New Instruments for Surveying Cross-Sections In Stream Restoration Projects

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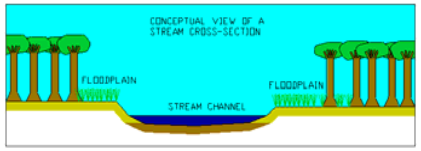
1. Introduction

- **In the US, Stream Restoration is a common and necessary form of water quality management, environmental enhancement and property protection**
- **Monitoring and measuring parameters like cross-sections are necessary for successful stream restoration**
- **Cross-Sections are 2-D profiles that are surveyed perpendicular to the direction of water flow**



- **Monitoring and measuring stream parameters is often rare or done improperly due to time and high costs**
- **A method for surveying cross-sections in a fast, reliable, economical and accurate would be desirable**

2. Objective

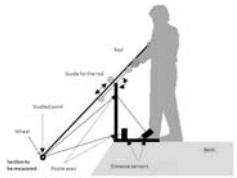
- **Build an instrument for surveying cross-sections in streams with speed and accuracy, competitive with more expensive methods, but still economical and convenient to use**

3. Method

- **Design and build a new prototype cross-section survey instrument(s) superior to existing instruments**
- **Test and evaluate the performance of the prototype instruments: measure measurement uncertainties**

4. The original idea: triangulation using string sensors

- **Built By Dr. Nedelec at Cemagref Research Institute in France**
- **Measures Coordinates with triangulation**
- **Designed for very small creeks less than 2.5 m wide**



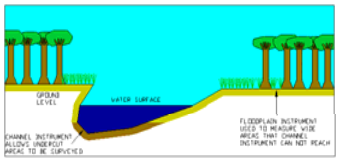
Schematic after Nedelec, 2003

Patent Number: 04.09806

- **Limitations of Prototype include Sag in the Strings, Limited Reach, Strings easily caught in small snag, and no absolute reference to verticality and horizontality**

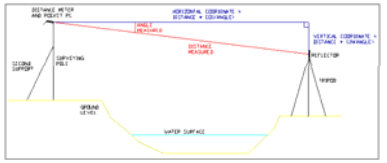
5. New Concept: two complementary instruments for surveying channel and flood plain

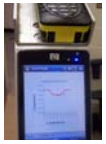
- **Laser Distance Meter and Tilt Sensor measuring absolute angle**
- **Laser pointed to a reflector**
- **Results stored in Pocket PC**
- **Results converted into Vertical and Horizontal coordinates using Trigonometry**



6. The Flood plain Instrument

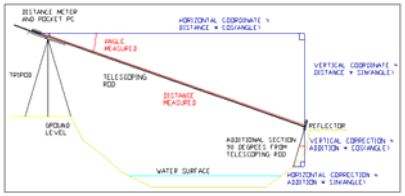
- **Still reflector, moving laser instrument mounted on a stilt surveying rod**
- **Can reach at least 30 m away from reflector**





7. The Channel Instrument

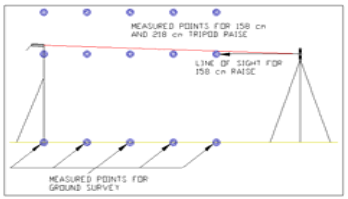
- **Moving reflector mounted on extending rod**
- **Laser/tilt sensor mounted on rod guide, itself mounted on survey tripod**
- **Undercut bank can be surveyed thanks to a 90° bend**
- **Can reach up to 6 m away from the tripod**

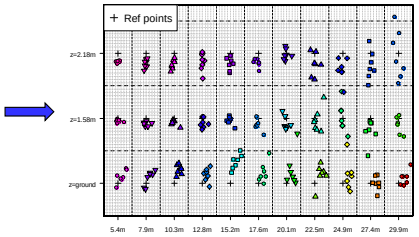


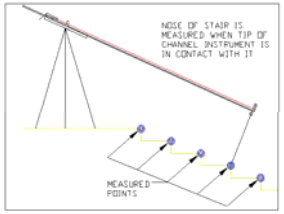
8. Preliminary evaluation of the new stream survey instruments

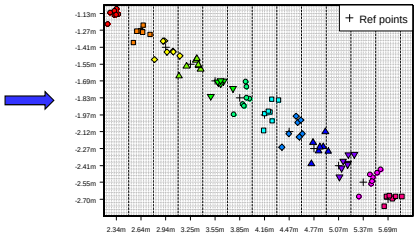
- **Flat pedestrian Walkway chosen as test site for floodplain instrument**
- **Stair noses used to evaluate the Channel instrument**

Grid size = 1 cm ×1 cm









Grid size = 1 cm ×1 cm

9. Statistics of Preliminary Evaluation

FLOODPLAIN_TEST_GROUND	
ROOT MSE FOR X (cm) =	1.180
ROOT MSE FOR Z (cm) =	3.407
BIAS FOR X (cm) =	1.849
BIAS FOR Z (cm) =	2.885
STANDARD DEVIATION FOR X (cm) =	1.125
STANDARD DEVIATION FOR Z (cm) =	3.249

FLOODPLAIN_TEST_218 cm	
ROOT MSE FOR X (cm) =	0.839
ROOT MSE FOR Z (cm) =	3.502
BIAS FOR X (cm) =	-0.196
BIAS FOR Z (cm) =	-2.789
STANDARD DEVIATION FOR X (cm) =	0.800
STANDARD DEVIATION FOR Z (cm) =	3.339

FLOODPLAIN_TEST_158 cm	
ROOT MSE FOR X (cm) =	1.034
ROOT MSE FOR Z (cm) =	2.604
BIAS FOR X (cm) =	0.038
BIAS FOR Z (cm) =	-1.394
STANDARD DEVIATION FOR X (cm) =	0.986
STANDARD DEVIATION FOR Z (cm) =	2.483

CHANNEL_TEST	
ROOT MSE FOR X (cm) =	2.748
ROOT MSE FOR Z (cm) =	2.410
BIAS FOR X (cm) =	1.659
BIAS FOR Z (cm) =	-0.055
STANDARD DEVIATION FOR X (cm) =	2.631
STANDARD DEVIATION FOR Z (cm) =	2.308

Note: ROOT MSE stands for Root Mean Square Error

- **Most results show ± 5 cm for X and Z for flood plain instrument even at 30 m distances**
- **Similar uncertainty for the channel instrument**
- **Uncertainty seems dependent to a point upon the user skills and experience**

10. Preliminary conclusions and future work

- **The instruments seem to perform acceptably (± 5 cm for X and Z) although more testing and ways to improve accuracy and precision are still needed**
- **The instruments are very easy to use and to carry out in the field**
- **A survey of a small channel could be done by one person within 10 min**
- **Needs further testing for more varying angles and distances**
- **A theoretical uncertainty calculation will be performed**
- **A comparison with other methods will be done**

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Abstract

A Better Method for Surveying Cross-Sections in Stream Restoration Projects
James Crouse, François Birgand, Michael Boyette and Yves Nedelec

Cross-Section profiles are an important part of the monitoring stage in stream restoration, as they provide useful information such as channel stability and evolution. Unfortunately, the monitoring stage often falls short of what is needed because it is time consuming and costly. Saving time and costs should be a priority in the monitoring stage. As for cross-section profiles, there are many instruments available that may be used; however they all have their limitations. Some instruments are inexpensive but make the job of surveying slow and tedious, while others make the job far more convenient and faster but could cost tens of thousands of dollars. Ideally, an instrument for surveying cross sections should be fast, accurate and reliable while still being inexpensive. In progress, is the development of two prototype instruments that are better for surveying cross-sections in streams.

The two prototype instruments have been built and are currently being tested. One was built with the intention of surveying floodplains and the other was built with the intention of surveying stream channels. Both rely on a laser distance meter and tilt sensor to calculate distances and angles, while a pocket PC with Microsoft Excel converts the distances and angles into vertical and horizontal coordinates using trigonometry. The initial tests show promising results but many more tests will be done. The instruments will be tested for errors and uncertainty and then in streams in order to find exactly how precise, accurate and usable they are.