	0.615	1.008
	0.1523	0.1577	0.1023	0.1101	0.698	1.013
	0.1536	0.1590	0.1105	0.1178	0.741	1.022
	0.1554	0.1607	0.1200	0.1268	0.789	1.033
	0.1575	0.1627	0.1307	0.1370	0.842	1.046
	0.1618	0.1669	0.1425	0.1483	0.889	1.073
	0.1681	0.1730	0.1540	0.1593	0.921	1.112
	0.1747	0.1793	0.1631	0.1681	0.938	1.152
	0.1821	0.1865	0.1728	0.1775	0.952	1.199
0.16681	0.1659	0.1730				1.000
	0.1677	0.1747	0.0935	0.1054	0.603	1.010
	0.1697	0.1766	0.1183	0.1282	0.726	1.021
	0.1714	0.1782	0.1268	0.1361	0.764	1.030
	0.1737	0.1804	0.1392	0.1477	0.819	1.043
	0.1766	0.1832	0.1505	0.1584	0.865	1.059
	0.1821	0.1885	0.1613	0.1686	0.894	1.090
	0.1874	0.1936	0.1727	0.1795	0.927	1.119
	0.1943	0.2002	0.1822	0.1886	0.942	1.157
	0.2018	0.2074	0.1919	0.1979	0.954	1.199

Q m^3/s	h_1 m	H_1 m	h_3 m	H_3 m	H_3/H_1 1	H_1/H_0 1
0.19473	0.1808	0.1895				1.000
	0.1832	0.1918	0.1103	0.1246	0.650	1.012
	0.1860	0.1945	0.1350	0.1469	0.755	1.026
	0.1889	0.1972	0.1453	0.1564	0.793	1.040
	0.1916	0.1998	0.1582	0.1684	0.843	1.054
	0.1949	0.2029	0.1692	0.1786	0.880	1.070
	0.1999	0.2076	0.1801	0.1889	0.910	1.095
	0.2066	0.2140	0.1910	0.1992	0.931	1.129
	0.2134	0.2205	0.2010	0.2087	0.946	1.163
	0.2217	0.2285	0.2112	0.2184	0.956	1.205

APPENDIX XVII: Upstream total head as a function of downstream total head