2d-Simulation of a Dam-break Flood-Wave Propagation in the Valley of the Toce River

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Abstract

At ENEL extensive measurements on a scale model representing the Pie di Lago valley were carried out. The inundation caused by the Toce river was observed at 32 gauging points. A comparison between measured results obtained from the 1:100 scale model and a 2d-simulation results was carried out using the FV-scheme FLOODSIM (Nujic 1998). The general agreement was good for all of the performed runs, although no special efforts had been undertaken on a detailed optimization of the digital terrain model.

1) Introduction

Two different hydrographs are given. Hydrograph 1 has a peak discharge of Q_{max} = 0.21 m_/s, hydrograph 2 a peak discharge of Q_{max} = 0.356 m_/s. The main runoff occured within 180 s. The Manning roughness was proposed to be n = 0.0162 $s/m^{0.33}$. The bathymetry on a raster of 5cm x 5cm was provided by ENEL. The computational grid consisted of about 210,000 nodes using the original grid. The model covers an area of approx. 55 x 13 m.

The calculations were repeated for a reduced roughness n = 0.0125 $s/m^{0.33}$.

Besides necessary modifications at the inlet and for a barrage in the downstream part of the valley, the topography was left unchanged (Figure 1). The urban areas were not resolved in detail. Instead, the effect was simulated by a locally increased Manning roughness n = 0.055 $s/m^{0.33}$ for the first and n = 0.035 $s/m^{0.33}$ for the second run.

At the inflow boundary a discharge was supplied to the numerical model along a line of nodes. At the downstream boundary a zero-gradient condition was introduced.

The total calculation time was about 6-7 hours on a IBM PC 350 MHz.

2) Results

The comparison of calculated and measured water elevations is plotted for the upstream, center and downstream part separately. Figure 2-4 show the time series for the upstream gauges, figure 5-6 the center part gauges and figure 7-9 the downstream gauges.

Gauge P28 is not plotted (just for simplification reasons).

Despite of the complexity of the domain the general agreement is good. There are just a few gauges with a deviation calculated/measured of more than 2 cm. A lot of control points show very good agreement between computational and measured results. For those gauges the difference between calculated and measured results is less than 1 cm. Even overtopping and reservoir filling of the basin in the center part of the physical model at gauge P12 is reproduced correctly.

Somewhat better results have been obtained with the basic roughness n = 0.0125 (instead of the proposed value n=0.0162). Especially concerning the water-front arrival times a significant improvement is gained. The proposed roughness value has been obtained by fitting a 1d-model to the experimental results. Regarding a certain model setup the average calibration roughnes for 2d-models generally is lower than the calibration roughnes for 1d-models. Thus the reduced Manning-value can be justified.

The chosen roughness value for buildings has little influence on the overall behaviour. But there is some effect perceived at the inflow area (for example: P1 and S6D) and it seems that even greater roughness values than n = 0.055 should be specified in this region. Maybe resolving buildings by finer discretisation would give better results. This computation has not been performed yet, due to lack of time.

Some of the control points, like P4, were placed at extremely sensitive areas, where the water elevation could vary from one computational point to another, by as much as 2 cm to 3 cm. The measured point lies between the calculated nodal points. So this would explain the existing discrepancy between the measured and calculated results for P4.

However, the discrepancy for the point P18, cannot be explained this way. The differences for this point are probably primary caused by 3-dimensional effects and flow contractions in this area. The calculated results for this point also seem to be quite insensitive to the performed changes in roughness.

Similar arguments could be applied to gauge P23. Here additionally the barrage is also important for the downstream part and a more exact implementation of the barrage should probably lead to better results. At gauge P10 there is a significant backwater effect due to the presence of a building. This building has not been discretized in the computational model.

3) Conclusion

The agreement between calculated and measured results is generally good. An improvement was observed when reducing the mean Manning roughness. Further improvements might be gained by a more detailed discretisation of the topography. Especially structures like walls, barrages and embankments might have stronger influence on the resulting dam-break flood wave propagation.

REFERENCES

Nujic, M., 1998 : Praktischer Einsatz eines hochgenauen Verfahrens für die Berechnung von tiefengemittelten Strömungen, Mitteilungen Heft 62, Institut für Wasserwesen, Universität der Bundeswehr München

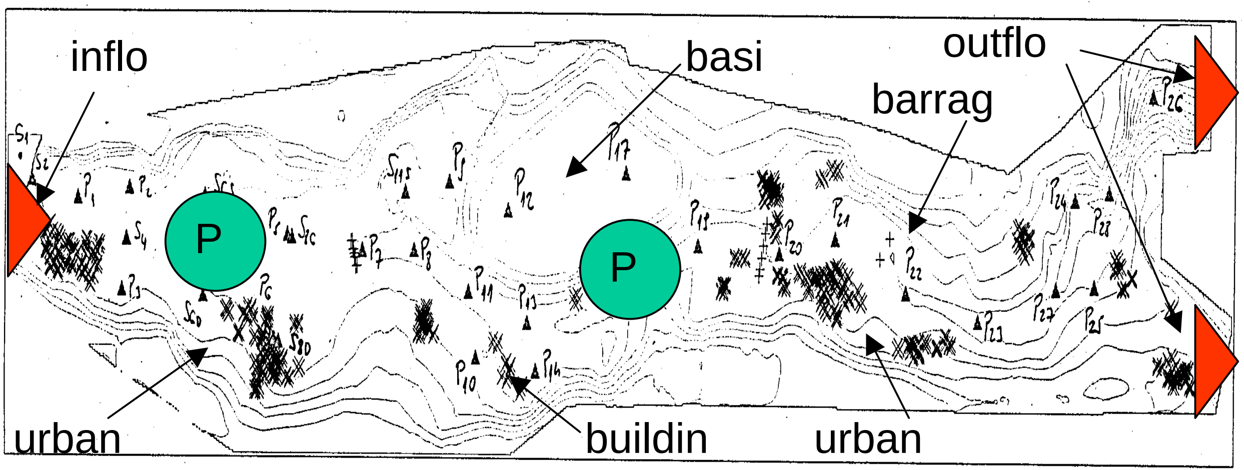

Figure 1 : Physical model of Pie di Lago

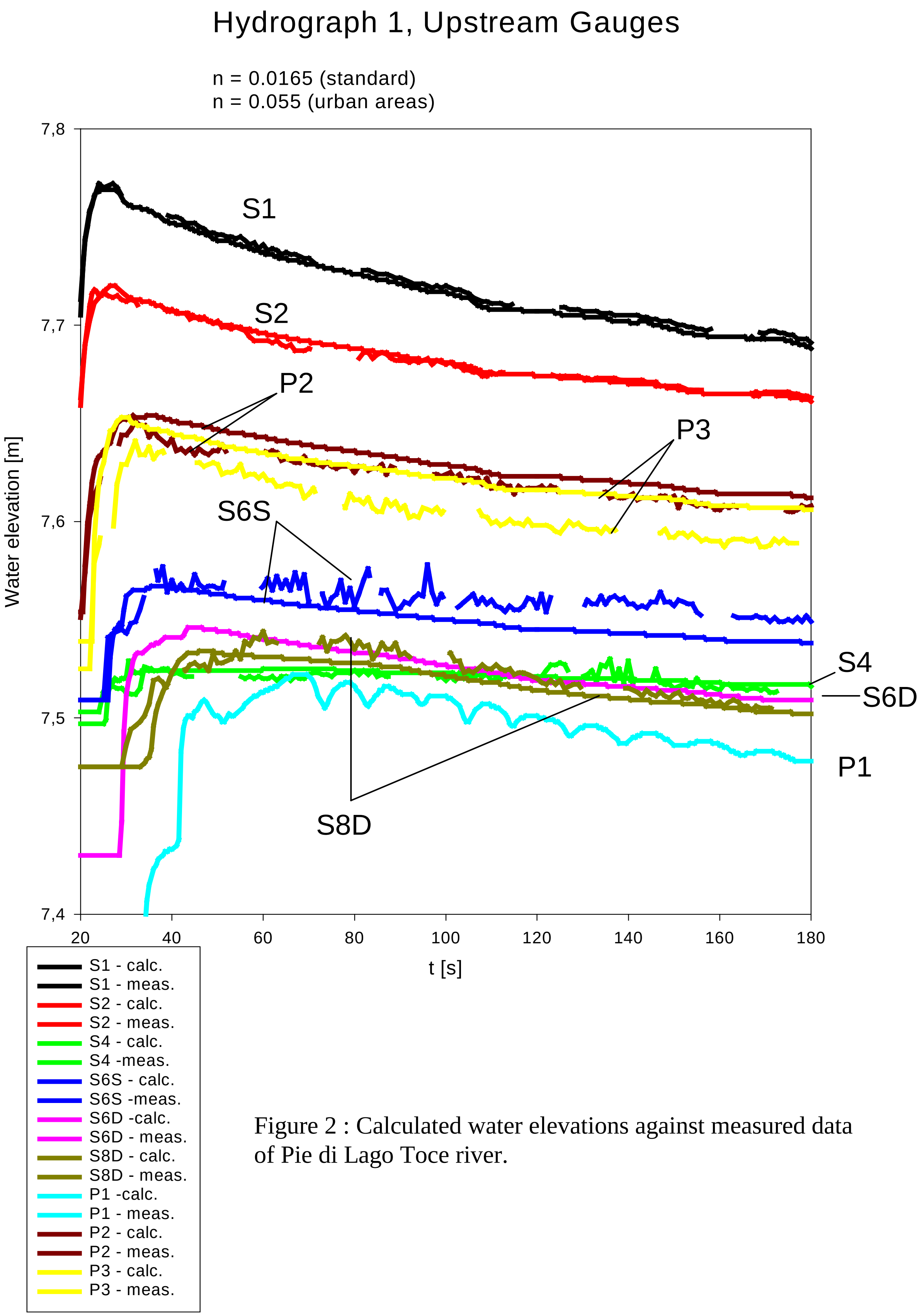

Figure 2 : Calculated water elevations against measured data of Pie di Lago Toce river.

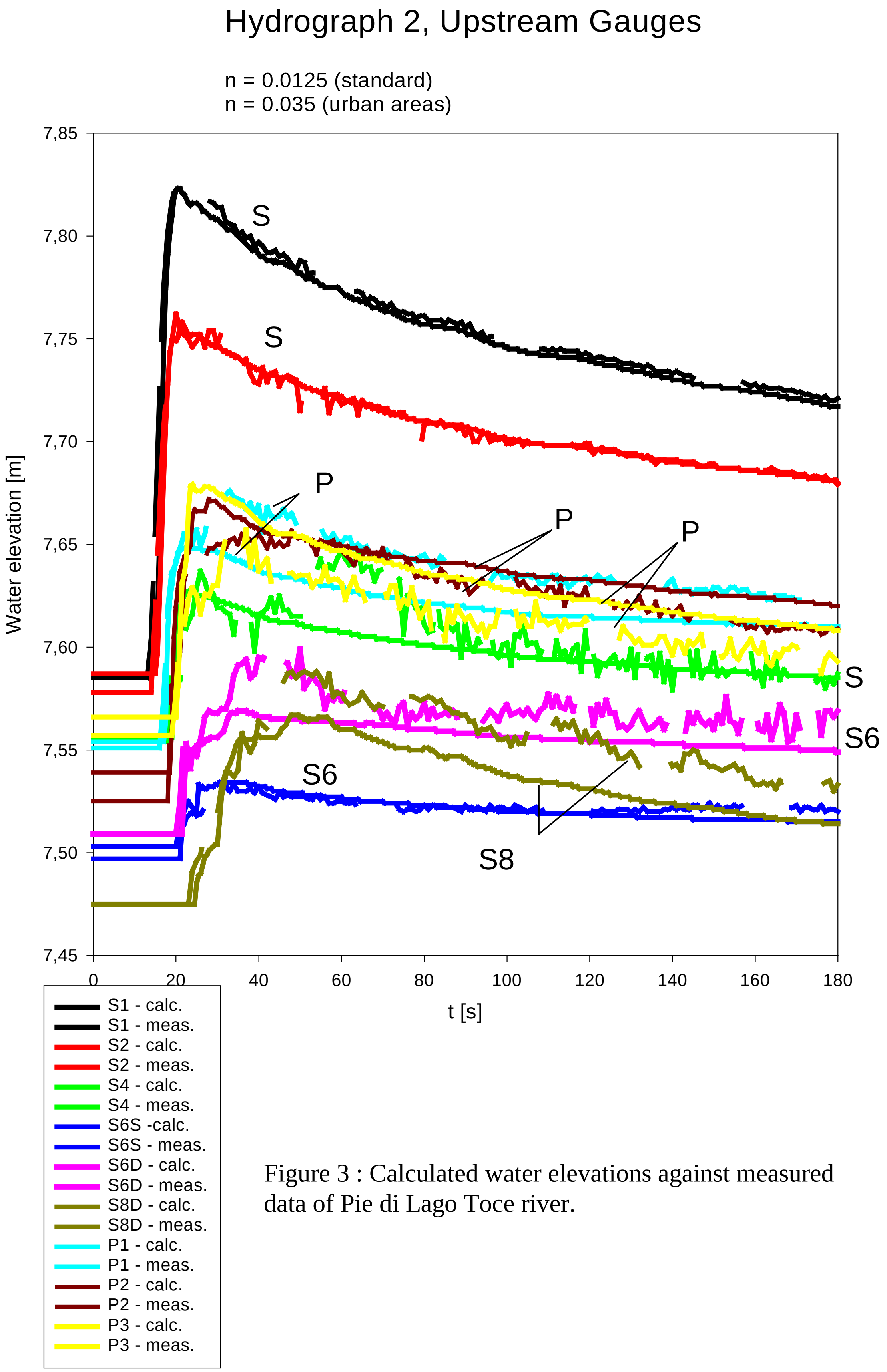

Figure 3 : Calculated water elevations against measured data of Pie di Lago Toce river.

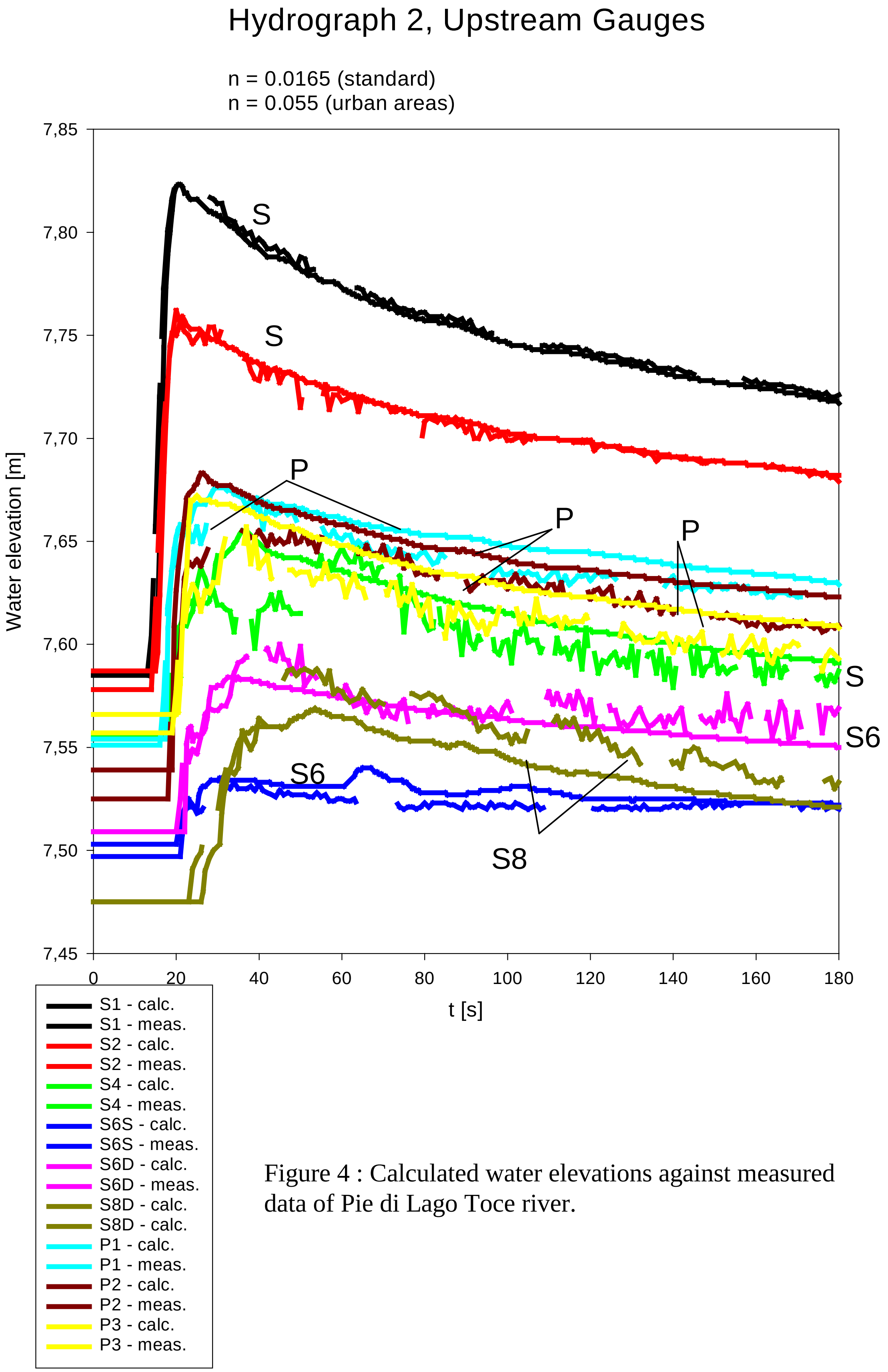

Figure 4 : Calculated water elevations against measured data of Pie di Lago Toce river.

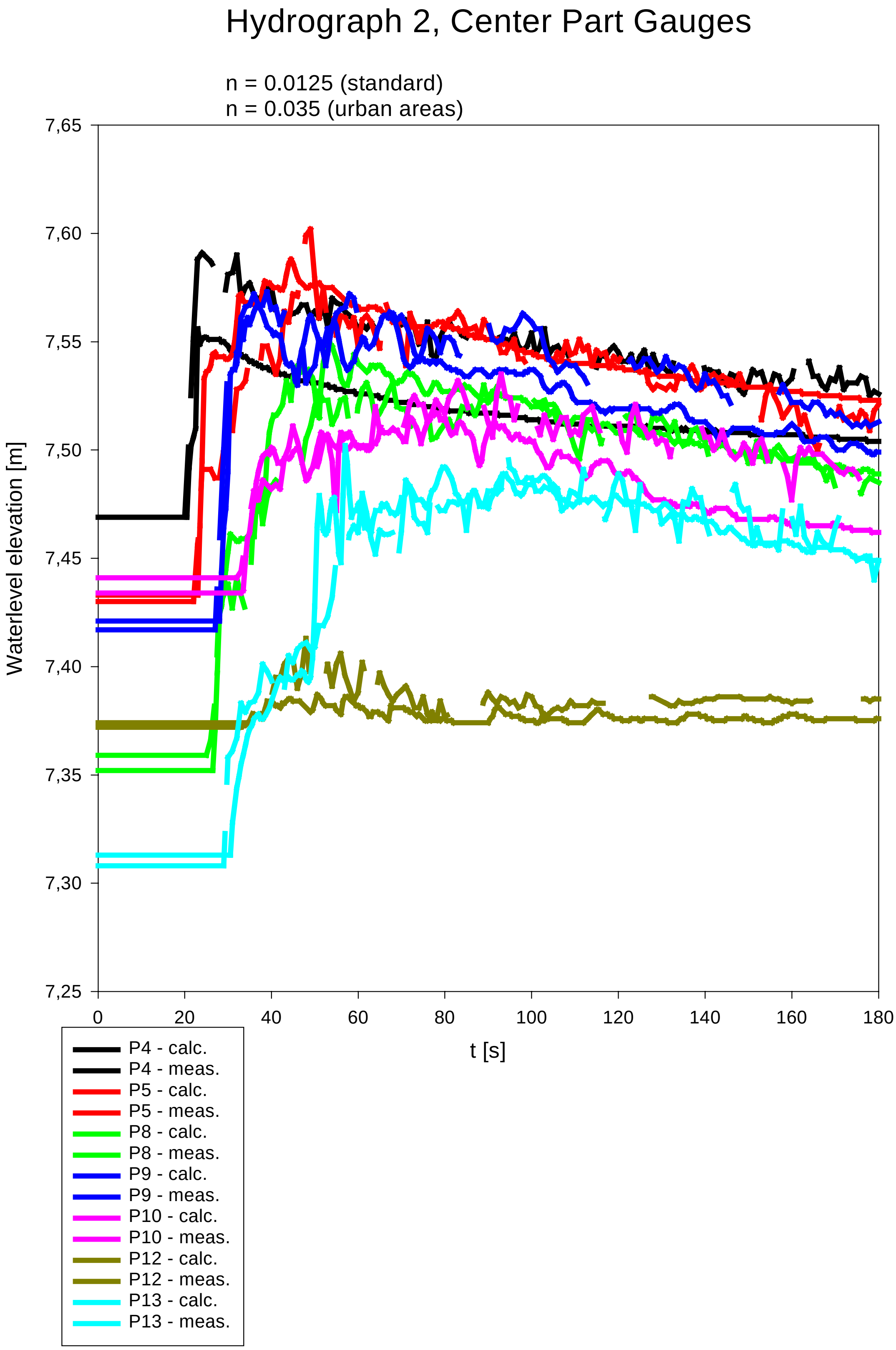

Figure 5 : Calculated water elevations against measured data of Pie di Lago Toce river.

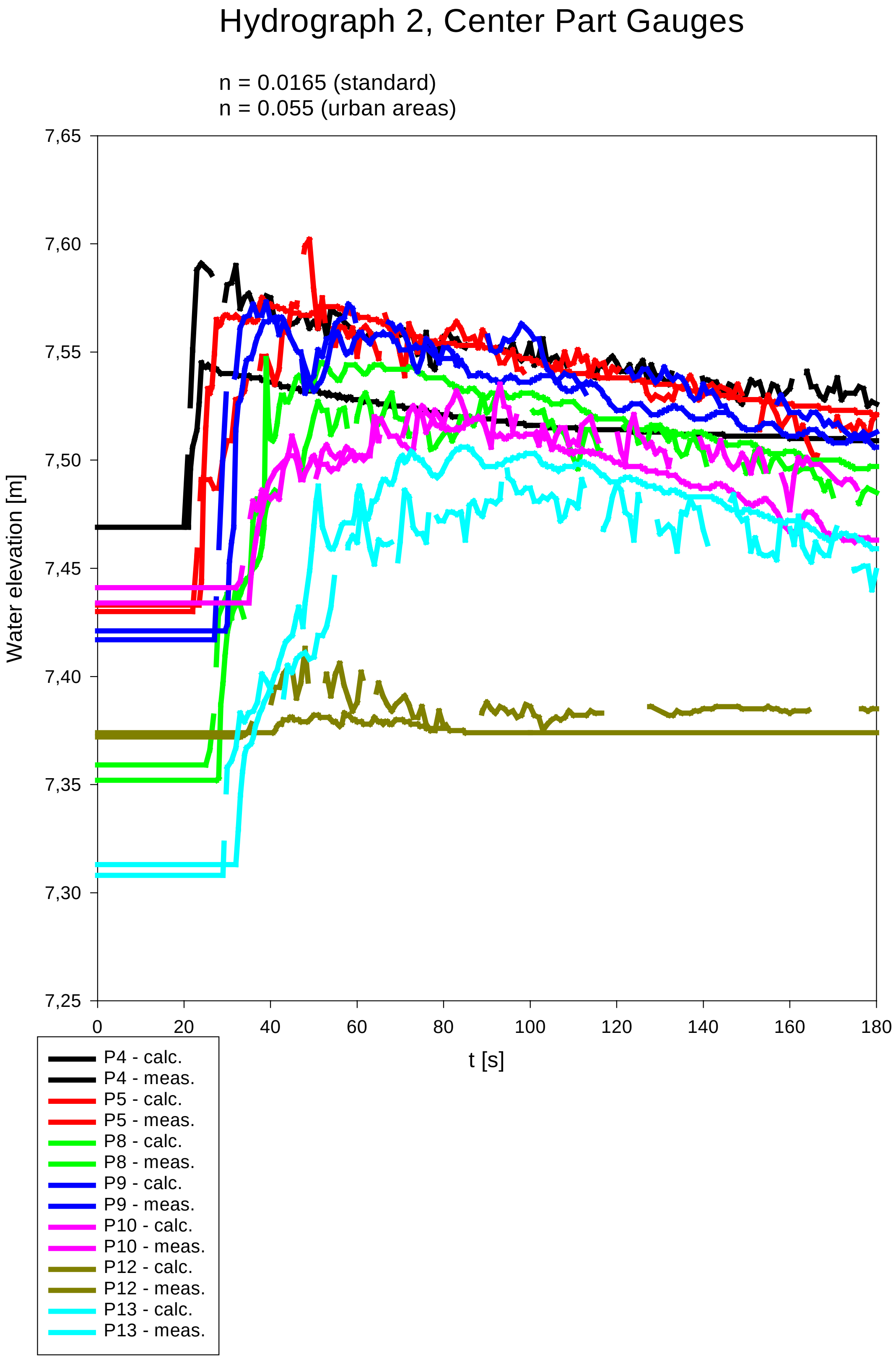

Figure 6 : Calculated water elevations against measured data of Pie di Lago Toce river.

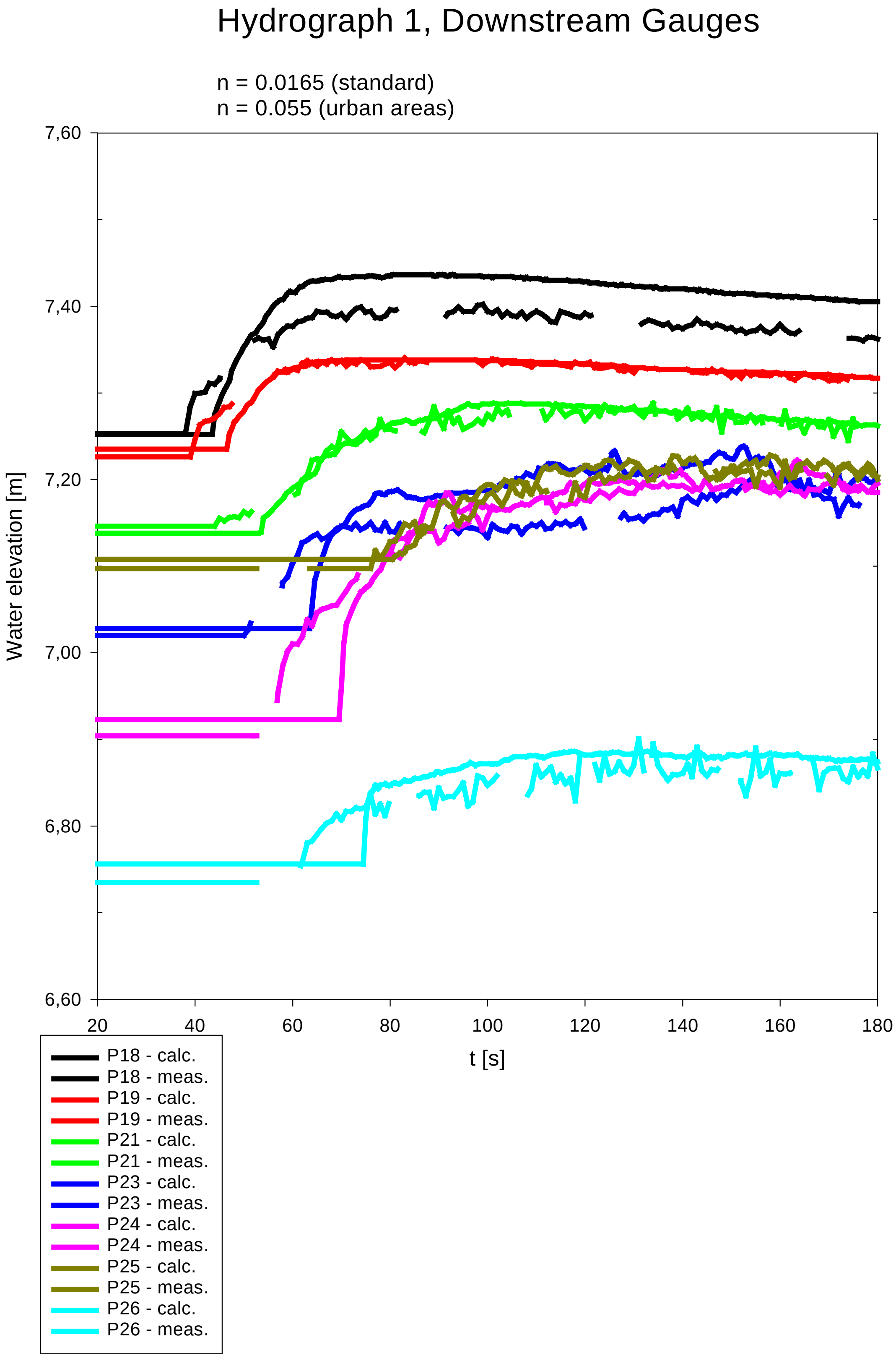

Figure 7 : Calculated water elevations against measured data of Pie di Lago Toce river.

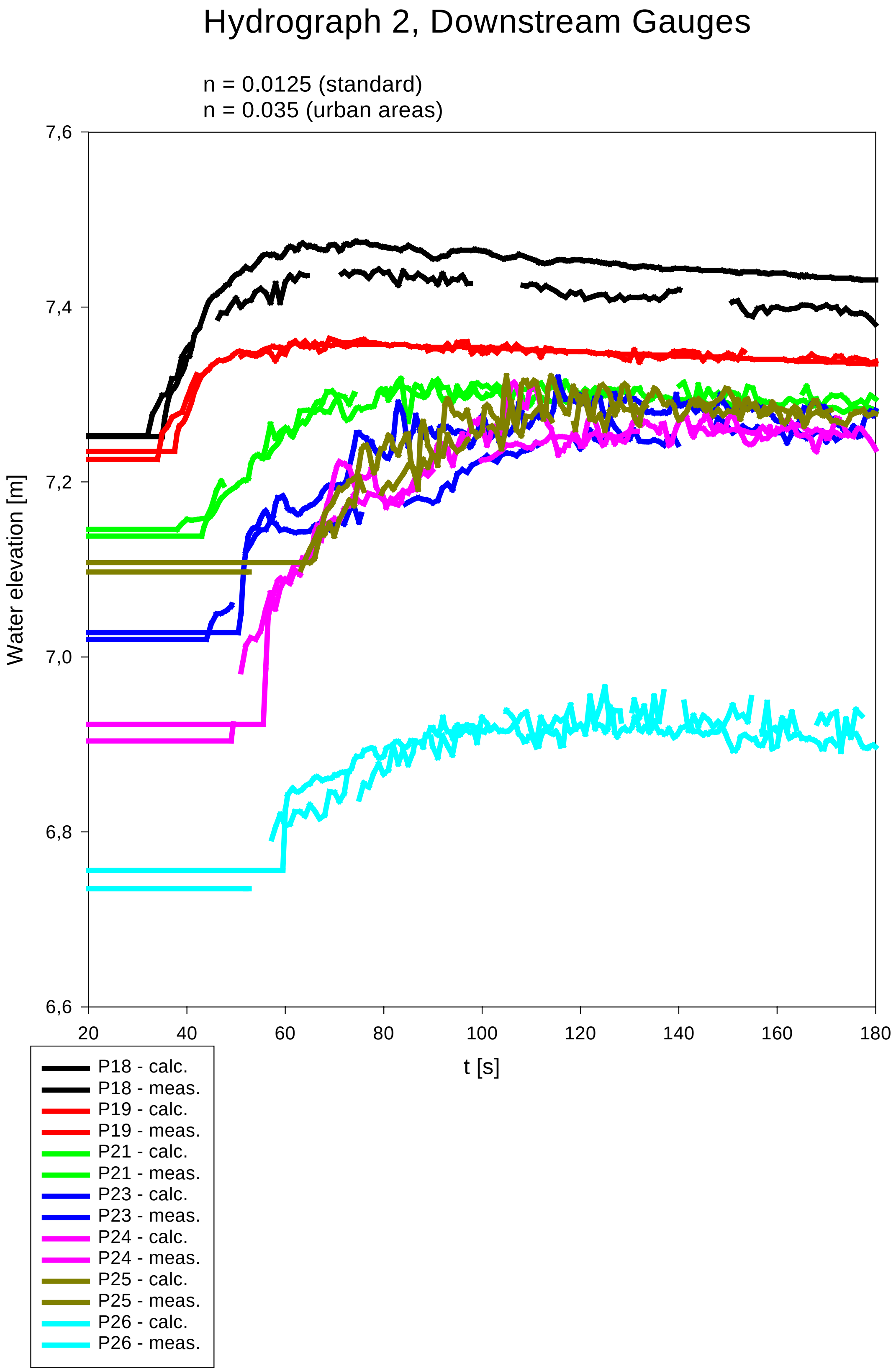

Figure 8 : Calculated water elevations against measured data of Pie di Lago Toce river.

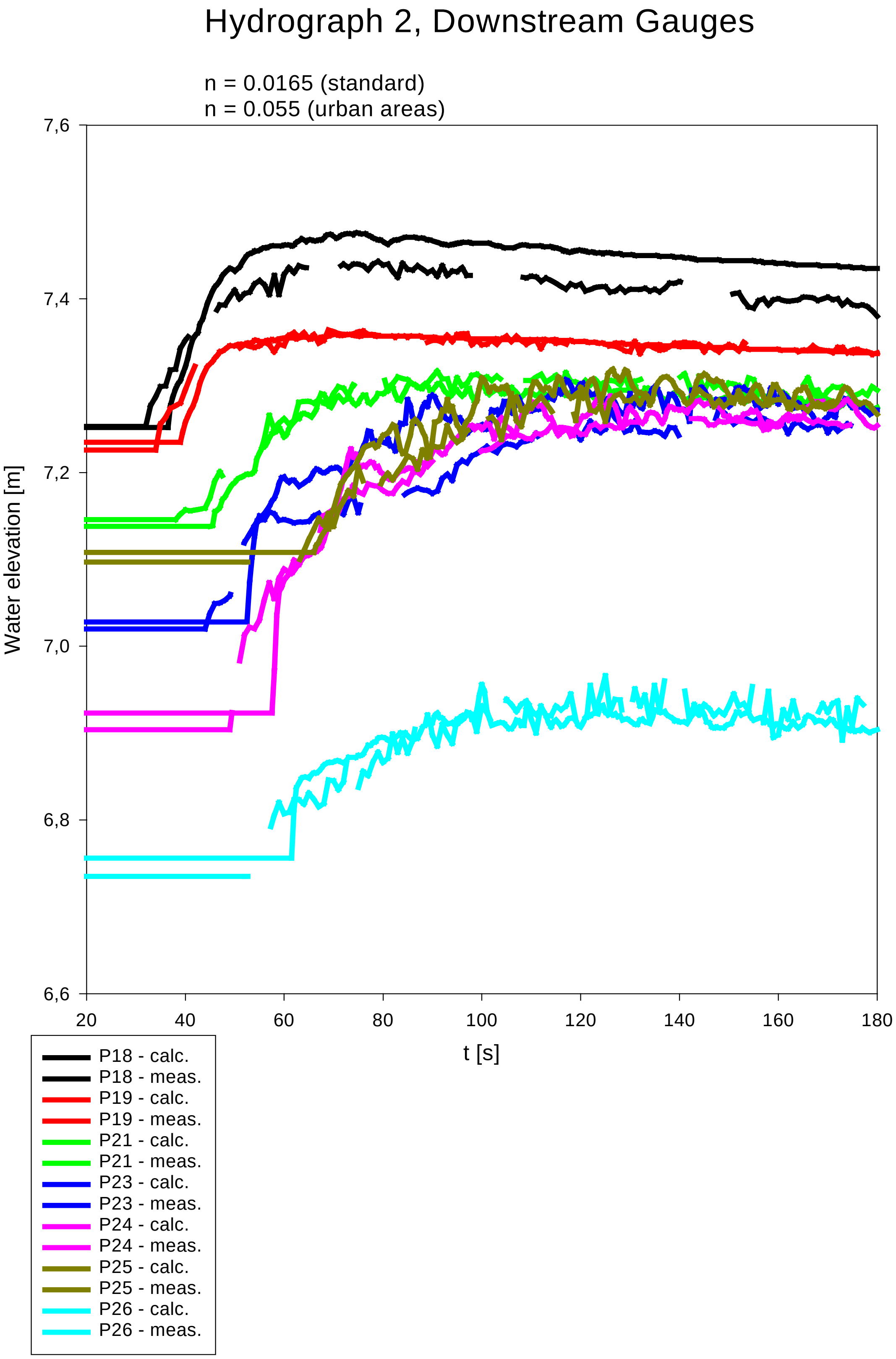

Figure 9 : Calculated water elevations against measured data of Pie di Lago Toce river.