RAPPORT

Nr. 30/2020

Uncertainty of Vinge or FlowTracker2 discharge measurement - User Manual

Brukermanual, software for usikkerhetsberegning, Flygel eller FlowTracker2

Alexandre Christophe Hauet

NVE Rapport 30/2020

Uncertainty of Vinge or FlowTracker2 discharge measurement - User Manual
Brukermanual, software for usikkerhetsberegning, Flygel eller FlowTracker2

Utgitt av: Norges vassdrags- og energidirektorat

Redaktør: N/A

Forfatter: Alexandre Christophe Hauet

ISBN: 978-82-410-2051-3

ISSN: 1501-2832

Sammendrag:

Dette er manualen til software for beregning av usikkerhet i Flygel- eller FlowTracker2-målinger.

This is the manual for the software for calculating uncertainty in Flygel or FlowTracker2 measurements.

Se også/see also Uncertainty of discharge measurement methods - A literature review (Rapport 27/2020, ISBN: 978-82-410-2048-3)

Link aug. 2020

Flygel: https://alexandrehauet.shinyapps.io/Uncertainty_Vinge_CurrentMeter/

FT2: https://alexandrehauet.shinyapps.io/Uncertainty_FlowTracker2/

Emneord:

Vannføring, vannføringsmåling, salt, fortynning, saltfortynning, saltmåling, nøyaktighet, usikkerhet, usikkerhetsberegning, måleusikkerhet, feilkilder, GUM, HUG, kvalitet

Discharge, discharge measurement, salt, dilution, salt dilution, salt measurement, accuracy, uncertainty, uncertainty calculation, measurement uncertainty, sources of error, GUM, HUG, quality

Norges vassdrags- og energidirektorat

Middelthuns gate 29
Postboks 5091 Majorstuen
0301 Oslo

Telefon: 22 95 95 95
E-post: nve@nve.no
Internett: www.nve.no
august, 2020

Forord

Denne rapporten er en av flere rapporter om usikkerhet i vannføringsmålinger skrevet av Alexandre Christophe Hauet, PhD, for hydrometriseksjonen på NVE. Hydrometri - Teknikk og feltdrift HHT, Hydrologisk avdeling, NVE.

Hauet jobbet i ett år for HHT, NVE, fra august 2019 til august 2020, finansiert av FoU-midler i prosjektet 80501 «Nye metoder for måling av vannføring og sedimenttransport». Usikkerhetsberegning var en viktig del av dette prosjektet.

Hege Hisdal

avdelingsdirektør

Morten Nordahl Due

seksjonssjef

Norges vassdrags- og energidirektorat

Report

Uncertainty of Vinge or FlowTracker2 discharge measurement: User Manual

---

Alexandre HAUET

Version of
August 6, 2020

Contents

1 Introduction 2

2 How to use the software 2
- 2.1 Analyse the measurement file 2
- 2.2 Results 2

3 How to understand and use the uncertainty budget 3

4 Examples of measurements, and how to improve them 6
- 4.1 Low uncertainty measurement 6
- 4.2 Measurement with a complex lateral velocity distribution 7
- 4.3 Measurement with 1 point per vertical 8
- 4.4 Measurement with very slow velocities 9

1 Introduction

Different methods have been published in order to compute the uncertainty of discharge measurements realized using a current meter and the velocity-area method. A recent literature review conducted at NVE shown that 3 methods are operationally used by hydrometric agencies in the world: the ISO 748 method [3] (the only standardized method existing), the IVE method [4, 1], and the Flaure method [2]. Those methods are not described in that User Manual, and the reader should refer to the literature review report or to the papers cited. The literature review proved that the Flaure method is the most advanced one, and is recommended to be used at NVE. A R application was developed in order to apply the 3 uncertainty methods listed above to a mechanical current meter measurement that have been analysed with the Vinge software. This document describes how to use it.

2 How to use the software

2.1 Analyse the measurement file

Two softwares were created to process:

- measurements done with a mechanical current meter and computed using the Vinge software. This software should be lauched at `https://alexandrehauet.shinyapps.io/Uncertainty_Vinge_CurrentMeter/`
- measurements done with a FlowTracker2. This software should be lauched at `https://alexandrehauet.shinyapps.io/Uncertainty_FlowTracker2/`

As illustrated in figure 1:

1. Select the .Vng file (for Vinge measurement) or the .dis.csv file (for FlowTRacker2 measurement)
2. Select the method you want to use to compute the uncertainty. The Flaure method must be used as the reference method, but you can also use Iso or IVE method to compare the results.
3. Compute the uncertainty

2.2 Results

The software shows two panels. In the Main panel, as illustrated in figure 2:

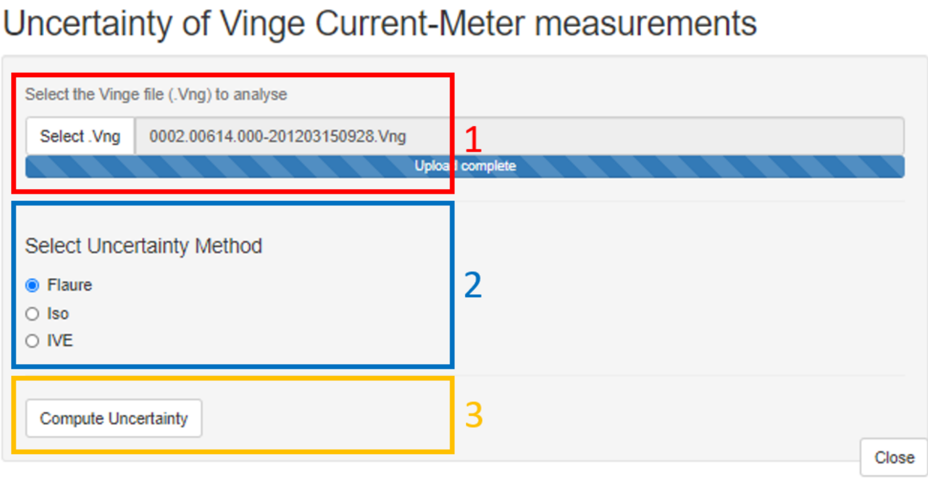

Figure 1: Import of a Vinge file and selection of the uncertainty method

1. The value of the discharge is displayed with it's expended uncertainty at the 95% confidence level.
2. A figure shows the bathymetry of the cross-section together with the location and the magnitude of the velocity measured and the corresponding verticals power units (depth $\times$ depth-average velocity)
3. A figure shows the relative weight of the different sources of uncertainty.

The panel called All uncertainty methods displayed the uncertainty budgets and expanded values computed using the 3 methods.

3 How to understand and use the uncertainty budget

The following uncertainty sources are considered:

- Systematic error represents the residual error with the true discharge value if the measurement was done in perfect ideal condition. It is fixed at 2% and can not be reduced.
- Width and Depth error are related to the measurement of the width and the depth. They are computed using the Iso 748 standard and are generally low.
- Depth averaged velocity error is related to the number of points per vertical used to computed the depth averaged velocity. To reduce it, you should consider to increase the number of points per vertical.

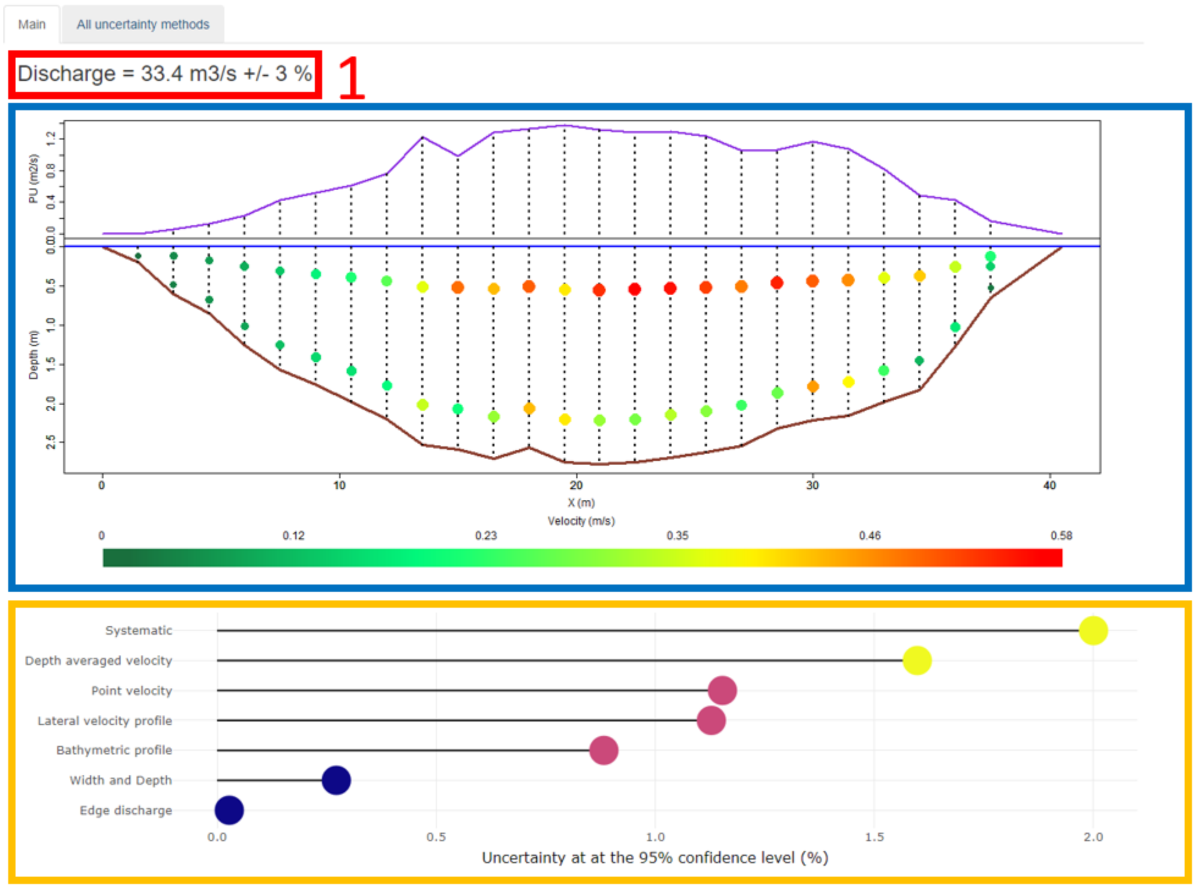

Figure 2: Illustration of the cross-section bathymetry together with the location and the magnitude of the velocity measured, and of the corresponding verticals power units (depth × depth-average velocity)

- Point velocity error is related to the measurement of a single point velocity and is mostly linked to the magnitude of the velocity (the slowest, the highest the error) and to the exposure time. To reduce it, you should consider to increase the exposure time, or to find a section with more velocity.
- Bathymetric profile error is related to the complexity of the cross-section bathymetry. The more complex it is (bumps, high gradients of slope), the more important is the error. To reduce it, you should do more verticals, or choose a cross-section with a smoother bathymetry.
- Lateral velocity profile error is related to the complexity of the velocity lateral distribution over the cross-section. To reduce it, you should do more verticals, or choose a

cross section with a smoother velocity lateral distribution.

- Edge discharge error is related to the extrapolation of the discharge close to the edges. To reduce it, you should locate the first and last verticals close to the banks.

4 Examples of measurements, and how to improve them

4.1 Low uncertainty measurement

Figure 3 shows a measurement with a very low uncertainty. The total expended uncertainty is low, about 3%, and the main error source is the systematic error, that is fixed and can not be reduced. It's not possible to reduce the uncertainty of this measurement, the best has been done !

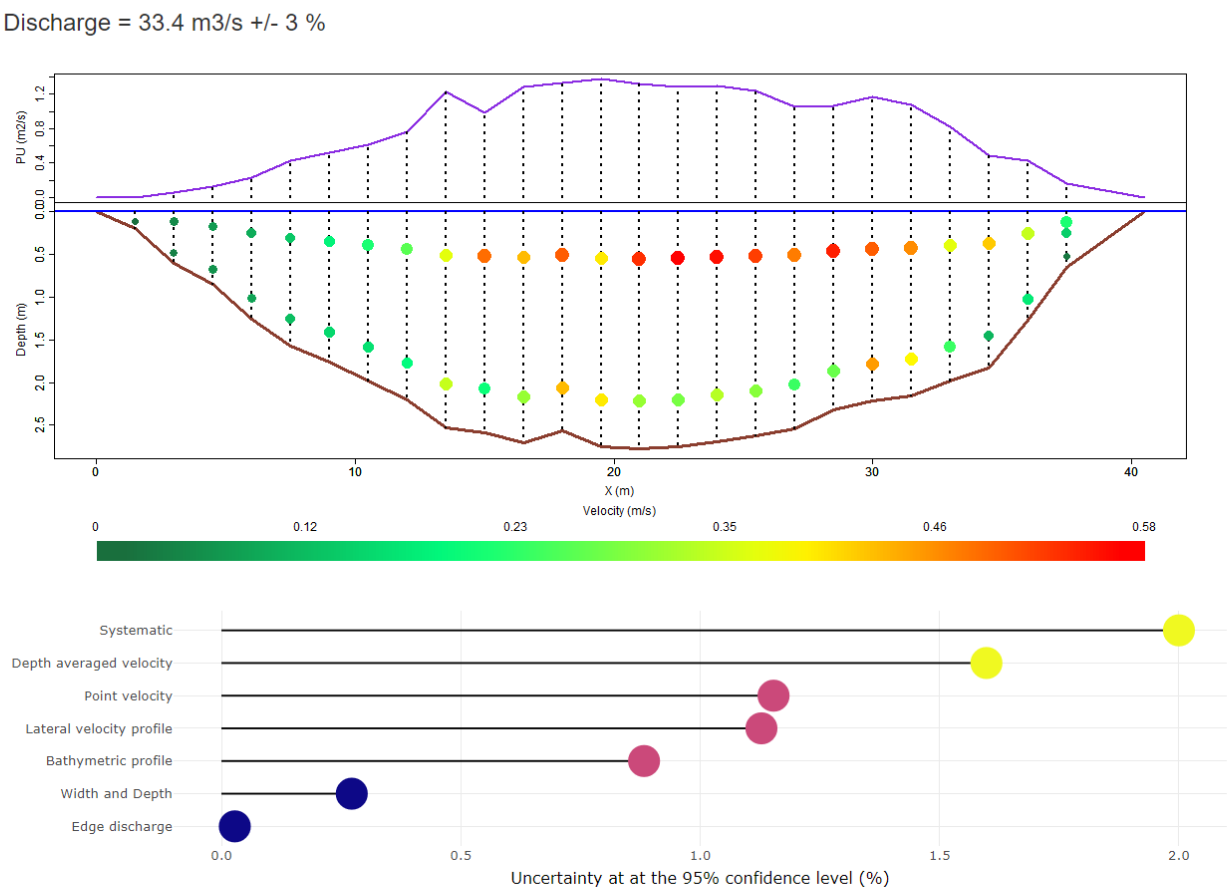

Figure 3: Measurement with low uncertainty

4.2 Measurement with a complex lateral velocity distribution

Figure 4 illustrate a cross-section with a lateral velocity profile showing high gradients. The total uncertainty is high, about 16%, and the main error source is the lateral velocity profile. One should have choose an other cross-section with a smoother velocity distribution, or, if this section was the only possible solution, one should have make more verticals to reduce the uncertainty.

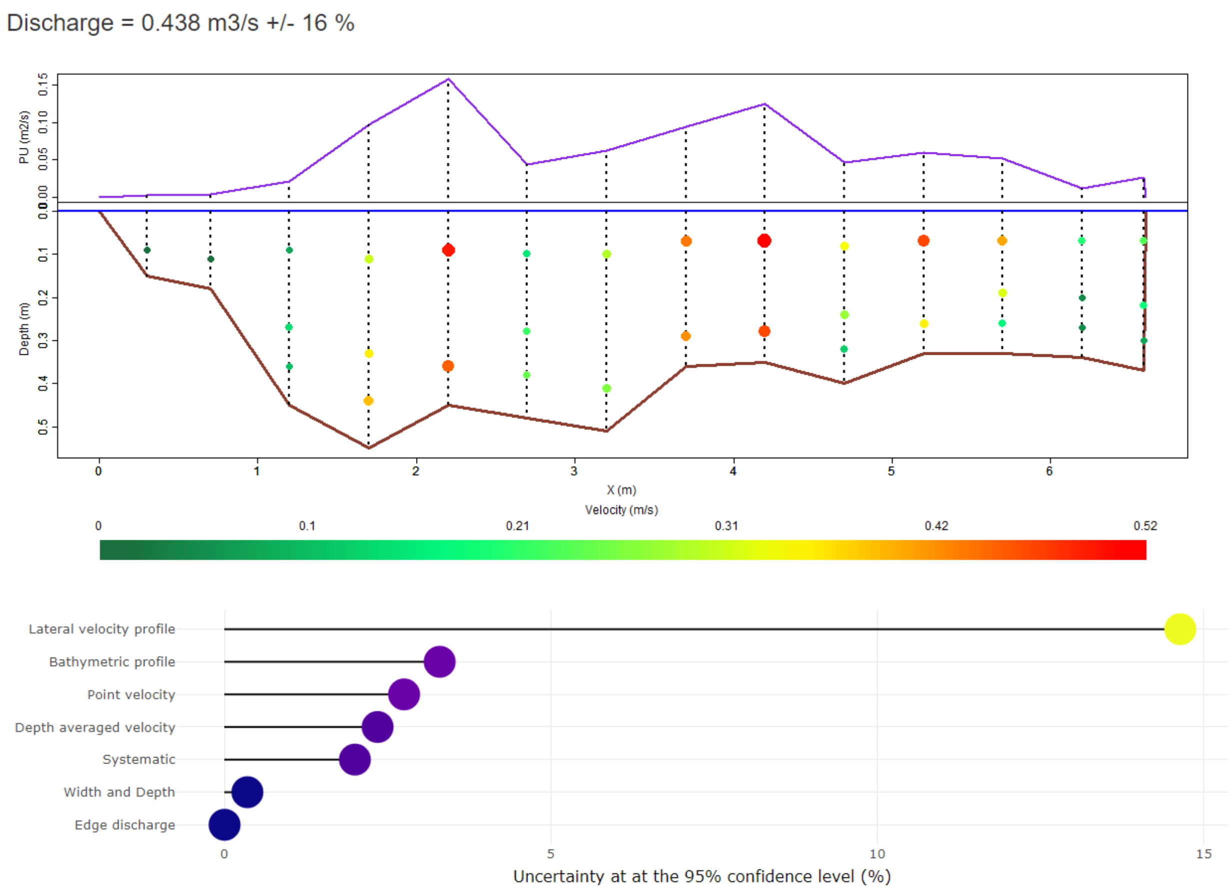

Figure 4: Measurement with a complex bathymetry and lateral velocity distribution

4.3 Measurement with 1 point per vertical

Figure 5 shows a measurement with a quite flat bottom. One single point of velocity was measured per vertical. The total uncertainty is quite low, about 4%, but the main error source is the computation of the depth averaged velocity. To reduce the uncertainty, one should do more points per vertical.

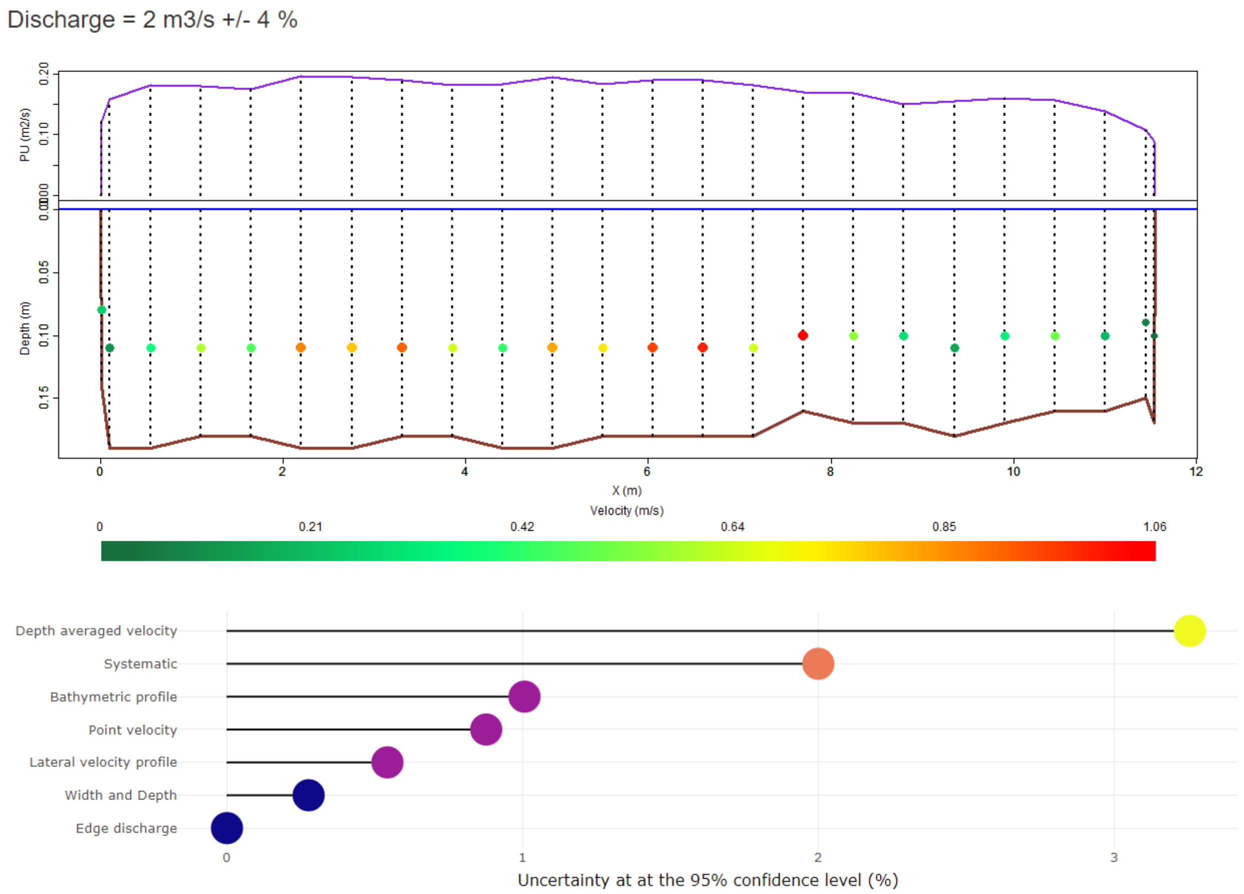

Figure 5: Measurement with 1 point per vertical

4.4 Measurement with very slow velocities

Figure 6 shows a measurement with slow velocities (mostly less than 10 cm/s). The total uncertainty is about 7%, and the main error source is related to the measurement of point velocity. To reduce the uncertainty, one should choose a cross-section with more velocity, or increase the exposure time (from 30s to 60s for example).

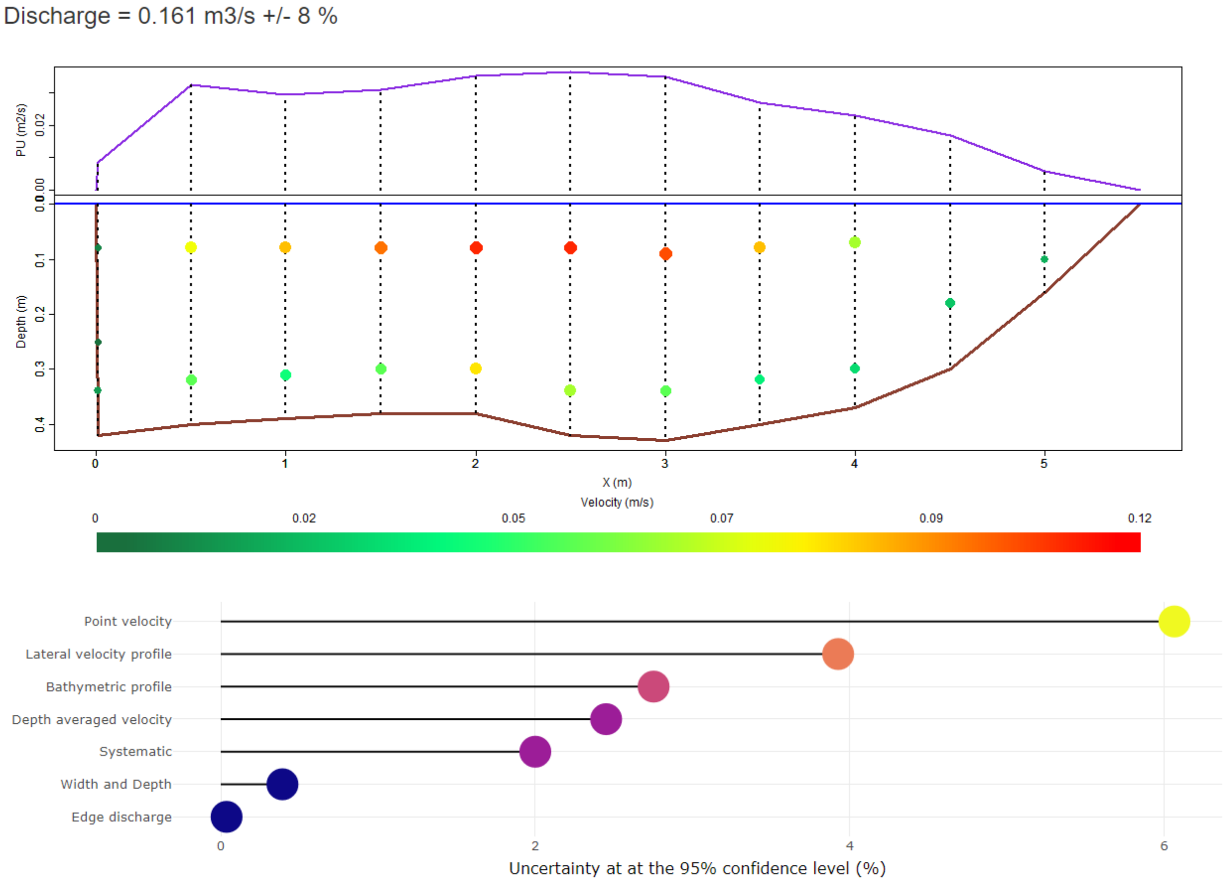

Figure 6: Measurement with very slow velocities

References

[1] T. Cohn, J. Kiang, and R. Mason. "Estimating discharge measurement uncertainty using the interpolated variance estimator". In: *Journal of Hydraulic Engineering* 139(5) (2013), pp. 502–510. DOI: https://doi.org/10.1061/(ASCE)HY.1943-7900.0000695.

[2] A. Despax et al. "Considering sampling strategy andcross-section complexity for estimating the uncertainty of discharge measurements using the velocity-area method." In: *Journal of Hydrology* 533 (2016), pp. 128–140. DOI: https://doi.org/10.1016/j.jhydrol.2015.11.048.

[3] ISO. *ISO 748 :2009 - Hydrometry - measurement of liquid flow in open channels using current-meters or floats*. ISO, 2009.

[4] J. Kiang, T. Cohn, and R. Mason. "Quantifying Uncertainty in Discharge Measurements: A New Approach". In: *World Environmental and Water Resources Congress 2009*. American Society of Civil Engineers, 2009, pp. 1–8.

NVE

Norges vassdrags- og energidirektorat

MIDDELTHUNS GATE 29
POSTBOKS 5091 MAJORSTUEN
0301 OSLO
TELEFON: (+47) 22 95 95 95

www.nve.no