Applied Hydroinformatics in Aquatic Systems

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Seminar Content and structure

Následující tabulka zobrazuje HTML náhled na zvolený rozvrh. Tiskovou verzi získáte volbou výstupu ve formátu PDF.

Den	08:45-09:30	09:30-10:15	10:30-11:15	11:15-12:00	12:15-13:00	13:00-13:45	14:00-14:45	14:45-15:30	15:45-16:30	16:30-17:15	17:30-18:15
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- Content: Applied Hydroinformatics
- Number: 10 lectures
- Duration: 1h 30min
- Examination: written test

- Lecture hand outs - PPT
- Literature – PPT
- Particpsation in lectures

Applied Hydroinformatics course

1. **Hydroinformatic fundaments**
   a. Definition
   b. Historical Development
   c. Goals and Challenges
2. **Magic of simulation modelling**
   a. Simulation model as virtual reality
   b. Model structure
   c. Governing equations
   d. Numerical methods
3. **Model build proces**
   a. Model formulation, conceptualization, schematization
   b. Surveys
   c. Model calibration and verification
   d. Model usage

Applied Hydroinformatics course

4. **Model Data**
    a. Data types
    b. Data architecture, Data model
    c. Errors in data
    d. Other data aspects
5. **Data Collection, Surveys**
    a. Concept of monitoring
    b. Types of surveys
    c. Practical aspects
6. **Power of Data Visualisation**
    a. From 0D to 3D visualisation
    b. GIS systems
    c. Internet presentation

Applied Hydroinformatics course

7. Hydroinformatic Systems

a. Tools and Technologies
b. Model example
c. DSS /HIS systems
d. Coupled models

8. Applied Hydroinformatics

a. Changes in Living Environment
b. Climate Change Challenges
c. Urban water planning
d. Role of simulation modelling

9. Case studies

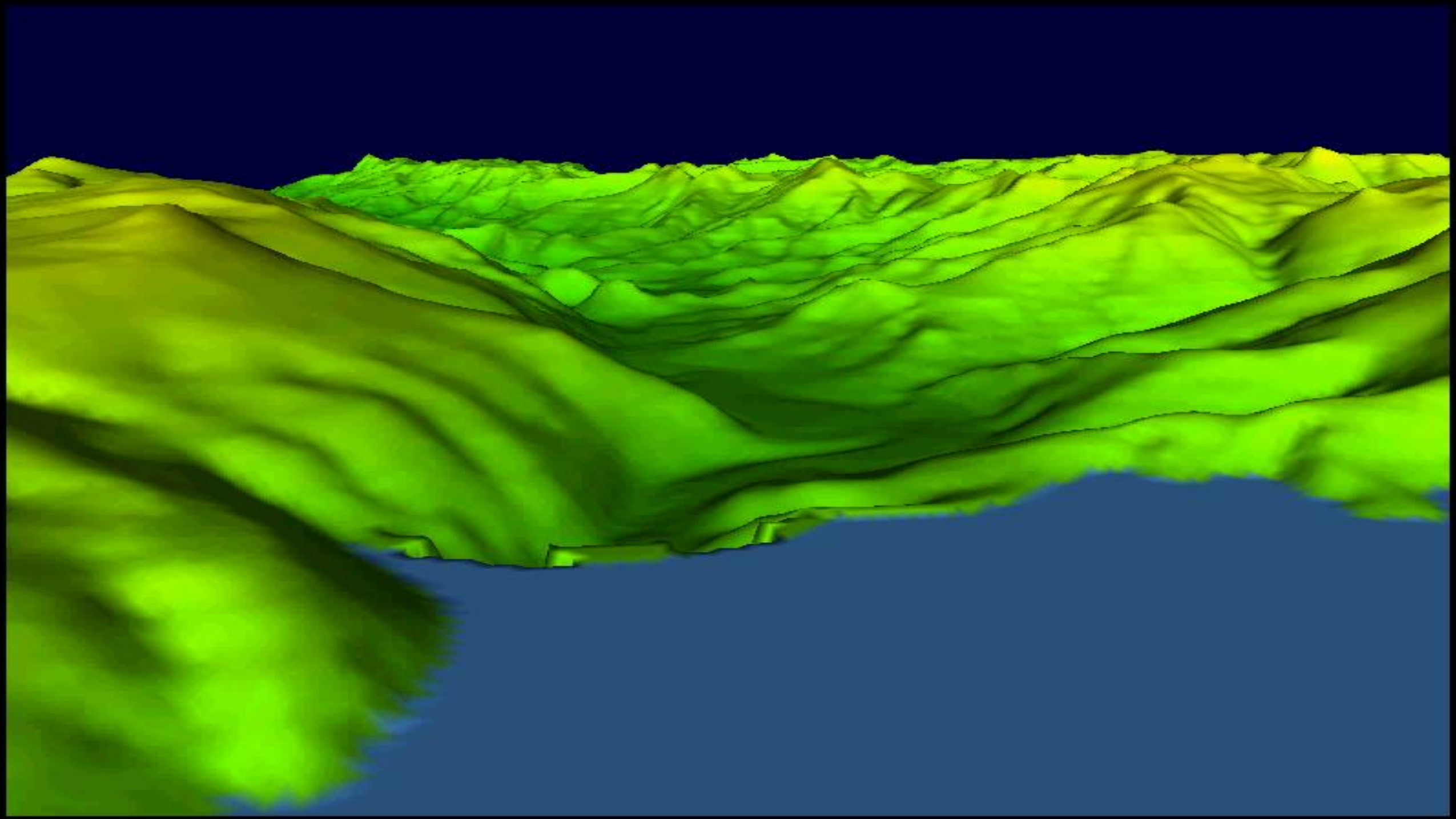
a. Urban water master plan
b. Urban flood studies
c. Other studies

Applied Hydroinformatics course

10. **Hydroinformatics as game changer**
    a. Complex water environment understanding
    b. Environemental and economic aspects
    c. Decision support for policy makers
    d. Investment optimization
    e. Education and social aspects
    f. Role of technology
    g. Impact on business
11. **Hydroinformatics summary**
    a. Written test

Hydroinformatics Fundaments

Setting up the battlefield



Hydroinformatics

New technology in Water and Environment based on development in IT

Computational Hydraulics - 1969 Prof. Abbott

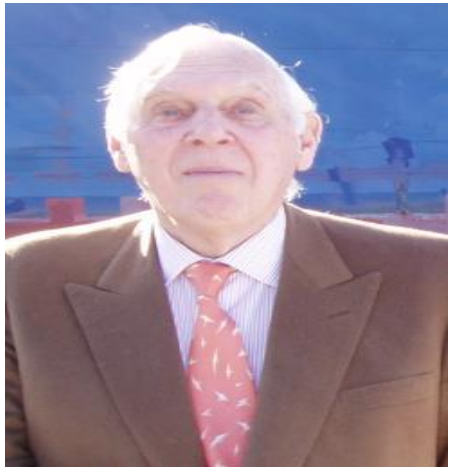
Goals of Hydroinformatics

To provide tools for Decision Makers, replace TRIAL and ERROR approach by IF …… THEN approach

Some helpful resources:

- **Journal of Hydroinformatics:** http://iwaponline.com/jh
- **Hydroinformatics Institute:** https://www.h2i.sg/
- **Wikipedia:** https://en.wikipedia.org/wiki/Hydroinformatics

Hydroinformatics - definition



Technological discipline (Abbott 1987) integrating computational hydraulics, Hydrology, Hydraulics, Informatics, information technologies into the framework, which affects evolutionary development of society

The simulation model describing the aquatic system is a basic element of hydroinformatics.

Hydroinformatics – definitions…

- **Hydroinformatics** uses simulation modeling and information and communication technology to help in solving problems of hydraulics, hydrology and environmental engineering for better management of civil engineering systems.
- **Hydroinformatics** is a branch of Informatics which concentrates on the application of information and communications technologies in addressing the problems of the use of water for many different purposes.
- Growing out of the earlier discipline of the numerical simulation, water flows and related processes remain basics of **hydroinformatics**, which focus not only on the technology but on its application in a social context.
- **Hydroinformatics** is a field that bridges the gap between **water resources** and **information technology**. In short, it's about using **information and communication technologies (ICT)** to **understand, manage, and optimize water resources** more effectively.

Theoretical Fundaments of Hydroinformatics

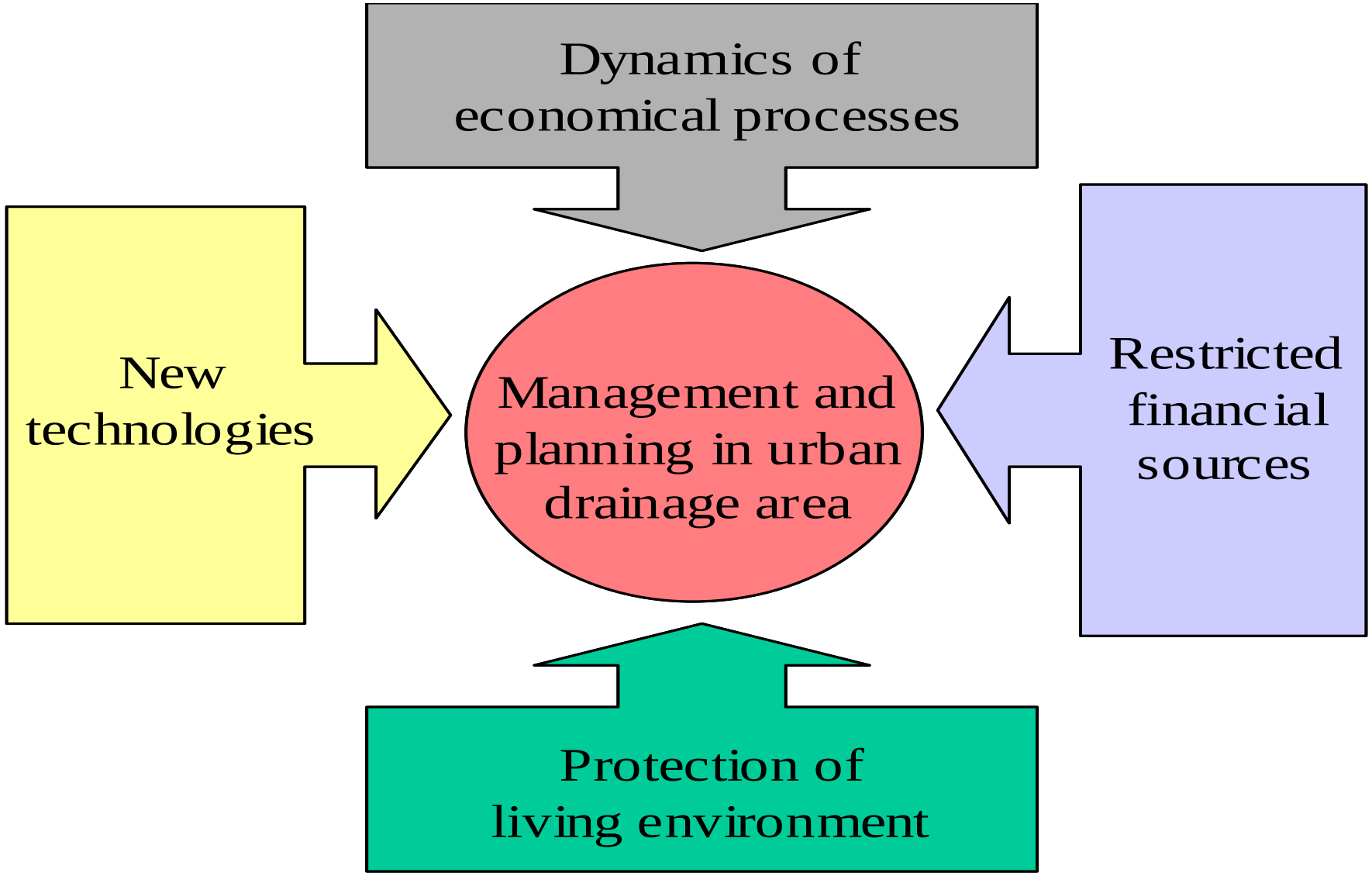
1. Hydraulics (physics of aquatic systems) – long tradition – fundamental scientific discipline
2. Hydrology – technological discipline
3. Computational hydraulics (Abbott - 1969)

   Def.: *scientific discipline integrating hydraulics, numerical mathematics, numerical methods and programming into unified framework*
4. Information technology, computer science
5. Ecology, Biology, Chemistry

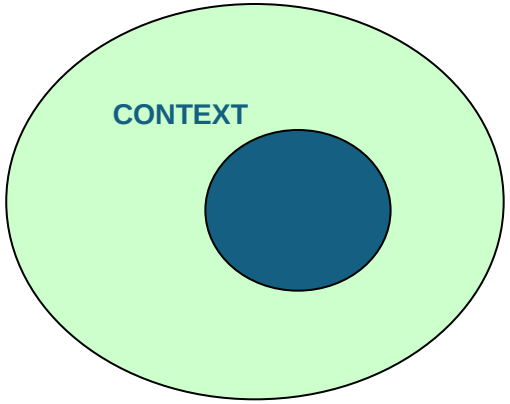
Conditions for Formation of Hydroinformatics

1. Development of **computational hydraulics** – FD, FE,… methods
2. Foundation of IT **Information Technology (HW+SW)**
3. Development of monitoring and methods for **data collection and analysis**
4. **Need for communication** among distinct engineering disciplines
5. **Need for understanding** the processes (visualisations, animations)
6. Leading institutions (NHL, DHI, DH, Hr, IAHR, IAHS)
7. Challenges in **management of complex systems**

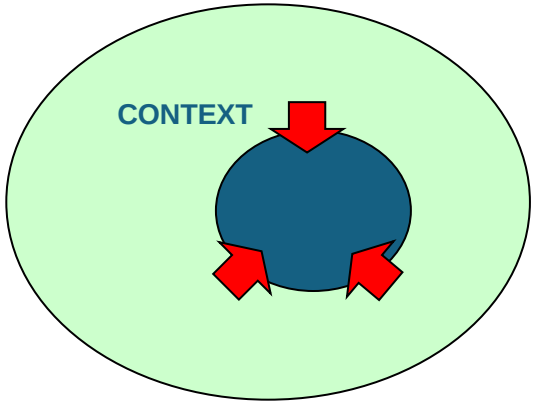
Changing Water Environment



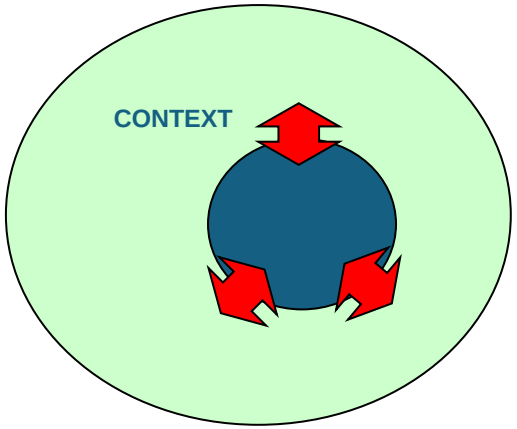
Management in Water Infrastructure



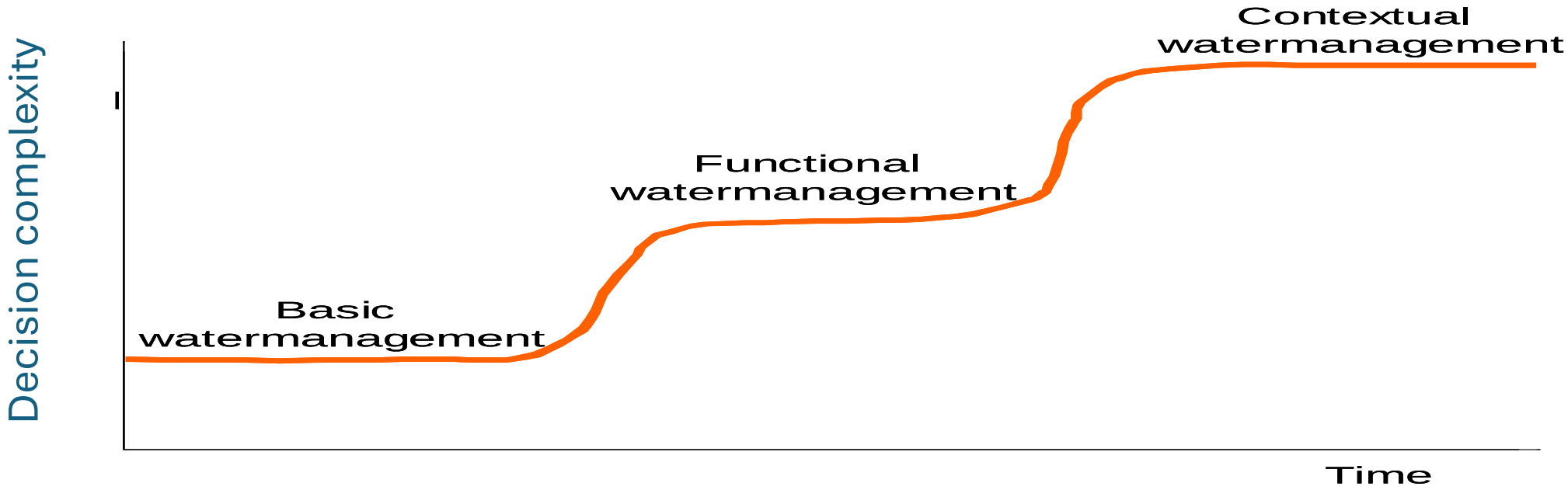
Basic management



Functional management



Contextual management



Challenges of Hydroinformatics

- To provide **predictive tools** for analysis of aquatic living environment
- To verify **effects of interventions** into ecosystems using **“if-then” scenarios**
- To support **decision-making proces** in complex environments
- To integrate **protection of living environment** in the engineering business
- To provide **managerial tools** for complex aquatic systems
- To **optimize investment** policy
- To offer **training tools** (dispatches games)
- To support other technological areas (e.g. GIS, Expert systems, DSS)
- To provide foundation for **legislation**
- To **optimize engineering** design work (parallel design)

Hydroinformatic System (HIS)

User

User interface

(GUI)

Information systems

Geografic information systéms	Databases	Knowledge bases

Models

Pollution sources	Transport processes	Water quality	Ecology

Decision Support systems

Strategic scenarios	Impact of environment	Socio - ekonomic impacts

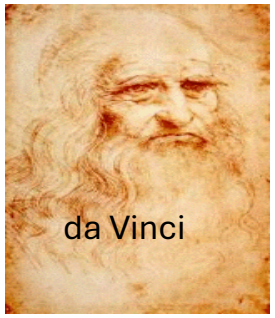
Domains of Application

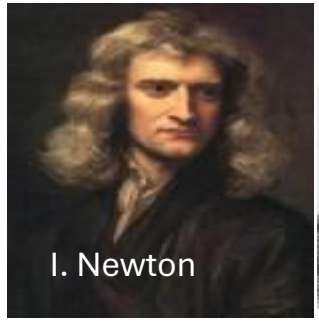
1. Urban water operation and planning
2. Urban and rural Flood protection
3. Water Resources management
4. Mining GWF modelling
5. Disaster Risk Management
6. Marine and coastal studies
7. Early Warning systems
8. Flood Nowcasting and Forecasting
9. Drougth management
10. Water quality management
11. Smart irrigation
12. Etc.

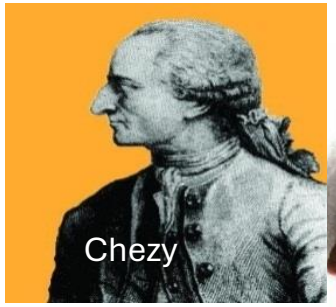
Historical Development of HYDROINFORMATICS

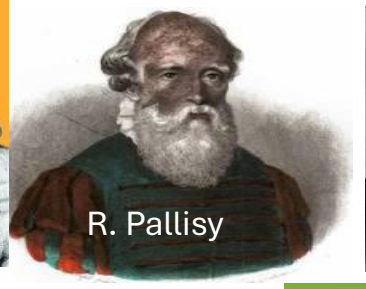
Historical Roots of Hydroinformatics

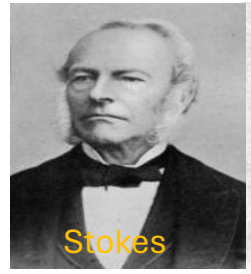
- **3-2 ths. BC** Egypt, China, India
- **1 -0 ths. BC** Greek and Roman philosophers
  - Archimedes, Platon, Aristoteles, Vitruvius
- **14-18 cent.** Rennaisance – experimental research
  - Da Vinci, Pallisy, Halley,Mariotte, Newton, Bernoulli, Chezy,…
- **1802** Dalton = evaporation
- **1822** Navier –Stokes – viscous liquids flow
- **1839** Hagen-Poisseuille = capilar flow
- **1850** Mulvaney = rational methods
- **1856** Darcy = flow in porous medium
- **1891** Manning = flow in open channels
- **1895** Reynolds, = transformation theorhem,
- **1914** Hazen = frequency analysis
- **1931** Richards = unsaturated flow
- **1933** Horton = infiltration theory
- **1950** - Abbot, Cunge, Priceman, Verwey = numerical methods

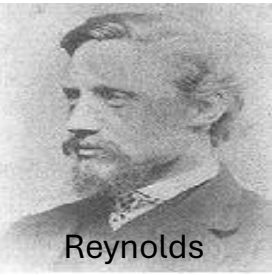


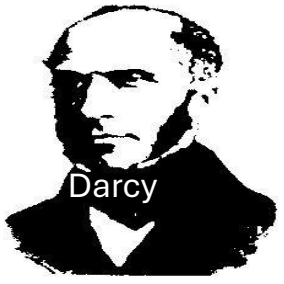


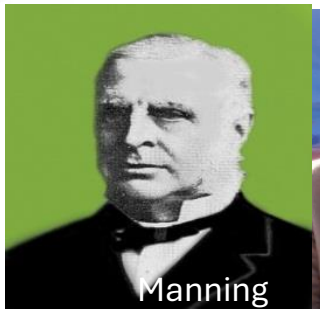












Historical Development of HW and SW

- **Hardware**
  - 1980 - IBM PC
  - 1983 - IBM XT (8088, 8086)
  - 1985 - IBM AT (80 286)
  - 1988 - IBM - PS/2 (80 386)
  - 1990 - IBM - 486 (80 486)
  - 1995 - IBM – Pentium
  - 2005 – multicore processors
  - 2014 – graphical cards (ENVIDIA)
  - 2018 – HPC (IT4I Ostrava)

Historical Development of HW and SW

- **Software development**
  - Operation systems (unification, HW dependance)
  - Application software -(text editors, spredsheets, graphical tools, GAMES!)
  - Specialised software - simulation models, GIS, CAD, etc.
  - Database RDBMS systems
  - GUI, Graphical user interface
  - Internet aplications,
  - Artificial Intelligence

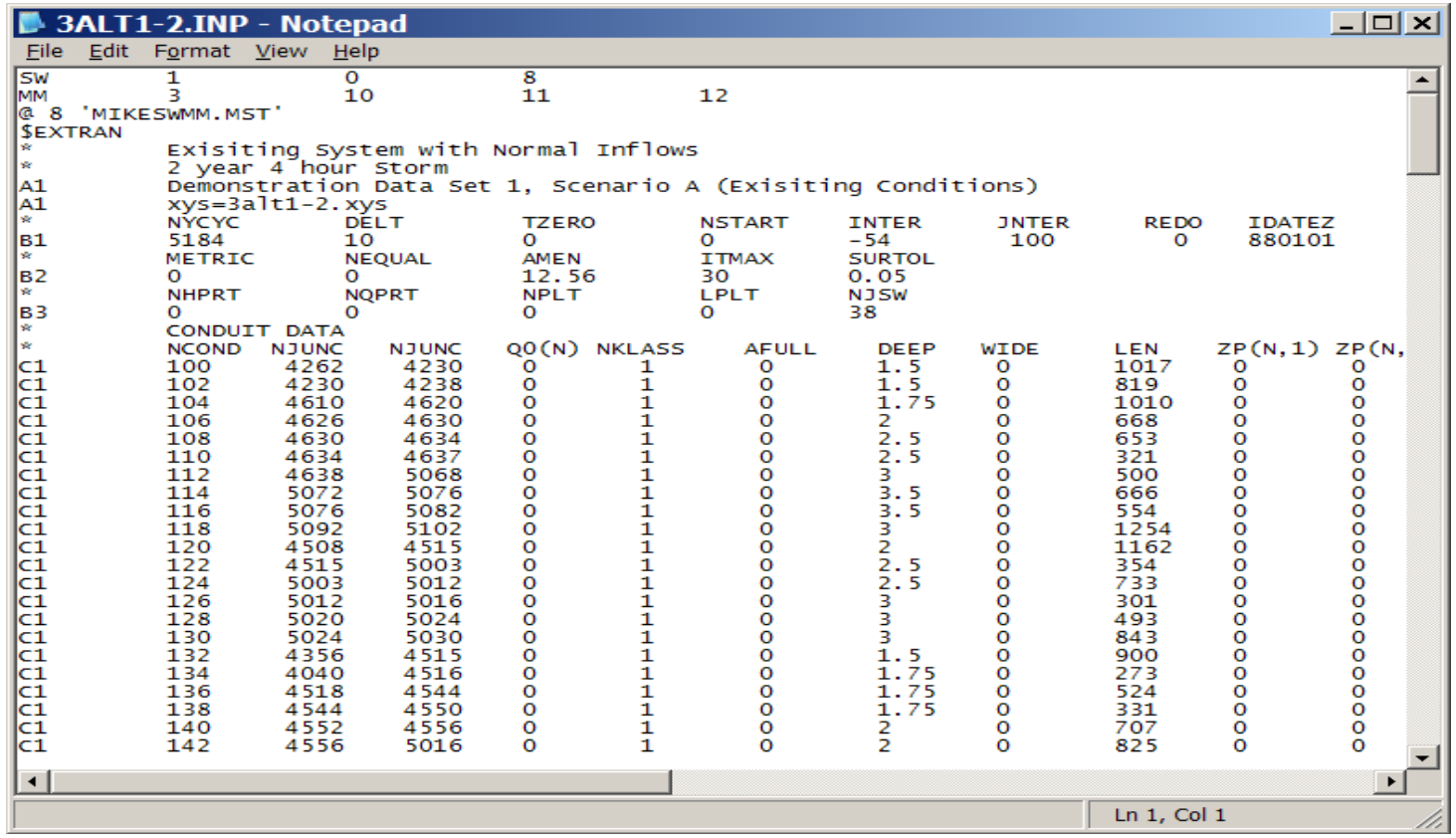
Historical development

Generations of simulation models

- 1.generation 50’, analytical solution of eq., analogs
- 2.generation 60’ specific use models, large laboratories
- 3.generation 70’ first simulation models, input variability
- 4.generation 80’ menu-driven systems, PC, DOS, no standardization
- 5.generation 90’, UNIX x Windows, databases, graphics,
- 6. generation 00’, client-server, GIS,
- 7. generation 10’, internet, clouds, SaS
- X. generation Future? (KBS, AI,…)

...3th. Generation

- Text inputs / result files



3ALT1-2.INP - Notepad

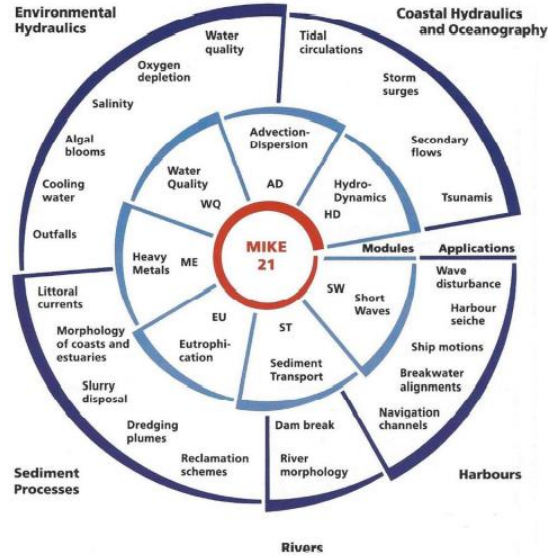
File Edit Format View Help

```
SW          1             0             8
MM          3             10            11            12
@ 8 'MIKESWMM.MST'
$EXTRAN
*           Exisiting System with Normal Inflows
*           2 year 4 hour Storm
A1          Demonstration Data Set 1, Scenario A (Exisiting Conditions)
A1          xys=3alt1-2.xys
*           NYCYC         DELT          TZERO         NSTART        INTER         JNTER         REDO    IDATEZ
B1          5184          10            0             0             -54            100            0    880101
*           METRIC        NEQUAL        AMEN          ITMAX         SURTOL
B2          0             0             12.56         30            0.05
*           NHPRT         NQPRT         NPLT          LPLT          NJSW
B3          0             0             0             0             38
*           CONDUIT DATA
*           NCOND   NJUNC     NJUNC    QO(N) NKLASS     AFULL     DEEP    WIDE      LEN     ZP(N,1) ZP(N,
C1          100       4262      4230     0        1         0      1.5       0      1017       0         0
C1          102       4230      4238     0        1         0      1.5       0       819       0         0
C1          104       4610      4620     0        1         0     1.75       0      1010       0         0
C1          106       4626      4630     0        1         0        2       0       668       0         0
C1          108       4630      4634     0        1         0      2.5       0       653       0         0
C1          110       4634      4637     0        1         0      2.5       0       321       0         0
C1          112       4638      5068     0        1         0        3       0       500       0         0
C1          114       5072      5076     0        1         0      3.5       0       666       0         0
C1          116       5076      5082     0        1         0      3.5       0       554       0         0
C1          118       5092      5102     0        1         0        3       0      1254       0         0
C1          120       4508      4515     0        1         0        2       0      1162       0         0
C1          122       4515      5003     0        1         0      2.5       0       354       0         0
C1          124       5003      5012     0        1         0      2.5       0       733       0         0
C1          126       5012      5016     0        1         0        3       0       301       0         0
C1          128       5020      5024     0        1         0        3       0       493       0         0
C1          130       5024      5030     0        1         0        3       0       843       0         0
C1          132       4356      4515     0        1         0      1.5       0       900       0         0
C1          134       4040      4516     0        1         0     1.75       0       273       0         0
C1          136       4518      4544     0        1         0     1.75       0       524       0         0
C1          138       4544      4550     0        1         0     1.75       0       331       0         0
C1          140       4552      4556     0        1         0        2       0       707       0         0
C1          142       4556      5016     0        1         0        2       0       825       0         0
```

Ln 1, Col 1

4th. Generation

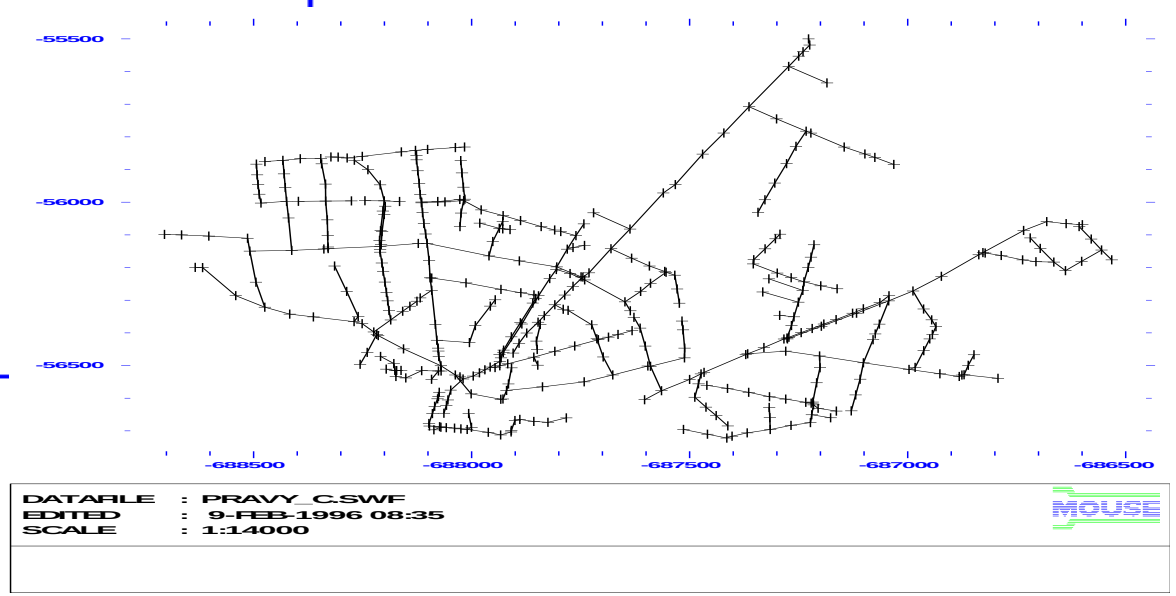
- Simple user interfaces
- First graphical results



F.6.5.2 DISCHARGE DATA Database name: KQ_LEVY

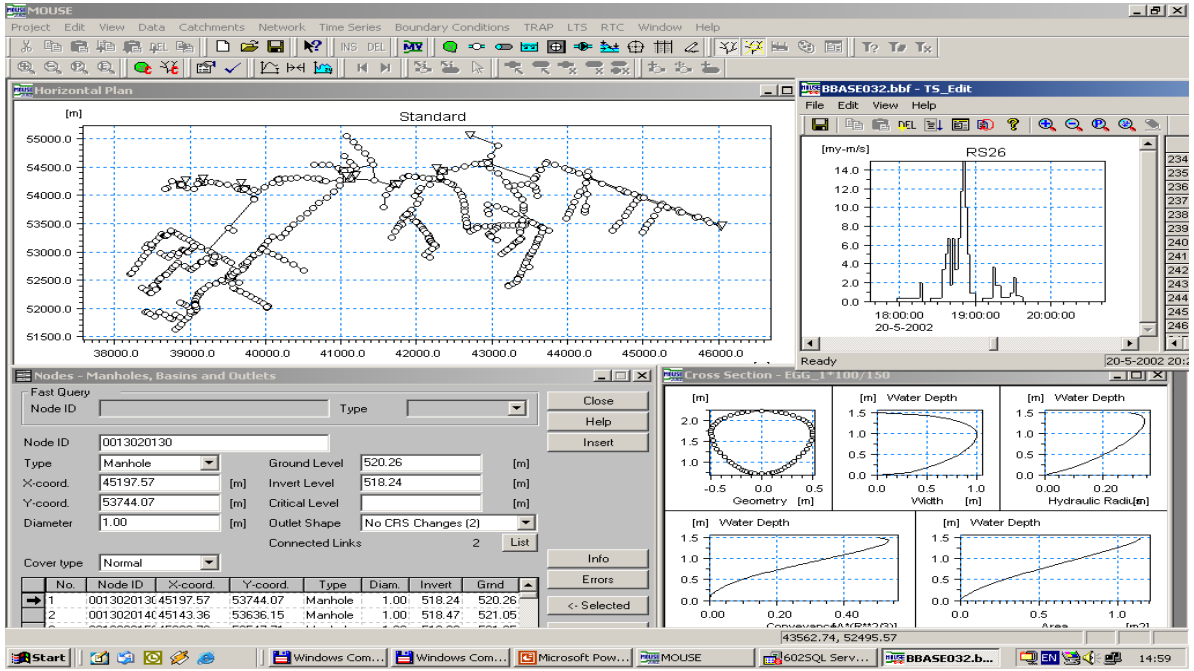
Identification :	QTK_983	Duration (h) :	25.000 Acc (m3): 2.156E+03
X-coordinate(m) :	0.00	Min.value :	0.0000
Y-coordinate(m) :	0.00	Max.value :	0.1500

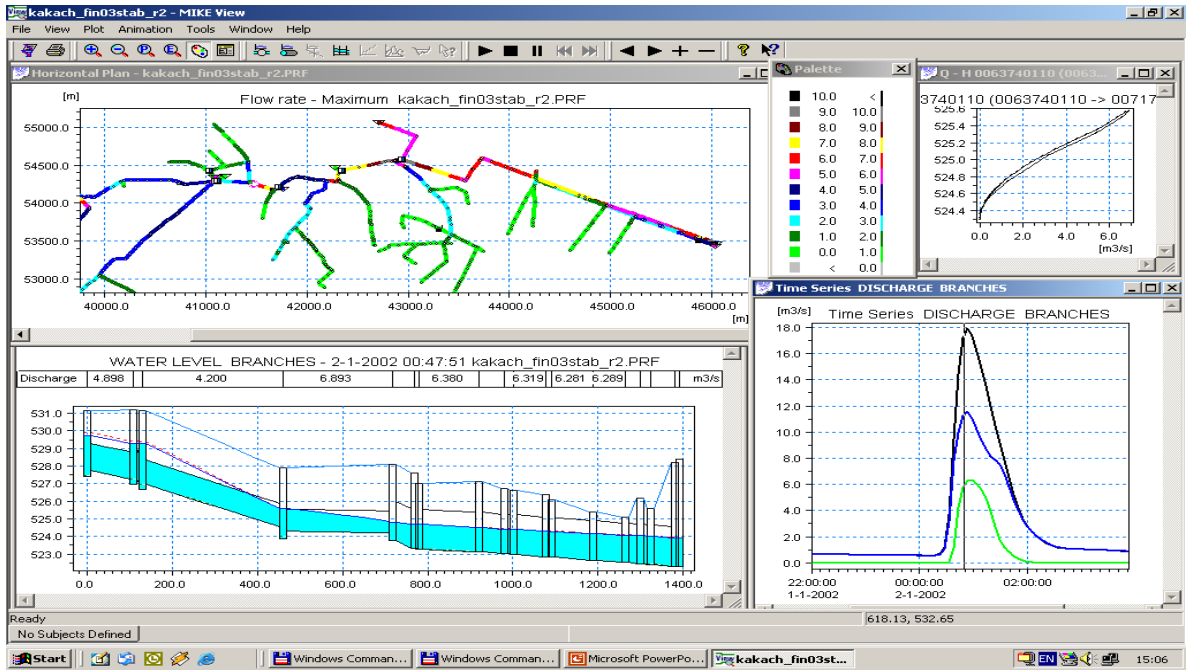
26	Date and Time YYYY-MM-DD HH:MM:SS						Discharge m**3/s
1	96	2	1	0	0	0	0.0050
2	96	2	1	1	0	0	0.0050
3	96	2	1	2	0	0	0.0050
4	96	2	1	3	0	0	0.0050
5	96	2	1	4	0	0	0.0100
6	96	2	1	5	0	0	0.0100
7	96	2	1	6	0	0	0.1500
8	96	2	1	7	0	0	0.1250
9	96	2	1	8	0	0	0.1250
10	96	2	1	9	0	0	0.1250



5th. Generation

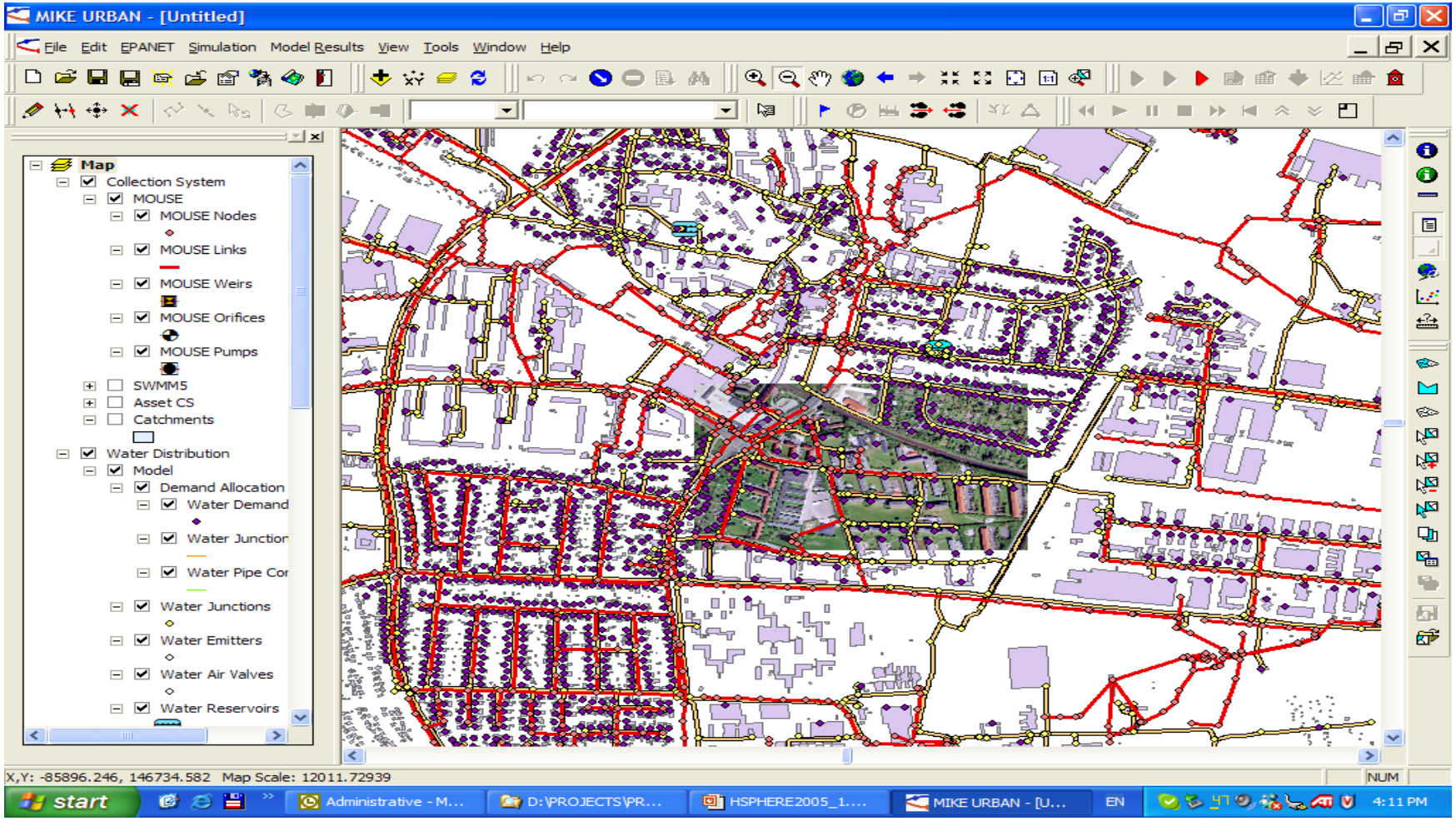
- Modular system
- Client – server interface
- Data model
- Separated model engine
- Complex presentation of results





6th. Generation

- GIS platform
- COM objects
- Configuration XML
- Multilanguage
- Model Integration
- On-line



7th. Generation

- paralellisation of processes
- multicore processing
- virtual cloud processing
- Software as service
- Internet and web