

PIONEERING WORKS IN POLISH ENVIRONMENTAL HYDRAULICS *THE FLAVOUR OF WORLD-CLASS SCIENCE*



**50 YEARS OF WORK
OF WŁODZIMIERZ CZERNUSZENKO**

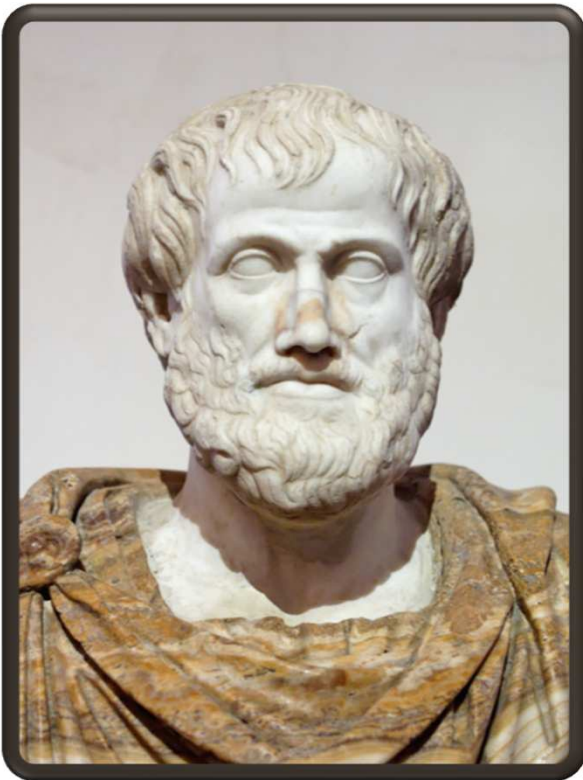


XXXII ISH 2012,
Łochów, Poland

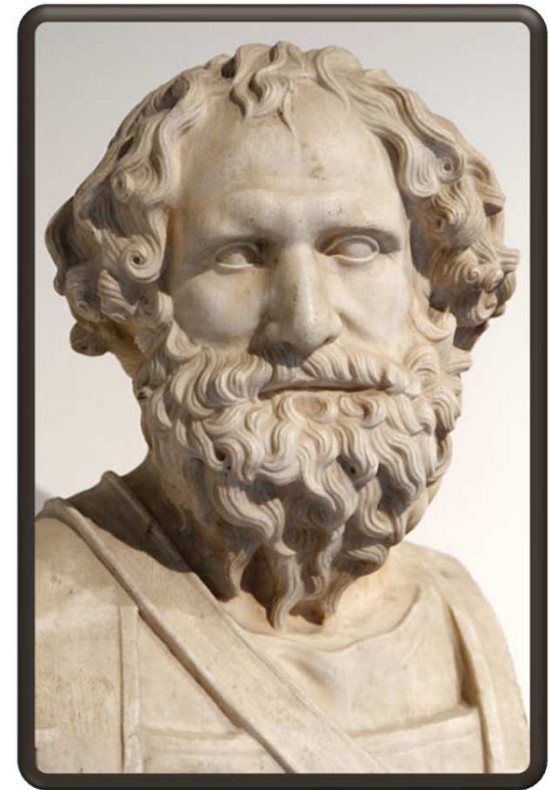
P. M. Rowiński, M. B. Kalinowska

„Beginning” of environmental hydraulics

Aristotle (384-322 B.C.)



Archimedes (287-212 B.C.)



Environmental Hydraulics



A domain of research and investigation of the physical, chemical and biological attributes of flowing water with the objective of protecting and enhancing the quality of the environment, including public welfare.

Prof. Włodzimierz Czernuszenko

- Born on 4th of June
1939 in Warsaw

The Royal Castle, Warsaw



Zygmunt's Column, Warsaw



Old Town Market Place, Warsaw



Prof. Włodzimierz Czernuszenko

- Born on 4th of June 1939 in Warsaw



Traffic jam on Marszałkowska street in Warsaw



Prof. Włodzimierz Czernuszenko

- Born on 4th of June 1939 in Warsaw
- 1st of September 1939 – World War II





1st of September 1939

Prof. Włodzimierz Czernuszenko

- Born on 4th of June 1939 in Warsaw
- 1st of September 1939 – World War II
- August 1944
Warsaw Uprising
 - ▣ Professors' mother Zofia was killed during the uprising



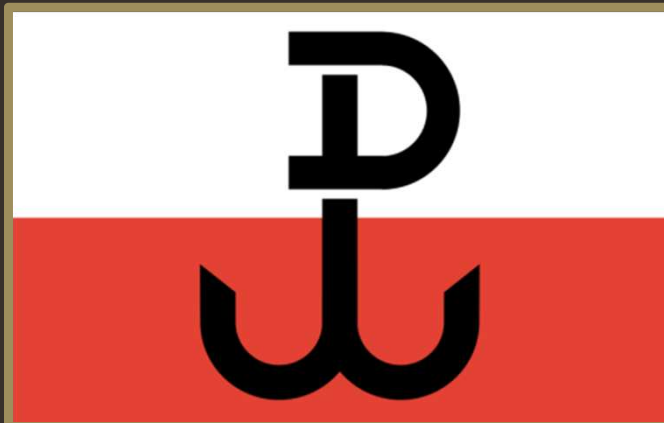
**Scout Postal Service
distributing insurgent press**



**This insurgent is coming out of sewers
and surrendering to Germans.**

Bundesarchiv Bild 146-1984-054-30
Foto: Arens | 1944 September - Oktober

The symbol
on the flag
is a combination
of letters
"P" and "W"
"Polska Walcząca",
i.e. "Fighting Poland"



Stukas bombing the Old Town



Warsaw Uprising, August 1944

Prof. Włodzimierz Czernuszenko

- Born on 4th of June 1939 in Warsaw
- 1st of September 1939 – II World War
- August 1944
Warsaw Uprising



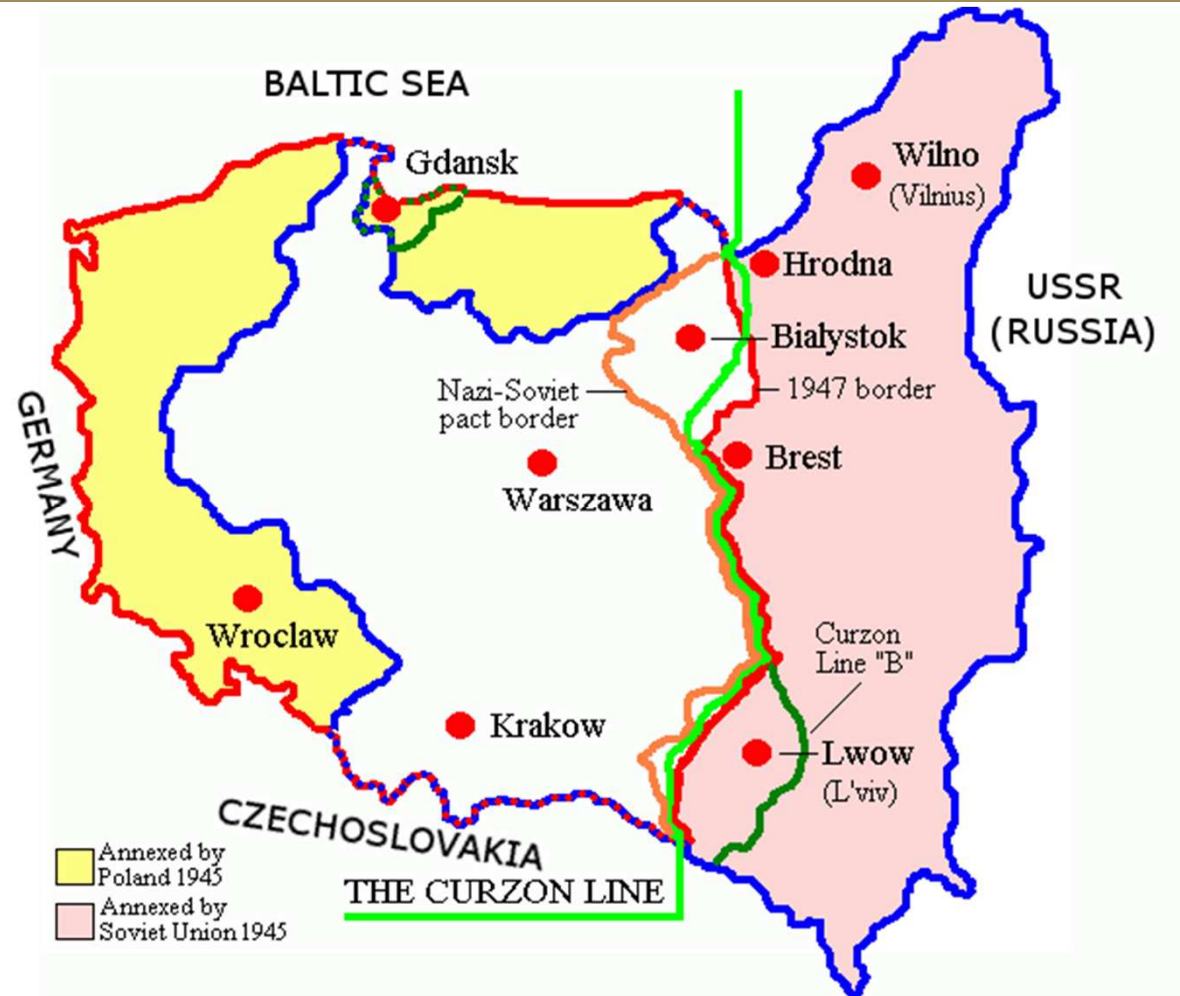
Prof. Włodzimierz Czernuszenko

- Born on 4th of June 1939 in Warsaw
- 1st of September 1939 – II World War
- August 1944
Warsaw Uprising
- “New” Warsaw,
“New” Poland



Prof. Włodzimierz Czernuszenko

- Born on 4th of June 1939 in Warsaw
- 1st of September 1939 – II World War
- August 1944
Warsaw Uprising
- “New” Warsaw,
“New” Poland



The Royal Castle, Warsaw



Royal Castle Warsaw 1945

Zygmunt's Column, Warsaw



Zygmunt's Column. 1945

Old Town Market Place, Warsaw, 1945





Destroyed Warsaw, capital of Poland, January 1945

August 1939: 1.300.000 inhabitants
Before August 1944: 900.000 inhabitants
After August 1944: 1.000 inhabitants



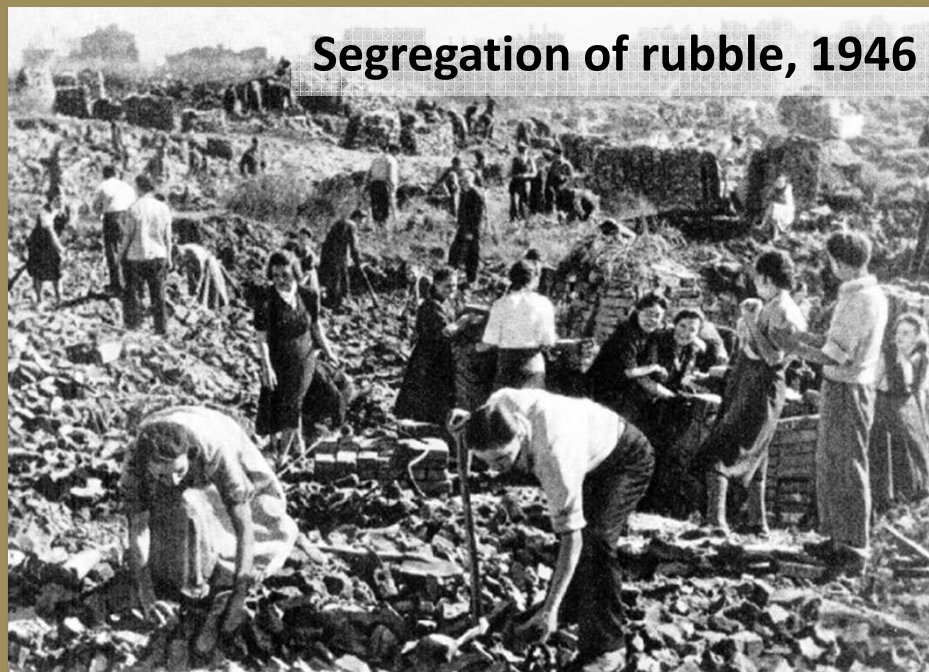
The city of ruins, slide from the Movie to be seen in Warsaw Rising Museum

Return to relative normalcy

- The rebuilding of Warsaw



Segregation of rubble, 1946



Transport of rubble



Return to relative normalcy

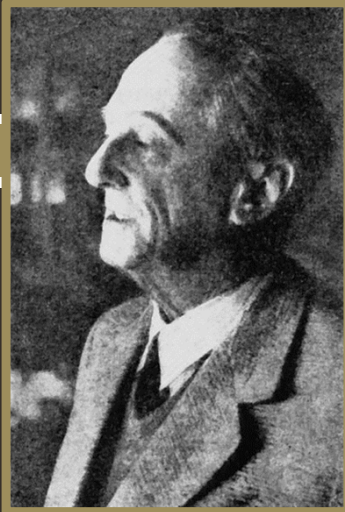
- The rebuilding of Warsaw
- The reconstruction of education and science

POLISH SCHOOL OF MATHEMATICS

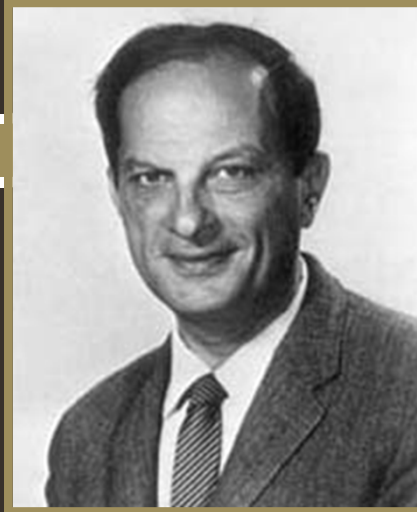
In the first half of the 20th century, Poland was a flourishing centre of mathematics



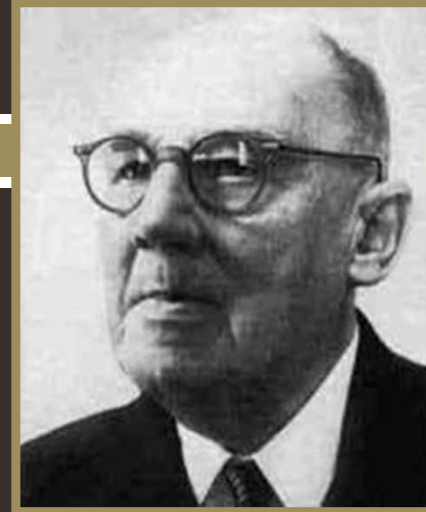
STEFAN BANACH
1882 -1945



HUGO STEINHAUS
1887-1972



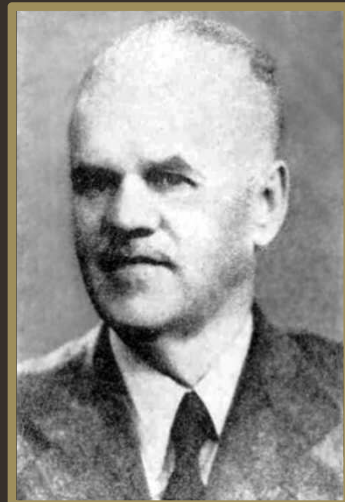
STANISŁAW ULAM
1909-1984



WACŁAW SIERPIŃSKI
1882-1969



LEOPOLD INFELD
1898-1969



MIECZYŚŁAW WOLFKE
1883-1947

The events of World War II
pushed many of them
into exile

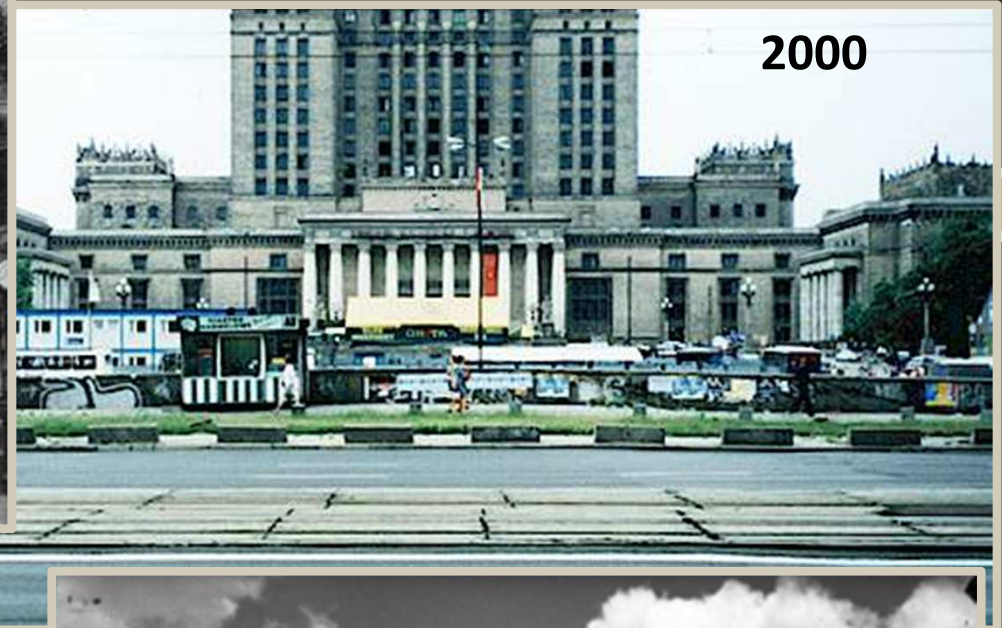
After the World War II

- 1953
Technical School of
Telecommunication
and
Radio-engineering
in Warsaw
- 1952-1955
Palace of Culture
and Science
construction





Before the War



2000



**EXACTLY IN THIS PLACE TODAY STANDS
THE PALACE OF CULTURE.**

A quarter of the city equal to the size of a medium sized town had to be undress (some buildings survived the Warsaw Uprising).

*"A gift from the Soviet Union
to the people of Poland"*



40 million bricks and 26 thousand tons of steel

Palace of Culture and Science

Beginning of scientific work

- Study in Department of Sanitary Engineering and Water Management, **Warsaw University of Technology**
- 1962 – started work in **National Hydrological and Meteorological Institute**
- 24th of April 1963
MSc thesis

**“MEASURING METHODS
FOR GROUNDWATER FLOW”**





PROF. JULIAN MICHAŁ LAMBOR
1901-1973

- ❑ Outstanding Polish hydraulic engineer and hydrologist
- ❑ Vice-President of European Regional Association of WMO (World Meteorological Organization)

... just before in 1962

□ Marriage with Władysława

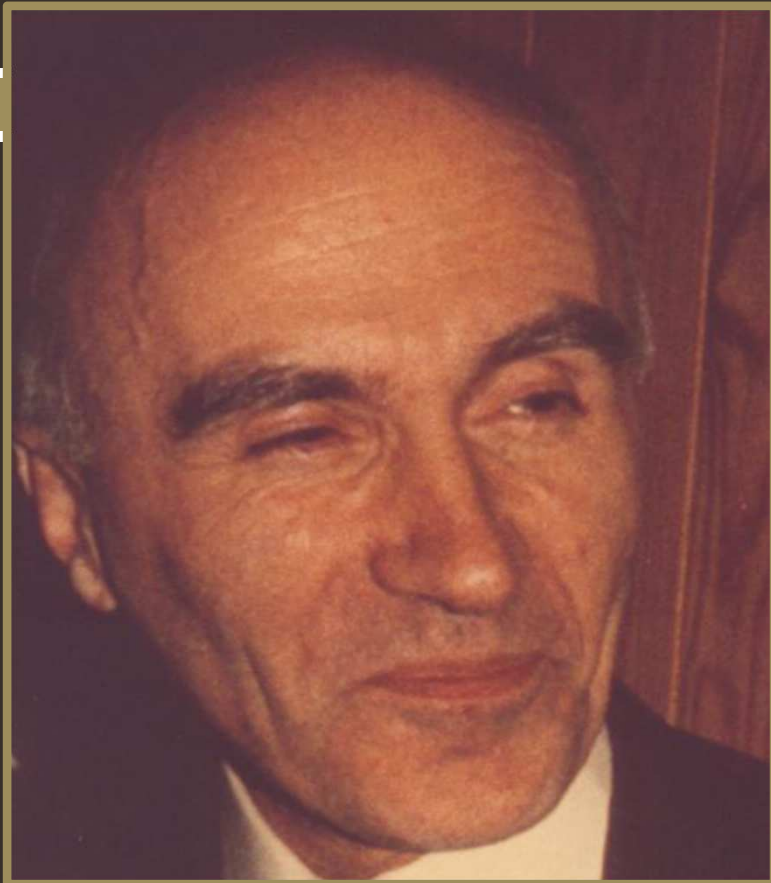


Beginning of scientific work

- 1964 - teacher at **Technical School of Geology**
- Study at Faculty of Mathematics and Physics of **Warsaw University**
- 29th of June 1971
MSc thesis

**“MATHEMATICAL PROBLEMS
IN FLUID MECHANICS”**





PROF. WŁADYSŁAW FISZDON
1912 - 2004

□ Outstanding scientist,
aerodynamist,
aviator and mathematician

Doctor of Technical Sciences

- 30th of October 1973
Department
of Sanitary Engineering
and Water Management,
**Warsaw University
of Technology**
PhD thesis

**“MASS TRANSFER IN THE
OPEN CHANNEL FLOW”**





□ Prominent specialist
in hydrology
and water management

PROF. ZDZISŁAW KACZMAREK
1928 - 2008

Beginning of international scientific cooperation

□ Hungary 1976

- Hungarian Hydrological Society, invited lecture
“Diffusion problems in rivers”

□ Denmark 1977

- Internship in Copenhagen DISA Elektronik

□ Netherlands 1978/1979

- Annual International Course of Hydraulic Engineering in Delft under the supervision of M.B. Abbott

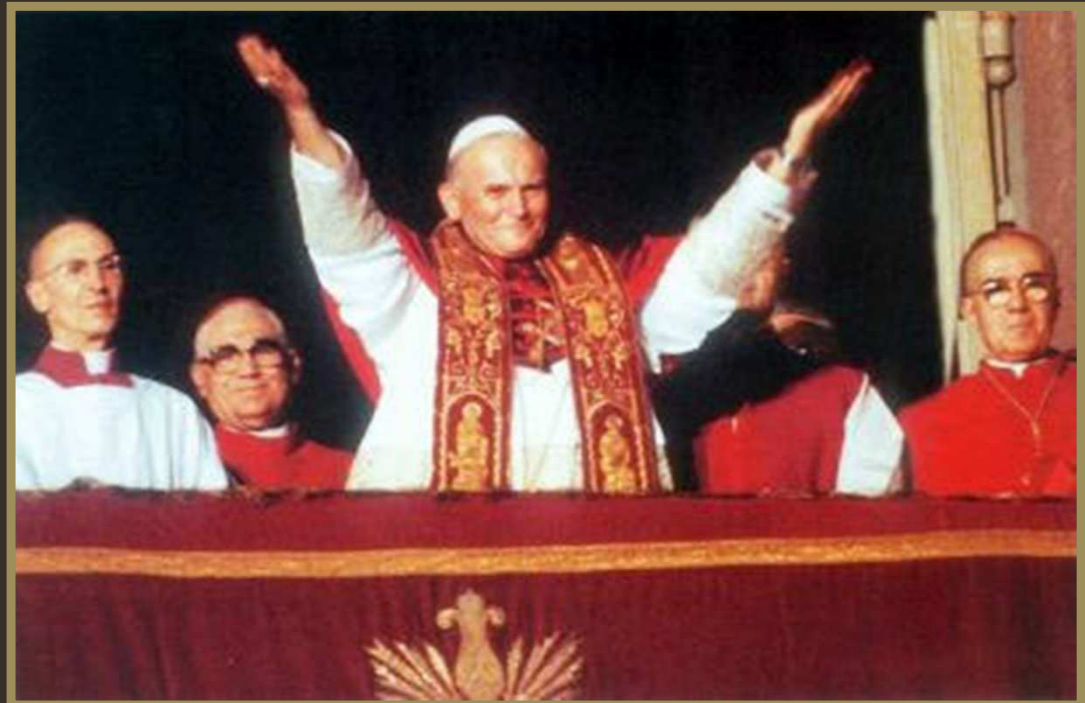
□ Yugoslavia 1980

- Yugoslav Association of Hydraulic Research, lecture
“Unsteady diffusion of solutes in natural streams”

1978 – Karol Wojtyła became the Pope



Pope John Paul II
1920 - 2005



1980 – Solidarity (Polish trade union)

Soviet bloc's first independent trade union



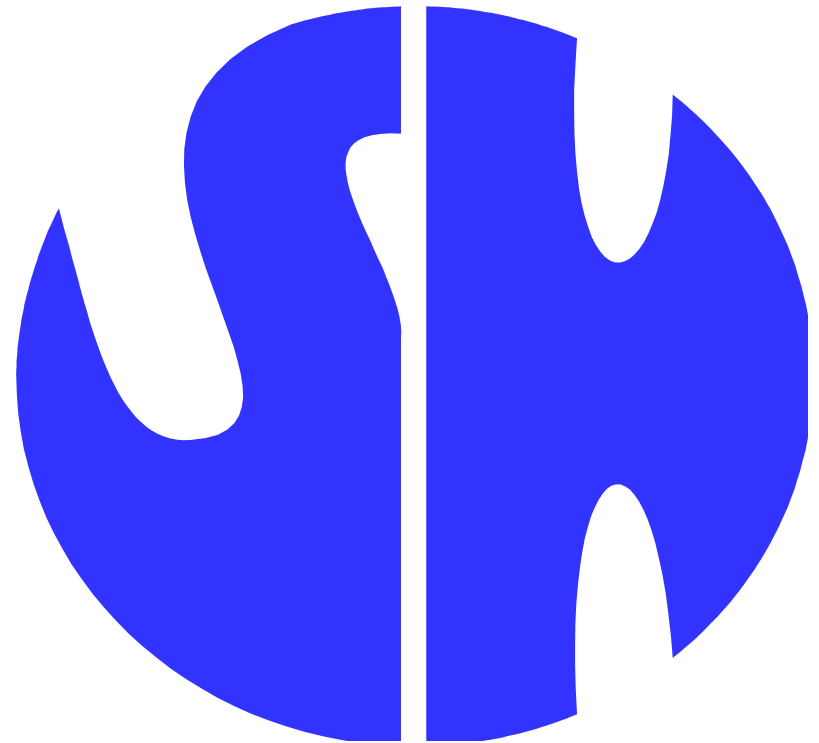
LECH WAŁĘSA

trade-union organizer,
human-rights activist ,
awarded the Nobel Peace Prize
in 1983,
and served as President of Poland



First School of Hydraulics

- 1981 – SH established
 - ▣ under the auspices of the Committee of Water Resources Management of the Polish Academy of Sciences
 - ▣ the initiative of Prof. B. Kordas
 - ▣ organized at Osieczany by Prof. W. Majewski



1981-1983 Martial law in Poland



T-55A on the streets
during Martial law in Poland

Mąka 1000 g XI 82	Cukierki 250 g XI 82	Cukier 500 g XI 82	Cukier 1500 g XI 82	Papierosy 6 pacz. XI 82
P. zhożowe 1000 g XI 82	W. Z. Nr _____ P-3 nazwisko i imię _____ adres: gmina-miasto-dzielnica _____			Papierosy 6 pacz. XI 82
Proszek 200 g XI 82				Alkohol 1 but. XI 82
Proszek 100 g XI 82	R-PiII 10 XI 82	Tłuszcze 375 g XI 82	Czekolada 100 g XI 82	R-PiII 20 XI 82

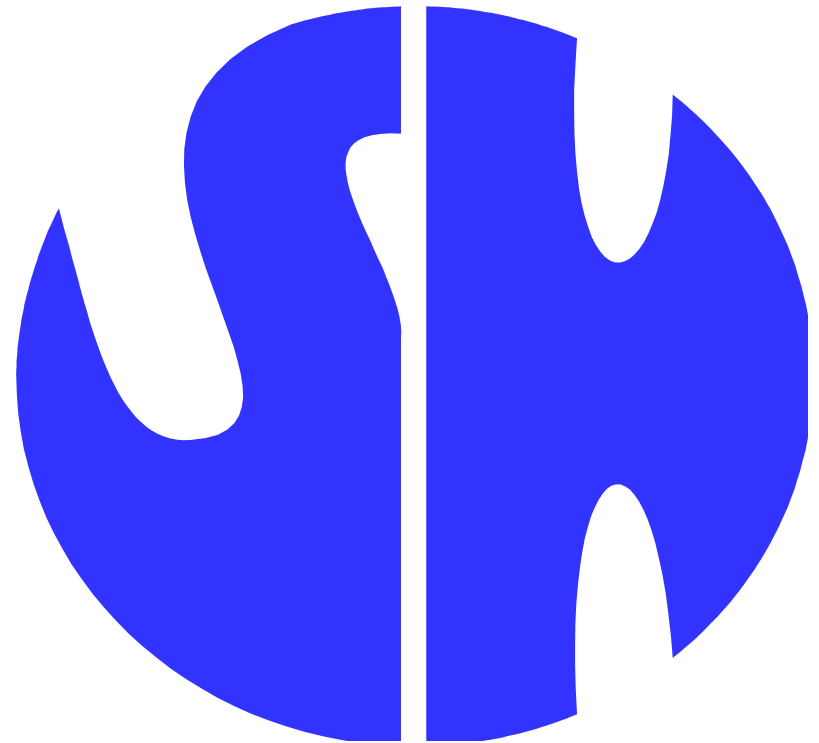
Food, alcohol and cigarettes rationing card

1981-1983 Martial law in Poland



Second School of Hydraulics

- 1982 – SH Stawiska
- Despite of organizational difficulties:
 - ▣ problems with funds for science
 - ▣ difficulties with food supply
- Since then regularly organized each year till now



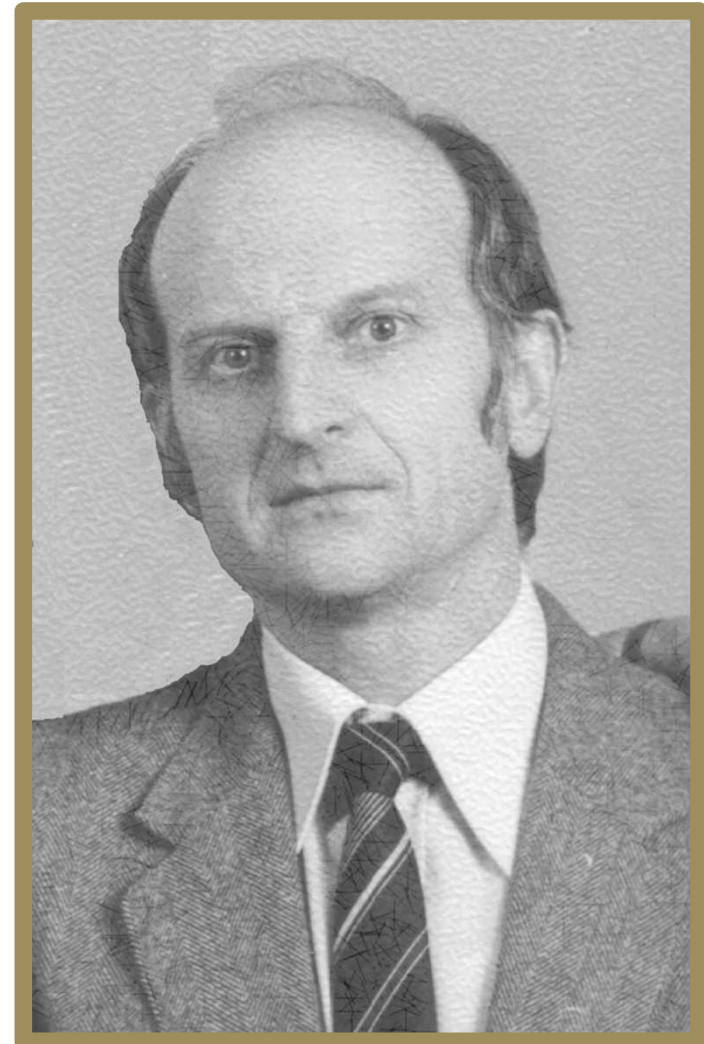
Habilitation

□ 1984

Department
of Sanitary Engineering
and Water Management,
**Warsaw University
of Technology**

Monograph:

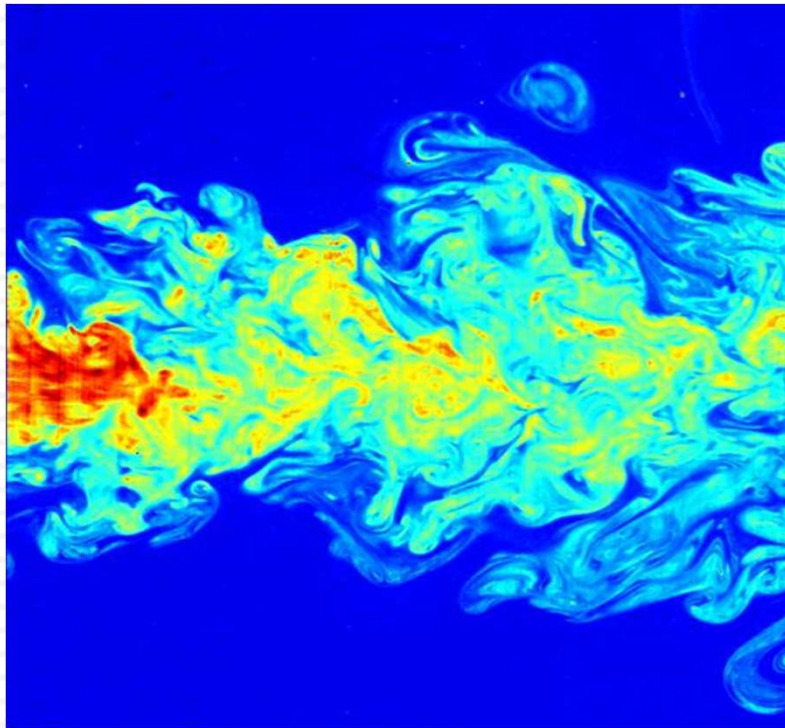
**“DISPERSION OF POLLUTANTS
IN RIVERS AND CHANNELS”**



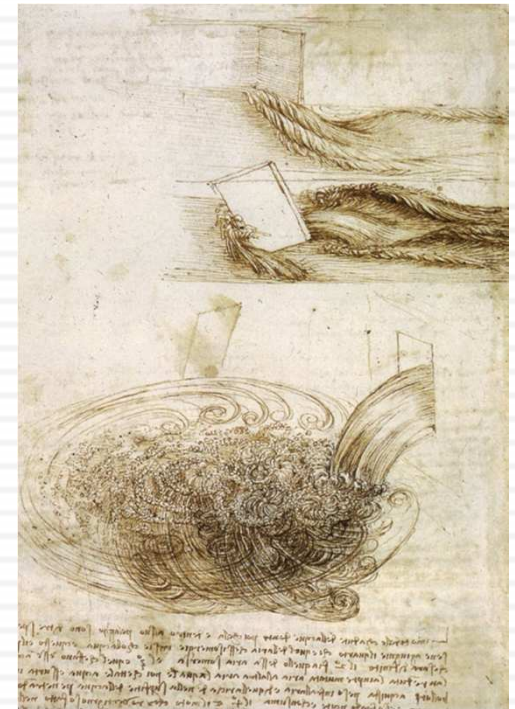
In spite of hard times ...

- Prof. Czernuszenko
 - ▣ Became an influential Polish hydraulician at the time of the explosion of west-east collaboration
 - ▣ Selected research studies:
 - ▣ River turbulence
 - ▣ Mass and heat transport in rivers
 - ▣ Solid particles' transport in rivers

River turbulence

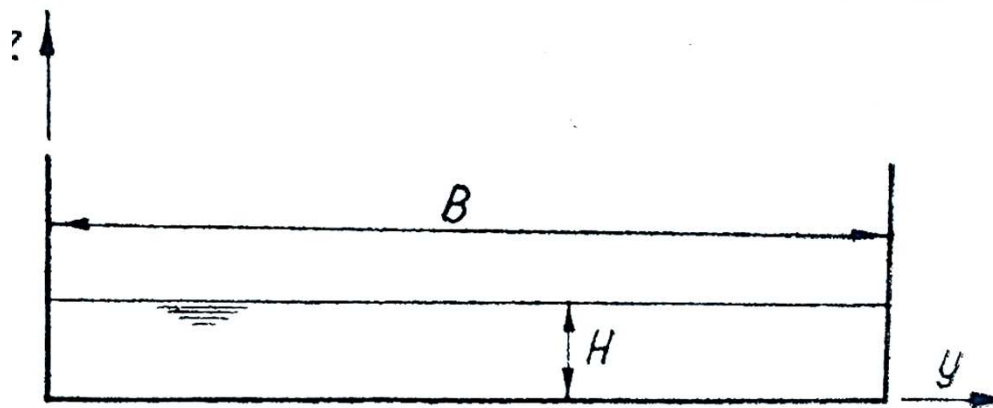


Turbulent jet

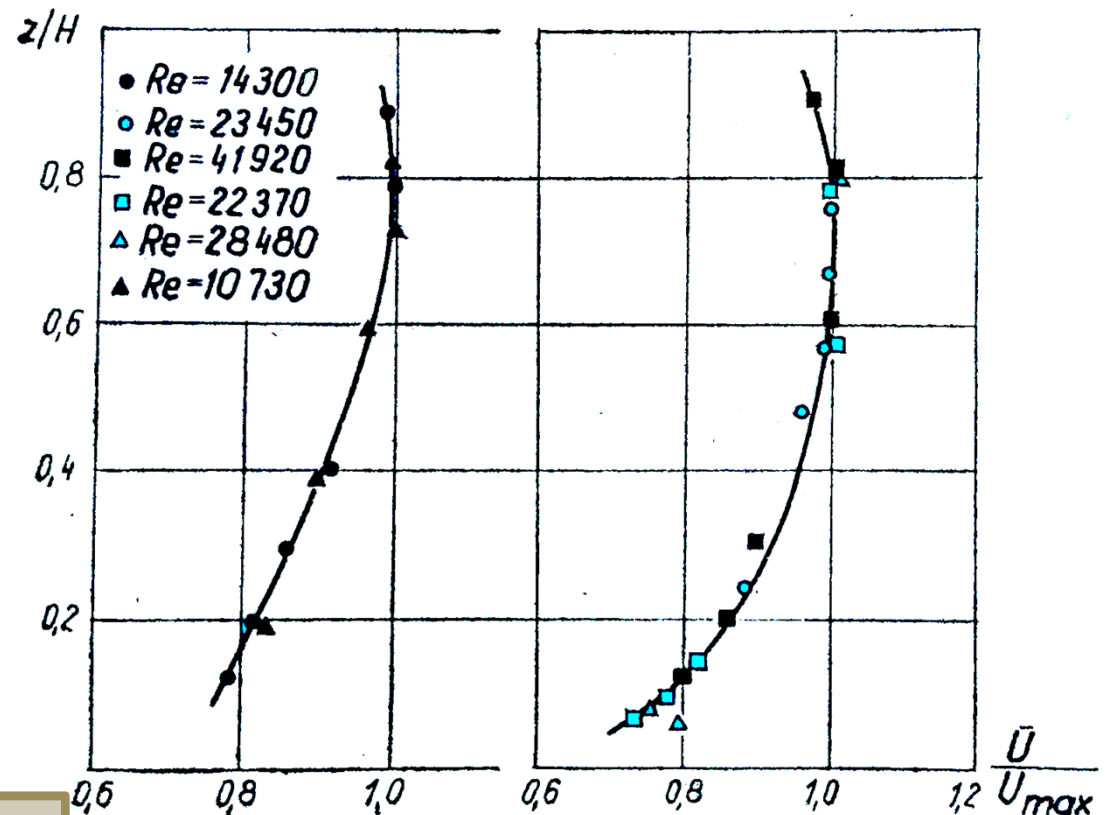


Turbulence characteristics in open channel

- First laboratory experiment in Poland allowing to determine the basic turbulence characteristic



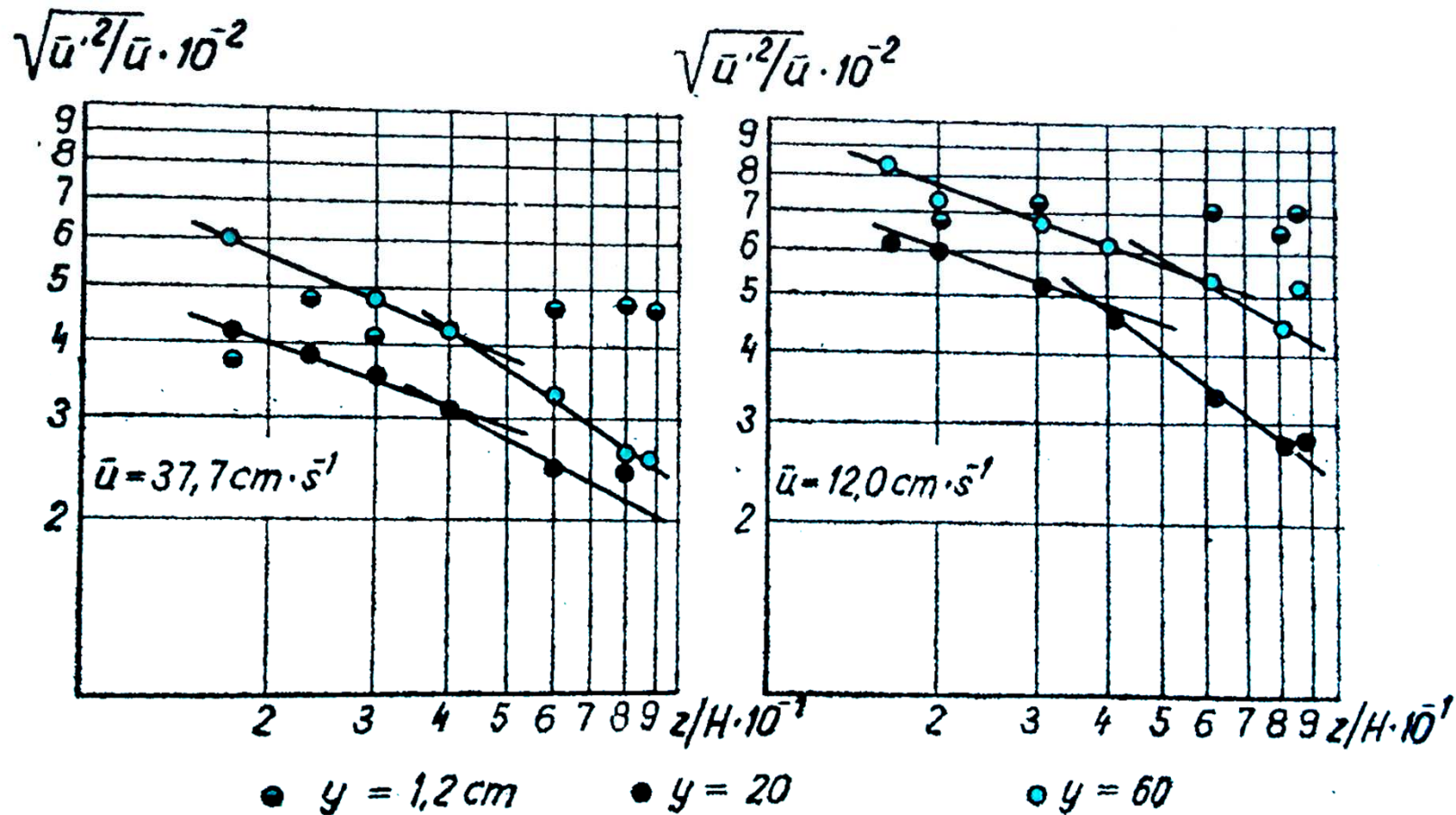
Cross-section of experimental channel



Average velocity profiles

Czernuszenko and Lebiecki (1980)

Turbulence characteristics in open channel



Changes in turbulence intensity with depth

Czernuszenko and Lebiecki (1980)

Warsaw University of Life Sciences



- 1979/1980
Lectures for PhD students:
 - ▣ Theory of turbulent flows
and turbulent diffusion
in open channels

Field campaigns



Vistula River

- Połaniec Power Station

Narew River

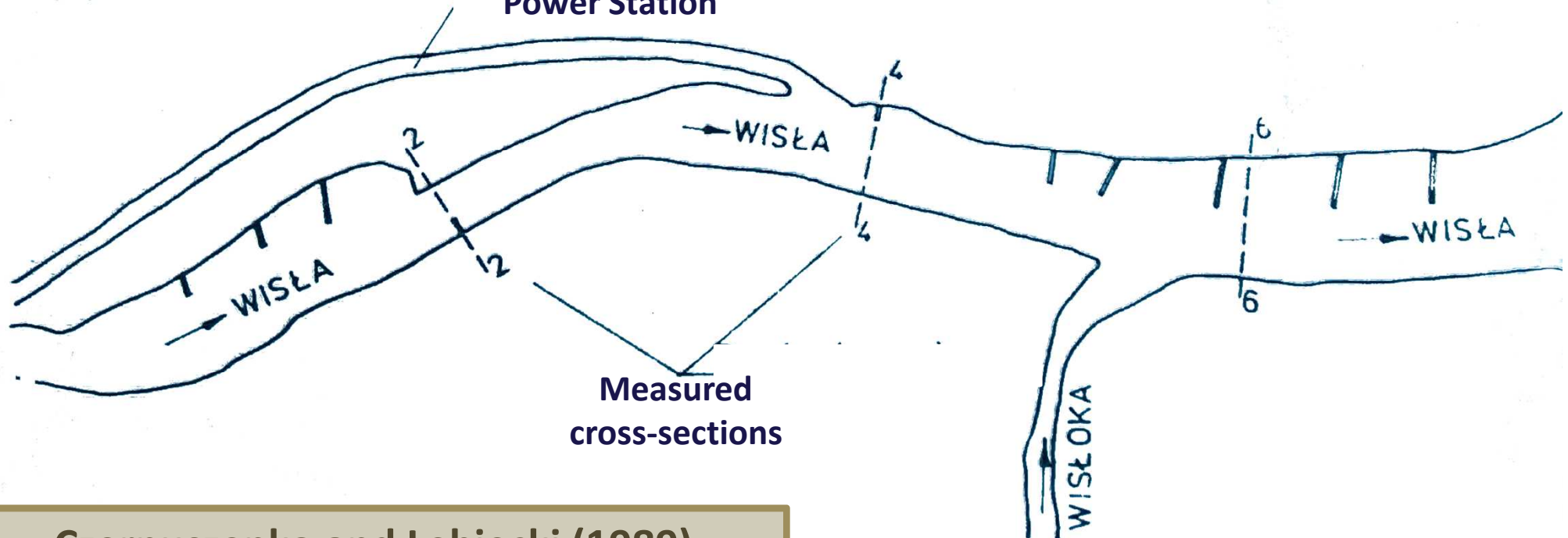
- Ostrołęka Power Station

Field campaigns

Vistula River

■ Połaniec Power Station

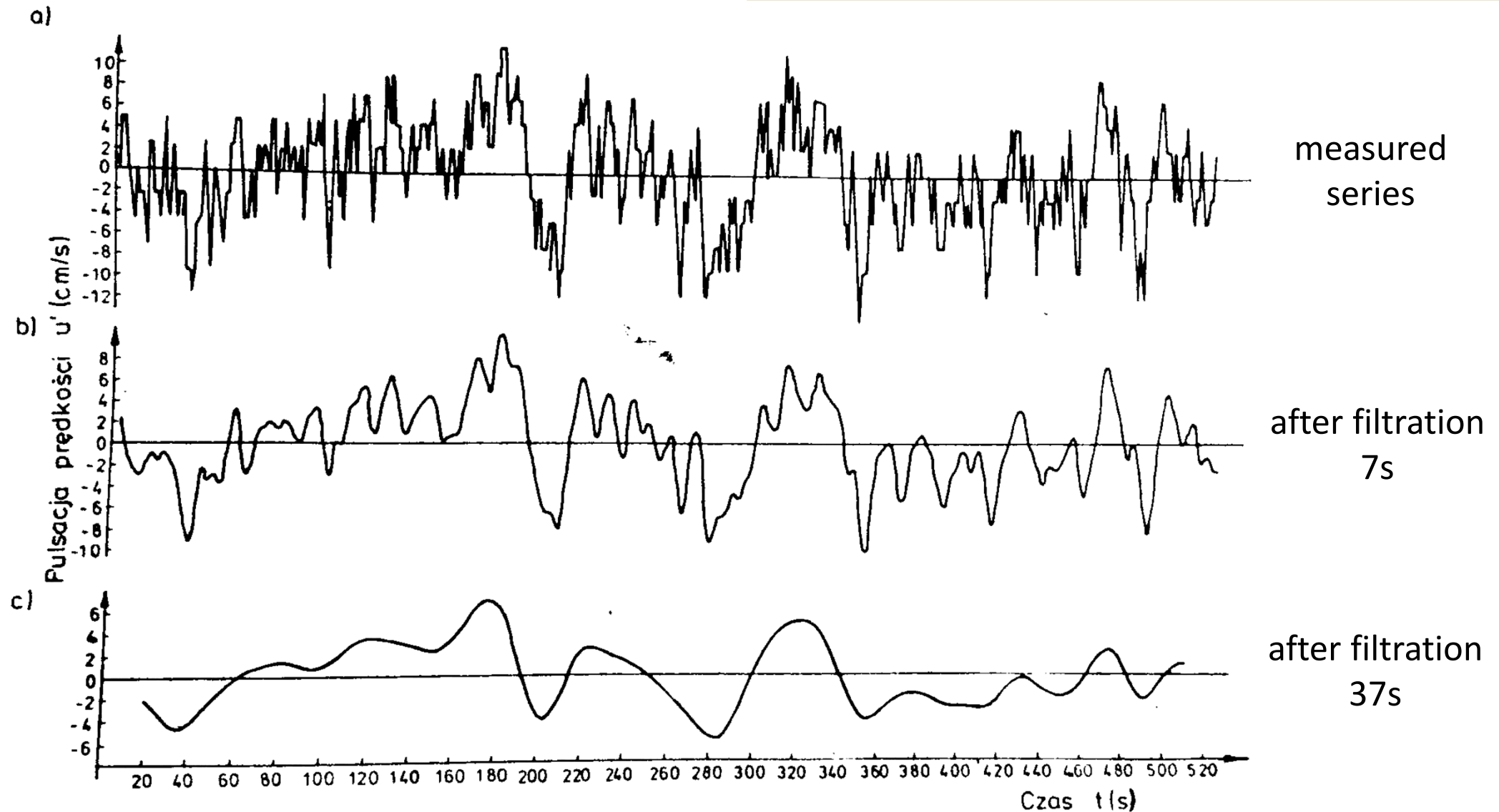
discharge from
Power Station



Czernuszenko and Lebiecki (1989)

Field campaigns

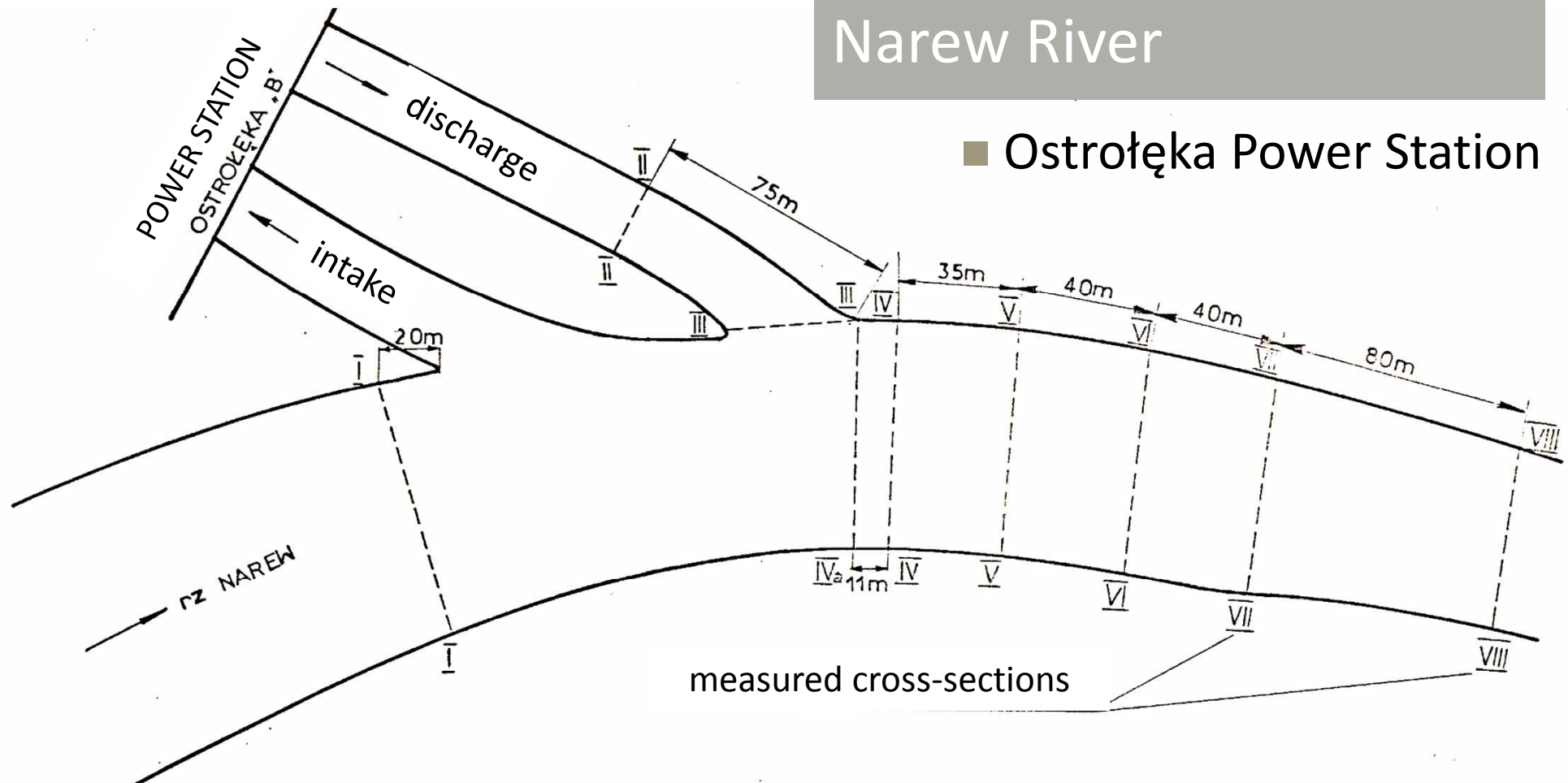
Czernuszenko and Lebiecki (1989)



Field campaigns

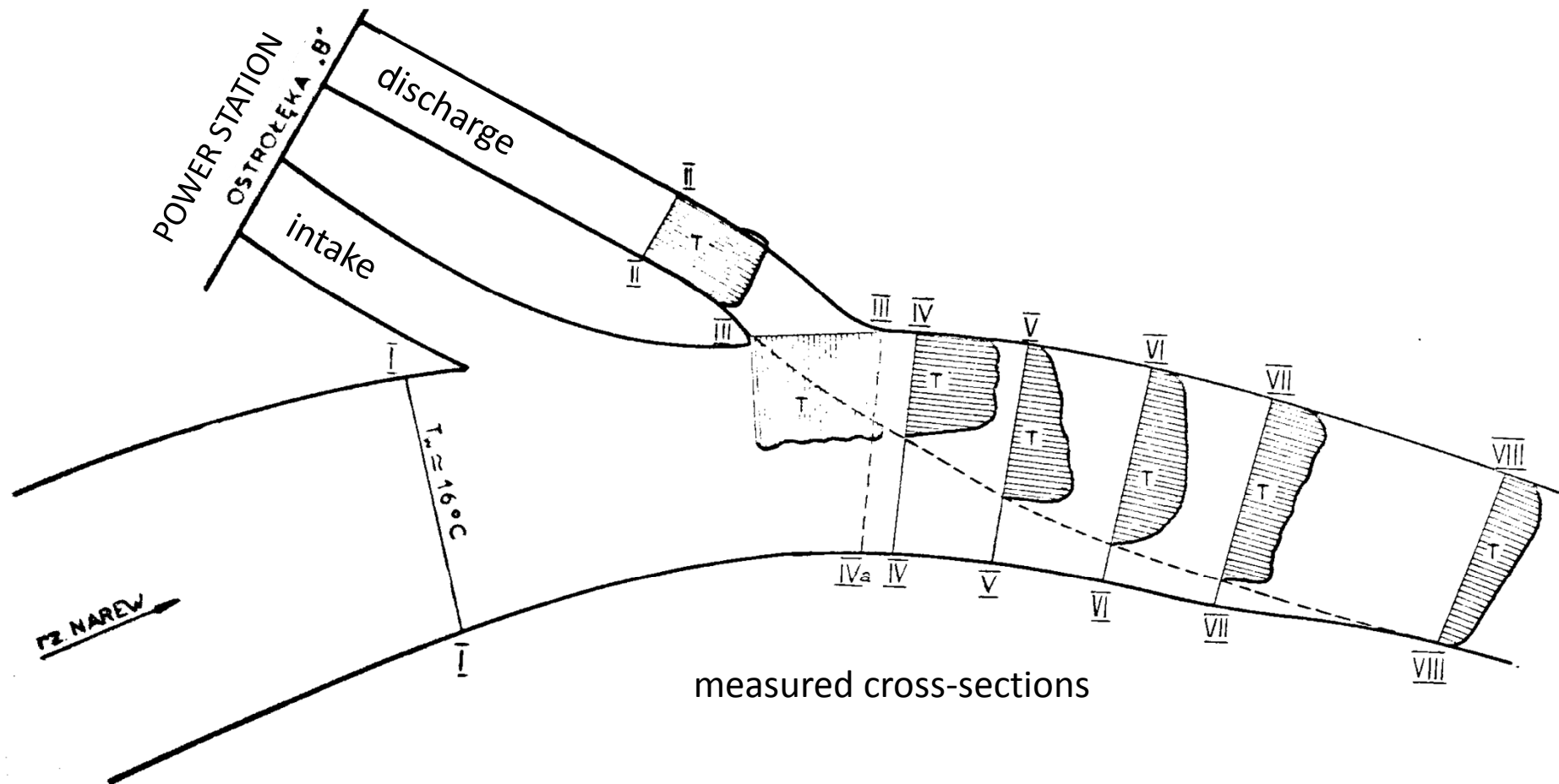
Narew River

■ Ostrołęka Power Station



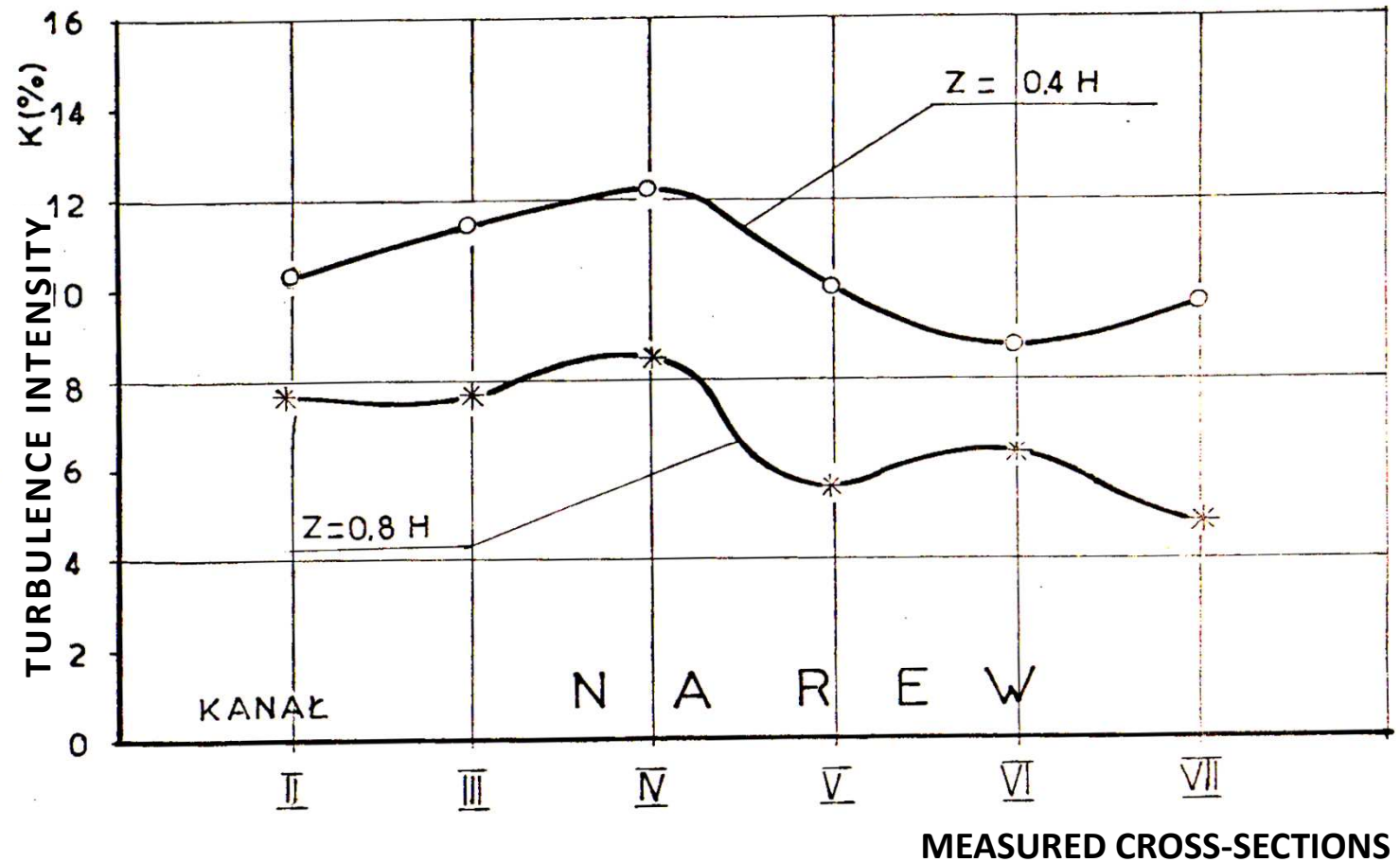
Czernuszenko and Rowiński (1989)

Thermal pollution



Field campaigns

Narew River



Collaboration with Prof. Nikora

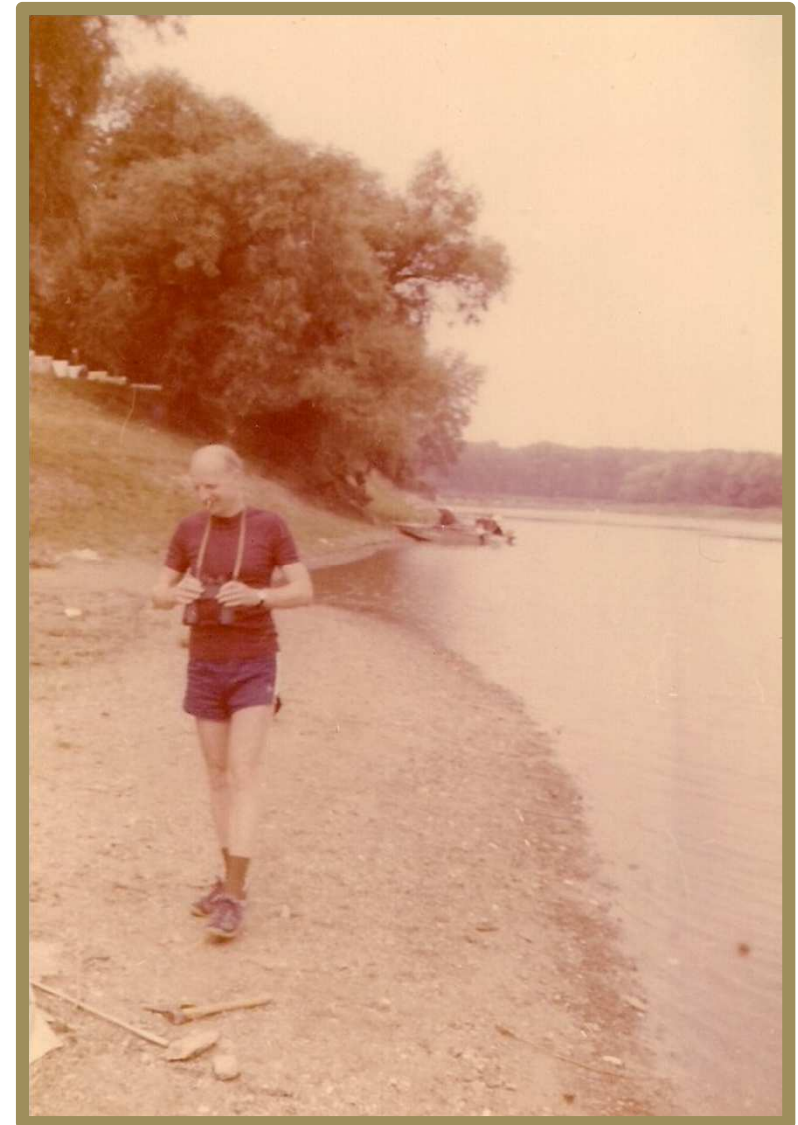
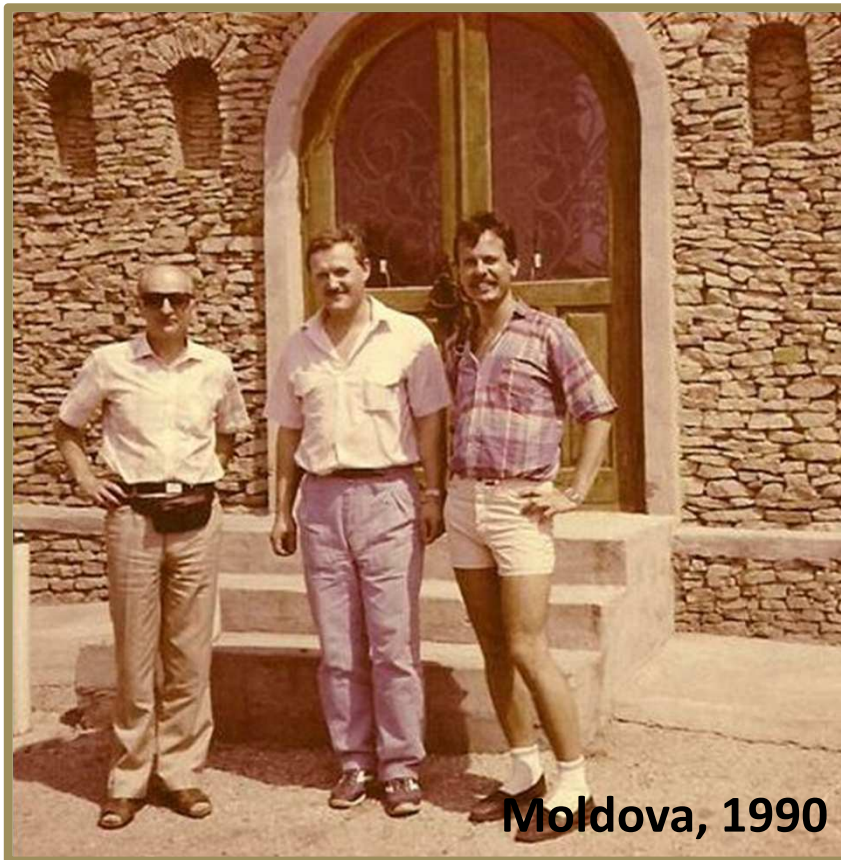
Moldova, 1990



Examples of Publications

- 1993, *Adv Hydr Sci Eng*
Nikora, Czernuszenko,
Sukhodolov, and Rowiński
- 1998, *Water Environ Res*
Sukhodolov, Nikora,
Rowiński, and Czernuszenko
- 2010, *River Flow*
Bialik, Rowiński,
Czernuszenko, and Nikora

Collaboration with Prof. Nikora



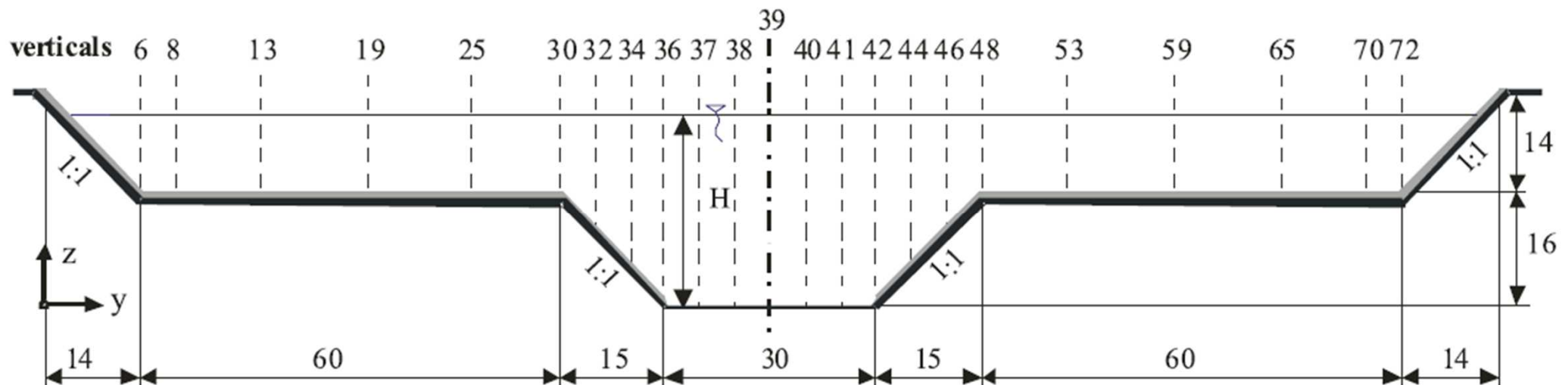
Collaboration with Prof. Nikora



Lisbon, 2006

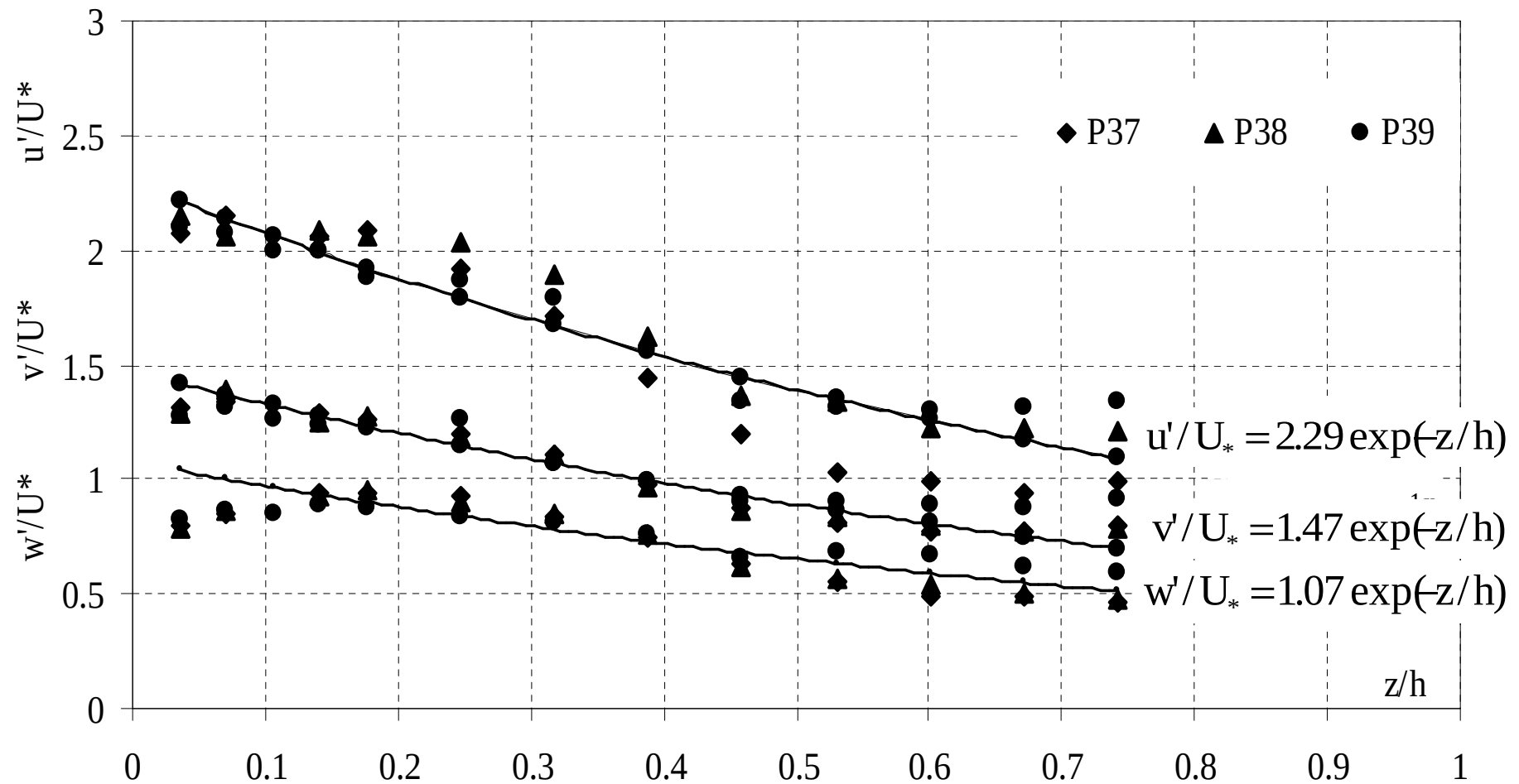
Various studies in a compound channel

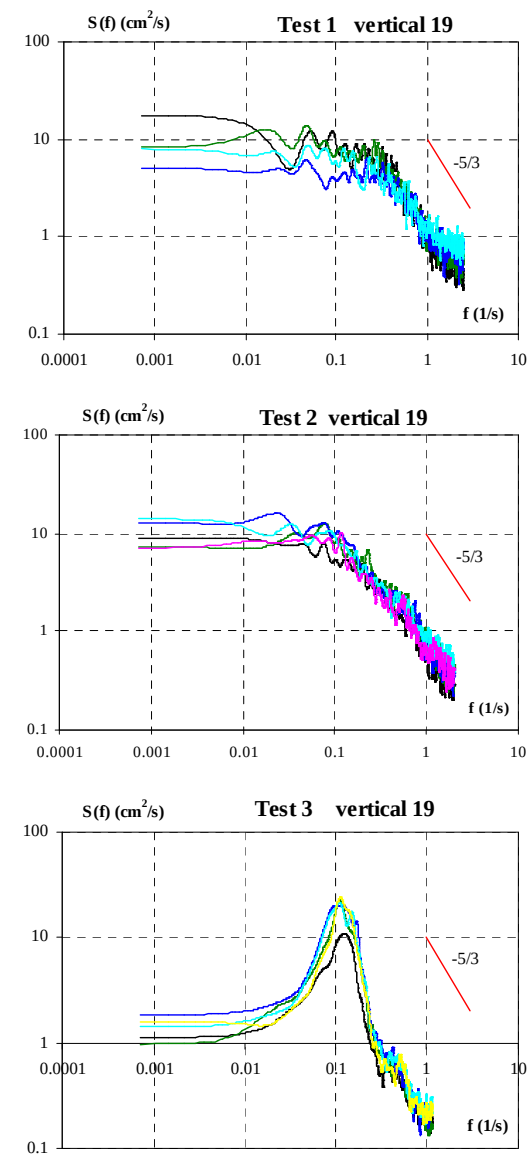
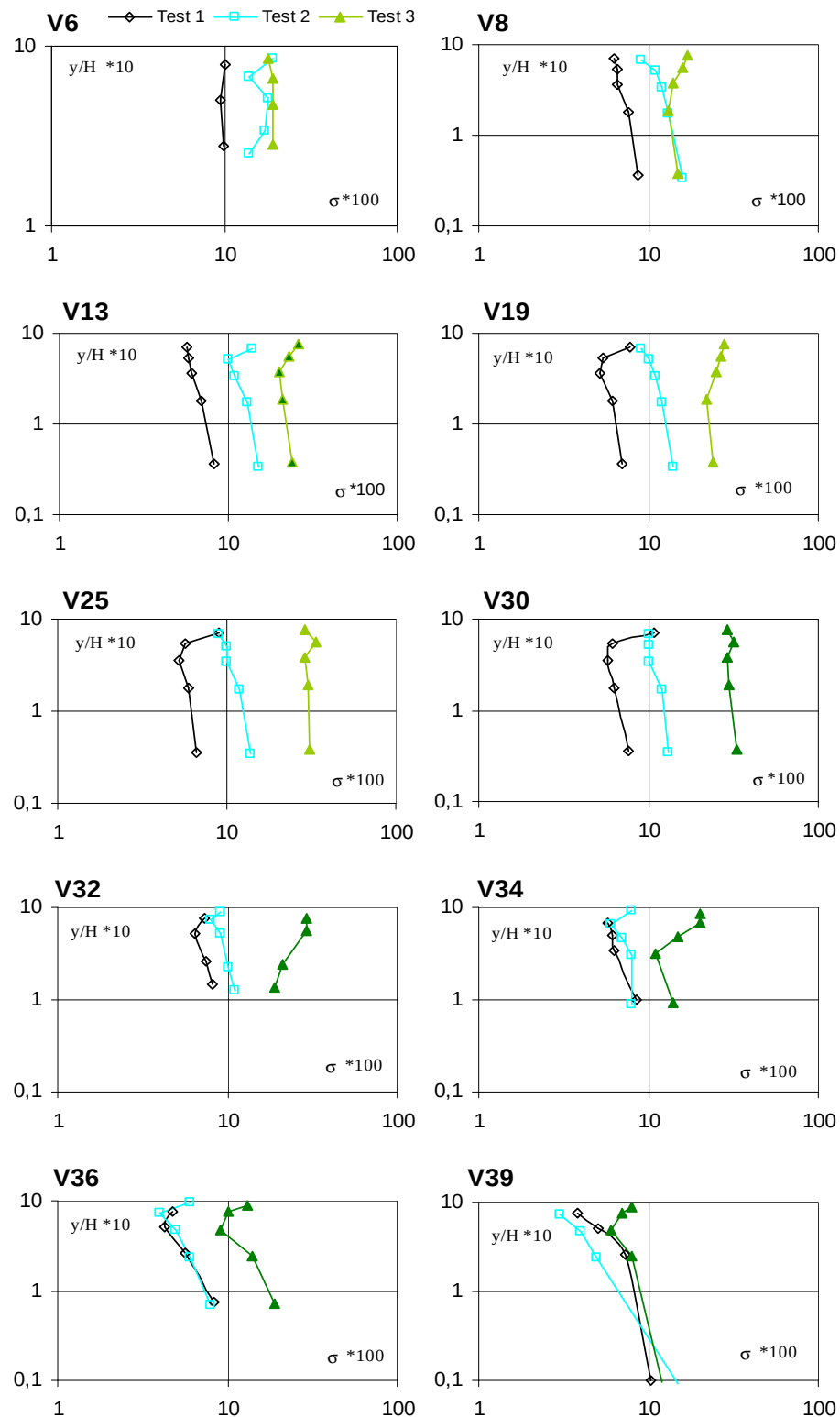
□ Experiment investigation



Scheme of experimental cross-section

3D turbulent velocities

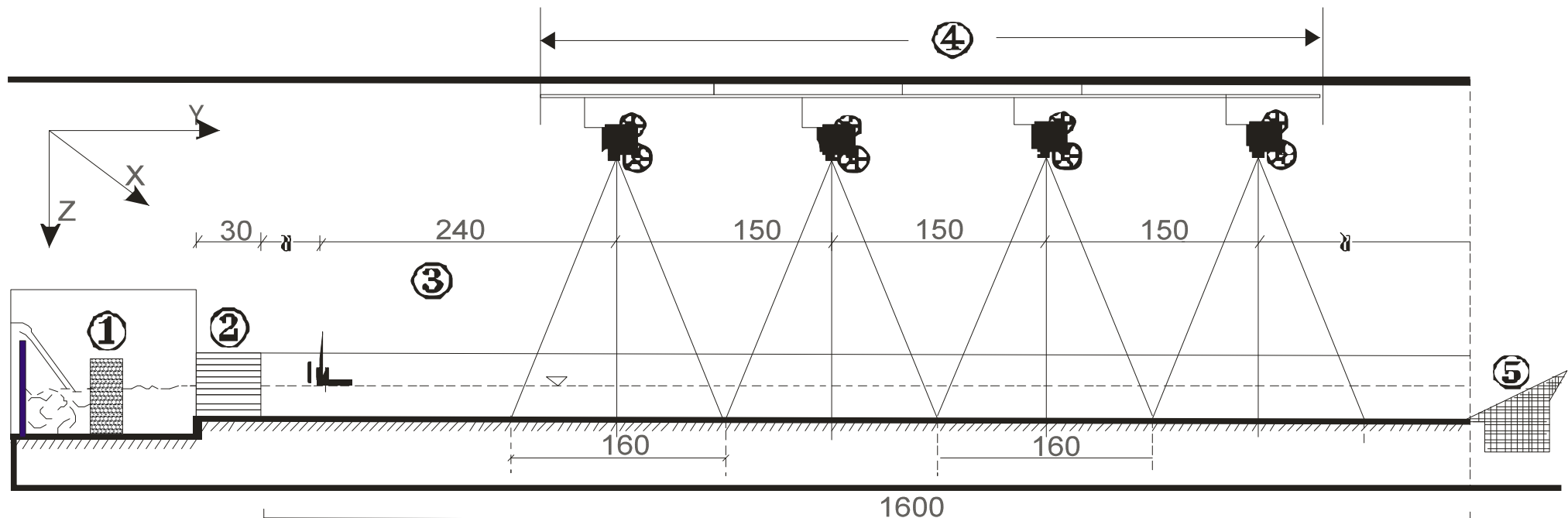




Compound channel – cases
with various roughness

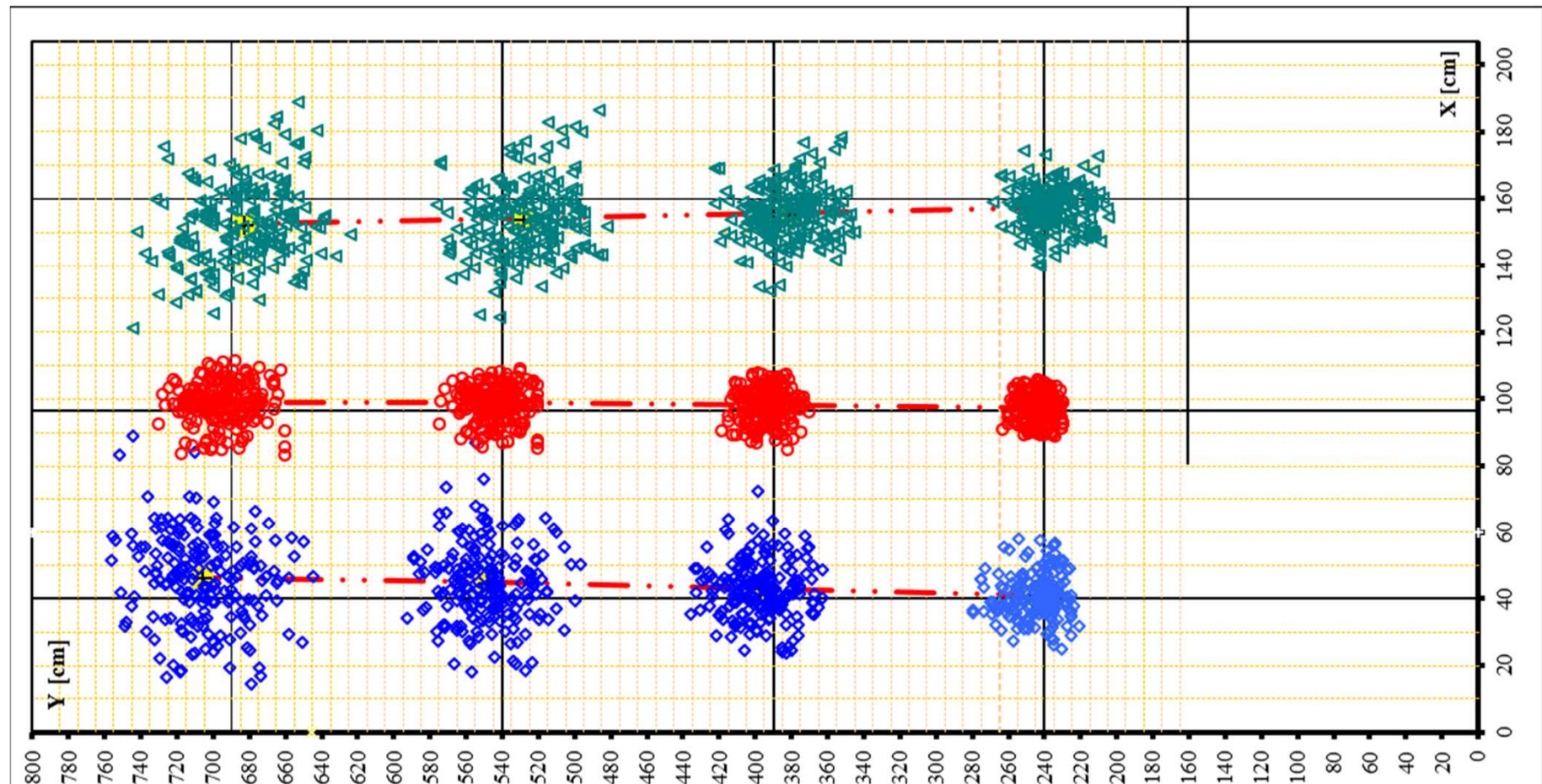
Particles' transport in a compound channel

- Experiment investigation
 - ▣ Rowiński et al 1998, 2002



Scheme of the laboratory setup for the video tracking of particles in a compound channel (1 - spillway; 2- flow soothing pipes; 3- particles' batcher; 4 - system of four digital cameras, 5 - net particles catcher)

Particles' transport in compound channel



Collaboration with Prof. E. Holley

- 3D turbulence study in rectangular channel at the University of Texas at Austin



Experimental channel looking upstream.

Turbulence in small streams (Wilga River)

□ Experiment in Wilga River



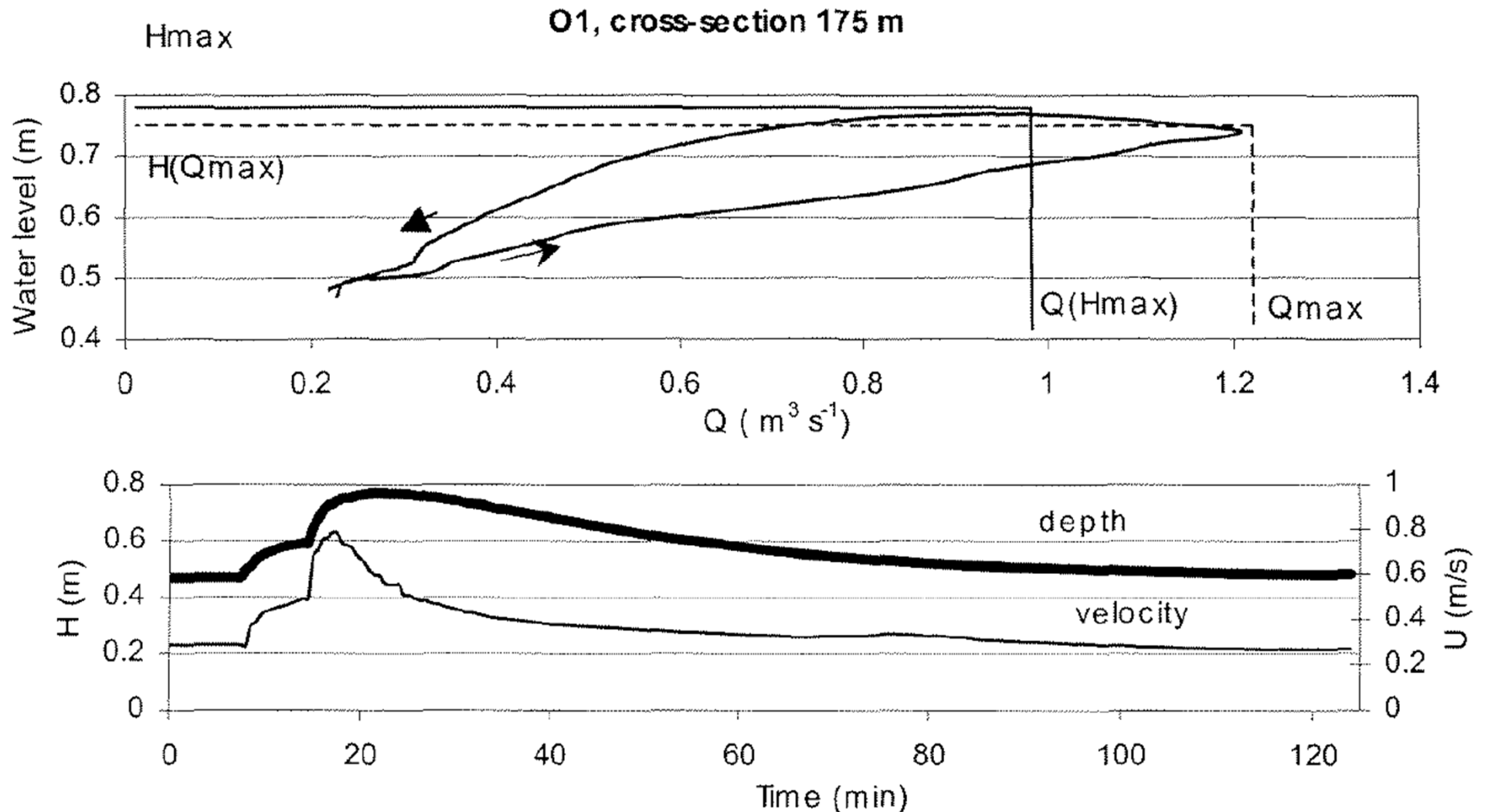
Turbulence in small streams (Wilga River)

□ Experiment in Wilga River



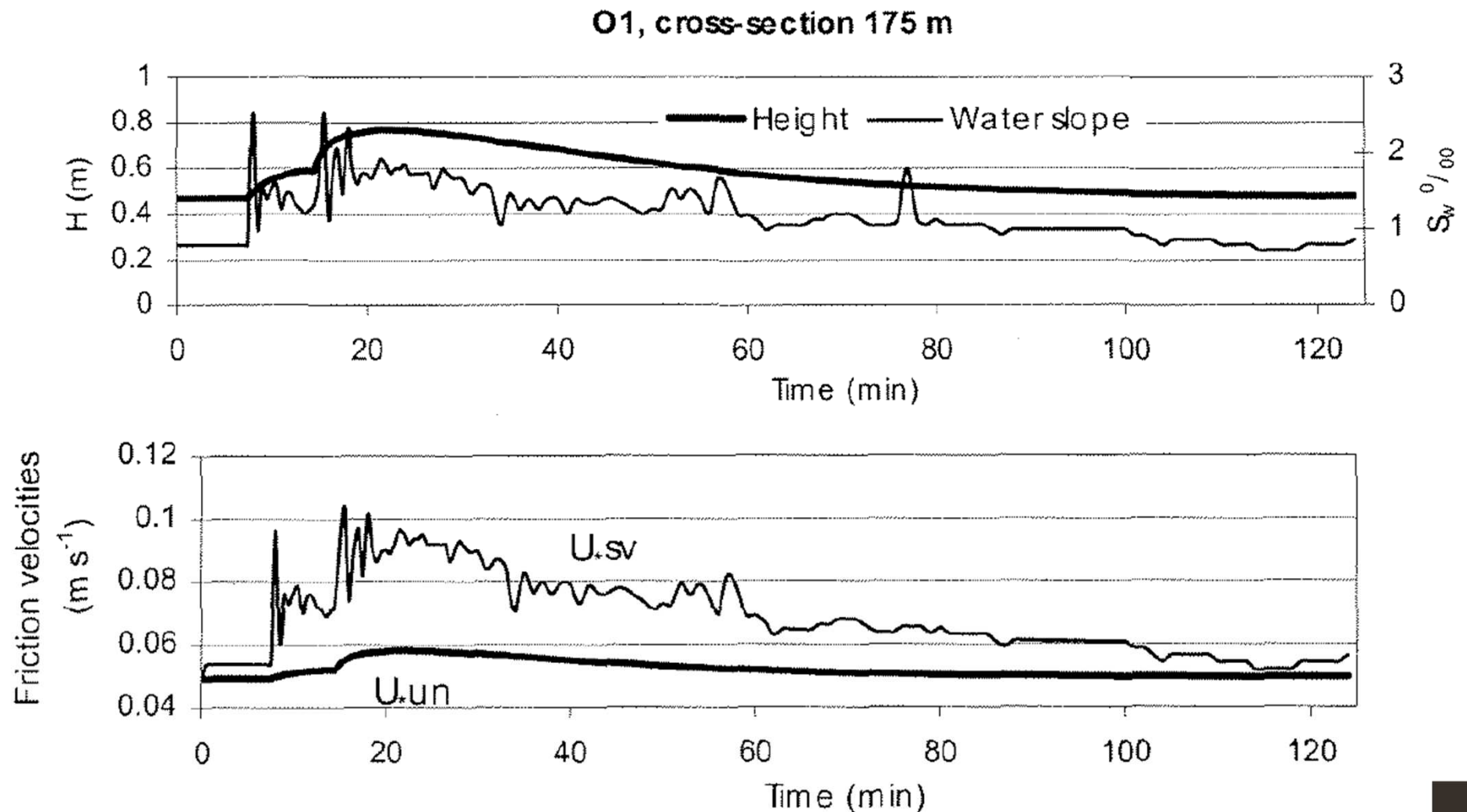
Turbulence during flood conditions

□ Experiment in Wilga River



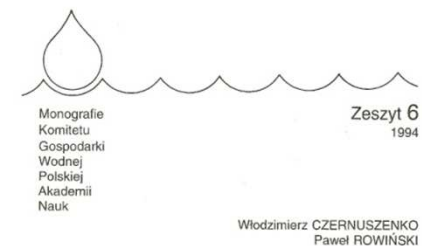
Turbulence during flood conditions

□ Experiment in Wilga River



Two-equations turbulence model

- 1994 – first attempt in Poland to use two-equations turbulence model for open channels
- Parabolic version of k-epsilon model; Patankar-Spalding method
- Additionally mass transport



WSPÓŁCZESNE
MODELE MATEMATYCZNE
PROCESÓW TRANSPORTU
I MIESZANIA
ZANIECZYSZCZEŃ W RZEKACH



WARSZAWA 1994
OFICyna WYDAWNICZA POLITECHNIKI WARSZAWSKIEJ

Collaboration with Dr. Rylov



Mądralin 2004



University of Mississippi

National Center for Computational Hydroscience
and Engineering

The University of Mississippi



□ 1991-1994



US-Poland



□ Technology Transfer Program



TTP Warsaw 2002

Mass and heat transport in rivers

Rapid development of industry



- Second Polish industrialization
after the World War II



Power stations in Warsaw

Rapid development of industry



- ❑ Second Polish industrialization after the World War II
- ❑ Many problems appeared in open channel hydraulics requiring a quick solution
- ❑ The need for environmental protection began to raise public awareness in Poland

Transport equation



- Clear mathematical description in each of mixing zone

Near field zone

- Vertical mixing prevails

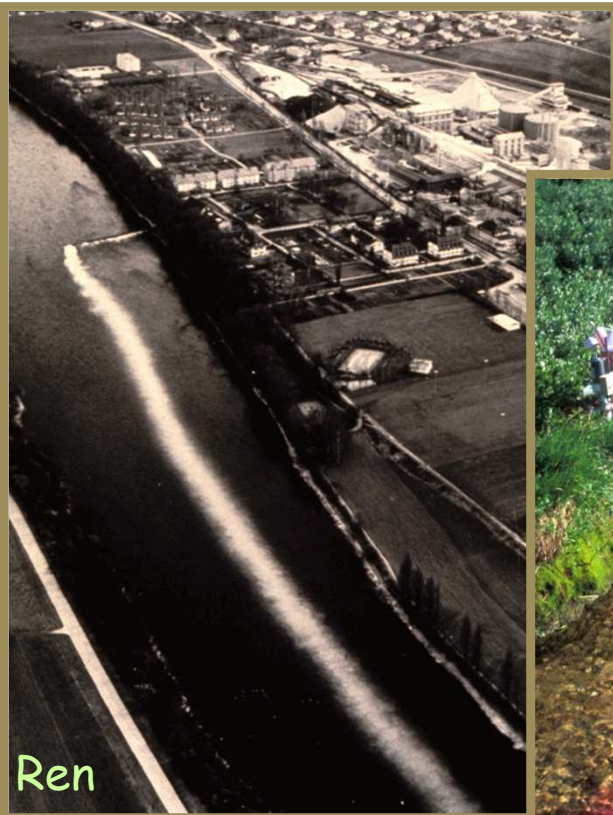


3D

Mid field zone

- May continue for a very long distance, horizontal mixing prevails

2D



Far field zone

- After complete mixing along the depth and with, longitudinal mixing previles

1D



Tracer test, Narew, 2006



Dead zones

Main channel

$$\frac{\partial C}{\partial t} = -\frac{Q}{A} \frac{\partial C}{\partial x} + \frac{1}{A} \frac{\partial}{\partial x} \left(AK_x \frac{\partial C}{\partial x} \right) + \alpha (C_s - C)$$

Advection

Dispersion

Transient storage

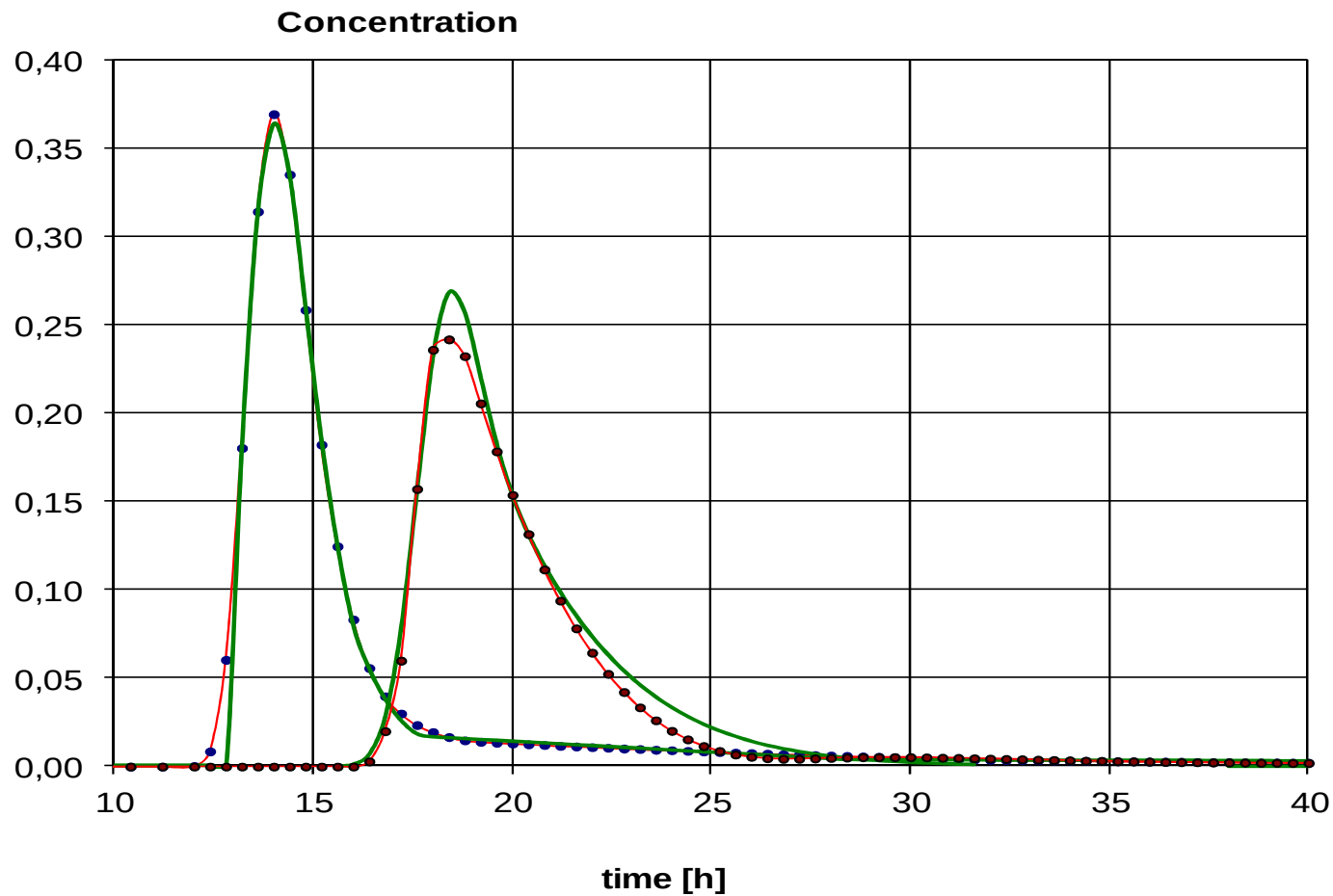
Storage zones

$$\frac{\partial C_s}{\partial t} = \alpha \frac{A}{A_s} (C_s - C)$$

- K_x longitudinal dispersion coefficient [m^2/s]
 A main channel cross-sectional area [m^2]
 A_s storage zones cross-sectional area [m^2]
 α storage zones exchange coefficient [$1/s$]

C, C_s main channel/storage zones solute concentration [kg/m^3]

Model with dead zones



Transport equation



- Clear mathematical description in each of mixing zone
- 3D equation averaging procedure
- Description of different mixing mechanism
 - ▣ Advection
 - ▣ Molecular diffusion
 - ▣ Turbulent diffusion
 - ▣ Dispersion

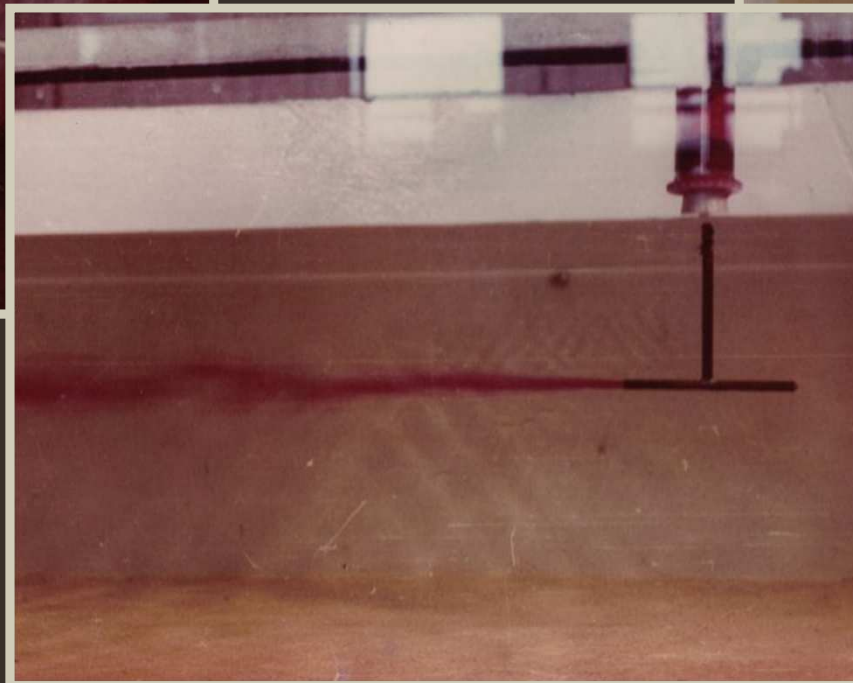
Laboratory experiments



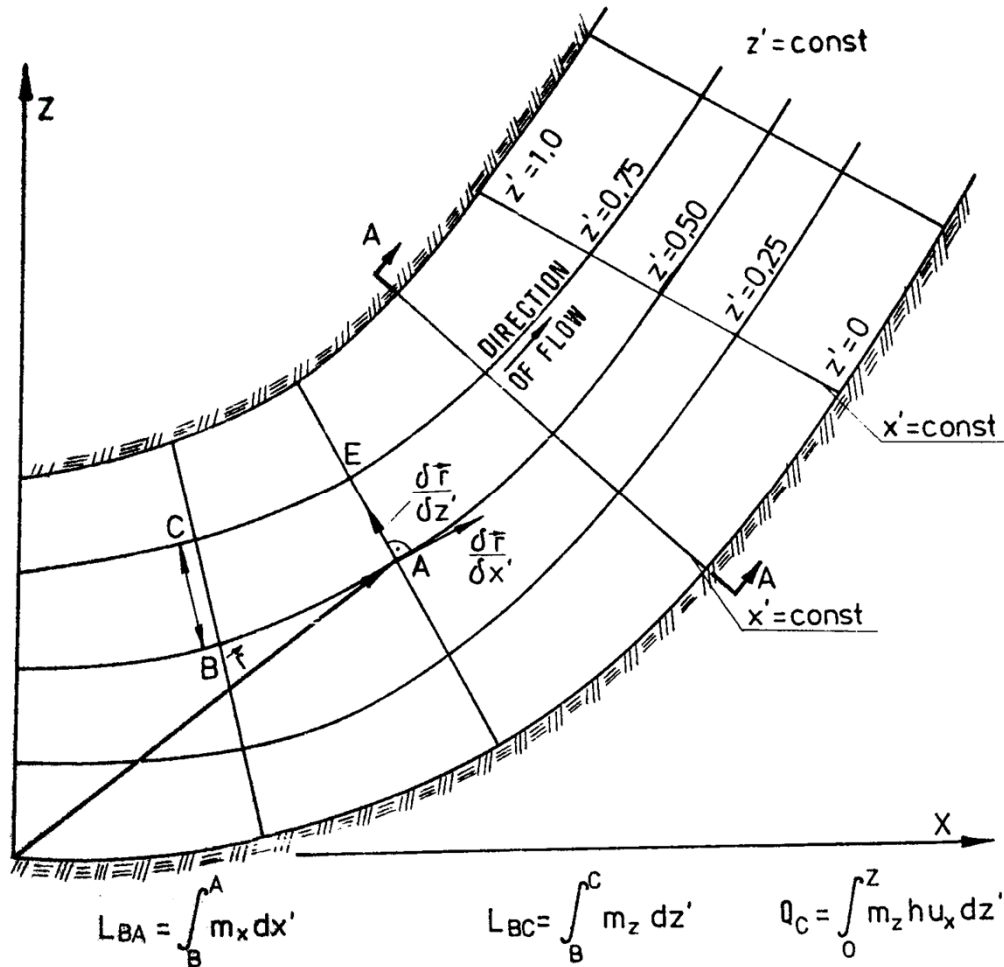
- Series of tracer tests in a rectangular channel in turbulent flow



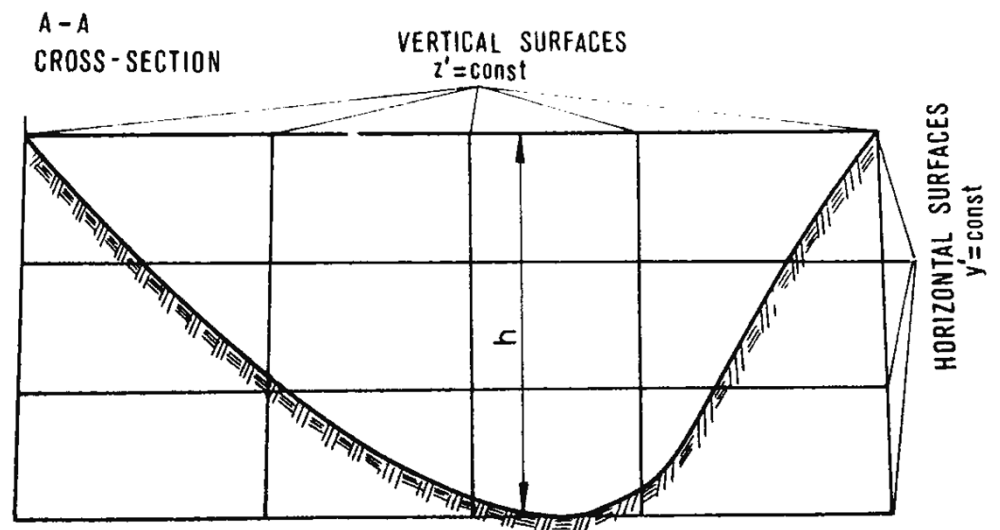
Tracer tests in
rectangular channel



Curvilinear Coordinate System



Natural system of curvilinear coordinates for a river

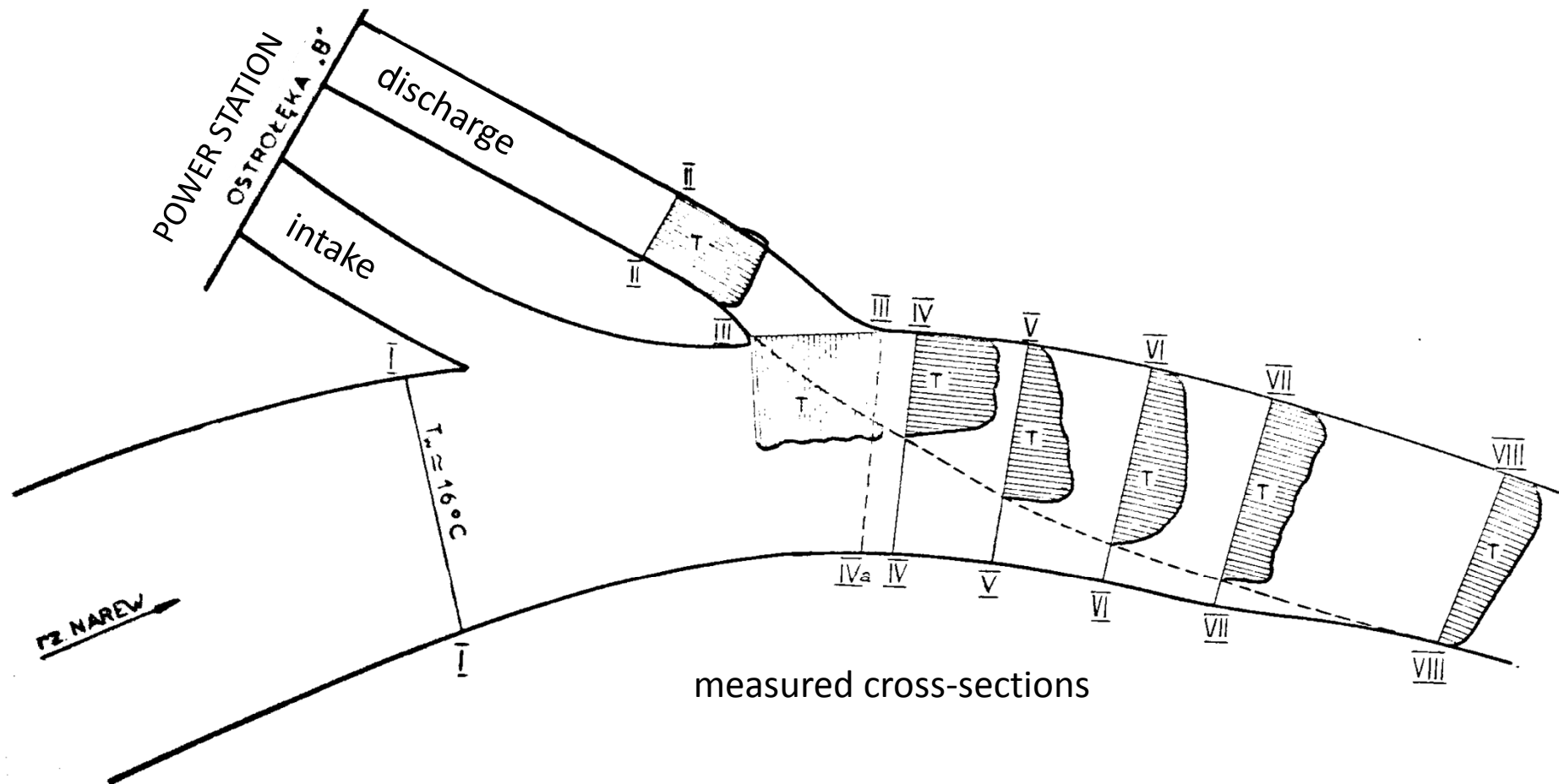


Thermal pollution



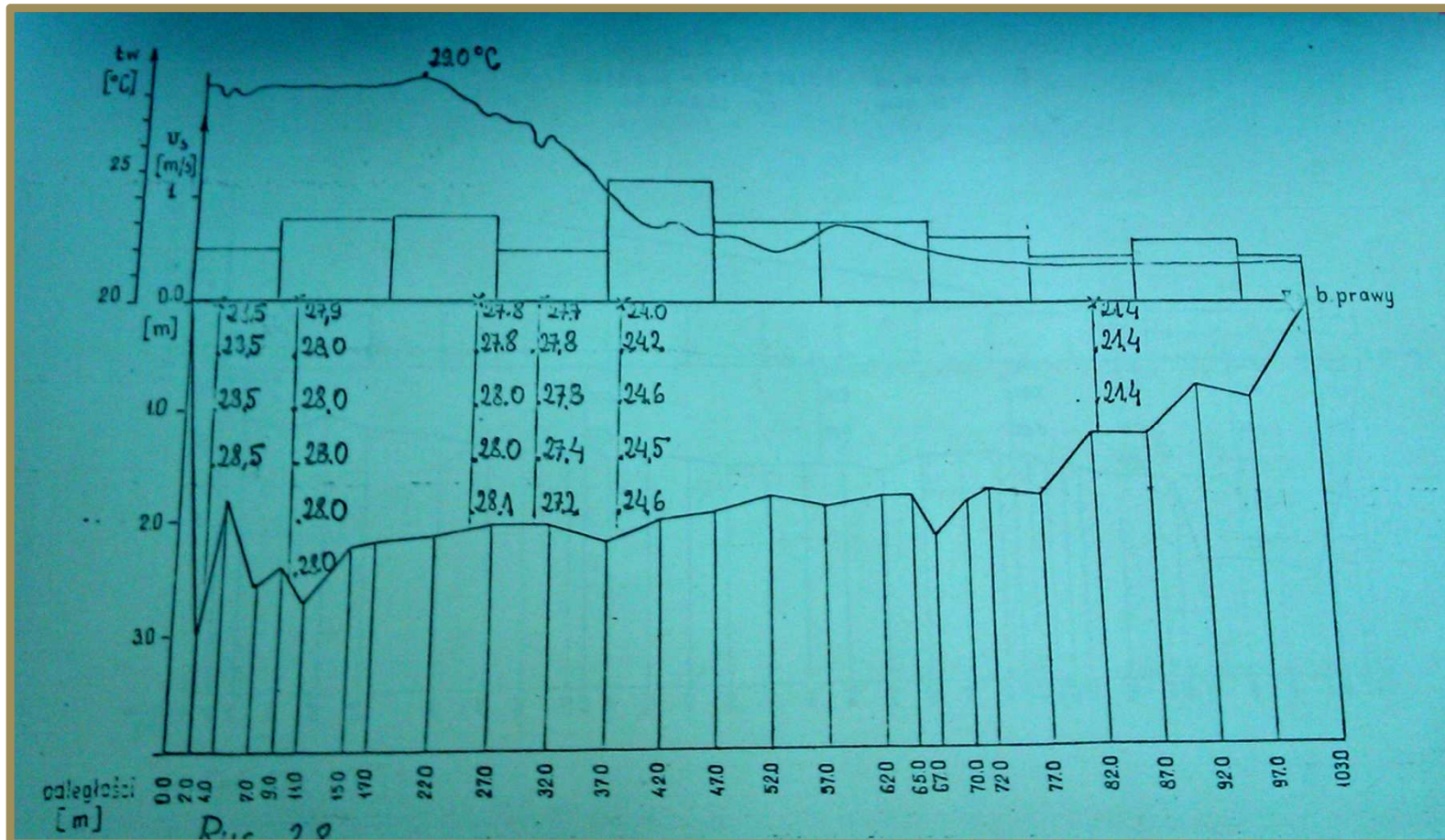
- Many experiments, data and observations

Thermal pollution

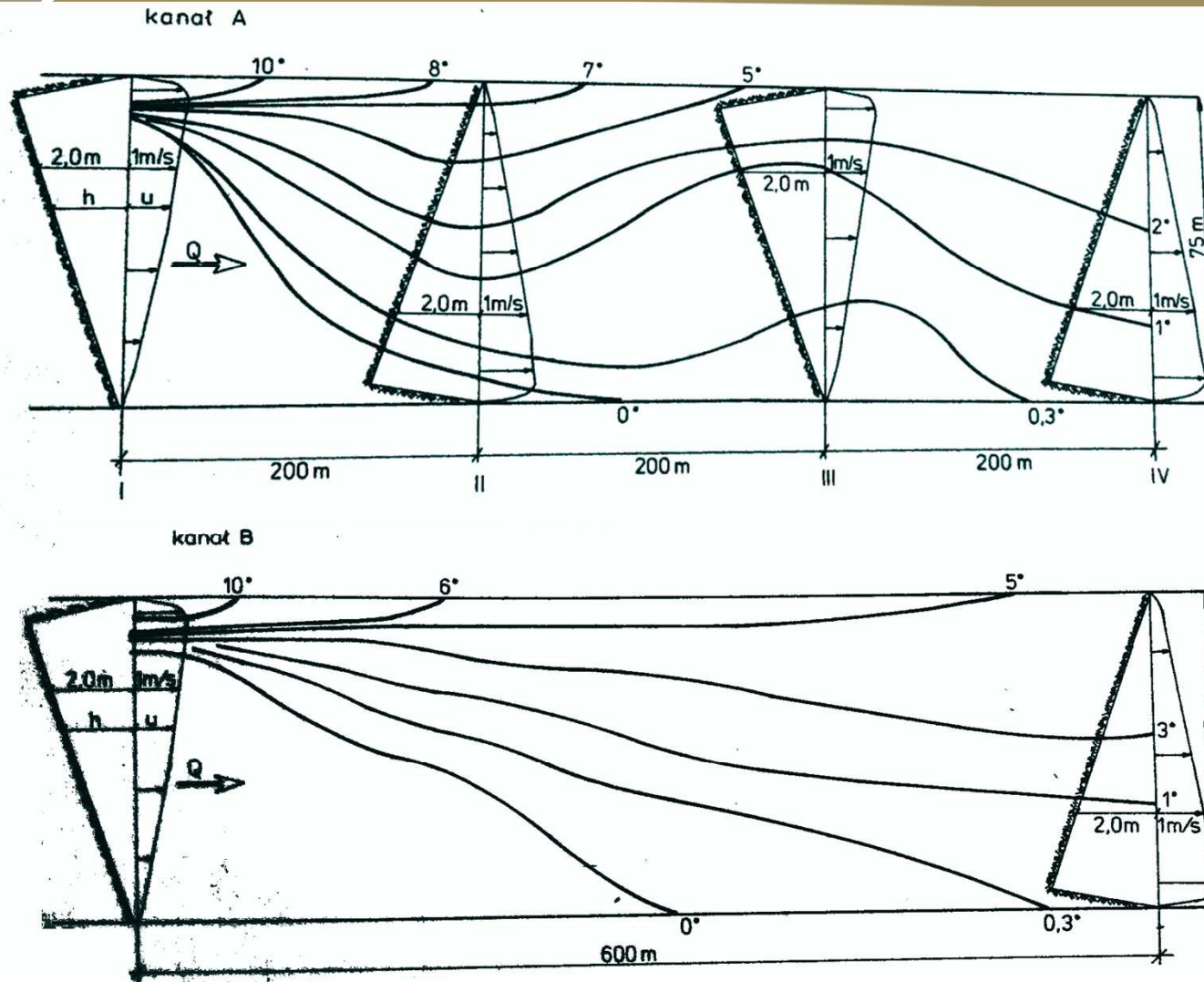


Response	Percentage
Yes, the current government is responsible	85%
No, the crisis is a result of global economic conditions	15%

- Many experiments, data and observations



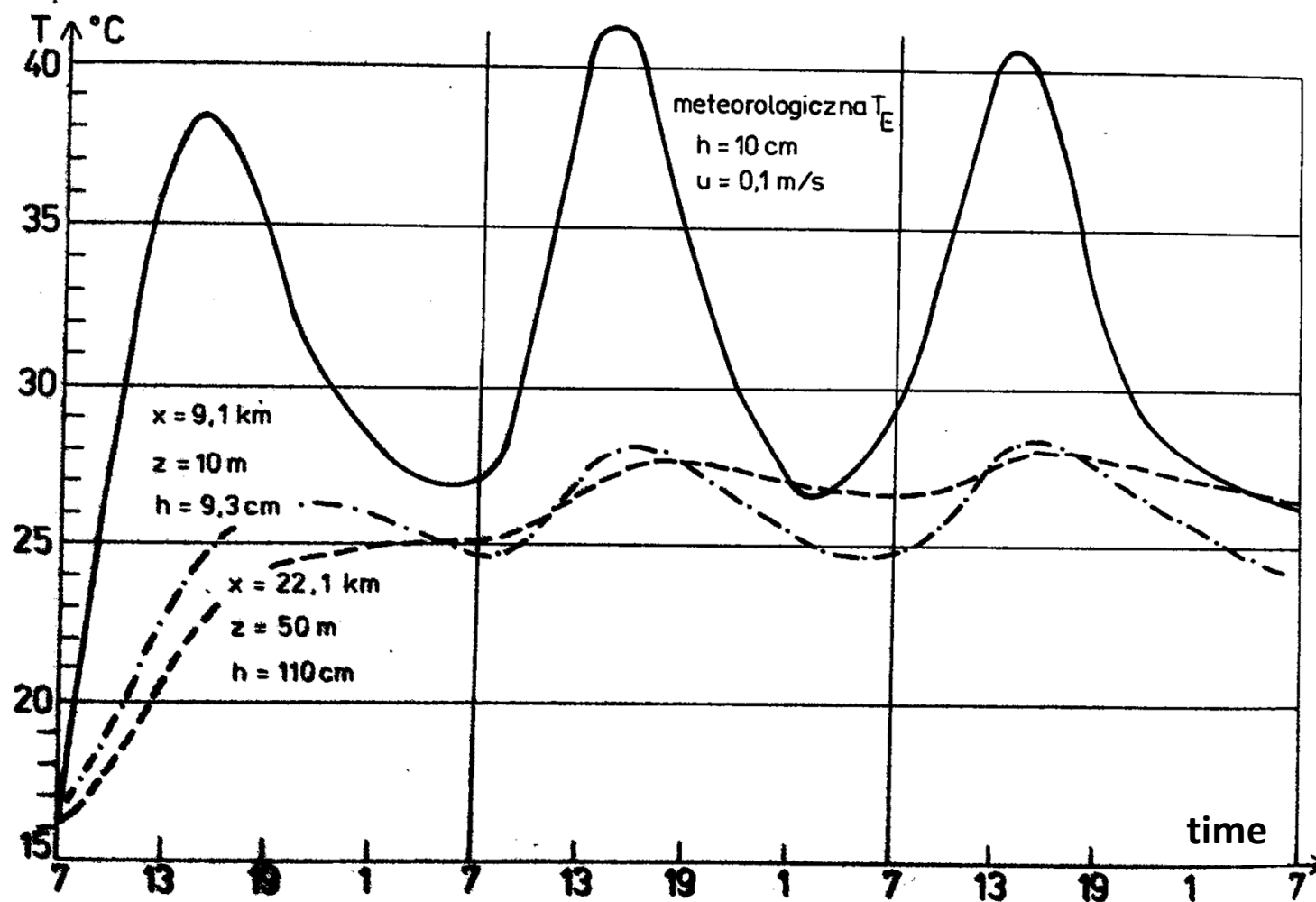
Thermal pollution - computations



Temperature distribution
in two channels with
different bathymetry

Czernuszenko and Paradowska (1987)

Thermal pollution



Variation of natural temperature for 3-day water-air heat exchange, SAN RIVER ($Q=28.7\text{m}^3/\text{s}$)

Czernuszenko and Paradowska (1987)

Selected computational models of pollution spreading

- 2D models of pollution spreading (including thermal pollution):
 - ▣ TADE
 - ▣ TDAH – included influence of bed topography
 - ▣ TDAQ – with the included water-surface heat exchange and influence of bed topography
 - ▣ TOPE – with the included water-surface and bottom heat exchange
- MIXC – program for calculation of transverse dispersion coefficient in rivers

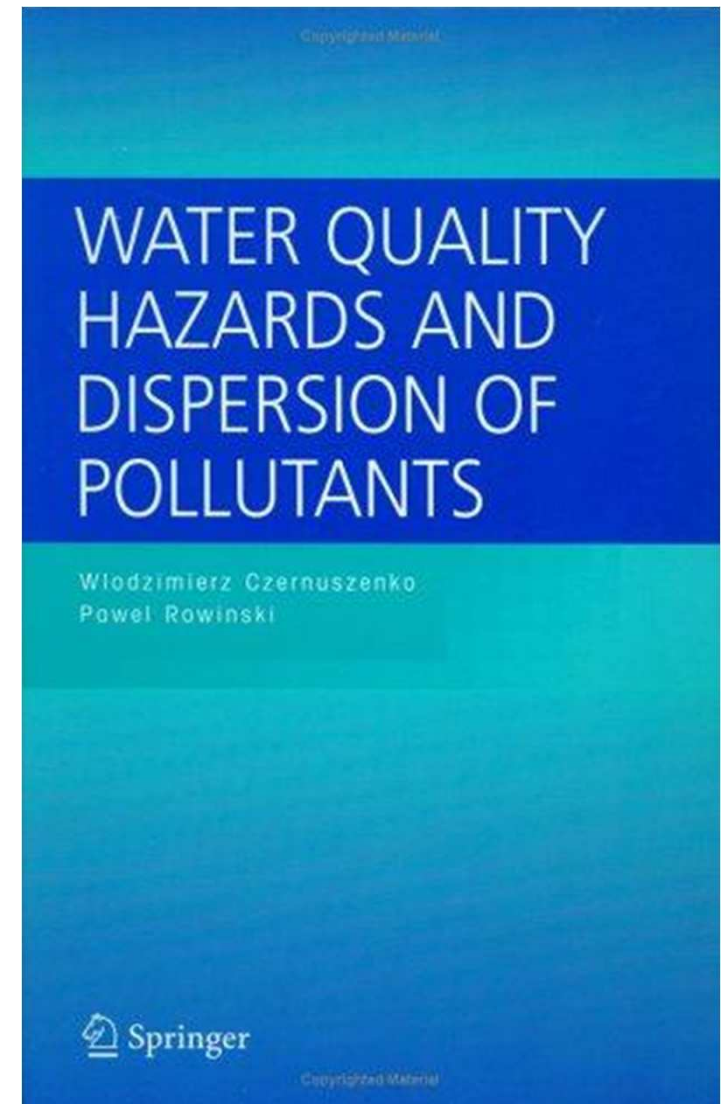
GEODEV – Center of Excellence



Mądralin, 2004

International Monograph

- Results of
 - ▣ the long lasting research in the subject of mass transport in rivers
 - ▣ strong international working groups



Solid particles' transport in rivers

Drift velocity concept for sediment-laden flows

$$\overline{\tilde{v}_{pd}} = -\varepsilon_{pd} \frac{\Delta C}{C}$$

$$\frac{\partial}{\partial x}(u_f C) + \frac{\partial}{\partial y}[(v_f - w_p)C] = \frac{\partial}{\partial x} \varepsilon_{px} \frac{\partial C}{\partial x} + \frac{\partial}{\partial y} \left[(\varepsilon_p + \varepsilon_{pd}) \frac{\partial C}{\partial y} \right]$$

C – local sediment concentration,

u_f, v_f – components of the fluid velocity

w_p – particle fall velocity in turbulent flow,

$\varepsilon_{px}, \varepsilon_p$ – turbulent diffusion coefficients for a single particle in horizontal and vertical direction

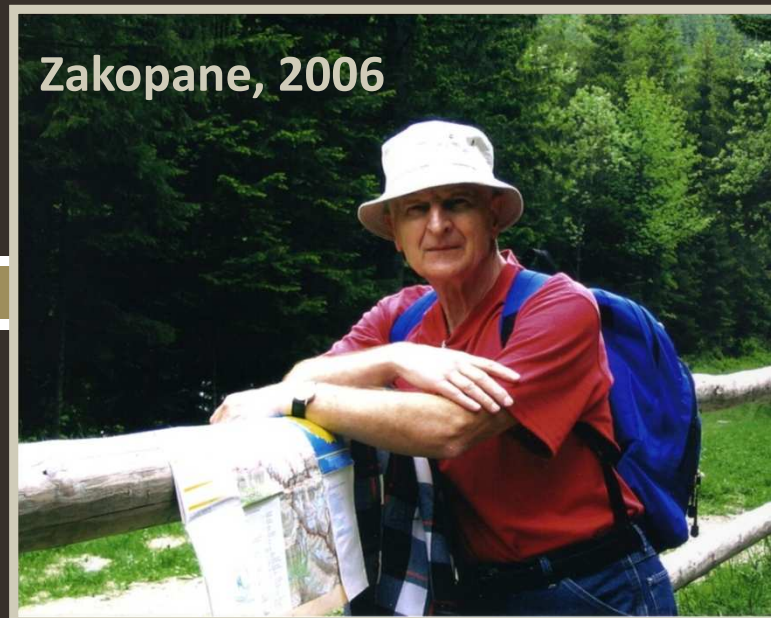
ε_{pd} – drift diffusion coefficient

$\overline{\tilde{v}_{pd}}$ – drift velocity

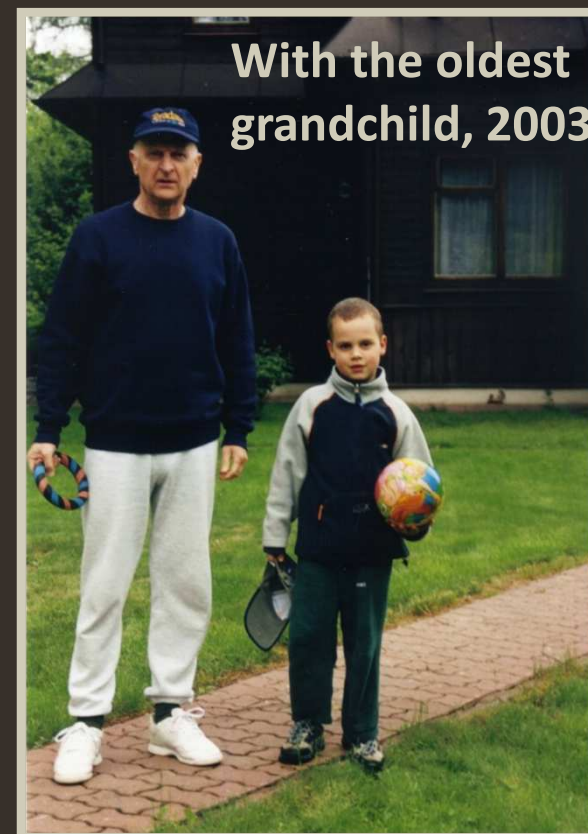
Czernuszenko (1998), J Hydr Res



Running on the occasion of National Day, 1993



Zakopane, 2006



With the oldest grandchild, 2003

PIONEERING WORKS IN POLISH ENVIRONMENTAL HYDRAULICS. THE FLAVOR OF WORLD-CLASS SCIENCE.



**50 YEARS OF WORK
OF WŁODZIMIERZ CZERNUSZENKO**



XXXII ISH 2012,
Łochów, Poland

P. M. Rowiński, M. B. Kalinowska