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Flow Rate Measurement of Mätäjoki and Haaganpuro

Feasibility study of Trout spawning at Mätäjoki & Haaganpuro

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Mätäjoki and Haaganpuro are two major streams in Helsinki with the larger catchment area. Trout and other vertebrates in this ecosystem are using these streams as a spawning site and natural habitat. These streams are helping to keep the ecological balance in the surroundings.

The main aim of this thesis was to find out the average flow rate and the discharge of Mätäjoki and Haaganpuro at a different time of the year and check if the stream is suitable for the trout spawning or not.

In a literature review, velocity area method, moving boat method and factors affecting the flow and discharge were described in detail. Depths, width, and the flow rate measurement were performed onsite and the calculations are based on obtained results.

The result shows that the flow rate of Haaganpuro was more than Mätäjoki, but the discharge of Haaganpuro was less than Mätäjoki due to small depth and width. Weather played a major role in the rise and fall in flow rate. The flow rate and depths of Mätäjoki are more suitable than Haaganpuro for trout spawning.

Keywords	Mätäjoki, Haaganpuro, Flow rate, Discharge, Velocity area method, Current meter

Acknowledgment

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Above all, I am very thankful to my supervisor, Mr. Kaj Lindedahl who immensely helped me during my field visit and overall thesis writing process. It would not have been possible to complete this project without his knowledge and guidance. I would also wish to express my gratitude to Mr. Bimesh Shrestha, Mr. Bibek Shrestha, Mr. Sanju Shrestha and Mr. Bigyan Dahal who provided valuable assistance during experiments and data processing.

I also hereby affirm that this thesis is my personal work and take responsibility for any factual or grammatical error. I also give my consent to anyone who wishes to work in a similar project using this study as a framework.

Bishal Shrestha

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List of abbreviations and symbols

m	meter
kg/km^2	kilogram per kilometer square
km^2	Kilometer square
%	percentage
Km	kilometer
l/s	litre per second
mm	millimeter
Q	Discharge
V	velocity
A	Area
ft.	feet
pH	potential Hydrogen
ft/s	Feet per Second
m/s	meter per Second
cm	centimeter
cm/s	centimeter per second
mins	Minutes
CH	Channel
$	Dollar
Os	Operating system
m$^{3/}$/s	Cubic meter per second

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1 Introduction

Urban stream with different catchment area plays a significant role in the hydrological cycle. The flowing water of the stream is the major component for aquatic life and inhabitants as a result, aquatic life such as sea trout can sustain when there is a suitable flow in the stream. Measurement of the flow has been an important issue in the present time because it helps to know the effects of global warming in water resources, the stream condition, management of water resources, etc. [25]

Flow measurement is one of the significant concerns for the local ecosystem. Flow measurement data are mainly used for project planning, treatment of water, designing of management measures. [4] The flow data of the stream help us to know about the water quality and aquatic habitat. Extremely endangered sea trout have chosen Mätäjoki and Haaganpuro as a breeding area where the quality and the flow of the water is comparatively better than in other urban streams. [2] Appropriate water flow is required to be the good habitat condition for fish and benthic organism. [4] Measuring the flow of the stream is necessary for the regular reproduction, migration, and maintenance of the water quality.

Discharge measurement is an important issue for the present context, therefore, various techniques have been created in a different time, for example, velocity-area method, floating method, crossing boat method, and an ultrasonic method. [11] These measurement methods are used according to the condition of the selected sites. Some of the measuring techniques are expensive and needs special skills to perform the experiment.

1.1 Mätäjoki

Mätäjoki is the second largest flowing river after Vantaa river, which is in Helsinki and Vantaa Municipality, and the stream flows in a direction from north to south. Kaivoksela and Louhelta are the starting point of this stream. Lassila, Konala, Malminkartano, Kannelmäki, and Hakuninmaa are the major catchment areas from which it flows and reached to the Gulf of Finland passing across Iso- Huopalahti.

The total length of the river is about 9 km and the catchment area is about 24.4 km^2, with the average flow of Mätäjoki is 170 liter per second. [2] Due to the large catchment area, the river is highly sensitive with the rainfall, therefore, flood arises over its culvert. [3] Strömberginkoski is one of the important waterfalls near Pitjänmäki (Tallinn transit garden) which makes the flow of water higher in comparison to the other spots above it. Figure 1 shows the sampling sites of Mätäjoki.

Figure 1: Mätäjoki stream

The quality of the river is satisfying for the aquatic animals, the quality of water has improved since 1970. The path from where the river flows consists of lots of bushes, trees, thus, it supports to preserve the bird life and nightflies. It also consists of a rocky ground which acts as a key component in nature. It is home for the most endangered sea trout (salmonid fishes), waterfowl, for example, hawks, tufts, and yards.

The Nitrogen level of the drainage was 330.8 kg/km^2 and the phosphorus level was 13.4kg/km^2 during 1995. Thus, the river is verified as polytropic. At the time 31 percent of the sample did not pass the inducative requirement for classification of bathing water [8]

1.2 Haaganpuro

Haaganpuro also was known as Mätäpuro before 2011, which is the small stream in comparison to Mätäjoki with the total catchment area about 10.7 km^2. The river flows in southern direction through the west, the river is mainly originated from Maununneva and passes from western Pakila and Pirkkola. The stream flows nearby Central Park and falls below the Hämeenlinna highway. It flows towards South Haagan park and south of Vihdintie and ends in Pikku Huopalahti. The total length of the stream is 11.6 km where 25% is pipelined mainly in Hämeenlinnaväylä section and the average flow rate of the stream is 100 l/s. [10] Figure 2 shows the sampling sites on Haaganpuro.

Figure 2: Haaganpuro stream

Haaganpuro is also one of the major streams in Helsinki, which is home for the urban seatrouts. Likewise, the catchment area of the stream has various ecological sites which provide the best habitat sites for the birds and other organisms. [9] Due to urbanization, the fish stock once collapsed in mid-1900 and the fish(trout) are still in risk of wastewater leakage, illegal fishing, building projects in the present period. The trout shown its presence in early 2000 after the quality of the water gets better. [10] [23]

1.3 Objectives

Mätäjoki and Haaganpuro have been home for the endangered sea trout from many years. In recent years, due to the lack of appropriate flow in the stream, maintaining the breeding area for trout fish has been one of the challenges for the local authorities. Many local organizations such as Helsinki Flyfishers and other NGO's are working to maintain the breeding area by making appropriate flow in the stream. [3] In spring 2013, about 1000 liter of fish-killing solvent was released accidentally in Mätäjoki by Teknos Oy. The highly toxic solvent killed the aquatic life and plants below the discharge points including two generations of sea trout. [2] [24] Haaganpuro also has been a victim of human activities, for example, Helsinki-Turku railway, Hakamäentie tunnel construction as well as infrequent chemical discharge by large- and small-scale industries.

Several activities are ongoing in Mätäjoki to preserve the sea trout like adding the gravel into the base of the stream to achieve a good spawning area, creating a small-scale area under bedding layer including gravel with different size. In Talli region, the stream has been drilled, paved along with flood dunes added to driftwood to maintain the proper flow and living environment for the Aquatic life and plants. These are the basic factor required during the preservation of the trout. The added gravel should be 20-50 mm and good condition. [3] In Haaganpuro different NGOs are working for the restoration of the stream, for example, the city of Helsinki is providing the stones, sand, and gravel to maintain the flow rate. [7] [23]

The main objective of this thesis research project is to study the current situation at the stream, measure the flow rate and the discharge of the stream. Data collection and analysis of the data will be made to determine that selected spot in Haaganpuro and Mätäjoki are suitable or not as a swamping site for the trout. This research would help in identifying the possible solutions and recommend the possible measures to solve the challenges, which is the main objective of this research.

1.4 Methodological Instruction

The flow rate of Mätäjoki and Haaganpuro was studied in the various spots in different days.

- Measure the velocity, depth, and width individually.
- Analyze the effect of geography & the weather condition in the flow rate.
- Compare the flow rate of these two streams with each other.

2 Literature review

2.1 Stream Flow rate / Discharge

Streamflow is one of the fundamental components of the water cycle and the eco-system which directly impacts on the biological and chemical components of the stream. For example, the hydrological cycle is the most important natural aspect of the environment which also depends on it. Streamflow means the volume of the water that flows from a certain point in the given period of time. The stream flows depend on many factors; thus, it can be changed in time and space. Flow rate and the volume of the water in the stream are the two aspects of the stream. The discharge of the stream is generally measured in cubic meter per second. [7] Discharge is mainly affected by the width, depth and the velocity of the stream as well as by weather, human impact, and seasonal change. [1] Flood forecasting, emergency management can be determined by the measurement of the discharge.

2.2 Factor affecting Discharge

- **Weather or climate**

  Weather or climate is one of the major factors that affect the volume of the stream. In the rainy season, the rainfall is high and the amount of water to the surrounding gets increases and the supply of water draining into the stream will also get rises; thus, the volume of the stream is huge in such a situation. [6]

- **Seasonal changes**

  Seasonal changes also influence the stream volume because in the peak summer the rainfall is very low and the availability of the water in the stream is very low but during the rainy season the rainfall is high; therefore, the volume in the stream Increases naturally. [6]

- **Merging tributaries**

  Tributaries are one of the major aspects that contribute to increasing the volume of the stream. A river or stream is always linked with a small brook which helps to increase the volume of the stream. [6]

- **Human impact**

  Humans are the major contributor which affect the volume of the stream or the river. For example, the water is used for irrigation, industrial and for daily life consumption from the stream as well as, dam and reservoir are made to generate electricity which is directly affecting in the volume of the stream. [6]

  Flow velocity is also known as flow speed which used to define the motion of the fluid in the directed direction. Generally, it expresses the motion in a mathematical way. Velocity is mainly depended upon downstream distance, depth, and transverse position. Flow velocity or the river velocity may be varied in different location according to the course of the river. The velocity of the stream varies by many factors which are as follow.

- **Channel shape**

  Channel shape is one of the aspects that affect the velocity of the stream. In a normal stream, the flow of the water is against the edge because of that the friction gets developed at the side and in the bed of the stream. Normally, the velocity of the stream is high when the flowing water faces less resistance due to a wide and deep river channel. [5]

- **Volume of water**

  The volume of water also affects the velocity of the stream, for example, when the volume of the stream increases, the velocity will get increase naturally. This may occur when there are occasions such as heavy rainfall, snow melting in the small stream, etc. When the volume of the stream gets higher for a longer period it may cause greater effects in velocity because mass water can cause erosion, as a result, the channel may get wider and deeper which allow water to move freely. [5]

- **Smooth and Rough Channels**

  A stream may have rocks, pebbles which create friction with the flowing water and decrease the velocity of the stream. When there are few rocks and pebbles, the friction between flowing water and the bottom will get low thus the velocity of the stream will get high. [5]

- **Riverbed's Gradient**

  The gradient of the river explains how the sudden rise or fall in the surface of the stream affects the velocity of the stream. For example, when the stream falls sharply downward in position the velocity of the stream will get high because of the gravitational force. The pulling force on a steep slope will be higher than on the plane surface. [5]

Flow measurement is an important issue for both human and aquatic life. Flow measurement of the stream required for the proper stream management such as flood control, water resource planning and pollution prevention, watershed project planning, design of management measures. There are different techniques to measure the flow rate of the river such as Moving boat method, Radioactive Tracer technique, and the velocity-area method. [11]

2.3 Velocity area method

Velocity area method also known as stream gauging is the most common method to determine the stream discharge. This method is generally applied in a stable flowing river or the stream which has a regular shape and size. The velocity of flowing water and the cross-sectional area of streams are the two major aspects to study during the experiment to determine the discharge. [11] This is one of the best methods to determine the flow rate from both an economical and a temporal angle. The total discharge can be determined by the following equation, where the stream is divided into an equal segment and the discharge of each segment is calculated by multiplying the segment area with the average flow rate of each segment. [11] [15] [19]

The discharge of the stream is can be determined by the following equation.

$$Q = V * A$$

Where Q is a discharge, V is the velocity of the stream and A is the cross section area.

In this method, the velocity of the stream should be measured in different points to determine the average velocity. Generally, a current meter is used to find the velocity of the stream. [21] [14] The current meter is equipment which measures the velocity of the given points and consists of a propeller that is placed under flowing water facing opposite of the flowing path. The average velocity of the stream can be determined by the number of rotations of the propeller which is attached with a measuring rod. [12] The current meter does not give an accurate result during the flood condition when there is high flow speed or when there is an obstacle in the river bed. When the flow of the water is very low then the current does not function properly which directly affect the results. To avoid such error, there need to be performed several measurements in several points in the same vertical line so that more accurate results can be obtained. [11] The velocity depends upon the depth and the width of the stream. It is important to measure the depth in a specific interval of points to determine accurate cross-section area of the stream. If the bed profile and stage are known, then the area of that portion is easy to determine. [12]

The velocity of the stream needs to be measured in several points when the width is too large because the water moves in different velocities in the cross-sectional area. The velocity of the water which flows near the edge of the stream faces more frictional force by the edges and bottom of the channel in comparison to the water that flows from the center of the channel. The number of measurements helps to get accurate data for further calculation. [12] During the velocity measurement $^{6}/_{10}$ of the total depth is suitable for the measurement which normally represents the average velocity of the stream. [4]

2.3.1 Measurement of depth

Depth can be measured in various ways according to the size of the stream for example if the depth of the stream is less than 0.9 m then wading or suspension rod can be used for the measurement but when the depth is about 4.6 m then sounding rod or handline is used for the depth measurement. When the velocity and the depth of the stream are too high then the cable line with the help of crane or echo sounder needs to be used. Measurement of depth is important because the propeller needs to be set up in $^{6}/_{10}$ of the total depth if the depth of the stream is lower than 2 ft. (0.60 m) but, if the depth of the stream is more than 2 ft. (0.60 m) then, the velocity must measure according to the two-point method. [15][20] The depth measurement technique can be seen in figure 3.

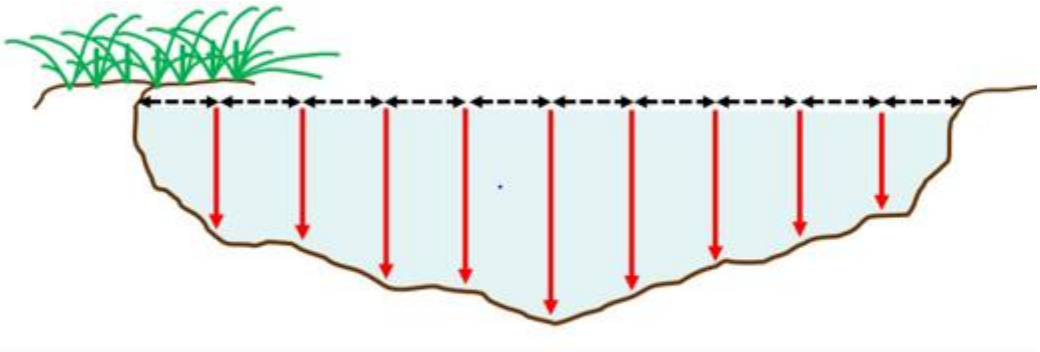


Figure 3: Depth measurement of the stream

Generally, the depths of the stream are determined by dividing the total width by 10 units for the accurate discharge [13]

2.3.2 Measurement of the flow velocity

Velocity may vary with respect to its position in the stream. River gradient, channel roughness and the shape of the stream are the major factors which directly affects the velocity of the stream. Velocity needs to measure separately in a different position to determine the accurate discharge. Although, there are various method to determine the velocity. For example, the current meter is one of the best methods to find out the velocity which usually used up to 3 ft. (0.915 m) the depth and the result will be in m/s. This is one of the oldest techniques which has been used over 300 years with a continuous modification over a period of time. This basically functions by the rotating element either by electric or brake switch under the water. Propeller and cup are the types of the current meter available in the market. [11]

The flow rate of the stream must be determined according to its depth, if the depth of the stream is large then the two-point method should be used. In this method, the flow rate should be measured in 0.2 and 0.8 depths below the surface of the water and the average of the measured flow rate should be considered as the flow rate of the measured section. [15] Figure 4 shows the velocity measurement method using the flow rate sensor.

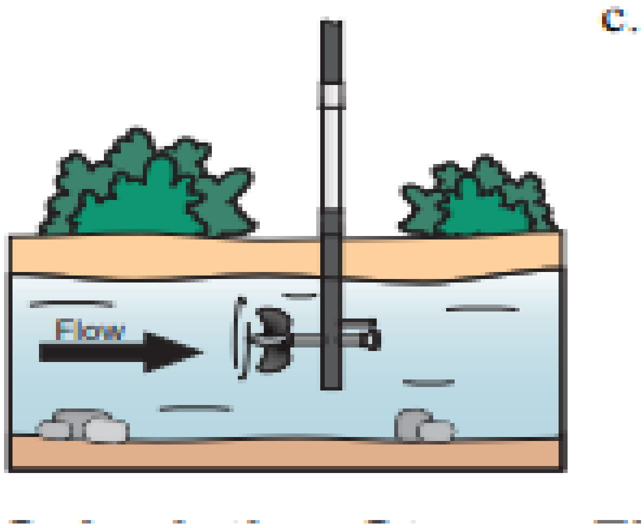


Figure 4: Measurement of stream velocity

The propeller is one of the important tools during the velocity measurement of the stream. It is normally used to measure the velocity of the liquid and gases whose characteristics are similar to those of the turbine meter with respect to technology and application. It is consists of a thick plastic which receives mechanical energy from the stream to rotate its rotor. The rotor is always facing towards stream flow placing the blade in such angel which convert stream flow energy into rotational energy. The propeller meter does not give an accurate data when the flow rate is very low because in such case the flow of water is not enough to rotate the rotor, but when the flow of water is fast the rotor rotates faster and provide a good result. The propeller should not be used in the stream when there is high velocity because in such condition bearing wear can be damaged.

A sensor is connected with the propeller known as propeller flow meter sensor which is placed outside of the stream to avoid for the false result. The propeller consists of a shaft blade whose movement can be noticed when there is a movement in the blade and the movement of the blade can be identified magnetically. Propeller meter is an easy tool to measure the velocity in the correct way without any significant error. [22]

2.3.3 Measurement of the width

To determine the number of depths and the cross-sectional area of the stream it is important to find out the width of the stream. Width is normally known as the distance between the banks of the stream. It is measured by the measuring tape kept 1m above the stream from one bank of the stream to the other. It is the basic way to measure the stream. There are various other ways to measure the width for example laser sensor, measuring tape. [18]

The measurement of the depth and width of the stream depends on the shape and size of the stream. Usually, the stream does not have a uniform shape (straight) and as well as the stream may consist of vegetation and rocks which bring a uniform error during calculation thus it is important to do several measurements to find out the average depth and width of the stream.

Velocity area method has some limitation which is not accepted in some situation for example when the river is too large it is difficult to perform the frequent measurement as well the cost of the measurement will be too high. This method will not provide an accurate result when there is no stable discharge caused by water release by the dams, barrages as well by the irregular land structure. [11]

2.4 Moving boat Method

The Moving boat method is another way of finding the flow rate of the stream, which is quite similar to the velocity-area method. Moving boat method was originated in 1960 because velocity area method was not applicable in all type of condition, for example, it was more time consuming, less accurate when the there is more flow of water in the stream and dangerous to use in large rivers. Moving boat method is mainly useful when the river stage fluctuates, and the flow condition varies. This method can be used in the reservoir and during the flood condition which gives the result in a short period of time with fewer risks.

In this method gauging launch, current meter, echo sounder, vane angle, rate indicator, and counter are the major equipment which is used during the experiment. Gauging launch is equipped with the current meter which is used to measure the integrate velocity of the stream and boat. The measurement is done by passing over the stream by the boat along with the equipment's where echo sounder figures out the cross-section of the selected path. In this technique, the boat travels across the stream in a preselected path with respect to the flow of the river. During the experiment around 40 to 60 observation was done while traveling across the river and the velocity obtains in each point by current meter assembly are the relative velocity of the flow. The meter assembly is intact with the stainless-steel shaft and a pointer by which the angel can be determined. Pointer gives the angle between the direction of the vane and the boat, which can be seen clearly in figure 5.

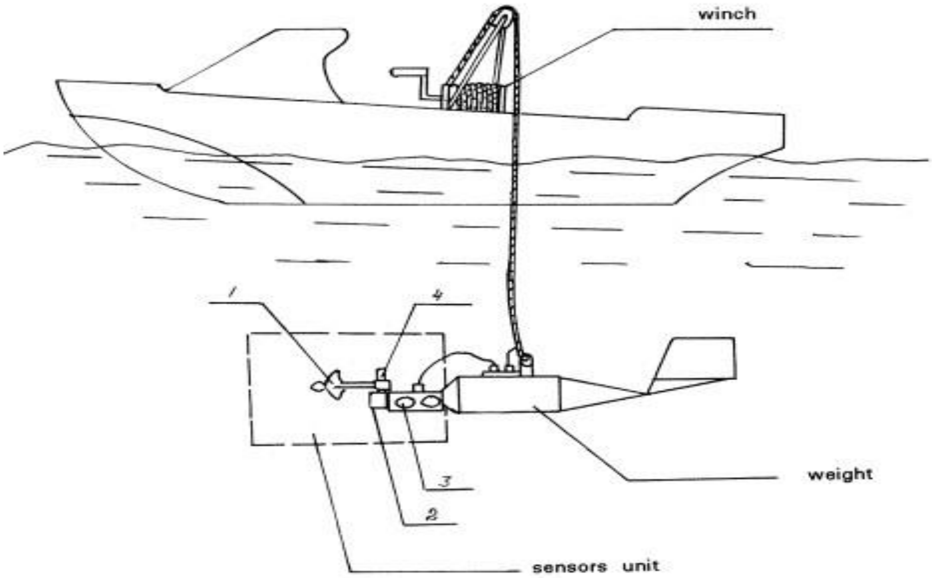


Figure 5: Moving boat Technique

The Moving boat method has also its own certain limitation, the equipment that is used in this method is more expensive than the equipment required in another method as well as it needs well-trained manpower to operate it. This method is not accepted in the narrow stream in addition to it is difficult to keep the boat on the same path while passing over the river or the stream. [26]

2.5 Vernier LabQuest

Vernier LabQuest is a measuring device which can operate its hardware or software independently by collecting or analyzing the data of the respected experiment. The LabQuest is a multifunctional device from which pH, Conductivity, Turbidity, Flow rate, Frequency of sound and many more data can be collected. It can transfer the collected data to the computer using Logger pro or Logger pro lite software. The measuring device consist of various ports on the top of the device where the sensor is connected, the device itself recognizes the type of sensor and it set itself for the data collection. The

Vernier LabQuest device can also measure the flow rate of the stream using the flow rate sensor.

Flow rate sensor is used to measure the velocity of the stream, river or channel as well as study the nature of the flow pattern and sedimentation transport. The flow rate sensor consists of 5 m cable along with three riser rods intact with it. The main component of the flow rate sensor is the blade, rotor and the bar magnet which are placed at the same spot. During the velocity measurement of the stream, the three-riser rod is dipped inside the stream opposite to the direction of flowing stream. when the water flows against the blade of the rotor it will start to rotate, the rotation of the blades depends upon the water flow rate of the stream. A bar magnet is intact with the rotator, which starts the reed switch in each half rotation. Conversion of pulses into a voltage sent by the switch to the signal conditioning box is proportional to flow rate. The flow rate sensor is already calibrated during the manufacture so, it does not need to calibrate while performing the new measurement. Flow rate is defined in meter per second (m/s) or feet per second (ft/s) and the basic design of the flow rate sensor can be seen in figure 6.

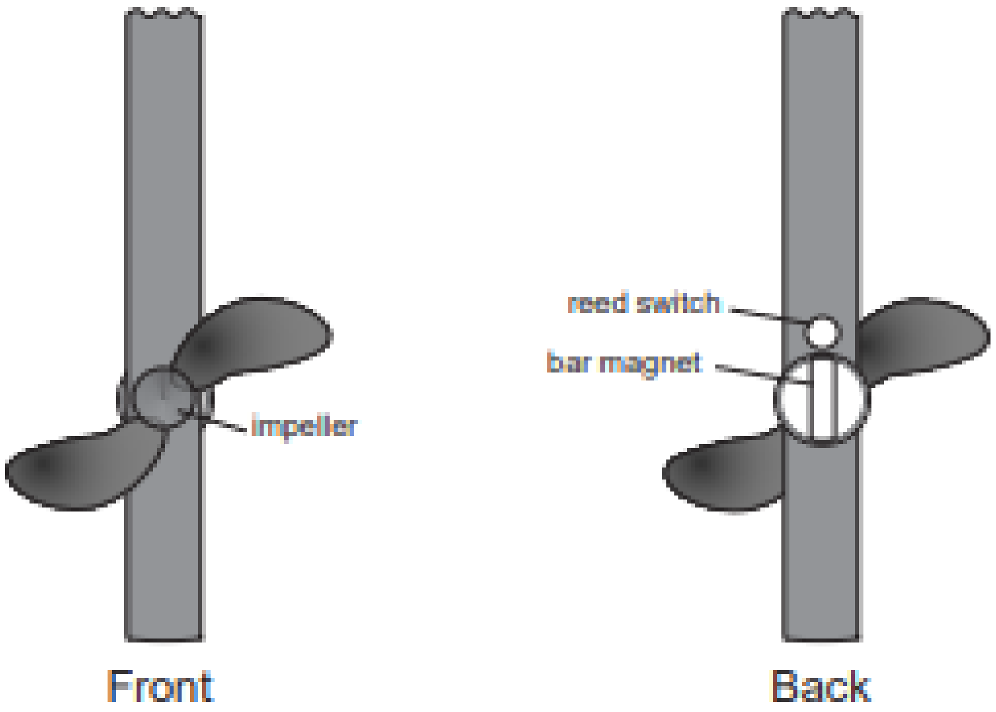


Figure 6: Flow rate sensor

Flow rate sensor has also its own limitation, the device cannot provide the accurate data when the weather condition is very poor because in such condition the streamflow may vary with the time also the sensor cannot function well when the measuring site consists of huge rocks or sand bars. To obtain the good result it is necessary to select the good spots where the flow of the stream is not affected by the above-mentioned factors. Time, date and weather are also the secondary factors that need to be considered before the measurement starts. [16]

2.6 Spawning site for salmon and trout

Salmon and trout usually prefer a small stream during the spawning period. In the case of Atlantic Salmon, the depth of the stream should be in between (20-50) cm and the average flow rate of the stream must be (35-65) cm/s. Trout usually prefer the stream whose flow rate is within (20-55) cm/s and depth is between 15 to 45 cm. Trout and salmon normally spawn in the slowly flowing stream and the base of the stream should consist of pebbles whose thickness should be (16-64) mm. [17]

3 Methodology

This experiment was entirely performed outside of the lab. In this experiment, every measurement was done in the selected spot which was requested by the Pekka Lindblad from Perhokalastajat ry on Mätäjoki and Haaganpuro stream. Velocity, width, and depth measurement are the major tasks performed using the same equipment at a different time of the year. All the measurement were performed on the site.

3.1 Sampling sites and condition

The field experiment was performed in various locations in Mätäjoki and Haaganpuro stream on a different date. The experiment was conducted in four different locations in Mätäjoki and only one location in Haaganpuro. It was started from mid of October and completed at the mid of November. The experiment was done over the period of a month on a weekly basis. The data was collected three times at every experimental spot and the mean value is taken as a result. Locations and experimental sites are shown below in Figure 7. The coordinates of the experimental sites are presented in tabular form in Table 1.

Table 1: Coordinates of Sampling sites

Stream	Sites	Longitude	Latitude
Mätäjoki	M1	24.864440	60.218844
	M2	24.864495	60.218681
	M3	24.863454	60.216785
	M4	24.861019	60.214592
Haaganpuro	H1	24.900234	60.211492

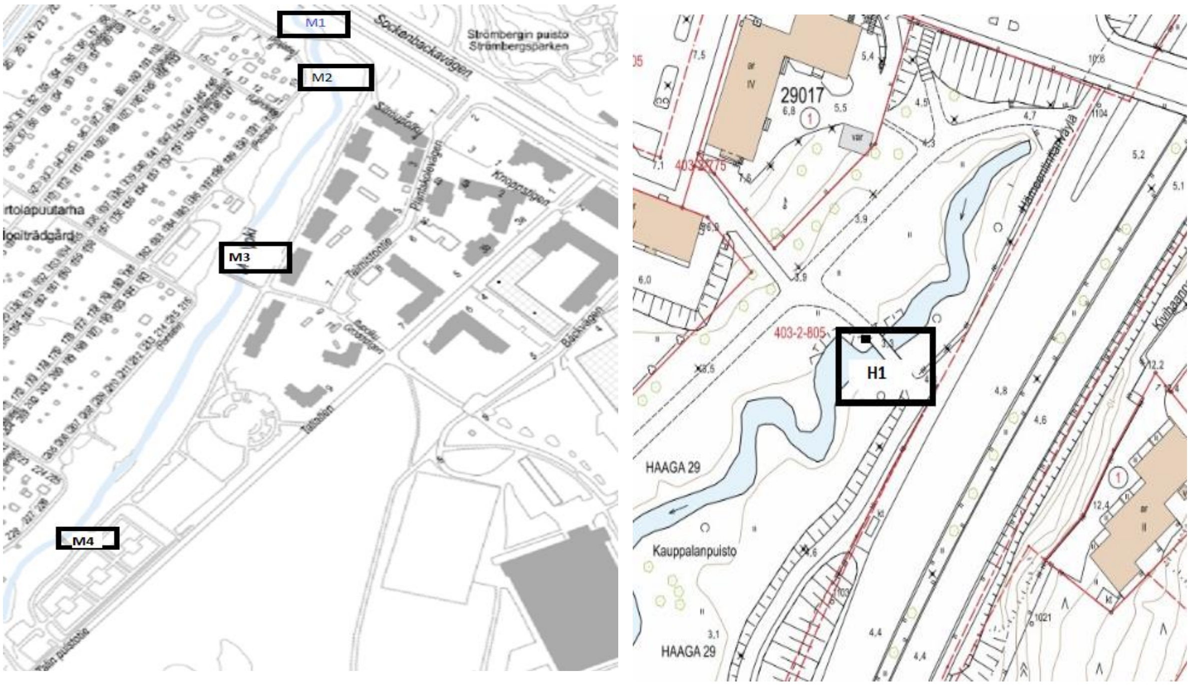


Figure 7: Sampling sites of Mätäjoki and Haaganpuro

3.1.1 Weather

The experiment was conducted at a different time in different weather condition in the same location repeatedly. At the beginning of the experiment it was raining and during the end of the experiment was lightly snowing.

3.1.2 Equipment used

The experiment was fully conducted onsite, and the equipment that was used listed below

- Vernier LabQuest - To measure the velocity of the stream
- Fishing Rod - To measure the depth of the stream
- Laser Measuring tape- To measure the width of the stream
- Measuring Tape - To measure the length of string that gets dipped inside the stream while measuring the actual depth

3.2 Procedure

All the experiment were conducted out in the field after collecting all the required equipment. Different techniques were applied during the experiment which is explained below.

3.2.1 Depth

Depth measurement is one of the major tasks to calculate the discharge of the selected spot. The depth was measured in the spot where the velocity of the stream was measured. The depth of the stream was measured at the various point in an upright position from one bank of the stream to the other side of the stream. The fishing rod was used to measure the depth by dipping the lead weight with the line by keeping float on water level surface. The float needs to be on the surface of the water and the lead weight should be on the bottom of the stream. After this, selected points depths were measured by scaling the dipped string with the measuring tape. The depth was measured according to the width of the stream, usually, five measurements were taken in all the spot except spot M3.

Haaganpuro stream is very small in comparison to Mätäjoki, thus, a normal measuring tape was used to measure the depth of the stream. The maximum depth of the stream was about 14 cm. Figure 8 shows the measurement of depth in Mätäjoki using a fishing float, lead weight, and rod.

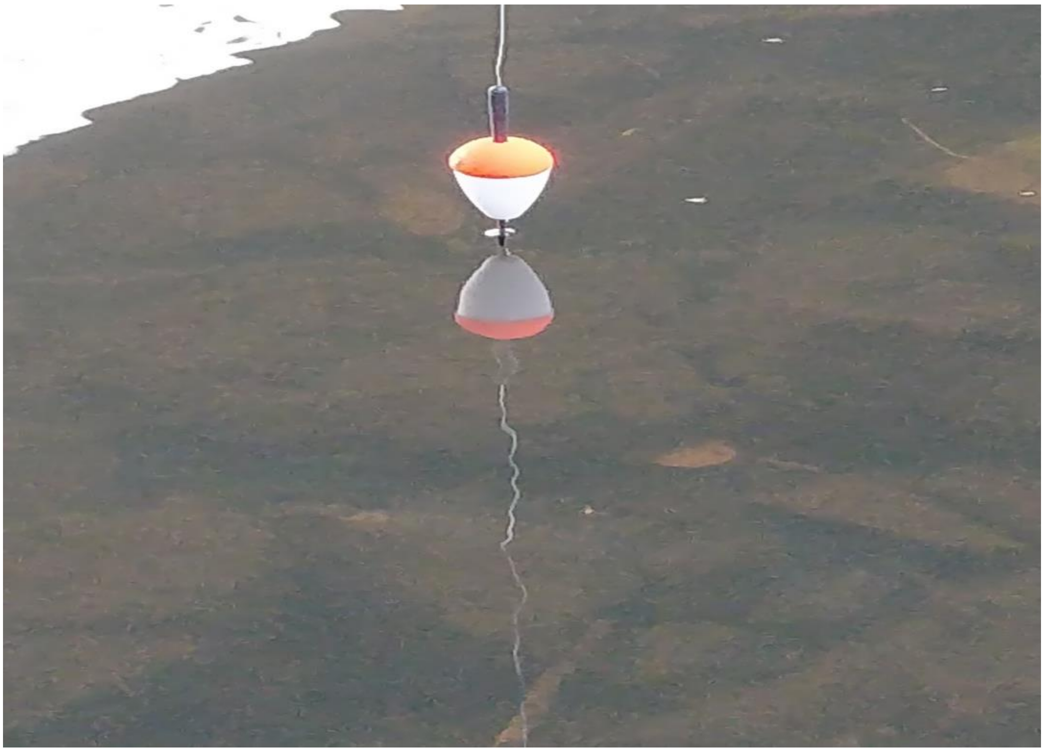


Figure 8: Measurement of depth using a fishing float, lead weight, and rod.

3.2.2 Width

The velocity of the stream is directly dependent with the width of the stream as mentioned above. In this experiment, the width of the stream is measured by using a laser and a normal measuring tape. The width of the Mätäjoki stream was large in comparison to Haaganpuro, it was difficult to measure the width of the chosen spot in Mätäjoki using a normal measuring tape; therefore, a laser device was used in Mätäjoki and normal measuring tape in Haaganpuro. Normally, the width of the stream was measured from one bank to another bank. In Mätäjoki, the laser was placed on one side of the bank and point out the laser into another side of the bank. In Haaganpuro, the width was measured by the measuring tape keeping on one edge to another edge as shown in figure 9 below and measured the width of the stream.

Figure 9: Measurement of width of the stream

3.2.3 Velocity Measurement

The velocity of the stream was measured using Vernier lab quest equipment along with the flow rate sensor. The width of the Haaganpuro stream is small in comparison to Mätäjoki; therefore, the velocity was measured in only one point in Haaganpuro, but the width of Mätäjoki is large so, the velocity was measured in two different positions vertically in the selected spots. During the experiment, the velocity was measured in the selected spot using the flow rate sensor with Vernier lab quest equipment by dipping the propeller with the help of the rod, facing it towards the stream. Normally, each measurement was conducted for about 4, 5 or 10 mins considering the nature of the selected spots. The width and the depth of Haaganpuro stream are small; thus, the velocity measurement was conducted only for 5 mins but in Mätäjoki stream, the experiment was run for 10 min in each selected point. The experiment was carried out from outside of the stream because it was prohibited to go inside the stream so, the flow rate measurement was not performed in each measured depth. In Mätäjoki, the measurement was done on both sides of the stream to achieve the mean flow rate of the stream. The measurement of the velocity of the stream is shown in Figure 10.

Figure 10: Measurement of the flow rate of the stream

Before measuring the velocity of the stream, the Vernier labQuest equipment was connected with the flow rate sensor. During the process, the flow rate sensor was connected in a port of the Vernier lab quest which is represented by `*CH*´. After connecting the sensor, the sensor menu on the display was clicked. After that, the *Sensor Setup* Option appeared*,* clicking on the sensor setup menu various channel options were shown, Where previously connected channel was selected and the flow rate was chosen during the sensor setup process.

In this experiment, the velocity of water was measured on a time base format. After setting up the flow rate sensor, the mode of measurement was selected to determine the time frame and the velocity measurement. The mode menu was located on the right side of the lab quest device through which the length of the measurement, as well as the number of samples per time, were determined during the flow rate measurement. The following process is shown in Figure 11 and Figure 12 below.

Figure 11: Flow rate measurement using Vernier labQuest (a)

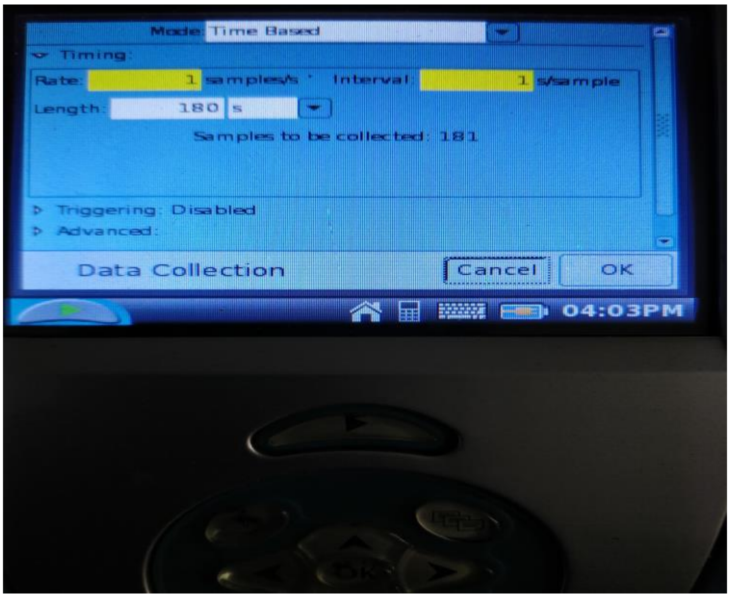


Figure 12: Flow rate measurement Using Vernier LabQuest (b)

After setting up the Vernier LabQuest device, the experiment was started by dipping the propeller with the help of rod into the water. The flow rate was measured by the device, displaying the velocity rate instantly. After collecting the result of the selected points, the recorded velocity data were stored in the device for further uses. The data can either stored in the device internal storage or in the external SD card. To save the data which was obtained during the experiment, first, open the file menu and click on 'save' afterward untitled text box will appear where the file can be saved.

The obtained data was in the *qmbl* format while saving in the LabQuest device which was unreadable by the normal software, but the data file was transferred to logger pro software. Logger Pro is data collection and analysis software from which collected data can convert from the *qmbl* file into Excel file.

The logger pro software cost around 339 $ due to which logger pro lite came as an alternative for us during the conversion of the data into excel file. The logger lite can be obtained from Vernier official site for both Windows and Mac Os, after installing the software, the experimental file was opened. After opening the file, the file menu on the taskbar was selected and clicked on *the Export* option, then the experimental data file need export on CSV format.

In this experiment, the CSV file was converted into Excel file in Google Sheets. To convert the file, CSV file was imported on Google Excel (Online) and converted it into Excel file. The converted CSV was readable in the Microsoft Excel from which the average velocity of each point of the Mätäjoki and Haaganpuro stream was determined. The collected result was used to determine the discharge of the stream.

4 RESULTS AND FINDINGS

The collected onsite data of Mätäjoki and Haaganpuro are presented below in two different labels as per the name of the stream.

4.1 Mätäjoki

The overall result of Mätäjoki stream was calculated using excel and presented in tabular form which is presented in Appendix 5. The obtained average flow rate of each sampling site is given in Table 2.

Table 2: Flow rates of Mätäjoki

Spots	flow rate on oct 17 (m/s)	flow rate on oct 29 (m/s)	flow rate on nov 4 (m/s)
M1	0.392	0.397	0.418
M2	0.106	0.116	0.139
M3	0.1655	0.0761	0.0764
M4	0.2315	0.2659	0.1529

The width in the figure below seems smaller than the depth of the stream but in real life, the width of the stream is Larger than the depth of the stream which can be seen in figure 13, figure 14, figure 15 and figure 16.

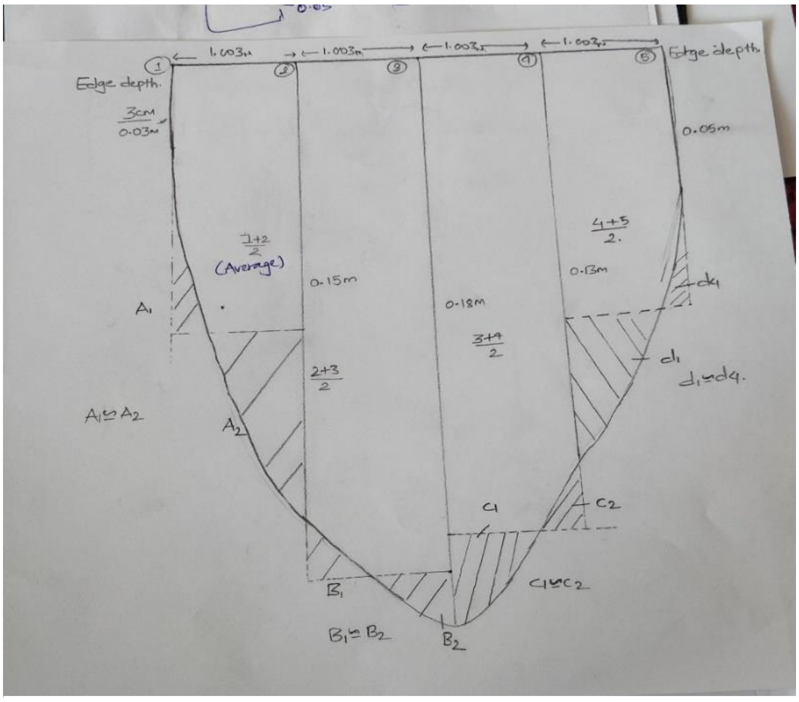


Figure 13: Area and Basic structure of M1 - Mätäjoki

4cm width= 1.003m actual width

1cm depth = 0.01m actual depth

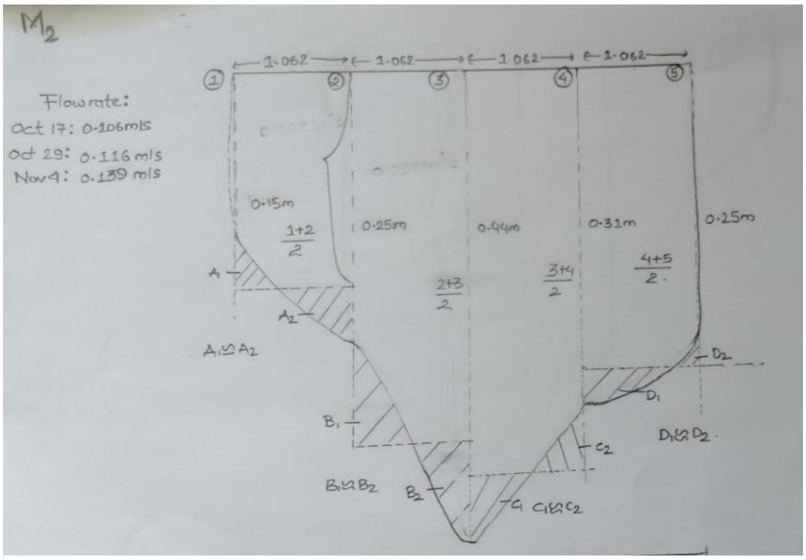
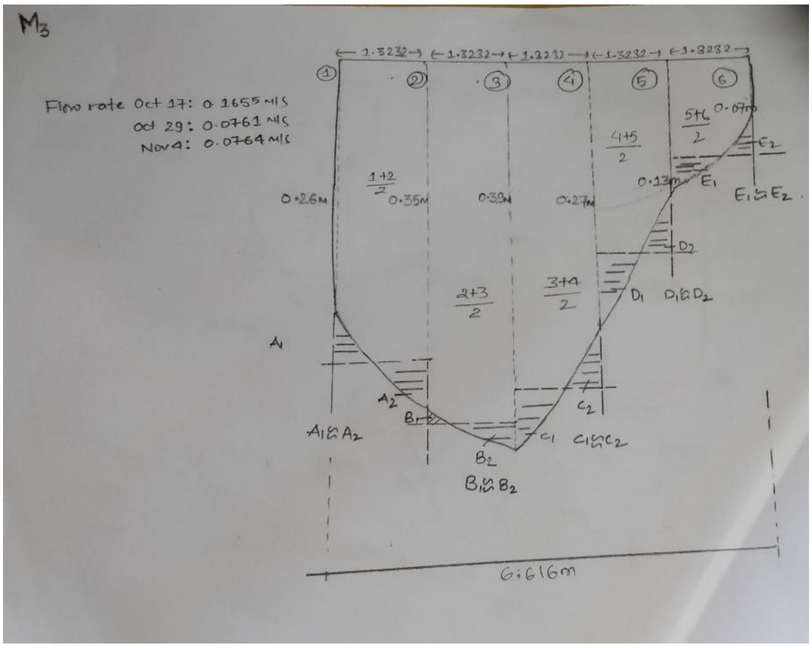


Figure 14: Area and Basic structure of M2 - Mätäjoki

4cm depth = 1.062m actual width

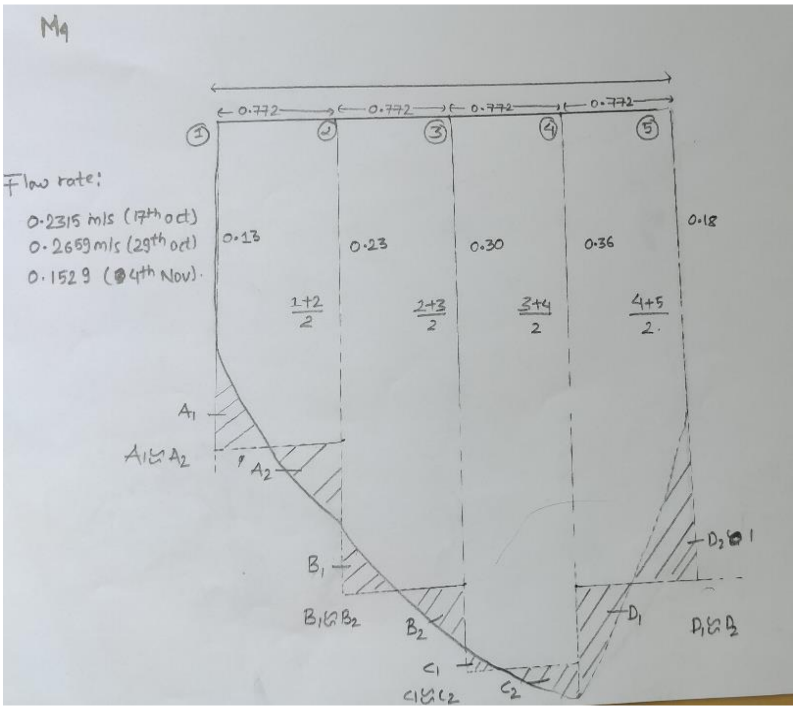
1cm depth = 0.03m actual depth



3cm width = 1.3232 m

1cm depth = 0.03 m actual depth

Figure 15: Area and Basic structure of M3 - Mätäjoki



4cm width = 0.772m real width

1 cm depth = 0.2m actual depth

Figure 16: Area and Basic structure of M4 - Mätäjoki

The above-mentioned spots in Mätäjoki are supposed to be the best spawning ground for the sea trout. The flow measurement was conducted thrice to determine the average flow rate and the average discharge of the selected spots of the stream. The depth and width of the stream ranged from (0.093 m to 0.28 m) and (3.8m to 6.61 m) in various selected spots. The velocity was measured either for 10 or 4 minutes according to the weather condition and 10 units of data were collected for each minute. 100 units of data, for example, was collected when the measurement was conducted for 10 minutes. The velocity was measured in two different places in M1 and M4 spot, where the flow of water seems to be high and only one measurement was taken in M2 and M3 spots where the flow seems low. The average flow rate was determined in excel by calculating the collected data by LabQuest as shown in table 1.

The individual discharge of the particular spot is the sum of the product of average depth, equally partition of the total width and the flow rate of the respective spot on the respective date. The above calculation can be seen in table 1. The overall flow rate and the overall discharge of the M1 are higher with the result of 0.418 m/s and 0.201 m^3/s and the lowest flow rate was in M3 with the result 0.0771 m/s and the lowest average discharge was in M2 spot with the result 0.153 m^3/s.

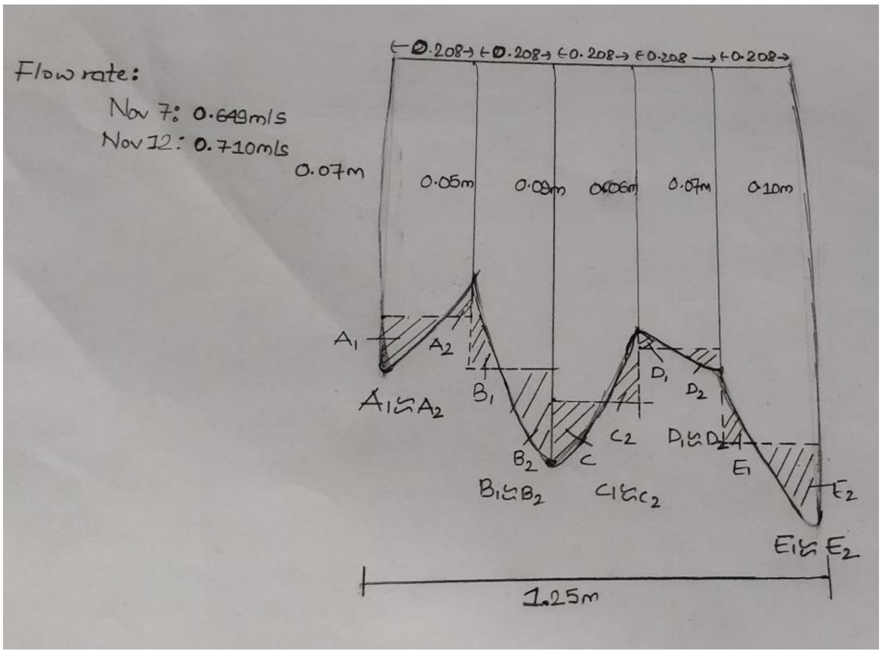
4.2 Haaganpuro

The data collected in Haaganpuro stream are shown in Table 3 and the calculated data are shown in Appendix 6.

Table 3: Flow rates of Haaganpuro

Sites	Dates	Average Flow rate (m/s)
H1	Nov 7	0.649
	Nov 12	0.710

In Haaganpuro, only two measurements were performed where the flow rate was 0.0649 m/s and 0.710 m/s respectively. The width of the stream is 1.25 m and the total width was divided into 5 equal sections with 0.208 m in length. The discharge on two different dates were 0.0479 m^3/s and 0.0524 m^3/s. The irregular structure of Haaganpuro was due to unequal distribution in depth which can be seen below in Figure 17.



2cm width = 0.208 m actual width

1cm depth = 0.01 m actual depth

Figure 17: Area and Basic structure of H1 - Haaganpuro

5 Discussion

In this section, the different results of the same spot and the overall result of Mätäjoki and Haaganpuro are presented.

5.1 Mätäjoki

All the obtain flow rates of the different spots of Mätäjoki are discussed below:

5.1.1 M1 spot

It can be seen in figure 18 that velocities of this spot at different time are not always the same. Here, the overall velocities of the spot were very high on October 29, where the overall velocities were low on October 17. The depths of this spot were less in comparison to the other spot and it is next to the curve path of the stream.

The weather condition had played a significant role in the result during the measurement. As seen in the chart, there was a huge difference in velocities before and after a snowfall. The velocity of the spot was maximum in 29^{th} Oct when the snowfall started then the temperature was high enough to melt snow, which results in high velocity in the spot. The overall weather condition was rainy after 29^{th} Oct so, the flow rate on 29^{th} Oct and 4^{th} Nov looks similar to each other. The flow rate on Oct 17 was low because the volume of water was low during that time and the availability of water was very low. The motion of the propeller can be interfered by leaves or other floating/moving bodies. In the graph below, it can be seen that there were some sudden changes in the flow rate which was caused by the interference in the propeller for a brief period, as observed. The different flow rate on different time period can be observed in figure 18 below.

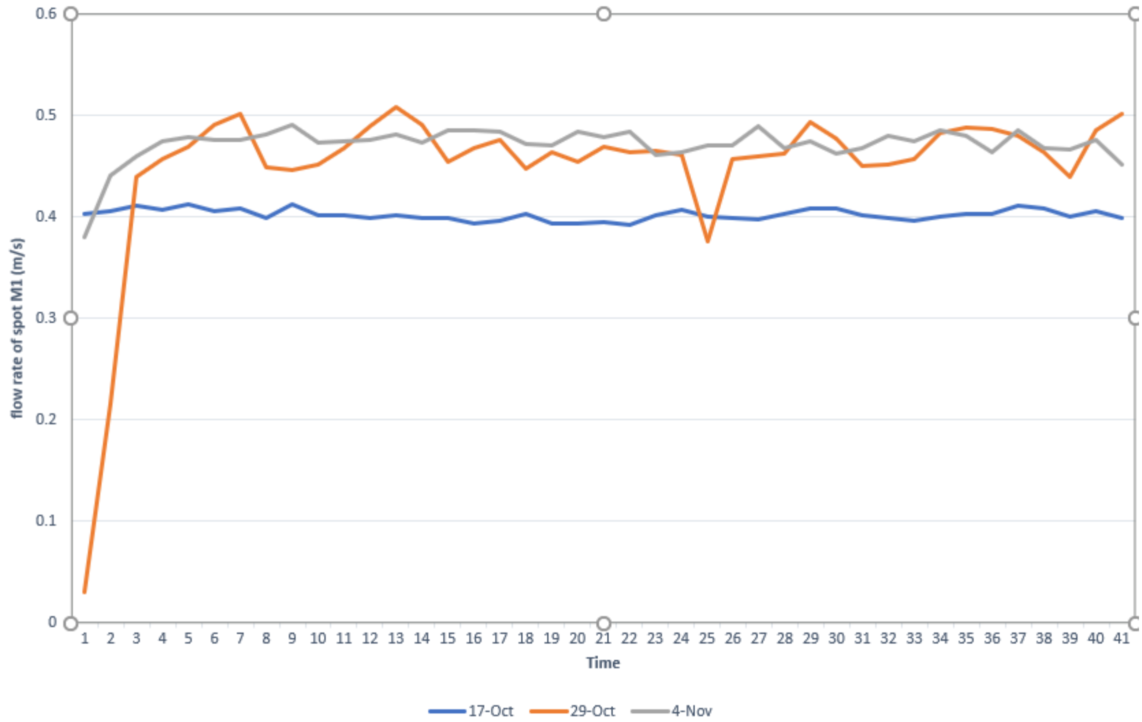


Figure 18: Flow rate comparison of M1 spot

The measuring spot was just above the sloppy surface; thus, the channel shape played a major role in the velocity of the stream. When the depth of the stream is very less than the flow rate of the stream will be high, which can be seen in the result, that the overall flow rate of M1 was high in comparison to others. Here, it is assumed that flow rate declines after M1 due to the frictional force with button pebbles, dead autumn leaves, and twigs. However, the flow rate should be more than obtained data but due to the frictional force with button pebbles as well as the dead autumn leaves, the overall flow rate was not as it should be.

The discharge of this spot was also more than the other measured spot. The discharge of M1 was 0.20m^3/s on Oct 17, 0.20 m^3/s on Oct 29 and 0.21 m^3/s on Nov 4. The overall discharge of this spot was very similar to each other on different dates.

5.1.2 M2 spot

The distance between M1 and M2 is about 41 meter and the overall velocities of this spot in three different measurements seem the same. M2 is wider and it has the highest depth among all the measure spots, but due to the plane surface and the obstacles, the flow rate was less and every result was similar to each other. Analyzing the result of different dates, it can be seen that the measured velocities were between 0.1 m/s to 0.15 m/s. The graph below shows that the changes in weather didn't play any significant role in the overall velocities. Figure 19 shows the flow rate of M2 spot on different dates respectively.

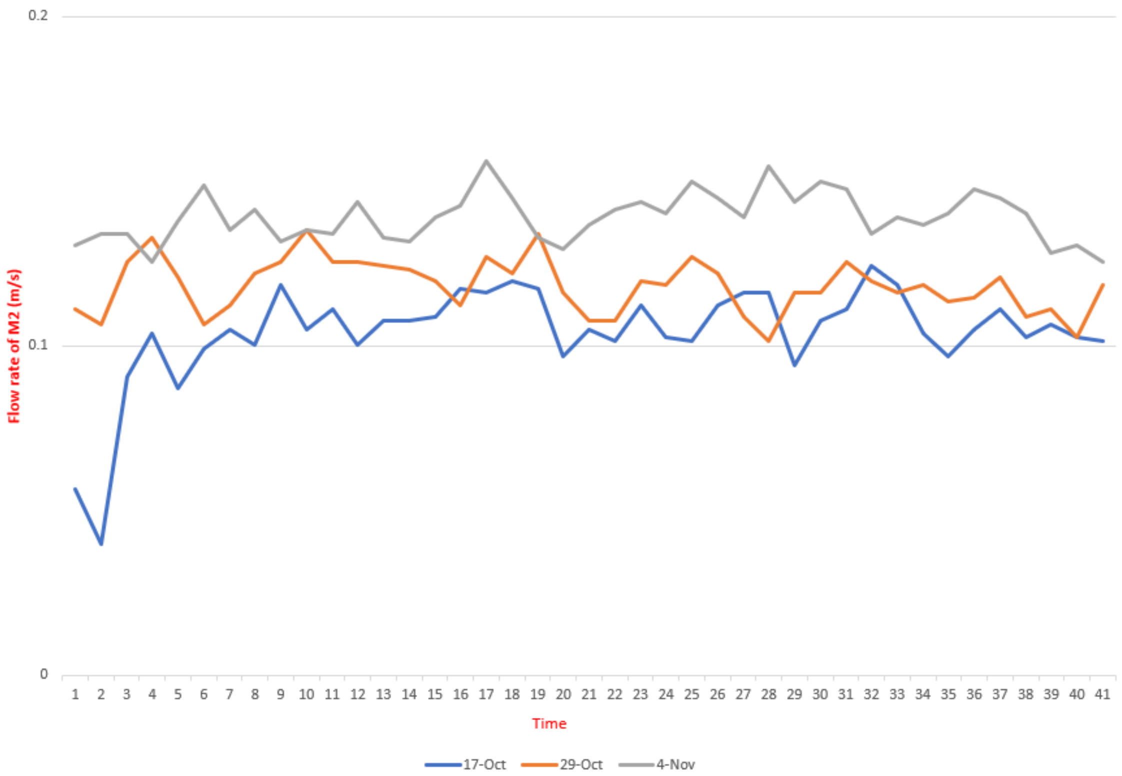


Figure 19: Flow rate comparison of M2 spot

The site was in between trees and buses, thus, there were a large number of fallen autumn leaves on the base of the stream. M2 had less sloppy surface and more roughness as well as slurry mud on the button of the stream. The flow rate of the spot was less in comparison to the first point. But, due to the larger depth and width, the overall discharge was close to other results. As seen in the graph, there were numbers of fluctuation during the measurement but when analyzing it closely only a small fraction of variation appears during the different measurement which means, the factor that is affecting the flow rate does not have any compelling effects in this section.

The discharge of this spot was 0.18 m^3/s on Oct 17, 0.15 m^3/s on Oct 29 and 0.14 m^3/s on Nov 4 respectively. The discharge of this measured spot was less in comparison to M1 and M4.

5.1.3 M3 spot

The distance between the M2 and M3 spot is about 200 m, which has a greater influence in the flow rate and the overall discharge of the stream. The width and depth of this spot were bigger than the others measured spot. There were lots of trees, bushes on the flowing path between M2 and M3. During the second and third measurement, the flowing path was cover by the dead autumn leaves and the twigs which directly made an impact on the flow rate of the stream. There was not any sloped surface in the flowing path, so the movement of flowing water was very slow near this spot.

Seasonal change has played a major role in this spot while measuring the flow rate. In the graph, it shows that the average velocity of the stream was more on Oct 17 and a less on Oct 29. Because of the smooth channel shape, there were fewer dead leaves before 1st measurement which create less friction with the flowing water. But, due to the changed weather condition the amount of the dead autumn leaves, twigs were higher which create a more frictional force with water, thus, there was a small change in the flow rate of this spot. It can be identified from the graph that the overall flow in this section was the same before and after the snow falls. Analyzing the graph closely the flow rate increase is very low. The different flow rate of M3 is shown in figure 20 below.

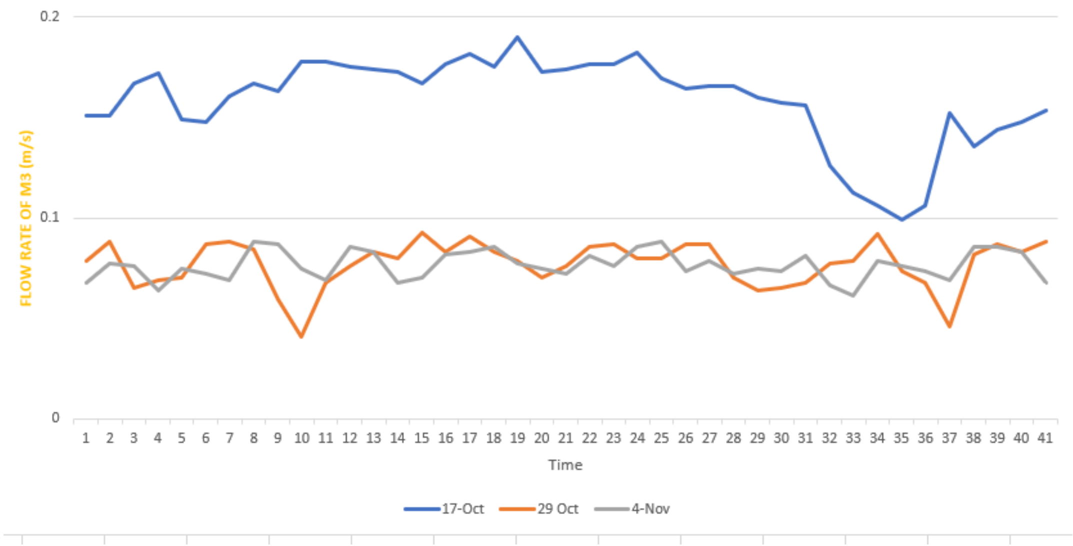


Figure 20: Flow rate comparison of M3 spot

The discharge of M3 was 0.26 m^3/s on Oct 17, 0.12 m^3/s on Oct 29 and 0.12 m^3/s on Nov 4. The flow rate of this spot was lesser than other but due the largest width and depth, the final discharge was very close to M2.

5.1.4 M4 spot

This spot has a small width in comparison to the other points with a total width of 3.862 m. This spot was in the sloped surface but due to the narrow body structure, the average flow rate was higher than the other two measure spot. Analyzing the graph below it shows that the flow rate of the spot was higher before the snowfall (November 4) and the overall velocity of the spot was low on 4th Nov after the snowfall.

Figure 21 shows that less amount of water has been passed from M3 to M4, the flow rate of M4 was fully dependent on M3. The graph shows that the changes in weather condition had played an important role in the flow rate. The flow rate of this section was high during the mid-October when there was less obstacle in the flowing path. In the later phase of the experiment, the flow of this section decreased due to excessive leaf fall in the stream which increases the friction with water flow. The longer distance between M3 and M4 could have impacted the flow rate as there could be some obstruction or blockade along the stream path. The nature of the graph of M3 and M4 spot is same thus, it can be analyzed the flow rate of the spot M4 mainly depends upon M3. So, whatever happens in M3 spot it will directly affect the M4. The channel shape of the M3 spot plays a vital role in the M4 spot.

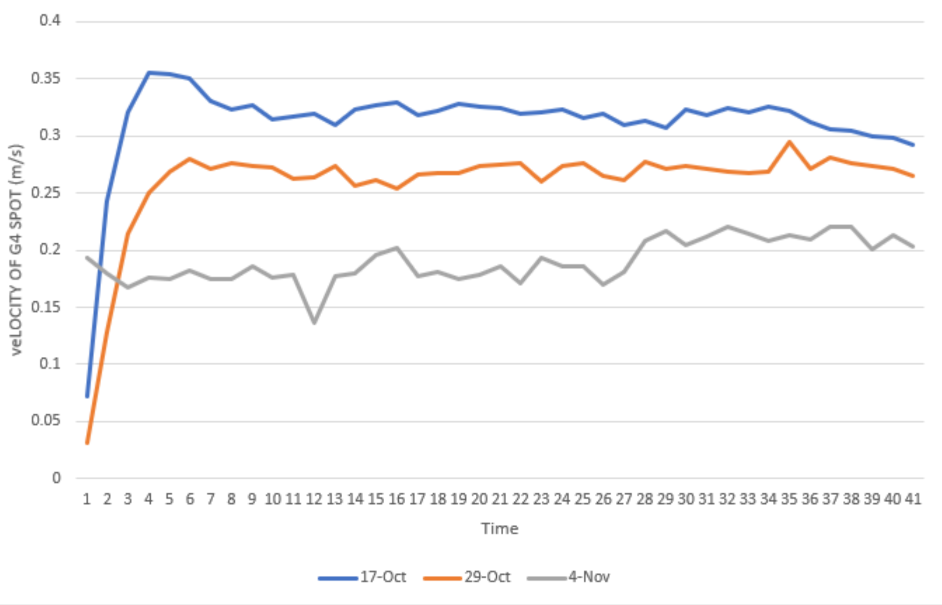


Figure 21: Flow rate comparison of M4 spot

The discharge of this spot was highly fluctuating in different weather condition. The discharge on Oct 17 was 0.19 m^3/s, 0.22 m^3/s on Oct 29 and 0.13 m^3/s on Nov 4.

The depths and the flow rate of M1 spots meets the requirement to be the spawning sites for the trout's also the depths of M2 and M3 spot is acceptable but the average flow rate of this point is below the required flow rate for the trout and salmon hence, M2 and M3 are the least suitable spot for spawning. The average depth and the average flow of M4 are also acceptable as spawning site in Mätäjoki stream.

5.2 Haaganpuro

Two different measurements were performed in Haaganpuro, the first experiment was carried out on Nov 7 and the next one was on Nov 12. The overall flow rate of the 2nd experiment was higher in comparison to the previous flow rate of our own experiment, because of rainfall happened on 12th November. The velocity of the stream was high because of the small depth, width, and sloppy surface. The velocity of the stream is inversely proportional to the area of the stream so, when the cross-sectional area is less the flow rate will be higher. The depth was higher in the edge than the center of the stream; thus, the frictional force acting on it will be less on the edge. The overall velocities of Haaganpuro can be seen in figure 22 below.

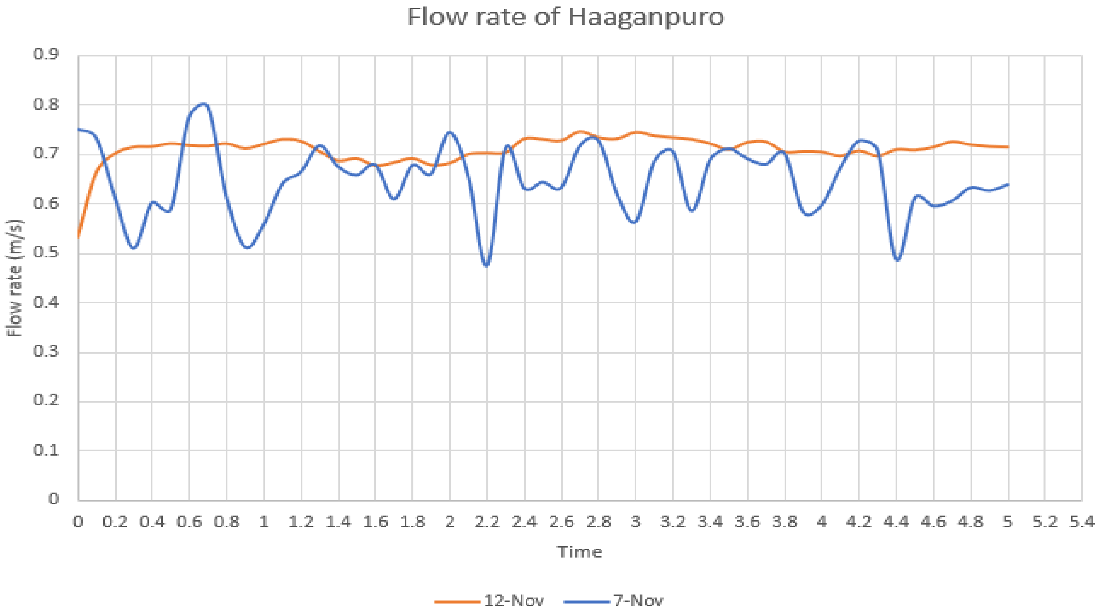


Figure 22: Flow rate of Haaganpuro

The discharge of Nov 12 was higher than the discharge of Nov 7 because of the rainfall. Due to a change in the weather, the flow rate of the selected spot and the overall discharge of this section increased. This spot of Haaganpuro is less suitable as a trout site because the overall depth of the stream is less than 0.15 m and the average flow rate was more than 0.55 m/s. The discharge of the measured spot was 0.05 m^3/s and 0.04 m^3/s on the following dates.

5.2.1 Factor affecting flow rate and discharge on measured stream

The result shows that the final discharge and the flow rate of the stream were affected by the stream channel shape, riverbed gradient, roughness or the smoothness of the stream as well the weather condition during the measurement. The flow rate of the stream was mainly affected by the depth and the position of the measured spot.

The result chart shows us that the discharge of Mätäjoki stream was increasing in downstream from M2 spot expect M1 whose gradient was higher than the other measure spot. The overall result was effect by the width and depth of the stream. As it can be seen, the flow rate of M3 spot is quite low in comparison to other spot but due to bigger width and the depths, the final discharge of the stream was higher than the M2. In Haaganpuro, the flow rate and the discharge of the same spot were changing slightly in two different weather condition.

5.3 Haaganpuro Vs Mätäjoki

The measured spot of Haaganpuro and Mätäjoki has different character while comparing. The width and depth of Haaganpuro are smaller than Mätäjoki, but the average flow rate of Haaganpuro was more than Mätäjoki. The discharge of every measured spot of Mätäjoki was more than the discharge of Haaganpuro, but the overall flow rate was changed in the different weather condition in both streams.

6 Conclusion

The main purpose of this thesis was to determine the flow rate and the discharge of Mätäjoki and Haaganpuro stream, along with the width and depth of the streams in different time intervals. The results of onsite measurement show us that, the flow rate of Mätäjoki was more favorable for the brown trout than in Haaganpuro. The flow rate and depth of Mätäjoki are feasible for the brown trouts except for M2 and M3, whose flow rate appeared low in all three measurements. The flow rate of Haaganpuro sampling site was very high and the depth was below the required depths. Thus, Haaganpuro is the least suitable spot for the trout.

Comparing the result of the same sampling site of different dates, the flow rate of the streams was highly affected by the weather condition, the volume of water on the stream, stream shape and its position. The flow rate of both Haaganpuro and Mätäjoki was increased during rainfall and snowfall but the examination showed that at M2 and M3 there were not any significant changes in flow in any weather condition due to the stream shape and its position in the stream.

This thesis provides the latest result on Haaganpuro and Mätäjoki. The limitation of this thesis was that only 2 to 3 different measurements were taken in a different interval of time and only one flow rate measurement was taken in the sampling site due to the trout spawning sites, we were unable to go inside the stream to take numbers of flow rate measurement. The depth of the sampling site was measured in five to six different points in the upright position and the distance between two sampling sites was not in equal distance. The experiment was conducted for about one month. To get a better result, the flow rate of the sampling site needs to be measured for at least 2 years. [21]. The velocity area method was applied in this experiment which has its own limitation, it will not provide the accurate result when there is unstable discharge caused by the dams, barrages as well by the irregular land structure.

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8 Appendices

Appendix 1: Width measure by the Laser device

Appendix 2: Vernier labQuest and Flow rate sensor

Appendix 3: Measurement of depth

Appendix 4: Flow rate raw data of Mätäjoki obtained from Vernier LabQuest and flow rate sensor on Oct 17

Run 1 : tin	Run 1: Flo	Run 2: Tin	Run 2: Flo	Run 3: Tin	Run 3: Flo	Run 4: Tin	Run 4: Flo	Run 5: Tin	Run 5: Flo	Run 6: Tin	Run 6: Flow Rate (m/s)
0	0.320816	0	0.403214	0	0.056686	0	0.151215	0	0.076065	0	0.072403
0.1	0.368042	0.1	0.405655	0.1	0.039749	0.1	0.151215	0.1	0.125732	0.1	0.243301
0.2	0.3862	0.2	0.411682	0.2	0.090637	0.2	0.166931	0.2	0.147552	0.2	0.320816
0.3	0.385056	0.3	0.406799	0.3	0.103912	0.3	0.171814	0.3	0.145111	0.3	0.355911
0.4	0.381393	0.4	0.412903	0.4	0.086975	0.4	0.148773	0.4	0.145111	0.4	0.354767
0.5	0.382614	0.5	0.405655	0.5	0.099106	0.5	0.147552	0.5	0.147552	0.5	0.349884
0.6	0.400772	0.6	0.40802	0.6	0.105133	0.6	0.160904	0.6	0.156021	0.6	0.330505
0.7	0.3862	0.7	0.399551	0.7	0.100327	0.7	0.166931	0.7	0.15358	0.7	0.323257
0.8	0.405655	0.8	0.412903	0.8	0.118484	0.8	0.163269	0.8	0.1548	0.8	0.326843
0.9	0.399551	0.9	0.401993	0.9	0.105133	0.9	0.177841	0.9	0.163269	0.9	0.314789
1	0.393524	1	0.401993	1	0.111237	1	0.177841	1	0.16449	1	0.317154
1.1	0.387421	1.1	0.398331	1.1	0.100327	1.1	0.1754	1.1	0.162125	1.1	0.319595
1.2	0.389862	1.2	0.401993	1.2	0.107574	1.2	0.174179	1.2	0.160904	1.2	0.309906
1.3	0.385056	1.3	0.399551	1.3	0.107574	1.3	0.172958	1.3	0.1548	1.3	0.323257
1.4	0.389862	1.4	0.398331	1.4	0.108795	1.4	0.166931	1.4	0.149994	1.4	0.326843
1.5	0.392303	1.5	0.393524	1.5	0.117264	1.5	0.17662	1.5	0.156021	1.5	0.329285
1.6	0.395966	1.6	0.395966	1.6	0.116043	1.6	0.181503	1.6	0.151215	1.6	0.318375
1.7	0.398331	1.7	0.403214	1.7	0.119705	1.7	0.1754	1.7	0.156021	1.7	0.322037
1.8	0.389862	1.8	0.393524	1.8	0.117264	1.8	0.189972	1.8	0.1548	1.8	0.328064
1.9	0.393524	1.9	0.393524	1.9	0.096664	1.9	0.172958	1.9	0.1548	1.9	0.325623
2	0.387421	2	0.394745	2	0.105133	2	0.174179	2	0.160904	2	0.324478
2.1	0.393524	2.1	0.392303	2.1	0.101471	2.1	0.17662	2.1	0.15358	2.1	0.319595
2.2	0.389862	2.2	0.401993	2.2	0.112381	2.2	0.17662	2.2	0.159683	2.2	0.320816
2.3	0.394745	2.3	0.406799	2.3	0.102692	2.3	0.182648	2.3	0.156021	2.3	0.323257
2.4	0.399551	2.4	0.400772	2.4	0.101471	2.4	0.169373	2.4	0.135422	2.4	0.315933
2.5	0.393524	2.5	0.398331	2.5	0.112381	2.5	0.16449	2.5	0.14267	2.5	0.319595
2.6	0.385056	2.6	0.39711	2.6	0.116043	2.6	0.16571	2.6	0.145111	2.6	0.309906
2.7	0.398331	2.7	0.403214	2.7	0.116043	2.7	0.16571	2.7	0.15358	2.7	0.313568
2.8	0.393524	2.8	0.40802	2.8	0.094223	2.8	0.159683	2.8	0.146332	2.8	0.307465
2.9	0.400772	2.9	0.40802	2.9	0.107574	2.9	0.157242	2.9	0.146332	2.9	0.323257
3	0.392303	3	0.401993	3	0.111237	3	0.156021	3	0.157242	3	0.318375
3.1	0.398331	3.1	0.398331	3.1	0.124512	3.1	0.125732	3.1	0.16571	3.1	0.324478
3.2	0.398331	3.2	0.395966	3.2	0.118484	3.2	0.112381	3.2	0.156021	3.2	0.320816
3.3	0.376511	3.3	0.400772	3.3	0.103912	3.3	0.106354	3.3	0.14389	3.3	0.325623
3.4	0.383835	3.4	0.403214	3.4	0.096664	3.4	0.099106	3.4	0.145111	3.4	0.322037
3.5	0.380173	3.5	0.403214	3.5	0.105133	3.5	0.106354	3.5	0.147552	3.5	0.312347
3.6	0.393524	3.6	0.410461	3.6	0.111237	3.6	0.152359	3.6	0.146332	3.6	0.306244
3.7	0.376511	3.7	0.40802	3.7	0.102692	3.7	0.135422	3.7	0.148773	3.7	0.305023
3.8	0.380173	3.8	0.400772	3.8	0.106354	3.8	0.14389	3.8	0.14267	3.8	0.300217
3.9	0.387421	3.9	0.405655	3.9	0.102692	3.9	0.147552	3.9	0.157242	3.9	0.298996
4	0.382614	4	0.398331	4	0.101471	4	0.15358	4	0.1548	4	0.291748
4.1	0.387421	4.1	0.398331	4.1	0.112381	4.1	0.169373	4.1	0.147552	4.1	0.295334
4.2	0.381393	4.2	0.395966	4.2	0.120926	4.2	0.169373	4.2	0.145111	4.2	0.289307
4.3	0.394745	4.3	0.392303	4.3	0.097885	4.3	0.17662	4.3	0.137863	4.3	0.283279
4.4	0.383835	4.4	0.39711	4.4	0.106354	4.4	0.168152	4.4	0.14267	4.4	0.271149
4.5	0.3862	4.5	0.40802	4.5	0.091782	4.5	0.168152	4.5	0.160904	4.5	0.283279
4.6	0.377731	4.6	0.406799	4.6	0.116043	4.6	0.181503	4.6	0.149994	4.6	0.283279
4.7	0.374146	4.7	0.388641	4.7	0.107574	4.7	0.172958	4.7	0.156021	4.7	0.283279
4.8	0.380173	4.8	0.394745	4.8	0.101471	4.8	0.174179	4.8	0.15358	4.8	0.301437
4.9	0.381393	4.9	0.401993	4.9	0.113602	4.9	0.166931	4.9	0.1548	4.9	0.286865
5	0.382614	5	0.411682	5	0.106354	5	0.160904	5	0.145111	5	0.291748
5.1	0.377731	5.1	0.393524	5.1	0.110016	5.1	0.180283	5.1	0.152359	5.1	0.283279
5.2	0.387421	5.2	0.391083	5.2	0.107574	5.2	0.163269	5.2	0.159683	5.2	0.295334
5.3	0.387421	5.3	0.394745	5.3	0.102692	5.3	0.13176	5.3	0.1548	5.3	0.301437
5.4	0.381393	5.4	0.398331	5.4	0.097885	5.4	0.134201	5.4	0.157242	5.4	0.300217
5.5	0.370483	5.5	0.388641	5.5	0.103912	5.5	0.158463	5.5	0.149994	5.5	0.298996
5.6	0.383835	5.6	0.39711	5.6	0.095444	5.6	0.16449	5.6	0.141525	5.6	0.305023
5.7	0.394745	5.7	0.399551	5.7	0.101471	5.7	0.166931	5.7	0.147552	5.7	0.301437
5.8	0.382614	5.8	0.404434	5.8	0.106354	5.8	0.166931	5.8	0.146332	5.8	0.306244
5.9	0.391083	5.9	0.393524	5.9	0.089417	5.9	0.16449	5.9	0.134201	5.9	0.308685
6	0.3862	6	0.393524	6	0.097885	6	0.169373	6	0.146332	6	0.301437
6.1	0.391083	6.1	0.391083	6.1	0.111237	6.1	0.170593	6.1	0.135422	6.1	0.305023
6.2	0.401993	6.2	0.393524	6.2	0.12207	6.2	0.169373	6.2	0.14267	6.2	0.305023
6.3	0.391083	6.3	0.389862	6.3	0.118484	6.3	0.163269	6.3	0.128174	6.3	0.300217
6.4	0.400772	6.4	0.40802	6.4	0.114822	6.4	0.1754	6.4	0.128174	6.4	0.295334
6.5	0.392303	6.5	0.399551	6.5	0.118484	6.5	0.174179	6.5	0.147552	6.5	0.296555
6.6	0.385056	6.6	0.389862	6.6	0.108795	6.6	0.177841	6.6	0.157242	6.6	0.294189
6.7	0.383835	6.7	0.383835	6.7	0.118484	6.7	0.177841	6.7	0.149994	6.7	0.302658
6.8	0.391083	6.8	0.377731	6.8	0.116043	6.8	0.168152	6.8	0.15358	6.8	0.318375
6.9	0.388641	6.9	0.389862	6.9	0.117264	6.9	0.174179	6.9	0.146332	6.9	0.312347
7	0.387421	7	0.393524	7	0.100327	7	0.170593	7	0.162125	7	0.324478
7.1	0.393524	7.1	0.385056	7.1	0.116043	7.1	0.179062	7.1	0.152359	7.1	0.309906
7.2	0.391083	7.2	0.393524	7.2	0.12207	7.2	0.163269	7.2	0.151215	7.2	0.315933
7.3	0.398331	7.3	0.3862	7.3	0.124512	7.3	0.179062	7.3	0.151215	7.3	0.312347
7.4	0.398331	7.4	0.3862	7.4	0.111237	7.4	0.1754	7.4	0.151215	7.4	0.319595
7.5	0.388641	7.5	0.401993	7.5	0.118484	7.5	0.169373	7.5	0.159683	7.5	0.319595
7.6	0.393524	7.6	0.383835	7.6	0.117264	7.6	0.174179	7.6	0.158463	7.6	0.309906
7.7	0.398331	7.7	0.387421	7.7	0.118484	7.7	0.179062	7.7	0.163269	7.7	0.294189
7.8	0.389862	7.8	0.3862	7.8	0.102692	7.8	0.170593	7.8	0.116043	7.8	0.320816
7.9	0.400772	7.9	0.389862	7.9	0.118484	7.9	0.1754	7.9	0.148773	7.9	0.318375
8	0.394745	8	0.3862	8	0.102692	8	0.1754	8	0.1548	8	0.318375
8.1	0.383835	8.1	0.393524	8.1	0.124512	8.1	0.172958	8.1	0.1548	8.1	0.320816
8.2	0.393524	8.2	0.400772	8.2	0.12207	8.2	0.169373	8.2	0.159683	8.2	0.325623
8.3	0.410461	8.3	0.399551	8.3	0.114822	8.3	0.1754	8.3	0.160904	8.3	0.325623
8.4	0.393524	8.4	0.388641	8.4	0.105133	8.4	0.179062	8.4	0.151215	8.4	0.328064
8.5	0.398331	8.5	0.382614	8.5	0.099106	8.5	0.166931	8.5	0.169373	8.5	0.320816
8.6	0.393524	8.6	0.3862	8.6	0.097885	8.6	0.180283	8.6	0.16449	8.6	0.328064
8.7	0.389862	8.7	0.39711	8.7	0.084534	8.7	0.174179	8.7	0.147552	8.7	0.330505
8.8	0.375366	8.8	0.371704	8.8	0.091782	8.8	0.177841	8.8	0.156021	8.8	0.341415
8.9	0.391083	8.9	0.3862	8.9	0.102692	8.9	0.170593	8.9	0.157242	8.9	0.331726
9	0.3862	9	0.387421	9	0.116043	9	0.172958	9	0.158463	9	0.343857
9.1	0.3862	9.1	0.371704	9.1	0.125732	9.1	0.166931	9.1	0.160904	9.1	0.343857
9.2	0.393524	9.2	0.3862	9.2	0.125732	9.2	0.169373	9.2	0.159683	9.2	0.351105
9.3	0.389862	9.3	0.387421	9.3	0.108795	9.3	0.174179	9.3	0.1548	9.3	0.334167
9.4	0.399551	9.4	0.387421	9.4	0.102692	9.4	0.179062	9.4	0.1548	9.4	0.334167
9.5	0.395966	9.5	0.382614	9.5	0.044556	9.5	0.169373	9.5	0.16449	9.5	0.328064
9.6	0.392303	9.6	0.387421			9.6	0.162125	9.6	0.160904	9.6	0.324478
9.7	0.388641	9.7	0.393524			9.7	0.171814	9.7	0.16571	9.7	0.330505
9.8	0.387421	9.8	0.388641			9.8	0.170593	9.8	0.170593	9.8	0.325623
9.9	0.403214	9.9	0.387421			9.9	0.172958	9.9	0.160904	9.9	0.328064
10	0.393524	10	0.380173			10	0.169373	10	0.152359	10	0.330505

Run 1 and Run 2	M1 spot
Run 3	M2 spot
Run 4	M3
Run5 and Run 6	M4 spot

Appendix 5: Discharge results of Mätäjoki

	A	B	C	D	E	F	G	H	I	J
1	Spot M1									
2	measured depths	avg. depth	equal distribution of	flow rate on oct 17	flow rate on oct 29	flow rate on nov 4	discharge on oct 17	discharge on oct 29	discharge on nov 4	overall discharge (avg.)
3	0.03	0.09	1.003	0.392	0.397	0.418	0.03538584	0.03583719	0.03773286	0.196588
4	0.15	0.165	1.003	0.392	0.397	0.418	0.06487404	0.065701515	0.06917691	0.1990955
5	0.18	0.155	1.003	0.392	0.397	0.418	0.06094228	0.061719605	0.06498437	0.209627
6	0.13	0.09	1.003	0.392	0.397	0.418	0.03538584	0.03583719	0.03773286	0.201770167
7	0.05						0.196588	0.1990955	0.209627	
8										
9	Spot M2									
10	measured depths	avg. depth	equal distribution of	flow rate on oct 17	flow rate on oct 29	flow rate on nov 4	discharge on oct 17	discharge on oct 29	discharge on nov 4	overall discharge (avg.)
11	0.15	0.2	1.062	0.106	0.116	0.139	0.0225144	0.0246384	0.0295236	0.1771416
12	0.25	0.345	1.062	0.106	0.116	0.139	0.03883734	0.04250124	0.05092821	0.1478304
13	0.44	0.375	1.062	0.106	0.116	0.139	0.0422145	0.046197	0.05535675	0.1350864
14	0.31	0.28	1.062	0.106	0.116	0.139	0.03152016	0.03449376	0.04133304	0.1533528
15	0.25						0.1350864	0.1478304	0.1771416	
16										
17	Spot M3									
18	measured depths	avg. depth	equal distribution of	flow rate on oct 17	flow rate on oct 29	flow rate on nov 4	discharge on oct 17	discharge on oct 29	discharge on nov 4	overall discharge (avg.)
19	0.26	0.305	1.3232	0.1655	0.0761	0.0764	0.066791828	0.030712134	0.030833206	0.259502676
20	0.35	0.37	1.3232	0.1655	0.0761	0.0764	0.081026152	0.037257342	0.037404218	0.119324191
21	0.39	0.33	1.3232	0.1655	0.0761	0.0764	0.072266568	0.033229522	0.033360518	0.119794589
22	0.27	0.2	1.3232	0.1655	0.0761	0.0764	0.04379792	0.020139104	0.020218496	
23	0.13	0.1	1.3232	0.1655	0.0761	0.0764	0.02189896	0.010069552	0.010109248	
24	0.07						0.285781428	0.131407654	0.131925686	0.166207152
25										
26	Spot M4									
27	measured depths	avg. depth	equal distribution of	flow rate on oct 17	flow rate on oct 29	flow rate on nov 4	discharge on oct 17	discharge on oct 29	discharge on nov 4	overall discharge (avg.)
28	0.13	0.18	0.772	0.2315	0.2659	0.1529	0.03216924	0.036949464	0.021246984	0.19212185
29	0.23	0.265	0.772	0.2315	0.2659	0.1529	0.04736027	0.054397822	0.031280282	0.22067041
30	0.3	0.33	0.772	0.2315	0.2659	0.1529	0.05897694	0.067740684	0.038952804	0.12689171
31	0.36	0.27	0.772	0.2315	0.2659	0.1529	0.04825386	0.055424196	0.031870476	
32	0.18						0.18676031	0.214512166	0.123350546	0.179894657

Appendix 6: Overall results of Haaganpuro

	A	B	C	D	E	F	G	H	I	J
1	Spot	Depth	Average Depth	Width	Partition Width	Flow Rate on Nov 7	flow rate	Discharge on Nov7	Discharge on Nov 12	overall discharge
2	H1	0.07	0.06	1.25	0.208	0.649	0.71	0.00809952	0.0088608	0.0524264
3		0.05	0.07		0.208	0.649	0.71	0.00944944	0.0103376	0.04792216
4		0.09	0.075		0.208	0.649	0.71	0.0101244	0.011076	
5		0.06	0.065		0.208	0.649	0.71	0.00877448	0.0095992	
6		0.07	0.085		0.208	0.649	0.71	0.01147432	0.0125528	
7		0.1	0					0.04792216	0.0524264	0.05017428