FLOOD PROTECTION EXPERIENCES ON THE DRAVA RIVER BASIN IN CROATIA

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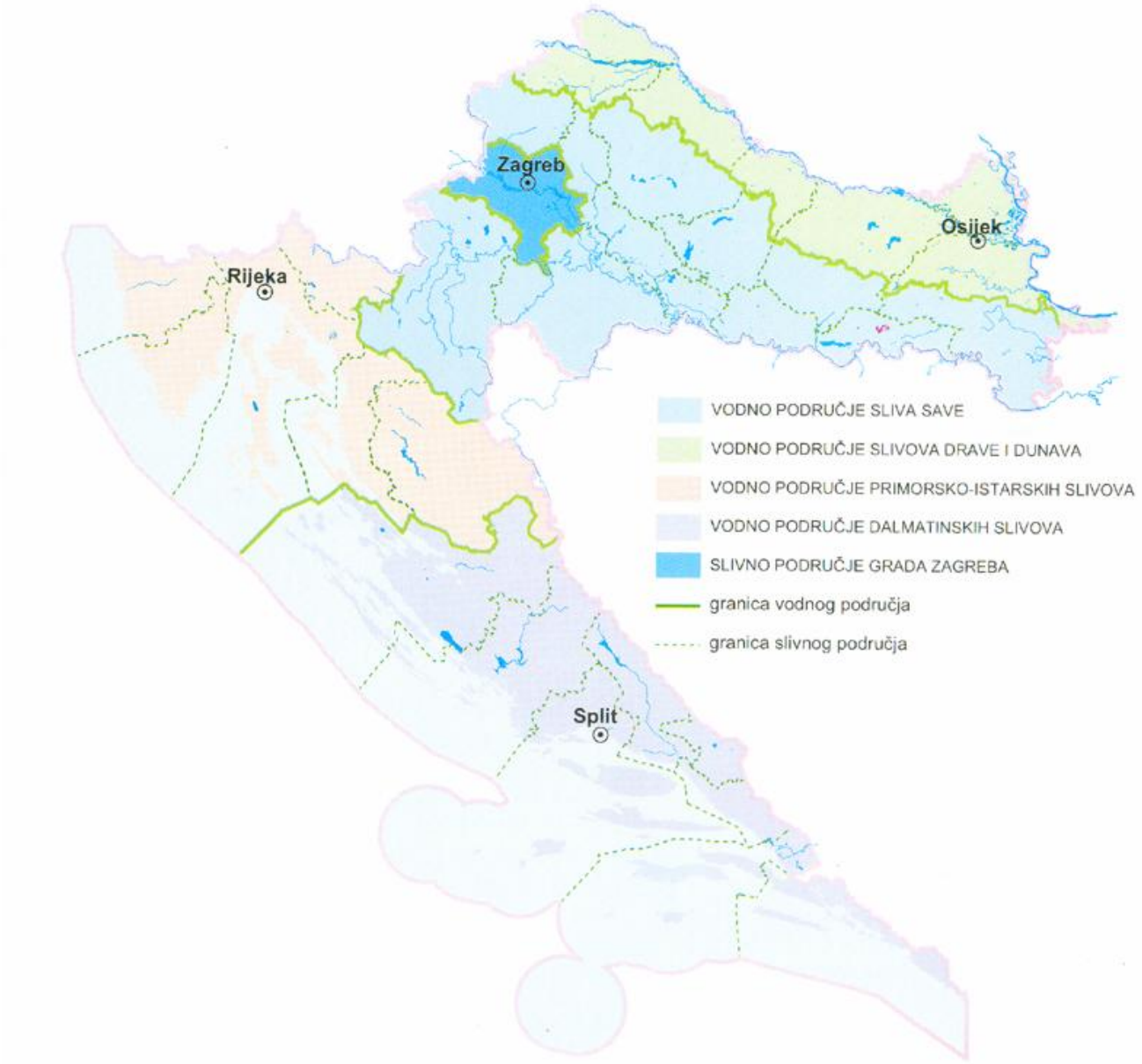
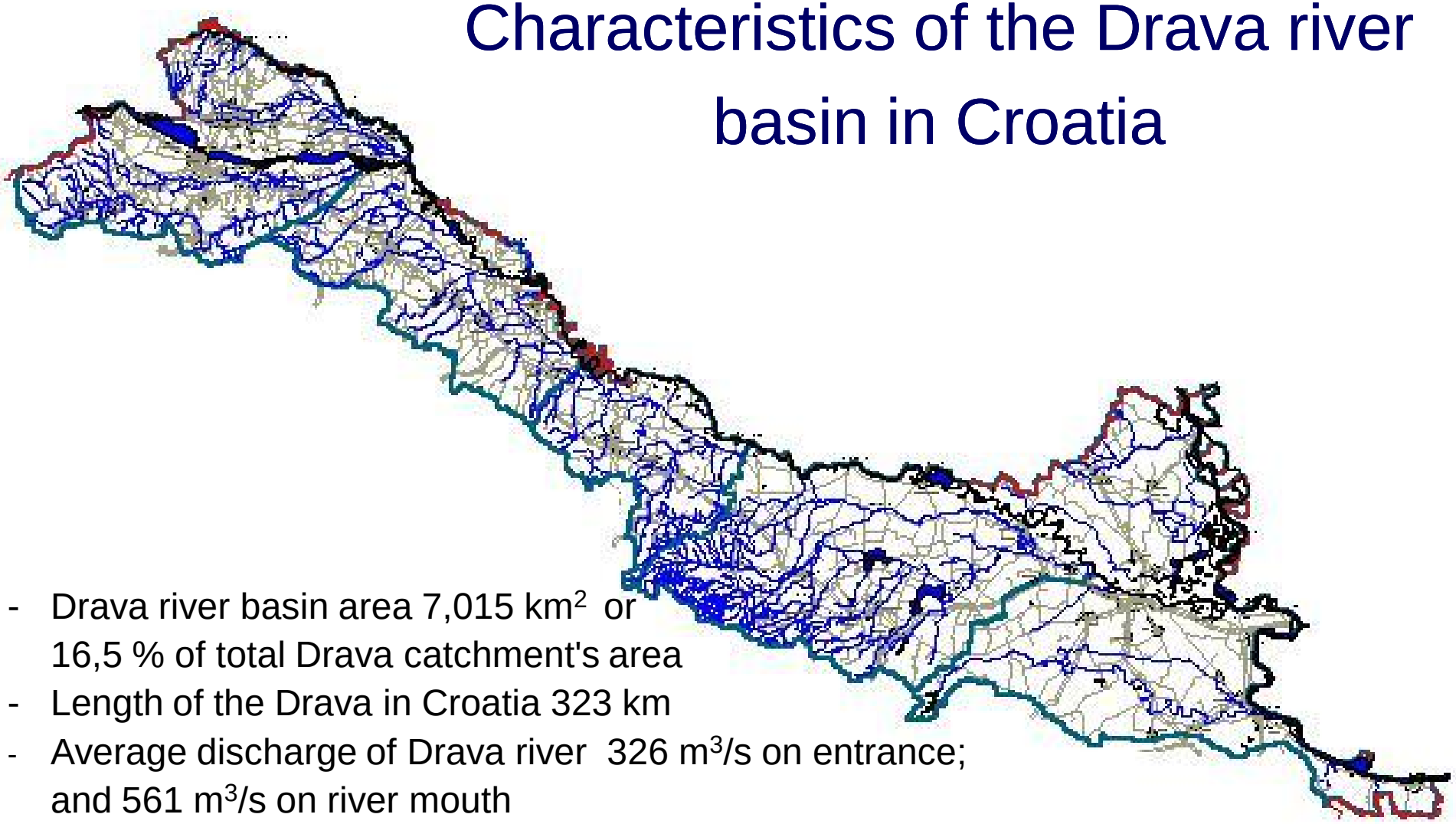


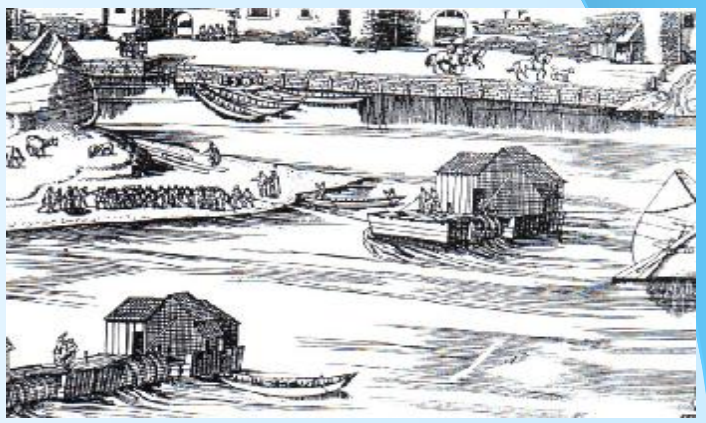
Characteristics of the Drava river basin in Croatia



- Drava river basin area 7,015 km^2 or 16,5 % of total Drava catchment's area
- Length of the Drava in Croatia 323 km
- Average discharge of Drava river 326 m^3/s on entrance; and 561 m^3/s on river mouth

Historical overview of floods in Drava river basin

- Benefits of Drava river throughout the centauries – water mills, navigation, gold exploitation
- Written traces, archaeological findings, geologic deposits testify about cataclysmic floods episodes of the Drava river in the past



Drava river basin floods historical review – upper Drava

- First written documents in 17th century: 1633, 1649, 1978, 1692, 1698 – the great floods and public waterworks on building dykes of Varaždin area (documentation of the Croatian Parliament)
- Similar situation in 19th century: 1827, 1851,1874,1878, 1882 on Varaždin and upstream area a lot of data about flood disasters

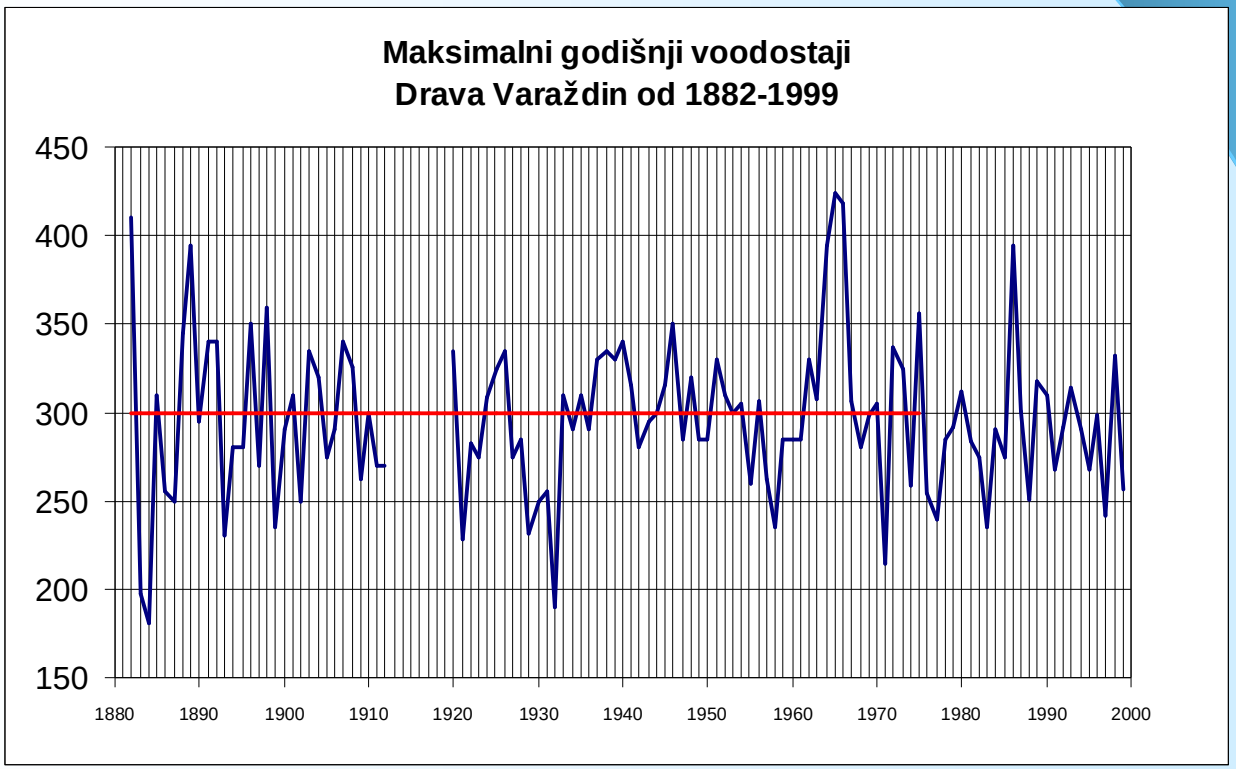
Drava river basin floods historical review – lower Drava

- Similar cataclysmic flood episodes on the most lower Drava – 02nd June 1770 – flood in Osijek
- **«Leave all – save your lives»** was the massage sent to inhabitants of Osijek and surrounding settlements which river flooded on 08th October 1814
- In annals was also memorised the June 1827 when Drava became furious, in annals stay

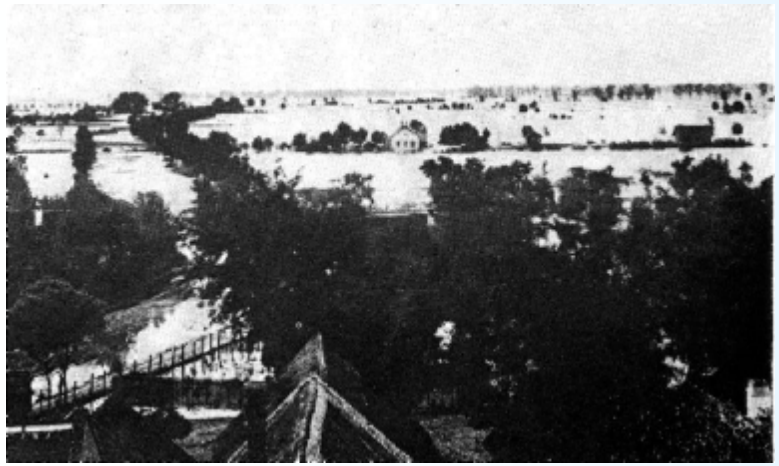
« So far Drava had flooded ours fields that only the sea you had been able to see from everywhere».

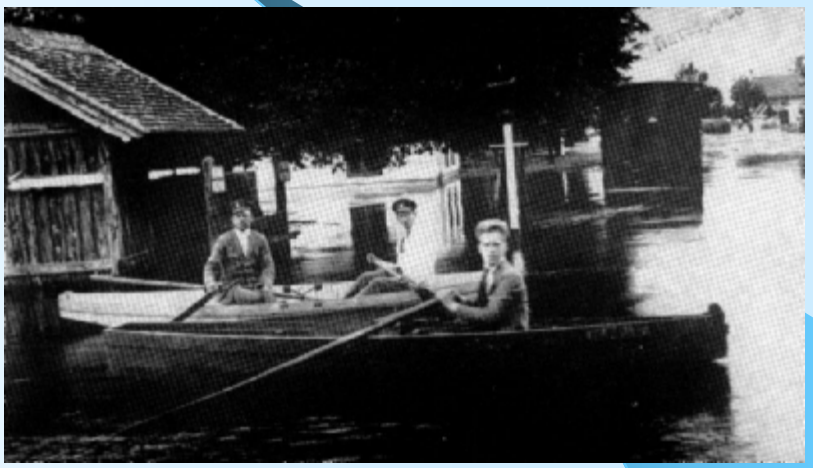
20th century floods on Drava river

- In 20th century 54 high water levels were recorded
- The largest flooding: 1926, 1954, 1965 and 1972



Floods on Drava and Danube river in 1926





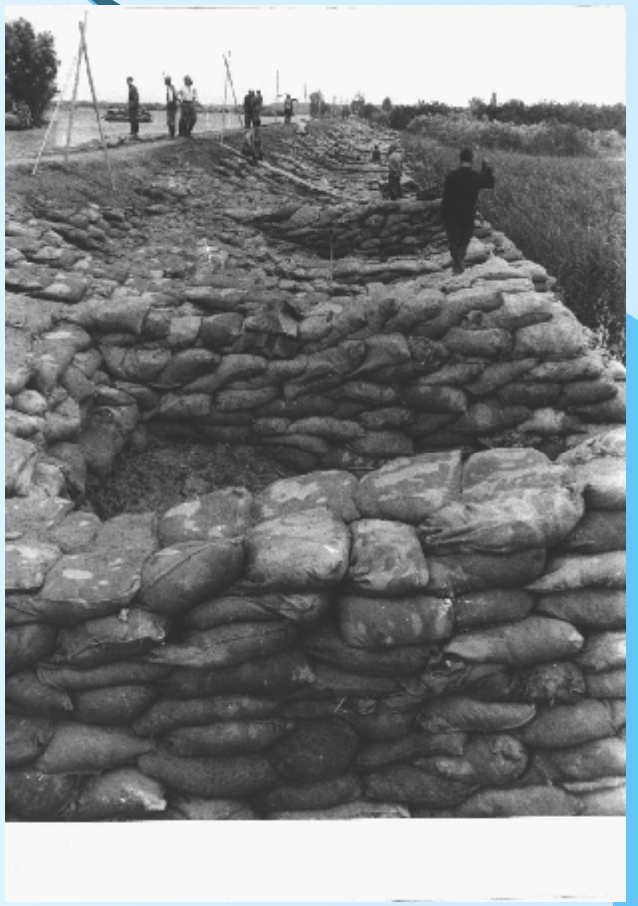
- Catastrophic scale
- Drava flooded city of Osijek and huge part of Baranja region
- 10th July 1926 river Danube flooded city of Vukovar

Floods on Drava and Danube in 1965

- The emergency flood protection measures was declared on 21th May 1965, but already on 25th June 1965. Drava river near to Osijek and Danube river near to Vukovar caught absolute water level maximum at +542 cm (caused by small surge capacity of the Danube river), respectively + 766 cm which is valid up now

Floods on Drava and Danube rivers in 1965

- **Despite huge human efforts lot of dyke breaches occurred**



Floods on Drava and Danube rivers in 1965

- The Osijek outskirts Tvrđavica i Podravlje with the end of June 1965....

Floods on Drava and Danube rivers in 1965

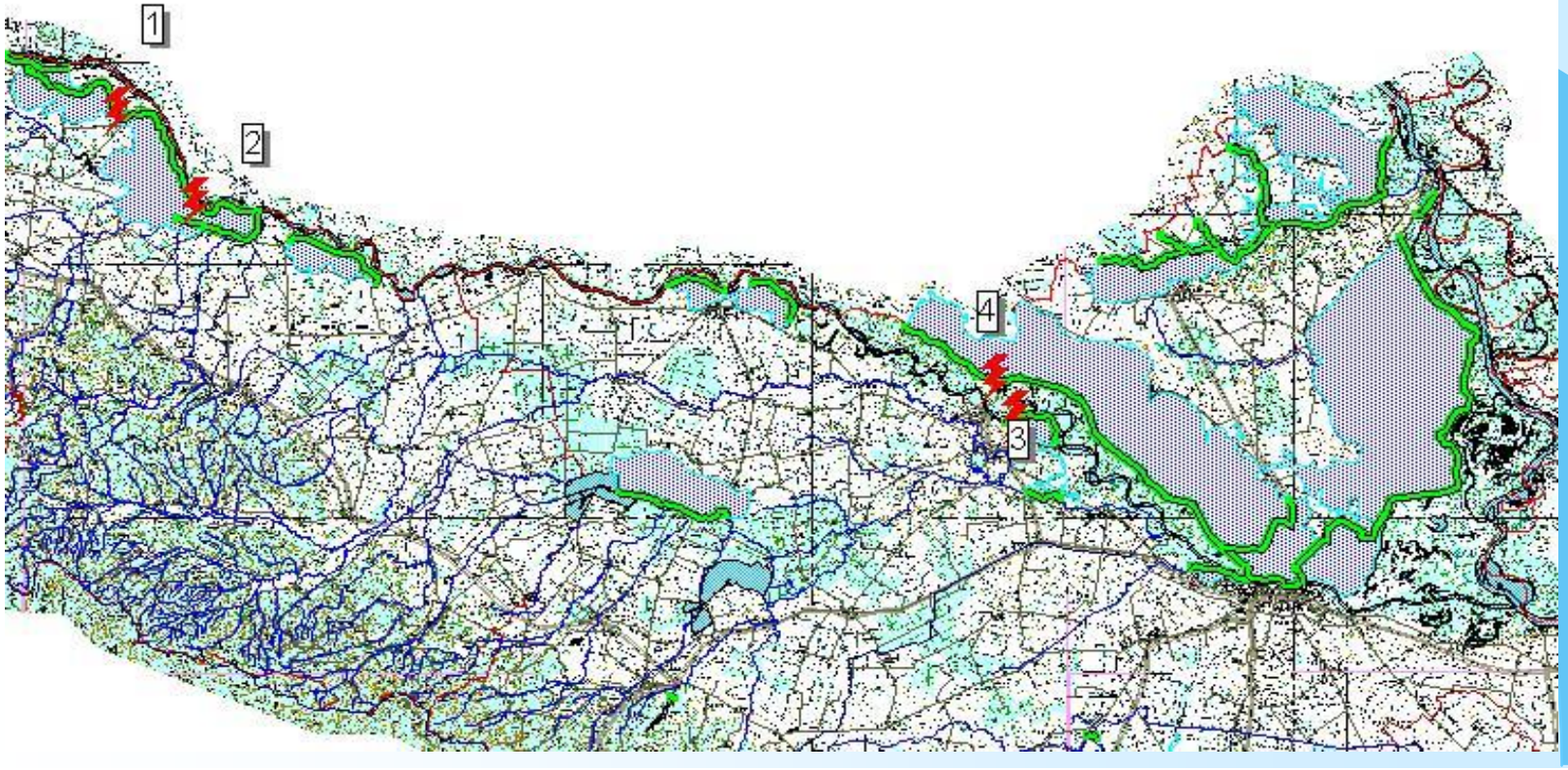
- The consequences of flood (duration: 105 days)
  - 82 settlements with 35,000 habitants were endangered
  - Flooded 3,448 apartment buildings (1,371 facility was crumbled)
  - 16 km of sewage network was destroyed, 42 km of water supplies network and roads in length of 52 km
  - Without human casualties

Floods on the Drava river in July 1972

- With its dimension and damages the floods exceed the catastrophic one from 1965
- The whole water district from Varaždin town to Osijek town was endangered again with numerous dyke breaches on four locations
- Maximum water level were recorded on Drava river gauging stations (valid up to now)

Floods on the Drava river in July 1972

- Despite on facts that on flood protection more then 30,000 people were involved, the great damages were not avoided but fortunately without human casualties
- Slavonian and Baranian fields are turned into vast lakes, but the highest destructions flood made on areas of Beli Manastir and Slatina



Flood protection system on water basin of the Drava river basins

- Flood protection, have a very long and rich tradition, thanks to fact that the human struggle against the nature lasts over the centuries in purpose to achieve a protection of fertile lowland areas from adverse effects of Krndija, Papuk and Bilogora torrential waters from one side, and high water levels of Mura, Drava and Danube rivers from the other side

- As a confirmation, organized water management in Croatia started on Drava river basin when the «Association for the Regulation of the Vuka River» was founded on 7th September 1876, with Josip Juraj Strossmayer, Bishop of Đakovo, as its elected chairman

Flood protection system on water basin of the Drava river basins

- The beginning of dykes building along the Drava river started in 18th century and continued throughout 19th century (Count Veterny ordered building of 6.7 km long dyke on Drava river mouth in 1720)
- After already mentioned disaster floods, during 1970's the flood protection system was build and all dykes are still in use today
- As a result of intensive flood protection works nowadays we have totally 522 km of dykes (340 km along the Drava river), which protect around 145,000 hectares of urban, forestry and agricultural areas (approximately 16% of Drava and Danube river basin area) mostly with protection from flood of 100 years return period of occurrence

CONCLUSIONS

- **Construction of flood protection facilities gave a positive result as well as favorable hydrological conditions**
- **In the last 35 years, floods of larger scale were not recorded on the river basin despite the occurrence of less extreme flood waves (backwater effects of Danube river)**

CONCLUSIONS

- **Justification of investments in flood protection system was confirmed in August 2002 and again in spring 2006 (near the Drava river mouth)**

- **Thanks to existing functioning flood protection system and thanks to timely taken flood protection measures, as well as professional approach in spirit of a hundred years old tradition in water management on this area, the situation as on upstream part of water basin was prevented**

CONCLUSIONS

- **In 2005 on the Mura river the new maximum water levels were measured**
- **In the future, similar situations (reaching and exceeding the historical maximum water levels) could be expected on Drava and Danube rivers, because of that further improvement of the flood protection system should be made**
- **Other measures for improving the system**
  - **Finishing remote flood alert system**
  - **Further development of hydraulic and hydrological mathematical models for flood forecasting**
  - **Raising of public awareness about flood hazard (flooding as a natural phenomenon that can not be completely prevented)**

Flood protection system on water basin of the Drava and Danube river basins

- commitment of the Republic of Croatia to establish international standards and international cooperation in the field of water management in practice is confirmed
- on Drava and Danube river basin through bilateral cooperation with neighboring Hungary and Slovenia on the basis of an agreement on water management relations
- in field of the flood protection is on a satisfactory level, but there is still room for further improvement