Usefulness of Terrestrial Laser Scanner for Determining Bank of the River

Beata WIECZOREK and Joanna KUCZYŃSKA, Poland

Key words: terrestrial laser scanning, Biebrza River, river bank, digital terrain model

SUMMARY

Terrestrial laser scanning is a modern measurement technology. Laser scanning technology has changed the way of phenomena of surrounding reality analysis, including the determination of river bank. Quick creation of the 3D terrain models and the spatial visualization of the extent of the river are the new possibilities.

The results of the Biebrza river valley measurements taken with a ScanStation 10 Leica scanner was used in the research. After point cloud filtration, DTM was developed. Based on comparison of the obtained and collected materials: orthophotomaps and topographic maps, usefulness of terrestrial scanner in the determination of the riverbank was evaluated.

STRESZCZENIE

Naziemny skaning laserowy należy do nowoczesnych technologii pomiarów geodezyjnych. Technologia skaningu laserowego zmieniła sposób analizy zjawisk zachodzących w otaczającej nas rzeczywistości w tym procesu wyznaczania brzegu rzek. Do nowych możliwości należy (szybkie) stworzenie modeli 3D terenu i wizualizacja przestrzenna zasięgu rzeki.

W niniejszej pracy wykorzystano wyniki pomiaru doliny rzeki Biebrzy wykonane skanerem ScanStation 10 Leica. Chmurę punktów poddano filtracji następnie opracowano NMT. Na podstawie porównania opracowanych i zebranych materiałów: ortofotomap i map topograficznych dokonano oceny możliwości wykorzystania naziemnego skanera w wyznaczeniu brzegu rzeki.

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1. INTRODUCTION

Terrestrial laser scanning is a modern measurement technology. Laser scanning technology has changed the way of phenomena of surrounding reality analysis, including the determination of river bank. Quick creation of the 3D terrain models and the spatial visualization of the extent of the river are the new possibilities.
The paper presents an evaluation of determination of banks of Biebrza River. Periodic monitoring of the Biebrza is needed by reason of oxbow lakes occurrence. Oxbow lakes pose important and inherent element of the Biebrza valley area, and are excellent objects for conducting research. All oxbow lakes have common flow during frequent flooding. Verification of oxbow lakes location was the aim of measurements in June 2011.

2. PLACE OF THE STUDY

2.1 Localization of the study area

Biebrza is a river in the northeastern Poland with a total length of 155 kilometers and the basin area of 7,057 km^2. The Biebrza River is a tributary of the Narew River and its springs are located south of Nowy Dwór (Chormański et al., 2011).
Study area was located in the middle Biebrza basin, near Goniądz town. Goniądz is a town in Mońki county in Podlaskie Voivodeship in northeastern Poland (Figure 1).

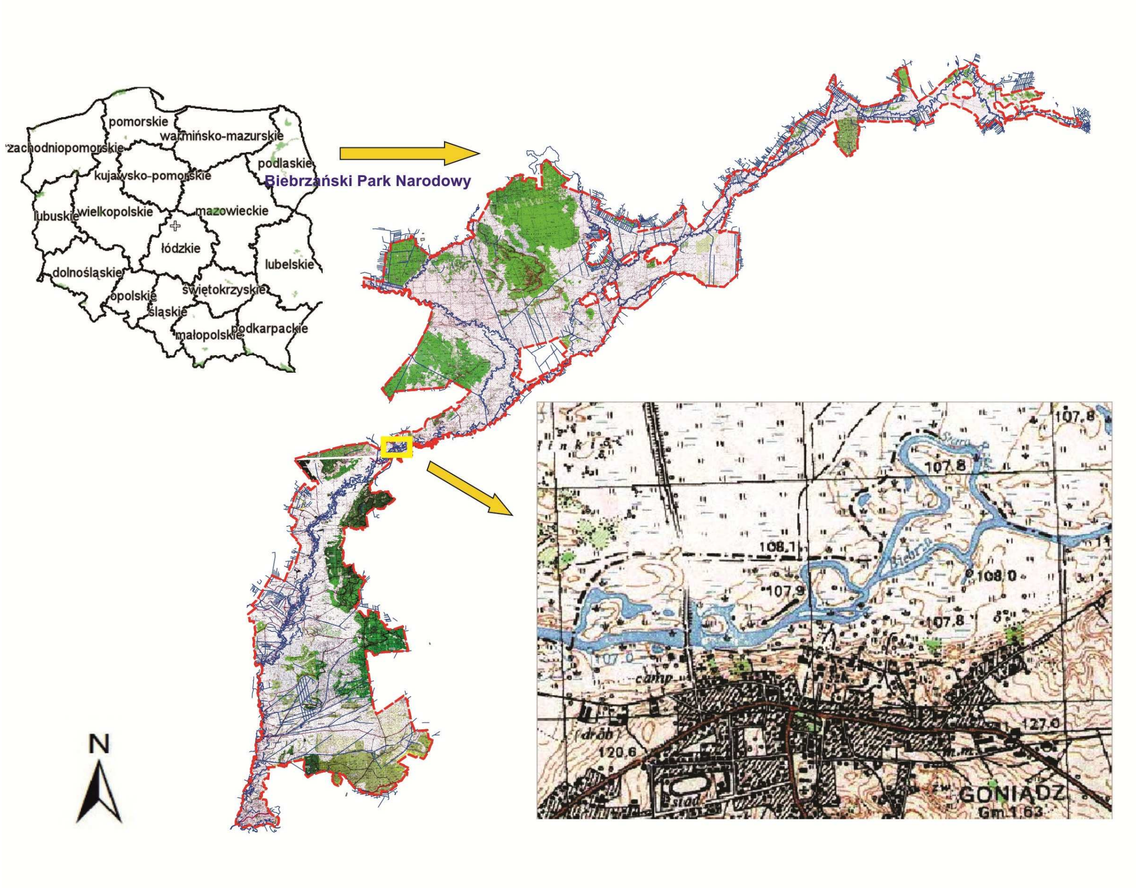

Figure 1. Biebrza River localization.

2.2 Biebrza River characteristic

Natural floodplains in Poland are protected by Natura 2000 Project (Figure 2). Biebrza Valley includes areas protected by Natura 2000, both the Birds Directive (Special Protection Area for Birds- SPA) and the Habitats Directive (Special Area of Conservation of Habitats-SAC):

- The Biebrza Valley-SPA (Code: PLB200002),
- The Biebrza Valley-SAC (Code: PLH 200005, PLH200008, PLC 200003).

The basin of Biebrza river is inhabited not only by hundreds of rare and endangered sorts of birds. It is also famous for its marshes and peatlands. In 1993 The Biebrza National Park was established. It is the largest of Poland's 23 National Parks. Its total area is 592.23 km^2. The Park includes 15 547 ha of forests, 18 182 ha of agricultural land, and 25 494 ha of wetlands. The area of 3 936 ha is under strict protection.

In the middle basin, which is the study area, the Biebrza River intensively meanders. Meandering riverbed of the Biebrza with numerous oxbow lakes in various stages of overgrowing maintains its natural character. The natural character is exemplified by annual floodings, usually caused by spring thaws. However, recharge with groundwater is dominant in this area, which leads to large peatland areas undergoing active peat formation processes (Chormański et al., 2011).

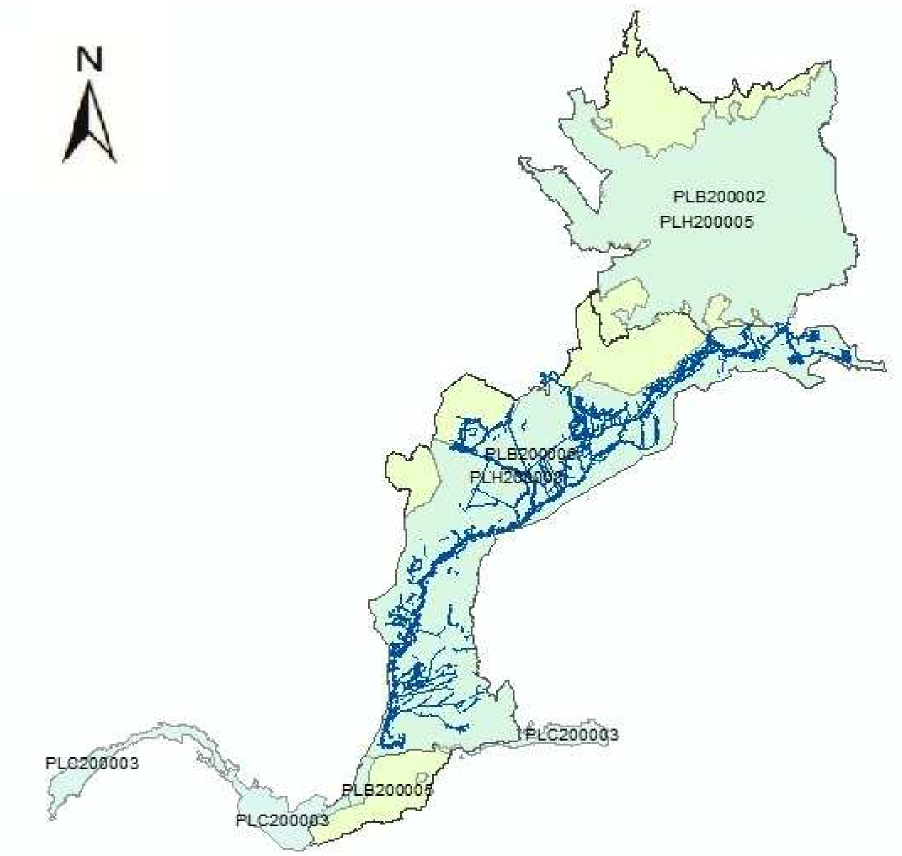

Figure 2. Biebrza River: Natura 2000 areas.

3. TERRESTRIAL LASER SCANNING

3.1 Measurements

Geodetic documentation which is used to analyse the Biebrza River bank consists of the topographic maps in 1:10000 and 1:25000 scales, the orthophotomaps generated from photo flown (2006) and from the satellite images (2008, Ikonos). Because of the necessity of frequent bank monitoring, alternative, effective, fast and inexpensive solution is being searched. For this reason, laser terrestial scanning was proposed and conducted using Leica ScanStation C10.

After consultation with hydrologists from University of Warmia and Mazury in Olsztyn, accuracy of the Biebrza River bank measurements was set to 10 centimeters. Because the river bank is not available for the direct measurements due to the mashes area, this setting covers high accuracy requirements. Terrain was grassy, what impeded terrain surface identification. Local conditions imposed terrestrial laser station position. Laser scanning and photographs were done on two stations. The first was situated on wetland (Station 7), close to the river bank. The second (Station 11) was situated on the bridge, further off the object (Figure 3).

Figure 3. Terrestrial scanner stations.

It was assumed that the measurement should fulfill the monitoring conditions. Making detailed assumptions concerning measurement planning was focused on surveys of the river bank. Minor control was established using GNSS receiver. To identify the photographs, targets were measured. Pictures were taken by ScanStation C10 built-in camera. While taking these pictures, one took into account the possibility of their use for filtering point cloud, the correction of the scan and the construction of a natural texture (Toś et al., 2010). Areas were scanned with the density of the 1 point/m^2 (Station 7) and 5 points/m^2 (Station 11). The total number of points from two stations was 1996634. In Figures 4, 5 and 6 the obtained point clouds are shown.

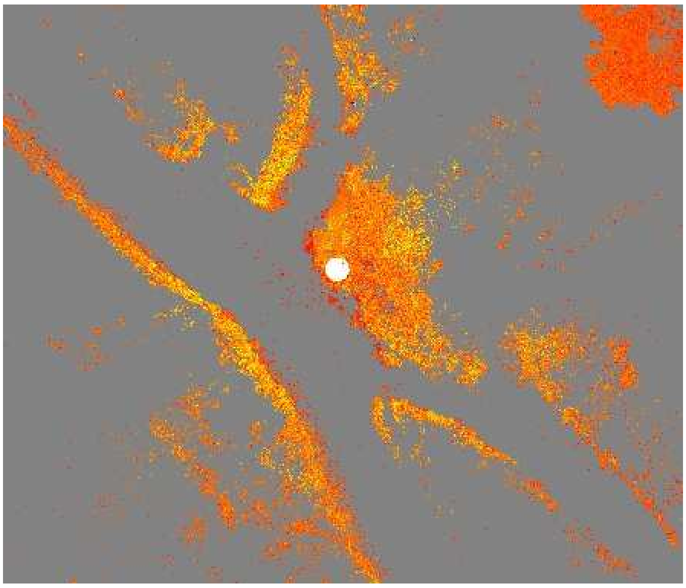
Figure 4. Point cloud: Station 7.

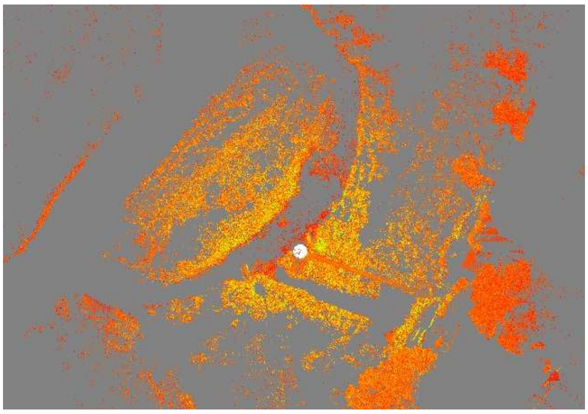

Figure 5. Point cloud: Station 11.

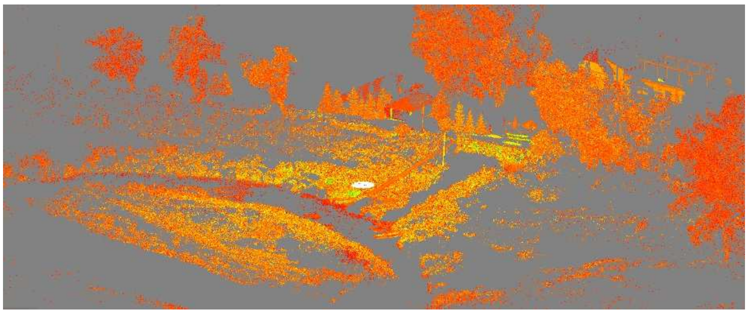

Figure 6. Point cloud: lateral view.

3.2 Data evaluation

Leica commercial applications, such as Cyclone and CloudWorx for MicroStation were used for data evaluation. Other commercial applications: PolyWorks and Pointools were also used. The first step was the point cloud filtration. Inadequate points such as trees, bushes and other plants were removed from the dataset. The next step was to remove points from the water table area. It allowed to reduce reflection effect. The final point cloud was the result of several stages of filtration. It was the basis for the river bank vectorization (Figure 7) and digital terrain model (DTM) generation (Figure 8).

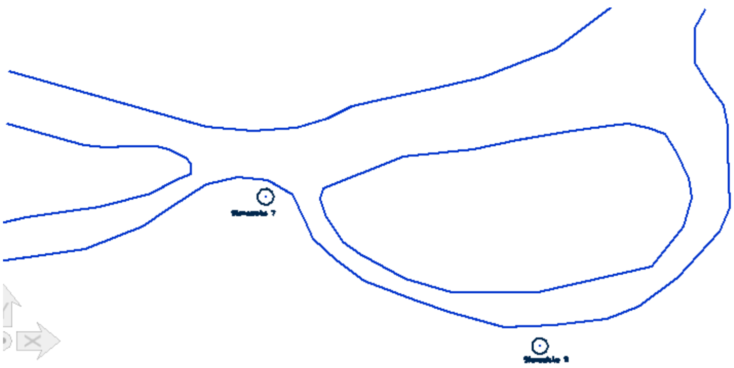

Figure 7. The Biebrza River bank.

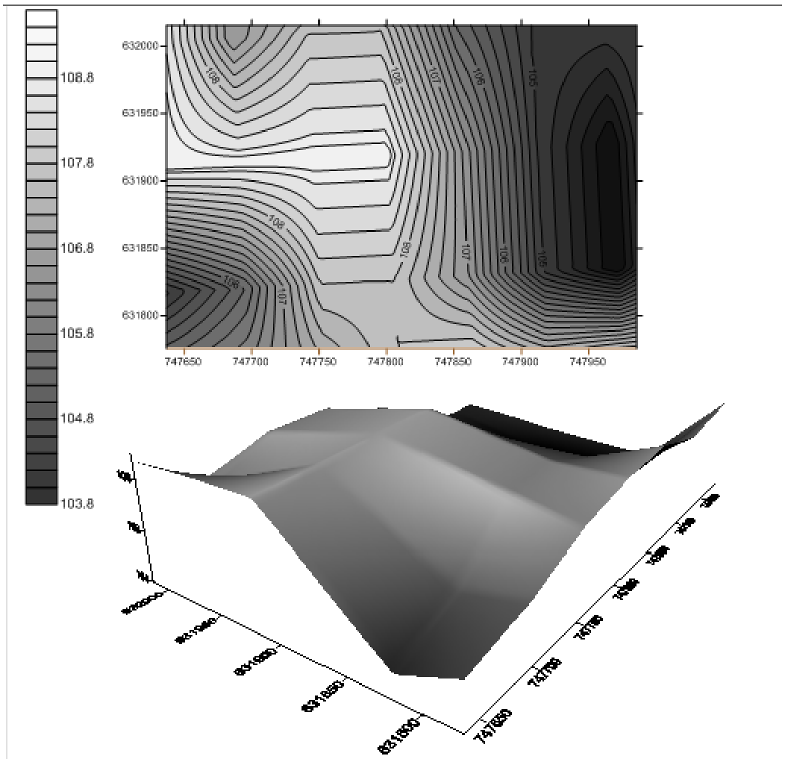

Figure 8. Digital terrain model.

4. COMPARATIVE ANALYSIS

Topographic map and orthophotomaps pose the datum documentation which was used in the analysis. Figure 9 presents the determined river bank and the vectorized river bank from topographic map in 1:10000 scale. The object boundaries do not coincide. This is the result of map generalization. In Figures 10 and 11 the river bank in the background of the orthophotomaps are shown. In these cases the boundaries coincide.

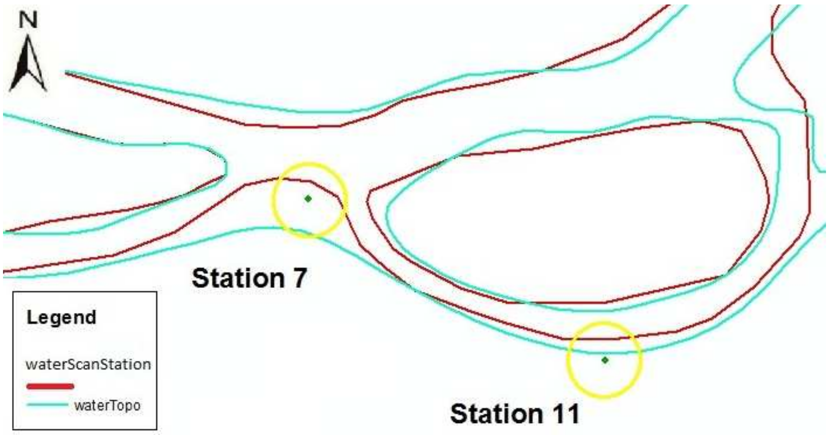

Figure 9. The Biebrza River bank: topographic map and terrestrial scanning.

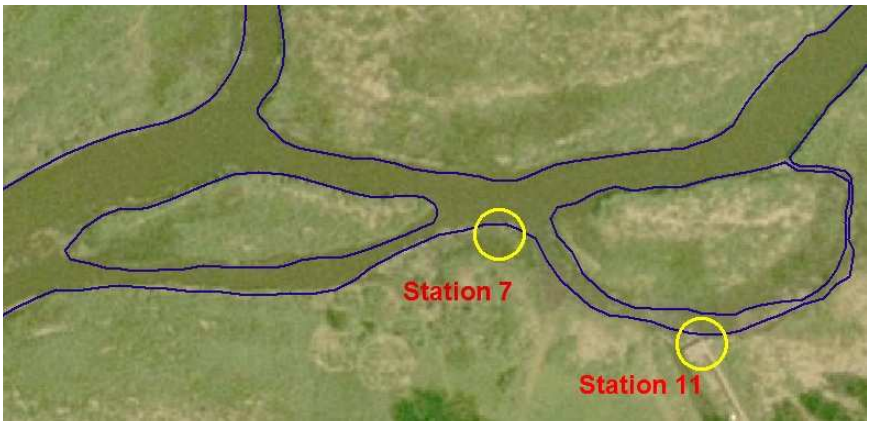

Figure 10. Orthophotomap generated from photo flown (2006) and the Biebrza River bank.

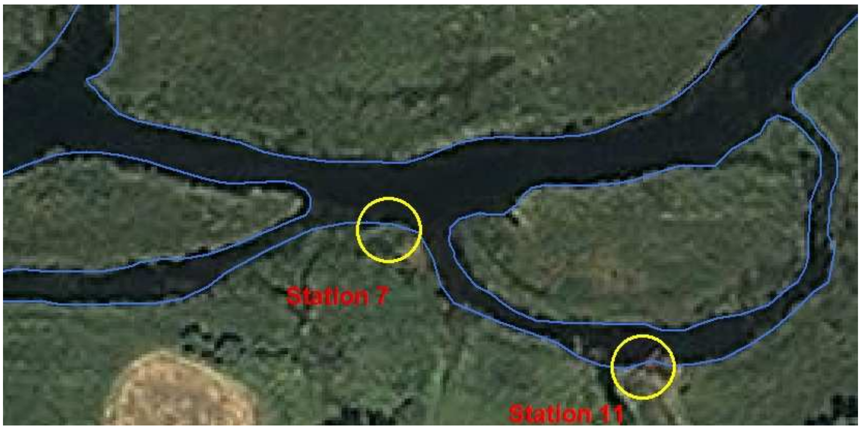

Figure 11. Orthophotomap generated from the satellite images (2008, Ikonos) and the Biebrza River bank.

5. CONCLUSIONS

It is possible to use a terrestrial laser scanning for determining a river bank. Figure 12 presents the Biebrza river bank vectors obtained from various sources: the topographic map, the orthophotomaps and the terrestrial scanning. Because the datum documentation has been collected over a few years, it allows to monitor river changes over time.
Terrestrial scanning poses the good alternative in a river monitoring. It is a cheaper option than an airborne laser scanning. However, the method has a few limitations:

- appropriate station location, which depends on the type of ground, the floodplain range, the river width and the scanner range;
- a lot of stations along the river (Leica ScanStation C10 scanner has a range up to about 300 meters, 500 meters can be assumed for open areas);
- at least 20-degree angle between the sight line and the surface of the object to get the optimal conditions for measuring (Toś et al., 2010).

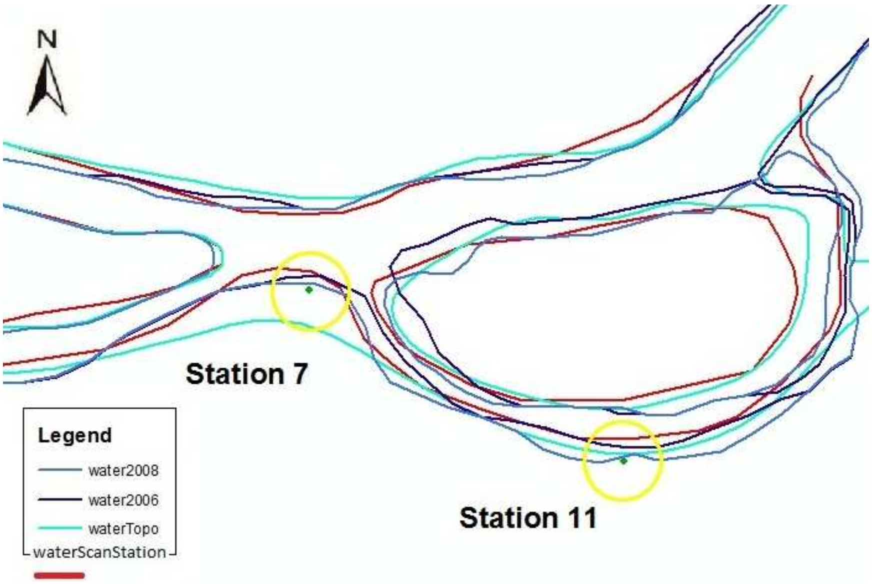

Figure 12. Differences in the determined river banks.

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BIOGRAPHICAL NOTES

Beata Wieczorek in 2010 (Ph.D.) University of Warmia and Mazury in Olsztyn (UWM), Faculty of Geodesy and Land Management, in 2006 (B.Sc.) UWM, Faculty of Mathematics and Computer Science. 2001-2005 Teaching of Institute of Geodesy (UWM); 2002-2004 office engineering of Chair of Photogrammetry and Remote Sensing (UWM); 2008-2010 The District Survey Enterprise in Olsztyn. 2010 till now: Assistant Professor of Chair of Land Surveying and Geomatics, University of Warmia and Mazury in Olsztyn.

Joanna Kuczyńska in 2007 completed studies in the field of Geodesy and Cartography, majoring in Geodesy and The Spatial Information System on Faculty of Geodesy and Land Management of University of Warmia and Mazury in Olsztyn (Poland). Since 2008 research worker and academic teacher in Chair of Land Surveying and Geomatics at UWM in Olsztyn.

CONTACTS

Ph.D., Beata Wieczorek
University of Warmia and Mazury in Olsztyn
Oczapowskiego 2
Olsztyn
POLAND
Tel. +48 89 523 48 78
Fax +48 89 523 48 78
Email: beata.zero@uwm.edu.pl

MSc, Eng. Joanna Kuczyńska
University of Warmia and Mazury in Olsztyn
Oczapowskiego 2
Olsztyn
POLAND
Tel. +48 89 523 48 78
Fax +48 89 523 48 78
Email: joanna.kuczynska@uwm.edu.pl