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١. Introduction

In the last few decades, pressures on the freshwater available on earth, has increased dramatically due to increased demand and more pollution of existing water sources. First, world population still is growing, which means increasing water consumption for domestic purposes. Secondly, the growth of industry and other economic activities requires more and more water. Thirdly, agriculture and the cultivation of even larger areas also helped to increase pressure on water resources. moreover the world faces in these days its biggest challenge in history, climate change, which has already led to drought in some countries, while others experience more and more severe flooding. Unfortunately, the amount of fresh water is restricted and cannot be increased. Therefore, the only thing that can be done, is better management and utilization of water resources. The better management and utilization cannot be achieved without accurate data on the elements of water cycle in the nature, among these elements are rainfall, evaporation and especially runoff into streams and rivers.

flow data is of great importance for the design of a series of engineering projects. A successful design of a dam depends on the accuracy of water flow in the river, the choice of a hydroelectric turbine also depends on the flow data for the river, how large an area to be covered by an irrigation project is also dependent on flow data of the river from which water is taken ... etc.

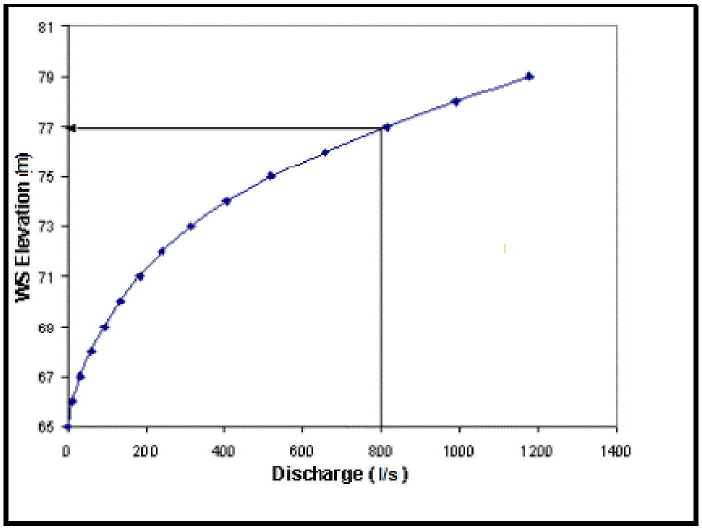
Since the beginning of measurement of discharge in streams and rivers, it has been usual to measure the water velocity by using an impeller . Water flow is calculated from the velocity and the area of the cross-section where the velocity is measured.

For the purpose of continuous discharge measurement in a river, a relation between discharge and water level (Q-H) is usually established for a certain cross section , such kind of relation is usually constructed by measuring discharge for a wide range of water level, once the relation is ready, the water level is measured continuously, and the relationship between them is used to determine the water flow.

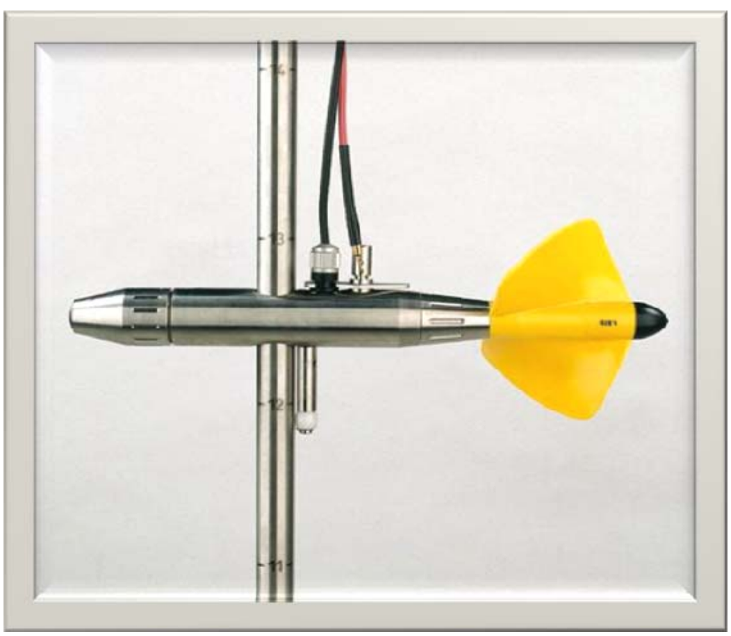
in the last ٢٠ years the scientists have attempted to develop new kind of flow meters, they tried to use technological developments in other fields of science, these attempts has led to the development of a new generation of flow meters called "acoustic Doppler current profiles" (ADCP), a new meter that uses acoustic signals below the water surface to measure water velocity and water depth. ADCP meter is in its infancy, it means that the technology is still evolving, and there must still performed many investigations before deciding on the propeller measurement can be replaced with ADCP technology. Would not ADCP meter can even provide accurate data to make a better administration of water resources possible.

The aim of the study

Since the beginning of flow measurement in Danish streams, the flow measurement in the streams have based on constructing of a relationship between water level (H) and water flow (Q) for a selected cross-section of the stream, se figure ١.



The relationship is established through measurement of the water level and measurements of discharge for a wide range of water level, discharge measurements are usually performed by using a current meter or propeller, se figure ٢.



Discharge measurement by using current meter is a time consuming process see

Once the relation is established only water level is measured continuously and converted to water flow by using the relation.

The problem with Q-H relationship is that the relation is not constant, it will change according to changes of the physical conditions of the cross section, which is not constant. The most significant change is the change of the river roughness (manning number, M), moreover changes of the bottom is also important especially in streams and rivers with large sediment transport . Therefore, the relation must be corrected by measuring both water level and water flow at least ١٠-١٢ times per year. This makes the operation of such Q-H relationship in a stream expensive for the water management authorities. This has led to a growing interest to find new methods of flow measurement in rivers and streams based on electronic instruments, that are easy to operate and are not dependent on the changes of the cross section.

The interest and the need for new and fast electronic equipment for flow measurement has led to the development of BB-ADCP meters. One of these devices is called StreamPro (shown in figure ٢). The purposes of this project can be summarized in the following statement:

To investigate whether StreamPro is an accurate and fast alternative to the classical methods to measure water flow in the rivers and streams

Purposes of flow Measurement

It is not without reason that the first civilizations were born at the edge of the world's largest rivers. The Summary civilization grew up at the edge of the Tigris and Euphrates and the Egyptian civilization at the edge of the Nile. Streams and rivers are considered to be the main sources of fresh water ,the water needed for domestic, agricultural and watering of animals could be recovered easily. Human dependence on streams and rivers became larger and larger over time. The social economic and industrial development has been and still is dependent on the existence of fresh water in the stream and rivers.

Discharge in rivers and streams is considered to be the only phase of the hydrologic cycle in which water is trapped in well-defined croos sections, making it possible to measure water quantity with reasonable accuracy. In other phases of the hydrological cycle the measurements are based on point measurements like measurements of and that makes them applicable to particular area. This leads to uncertainty, which is difficult to estimate (Herschy, ١٩٩٥).

Management of water resources and political decisions depend usually upon flow data in rivers. It is therefore very important that the staff who collect data on runoff into streams and rivers, can ensure that raw data is of sufficient quality

The flow measurement in rivers and streams can be used for a number of purposes, here are the most important:

• Water supply.
• Agriculture.
• Water supply to industry.
• Transport.
• Fisheries.
• Control of pollution.
• Control of flood.

The purpose of data collection of rivers and streams discharge varies from one country to another, and can also vary over the time within the same country. In countries like India and Bangladesh the purpose of discharge measurement is the control of flooding, while water supply is the main purpose in England. The purpose In Iraq, where a number of dams are built, is to control flooding, provide water in summer to domestic uses and agriculture and the production of electricity. Whatever the purpose of discharge data is, the successful planning of the use of water depends on how accurate the discharge data are.
In the Middle East, where water resources are very limited and insufficient for the various

uses and the river catchments extends over several countries borders, discharge of the rivers, located in the Middle East, has been on the table at the highest political levels. Use of water by the countries located in upstream affect water quantity and quality that will limit opportunity of the countries located in the rivers downstream. The best example of such a river is Euphrates, whose catchment is located in Turkey, Syria and Iraq.
in past the purpose of discharge measurement in Denmark was collecting flow data needed for river regulation and drainage projects, today it is necessary for environmental planning, management of water resources and protection of watercourses

The location of the study

to fulfill the aim of the study first of all it was necessary to find a location to carry out the necessary discharge measurements by using both methods the traditional using propeller and by the StreamPro. The stream that is been chosed for this purpose is called (Østerå) located at the north of Denmark se figure ٣

The stream is about ١٥ km long located at the south of the city Aalborg, it has a catchment of about ١٠١ sq. km. The average discharge is ٦٥٠ l/s. in past The stream flowed into the sea at the centrum of Aalborg, and it was an seaport during Viking times. At the late ١٨٠٠ the stream is covered and diverted to outside of the city center (Wkipedia, ٢٠٠٧, ١).

Discharge Measurement By Current Meter

The rotation of the propeller per second can be converted to water velocity by using the calibration formula. (Danish Environmental Center, ٢٠٠٧)

$v = a . n + b$

v = water velocity

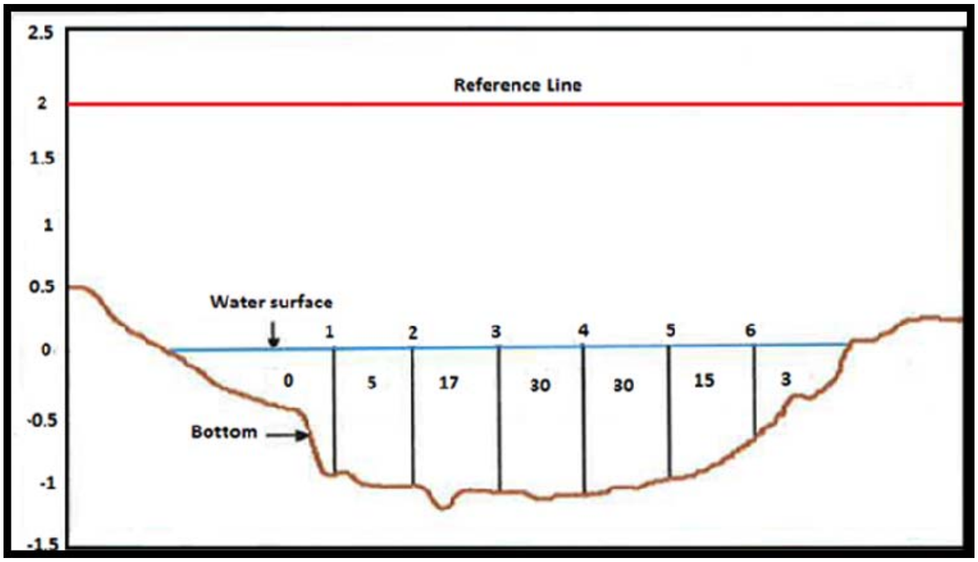
a = constant depending on the current meter.

b = Friction Constant

n = Rotation number per second

To measure water velocity with impeller, a reference horizontal line must first be selected above the water surface along the river profile, se **Error! Reference source not found.** . The river or stream profile must be divided to several segments by placing a number of verticals to the reference line, the position of the verticals must be marked on the reference line.

The water velocity flow rate will be measured at one or more points on each vertical and the depth of the verticals in the water. Water average velocity is calculated for each vertical on the basis of water velocity at these points and the depth of the vertical



The distance between the verticals will be measured, using the measured distance and the average velocity of the vertical the discharge can be calculated, the calculation method will be mentioned in another section of this rapport. The velocity measurement is usually carried out either from a bridge or while standing in the water for shallow streams.

ADCP Discharge Meter

As mentioned above since the beginning of discharge measurements in rivers and streams it has been a common procedure to establish a well-known Discharge-Elevation relation (Q_H curve) for a particular station in a stream or a river.

In the last ٢٠ years the technological development has made it possible to measure discharge in rivers and streams directly, easily and faster than before. This development has been created by use of a new type flow meter which is called ADCP meter. ADCP (Acoustic Doppler current profiles) meter has been in use in the U.S. since ١٩٨٥ (United States Geological Survey, ٢٠٠٥).
An ADCP meter is an electronic instrument that uses acoustic signals under water to measure water velocity in rivers in streams and rivers (United States Geological Survey, ٢٠٠٥). It can also measure water depth from the time signals reflecting from the river bottom.

ADCP meter has led to three important changes in the direct measurement of water flow (American Geophsical Union, ٢٠٠٤):

Propelmåling kræver måling af vandhastighed i mindst ٢٠ punkter, hvilket kan kræve flere timers arbejde for at gennemføre, mens der er tale om minutter og ikke timer, når vandføring skal måles ved ADCP uden, at det gås kompromis med nøjagtigheden.

ADCP kan bruges i tilfælde eller miljøer, hvor gennemførelsen af propelmålinger enten er umulige eller besværlige. Fx afstrømninger, som er påvirket af tidevandet, tilfælde af oversvømmelser og ikke stationære afstrømning.

ADCP måler den vertikale hastighedsfordeling nøjagtigt, mens hastigheden ved måling med propel bliver målt i nogle punkter, og fordelingen bliver antaget.

Using current meter for discharge measurement requires the measurement of water velocity at least ٢٠ points, which may require several hours to complete, while by using ADCP meter discharge can be measured in few minutes and not hours.

ADCP meter can be used in places or environments where the discharge measuremnt by current meter is impossible or very difficult.

ADCP measures the vertical velocity distribution accurately, while by using current meter the velocity will be measured at few point a long a vertical in the water.

Et andet bidrag af ADCP, som synes at være rigtigt, er, at ADCP har skabt mulighed for kontinueret måling af flow. Derudover har ADCP reduceret kildefejl fra at være tre med propelmåling instrumentfejl, procedurefejl og beregningsfejl til at være kun være et.

Since ١٩٨٥, when the ADCP was used for the first time in the United States, the ADCP meter has been improved very much and ADCP meters have become more user-friendly. Nevertheless, it is necessary for a user to have knowledge of the following things (United States Geological Survey, ٢٠٠٥):

- Basic principles of acoustic physics.
- User instructions for the instrument.
- The software belonging ADCP meter.

The Measurement Results

In the following sections, the measurement results are presented. A comparison between the two methods results is established.

Measurements carried out by Current Meter

From ١ October ٢٠٠٧ to first December ٢٠٠٧ the discharge in Østerå at the selected cross section, have been measured ١٤ times by using current meter. For the first measurement, which is conducted on ٢. October ٢٠٠٧, the cross section is divided into ٧ segments by using six verticals as shown in Figure ٣٤, The figure also shows the bottom of the stream as measured on ١. October.

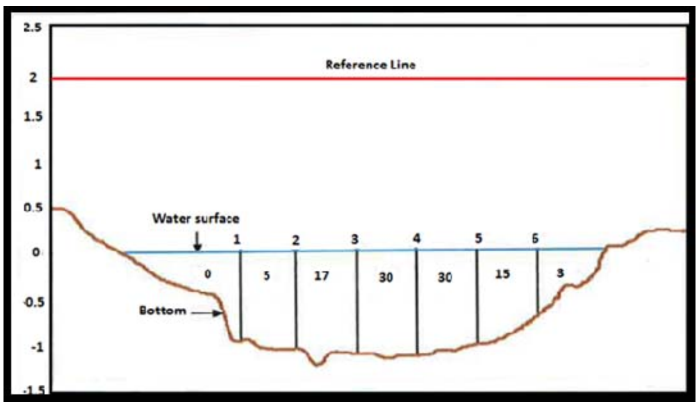


Figure ٣٤ ٦ verticals of ٢ October

the calculated discharge shown in figure ٦ shows to sections that contains ٣٠ percent of the total discharge, which is considered to be too much, to avoid this the number of the sections has been increased for the following days measurements. To more verticals are placed as shown in see Figure ٣٥

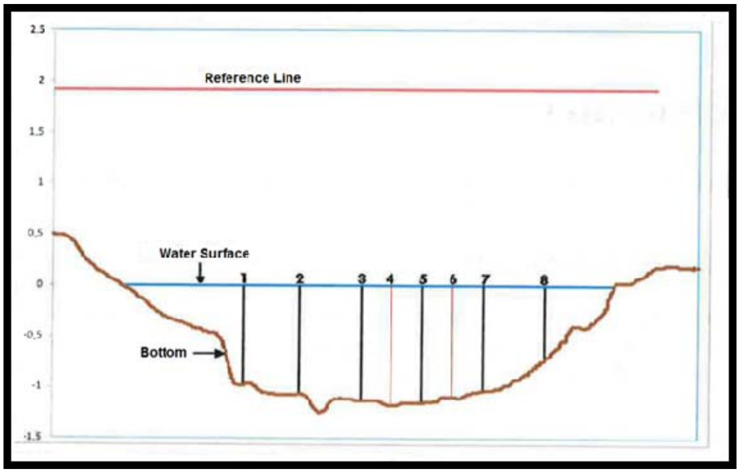
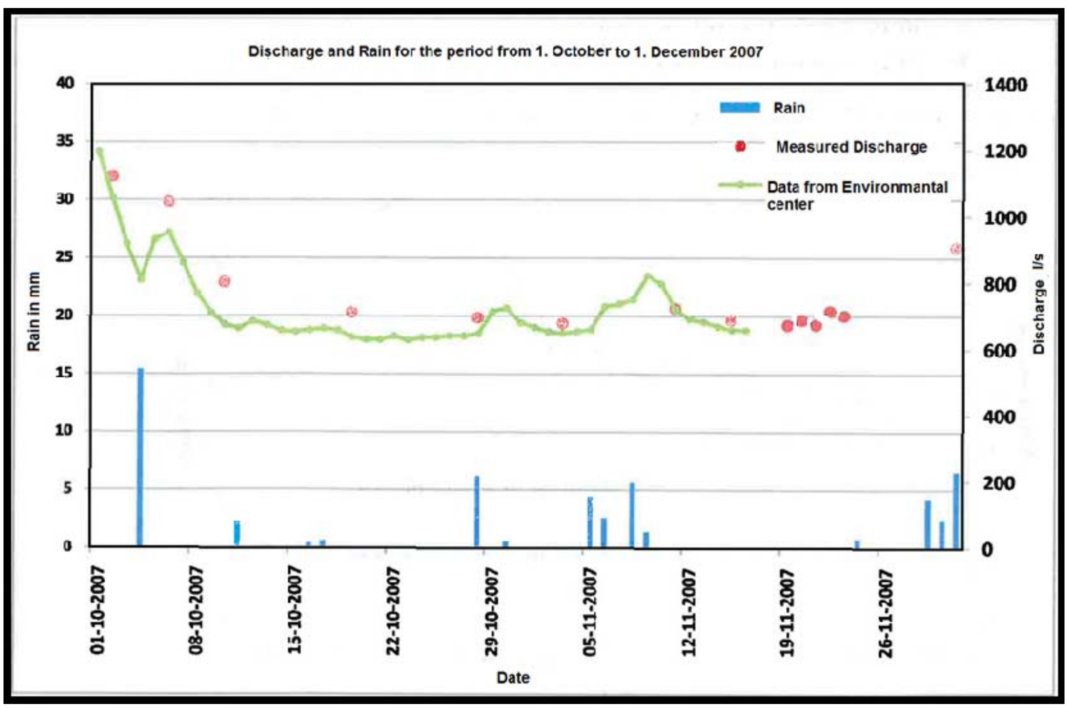


Figure ٣٥ ٨ verticals from ٦th October to ١٥ November

The collected data is used to calculate discharge, see Appendix ١ Calculation results are shown in Figure ٣٧. The precipitation data is also shown on the figure, the rain data cover the same period, that means from the second October to ١ December. Precipitation data belongs to the nearest rain gauge, located in Svenstrup. Moreover discharge measurements performed by the Environmental authoriteis in Aalborg for this period, are also shown on the figure.



these measurements are also shown on the filn addition to that it is also shown the figure there is also shown Østerå the intended environment of the center Aalborg between ١ October - ١ December

Generally the measured discharges follow the amount of precipitation during the period between

٢nd October and ٦th December.
There are up to ١٦% difference between the water flow, which is measured in the project and the values that are constructed from Aalborg Environmental Centre. Flow time series of the center is plotted on the basis of QH relationship. Usually there is a difference of ٥% -١٠% between discharge measured with a current meter and discharge calculated on the basis of QH relation (United States Geological Survey, ٢٠٠٥).
The relatively large difference of ١٦% shows that the discharge data obtained by Q-H relationship can be improved significantly by using alternative new more accurate methods.

Measurements carried out by ADCP StreamPro

StreamPro
The ADCP discharge meter that is used in this project is located on a measuring boat and called f StreamPro ADCP. StreamPro is produced by the American company TELEDYNE RD INSTRUMENTS. It is specially produced for measuring discharge in shallow streams. StreamPro is located on a relatively small boat, which is ٧٠ cm in length and ٤٤ cm wide and weighs only ٥ kg included electronic instruments, which is located on the boat see The electronic components are located in a box (١٥ · ٢٠ · ١٩) cm and positioned on the boat. A transducer of ٢.٠ MHz can be mounted on the boat and connected to the electronics.

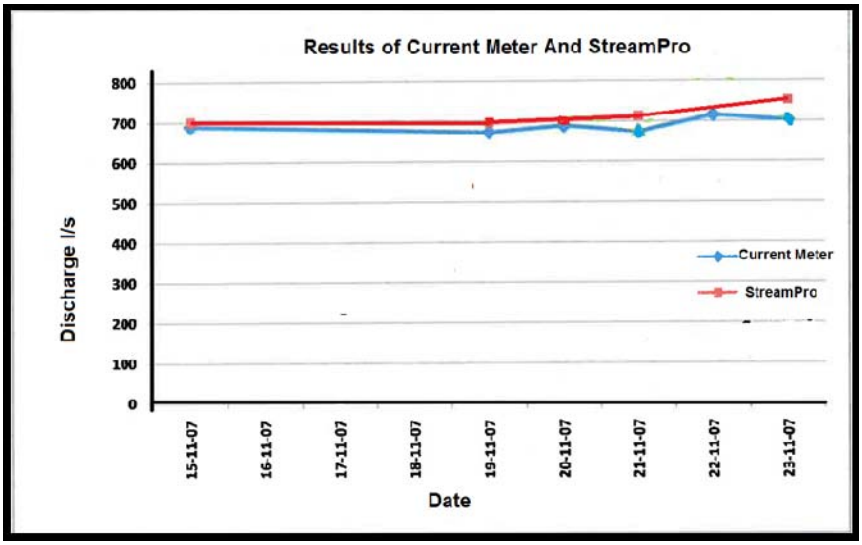
In this study it is chosen we have chosen fix a rod on each side of the stream. On each rod a pullet is fitted is fitted on which a wire passes from one rod to the other.

The boat is bonded to the wire so that it can be moved above water surface from one side of the stream to the other, see Figure

Discharge of the stream is measured five days by using StreamPro meter. The measurements are curried out between ١٥th October and ٢٣rd of October, on the same days and almost the same time discharge in the stream is measured by current meter. The results of the measuremnt by StraemPro I s shoen in table ١

Date	١٥th October	١٩th October	٢٠th October	٢١st October	٢٣rd October
Q l/s (Average)	٧٠٢	٦٩٨	٧٠٩	٧١٤	٧٥٢

One of the most important things that must be considered during measurement I of discharge by ADCP meters is the boats velocity, USGS recommends (United States Geological Survey, ٢٠٠٥), that the boat velocity must be less or equal to the average velocity of the water.
In this study a boat velocity of about ١٢ cm/s is used, which is almost equal to the average velocity of the water, which was between ١٠ to ١٤ cm /s.
The measurement results for bpth current meter and StreamPro for the period between ١٥th october to ٢٣th october are shown in figuer.
The comparison between the two set of measurements shows a difference of ٢% between StreamPro's performance and current meter results.
A study carried out by DDH in ١٩٩٢ (Schulunsen et al, ١٩٩٢). shows that the calculation methods which is used to obtain discharge data on the basis of current meter, underestimate discharge by ٢%. If the results obtained by current meter is increased by ٢%, achieved a fine line between the two methods results.



There is a difference of ٢% between StreamPro's performance and propeller results. The calculation method which is used to bregning of water flow on the basis of data collected through porpel, underestimates the likely water flow by ٢%. This is demonstrated in a study prepared by DDH in ١٩٩٢, a number of bregningsprogrammer, see (Schulunsen et al, ١٩٩٢). If propels results increased by ٢%, achieved a fine line between the two methods results.

conclusion

The comparison of the results of the current meter and those of StreamPro shows a good conformity. Therefore, it is concluded that discharge measurements by means of the propeller has been and is still the most reliable method
The Danish and foreign guides determines the number of the necessary verticals only on the basis of river vredde. The project is aware that it is also important to investigate the velocity distribution along the cross section. This is particularly important in relation to the location of vertical markets.

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٢. Bilag ٣

Q-H relation – Deterministiske metode

Y i m	A i m ٢	P i m	R i m	$R^{\frac{2}{3}}$	$A \cdot R^{\frac{2}{3}}$
٠,٢	٠,٤٨	٤,٣٩	٠,١٠٩	٠,٢٢٩	٠,١١٠
٠,٤	١,٥١	٦,٠٤	٠,٢٥٠	٠,٣٩٧	٠,٥٩٩
٠,٦	٢,٨٣٦	٧,٤٨٦	٠,٣٧٩	٠,٥٢٤	١,٤٨٥
٠,٦٥	٣,٢١٩	٧,٨٤	٠,٤١١	٠,٥٥٢	١,٧٧٨
٩,٧٣	٣,٩٢٣	٨.٦٠٩	٠,٤٥٦	٠,٥٦٢	٢,٣٢٣
٩,٧٣	٣,٩٢٣	٨.٦٠٩	٠,٤٥٦	٠,٥٦٢	٢,٣٢٣
٠,٧٤	٤,٠٢٩	٨,٦٧٤	٠,٤٦٤	٠,٦٠٠	٢,٤١٦
٠,٧٥	٤,١٢٥	٨,٦٧٣	٠,٤٧٦	٠,٦٠٩	٢,٥١٣
٠,٧٧	٤,٢٤٤	٨,٥٥٤	٠,٤٦٩	٠,٦٢٧	٢,٦٦٠
٠,٧٨	٥,٠٦٧	٩,٤٢٧	٠,٥٣٧	٠,٦٦١	٣,٣٥٠
٠,٨	٥,٢٤٨	٩,٥٧٦	٠,٥٤٨	٠,٦٧٠	٣,٥١٥
٨,٨١	٥,٥٢٥	٩,٧٩٨	٠,٥٦٤	٠,٦٨٣	٣,٧٧١
٠,٨٧	٦,٠٠٩	١٠,٠٩٢	٠,٦٠٤	٠,٧١٥	٤,٣٦٠
١	٧,٣٦٢	١٠,٦٤٧	٠,٦٩١	٠,٧٨٢	٥,٧٥٦
١,٠٦	٧,٨٧	١٠,٨٦٣	٠,٧٢٤	٠,٨٠٧	٦,٣٤٨

Ved at tegne vanddybden y mod $A \cdot R^{\frac{2}{3}}$ kan der nedenstående forhold:

Graf

$$A \cdot R^{\frac{2}{3}} = c \cdot y^{b}$$

$Q = M \cdot \sqrt{I} \cdot c \cdot y^b$

$a - M \cdot \sqrt{I} \cdot c$

$Q = a * y^b$

$c = 5{,}486$