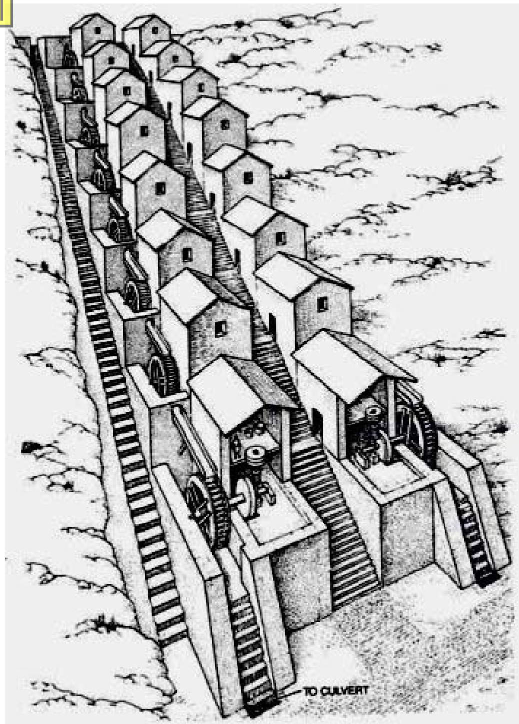
Lesson 2: History & development of IWRM

WVLC
United Nations
Water Virtual
Learning Centre

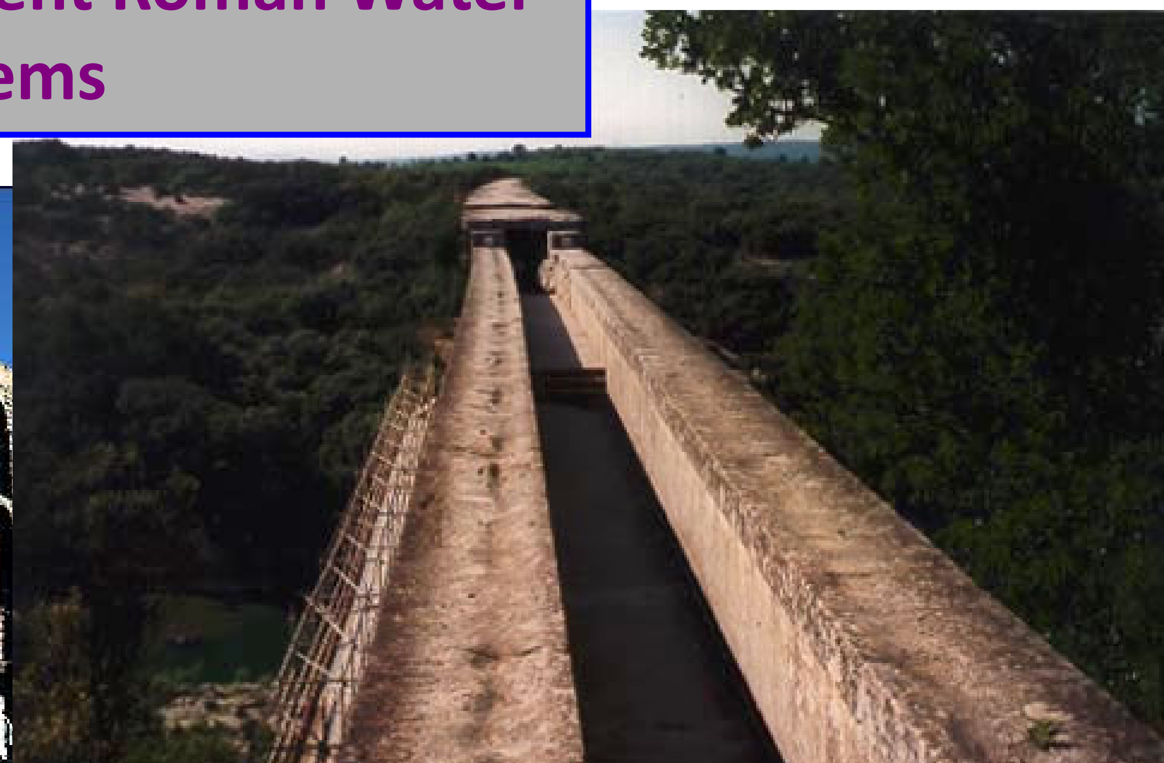
Lesson 2

- This lesson traces water management practices from historical times till present



Ancient Rome

Ancient Roman Water Systems

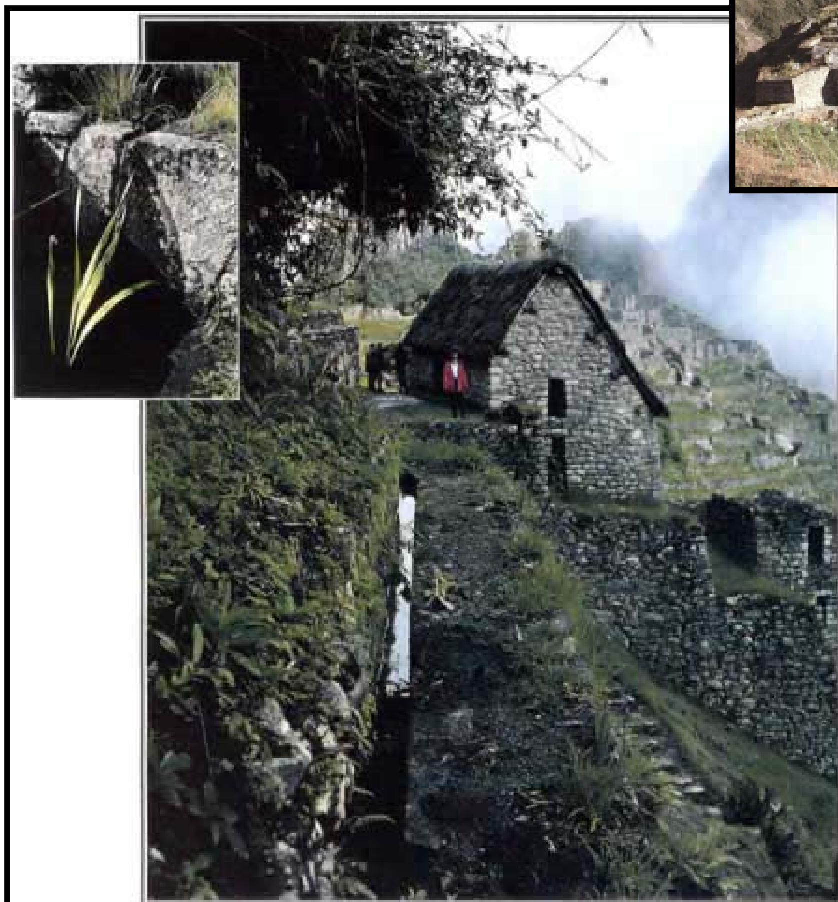


From: http://www.waterhistory.org

Machu Picchu

Peru

Inca Canals in the Peruvian Andes



Machu Picchu water supply canal

Interceptor Drain Running across Agricultural Sector and Emptying into Dry Moat at Machu Picchu

Peru

Inca Canals in the Peruvian Andes

From: http://www.waterhistory.org

China

The oasis at Turpan, located in the desert expanse of northwestern China (PRC), owes it surprisingly lush green environment to the karez (or qanat) system of water supply. A karez is a horizontal underground gallery that conveys water from aquifers in pre-mountainous alluvial fans, to lower-elevation farmlands

Uyghur and Chinese versions of karez technology date back over 2,000 years ago.

China

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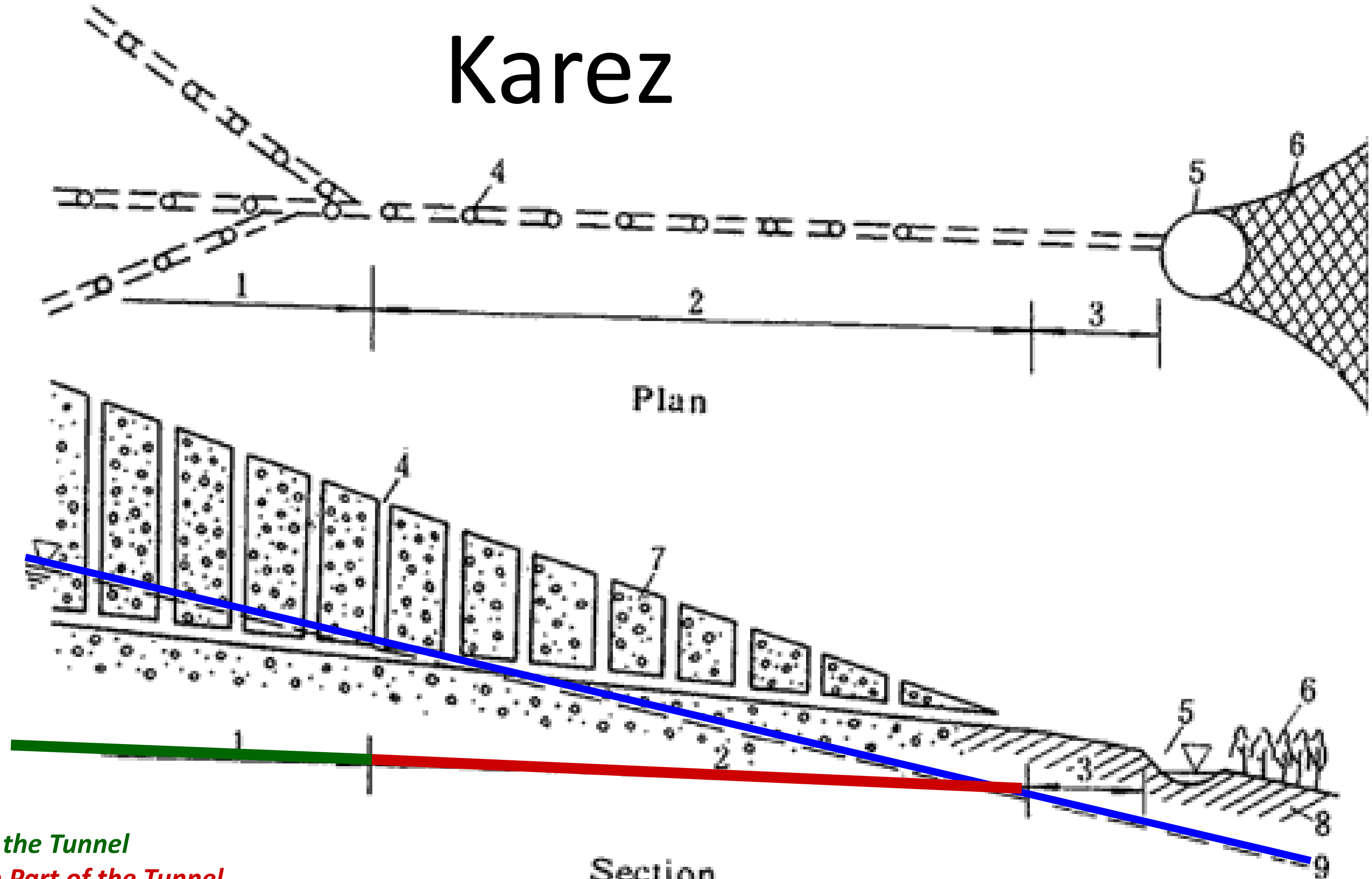
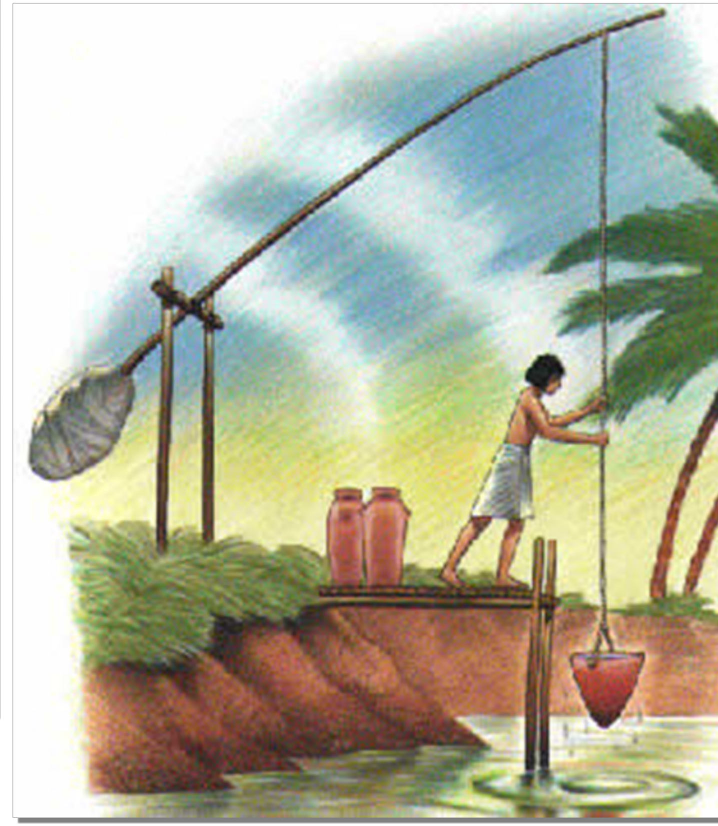
From: http://www.waterhistory.org

Karez



*(1) **Infiltration Part of the Tunnel***
*(2) **Water Conveyance Part of the Tunnel***
(3) The Open Channel
(4) Vertical Shafts
(5) Small Storage Pond
(6) The Irrigation Area
(7) Sand and Gravel
(8) Layers of Soil
*(9) **Groundwater Surface***

Schematic of a Karez Project



Egypt

Overall, Ancient Egypt's system of basin irrigation proved inherently more stable from an ecological, political, social, and institutional perspective than that of any other irrigation-based society in human history. Fundamentally, the system was an enhancement of the natural hydrological patterns of the Nile River, not a wholesale transformation of them.

From: http://www.waterhistory.org

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From: http://www.waterhistory.org

There are four main stages in the evolution of IWRM. They occur along an uninterrupted pathway and overlap considerably.

For the sake of convenience, we will deal with each "period" separately.

- The Sectoral Approach - 1820 to 1950s
- The Cooperative Approach - 1960s and 1970s
- Management-oriented IWRM - 1980s
- Goal-oriented IWRM - 1990s to present

Evolution of Water Management

Evolution

Water Management: Phases of Development	Dates	Conferences
1. The Sectoral Approach	1820 to 1950s	
2. The Cooperative Approach	1960s and 1970s	
3. IWRM - Management-oriented	1980s	Mar del Plata (UN, 1977)
4. IWRM - Goal-oriented	1990s	
5. Capacity Building for IWRM	2000+	New Delhi meeting (1990) Dublin meeting (1992) Rio de Janeiro (UNDP, 1992) Ministerial Conference in Noordwijk (1994) Johannesburg (2003)

Evolution of Water Management

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Sectoral Approach

1. **The Sectoral Approach**

   Each sector involved in water and water issues does its own planning and implementation except when the sectors overlap responsibilities.

   There are therefore separate:

- **Planning and implementation processes**
- **Activities and tasks (such as water storage, transmission, distribution, allocation)**
- **Physical and construction measures (water canals, dams, reservoirs)**
- **Legal and economic instruments such as regulations and incentives**
- **Institutional and organisational requirements**

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2. The Cooperative Approach

Cooperation between the many agencies involved in planning and activities in the water sector improves.
There are some joint planning and joint activities with two or more agencies or stakeholders – even where their legal responsibilities do NOT overlap.
As it became clear that these plans, activities, regulatory activities, and legal and economic frameworks intersected, ad-hoc cooperative efforts became common. The features of these cooperative efforts were:

- **Joint planning processes for two or more agencies or stakeholders**
- **Rationalisation of certain activities**
- **Interactions to improve regulatory and economic frameworks**
- **Better institutional cooperation**

Gradually, the concept of an integration of many of the functions surrounding the supply of water (for all purposes, not just for drinking water) came into being.

It began as a realization that to manage water effectively, one needs to look at a broader scale picture -- that of the watershed (or drainage area of the river or lake) that supplies the water.

Where groundwater was the primary or a substantial component, the recharge area (where water enters the groundwater system) and any other region that could affect the quantity and quality of the groundwater, must also be considered.

Evolution of Water Management

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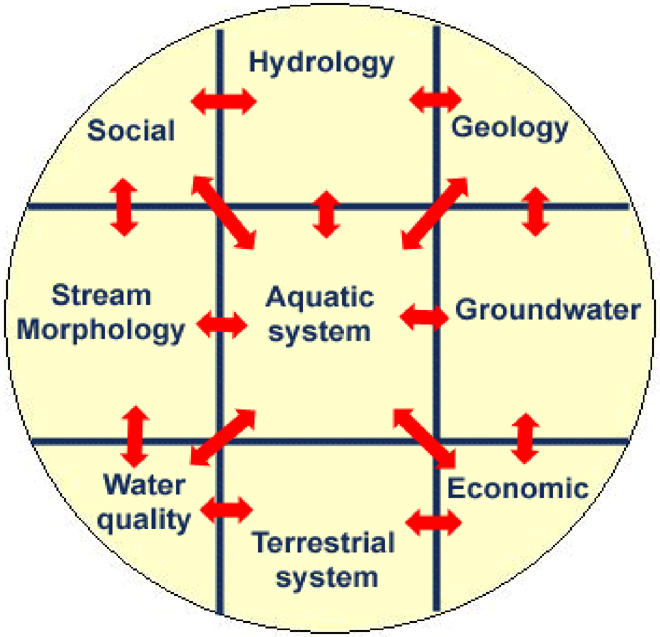
IWRM - management

3. **Initial attempts at Integration of Water Resource Management - Management-oriented – (Ecosystem Management)**



An Integrative Approach to Water Resource and Watershed Management

There are many examples of early attempts at IWRM. Some recommendations for Canadian policies were developed by Pearse et al (1985). The "key" principles were;

- **A watershed plan sufficiently comprehensive to take into account all uses of the water system and other activities that affect water flow and quality.**
- **Information about the watershed's full hydrological regime.**
- **An analytical system, or model, capable of revealing the full range of impacts that would be produced by particular uses and developments in the watershed**

IWRM - Model

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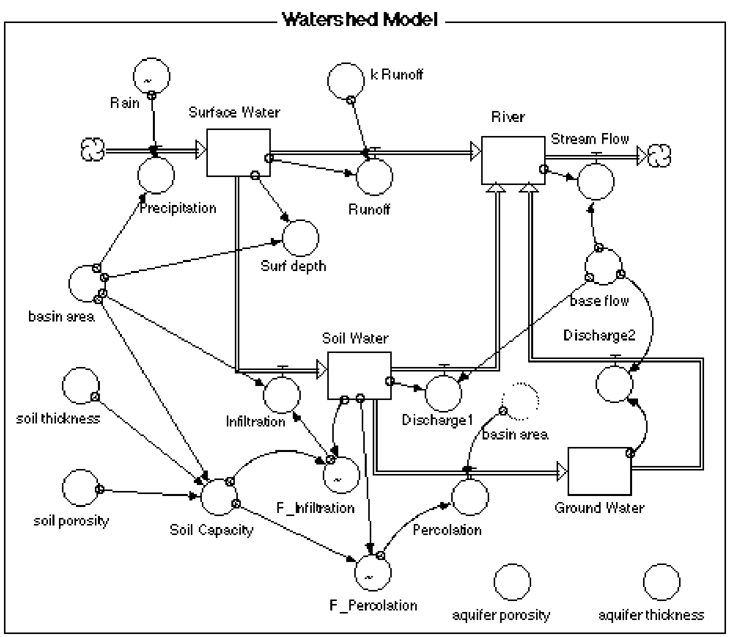
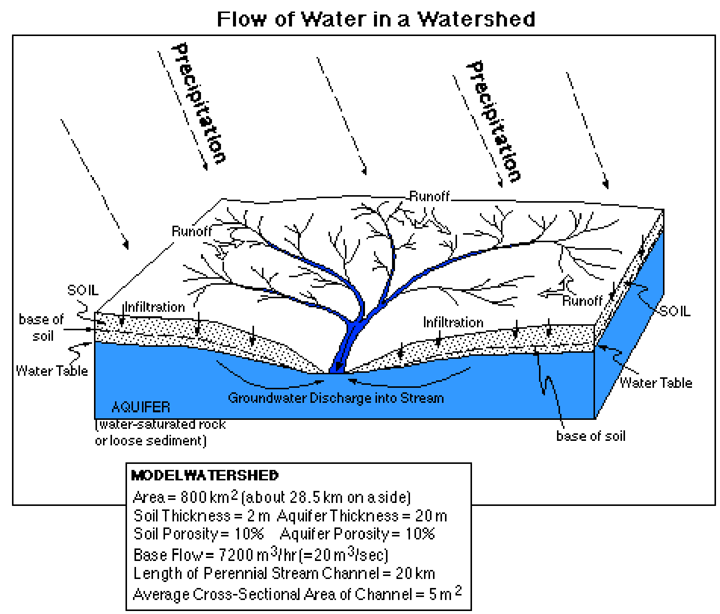
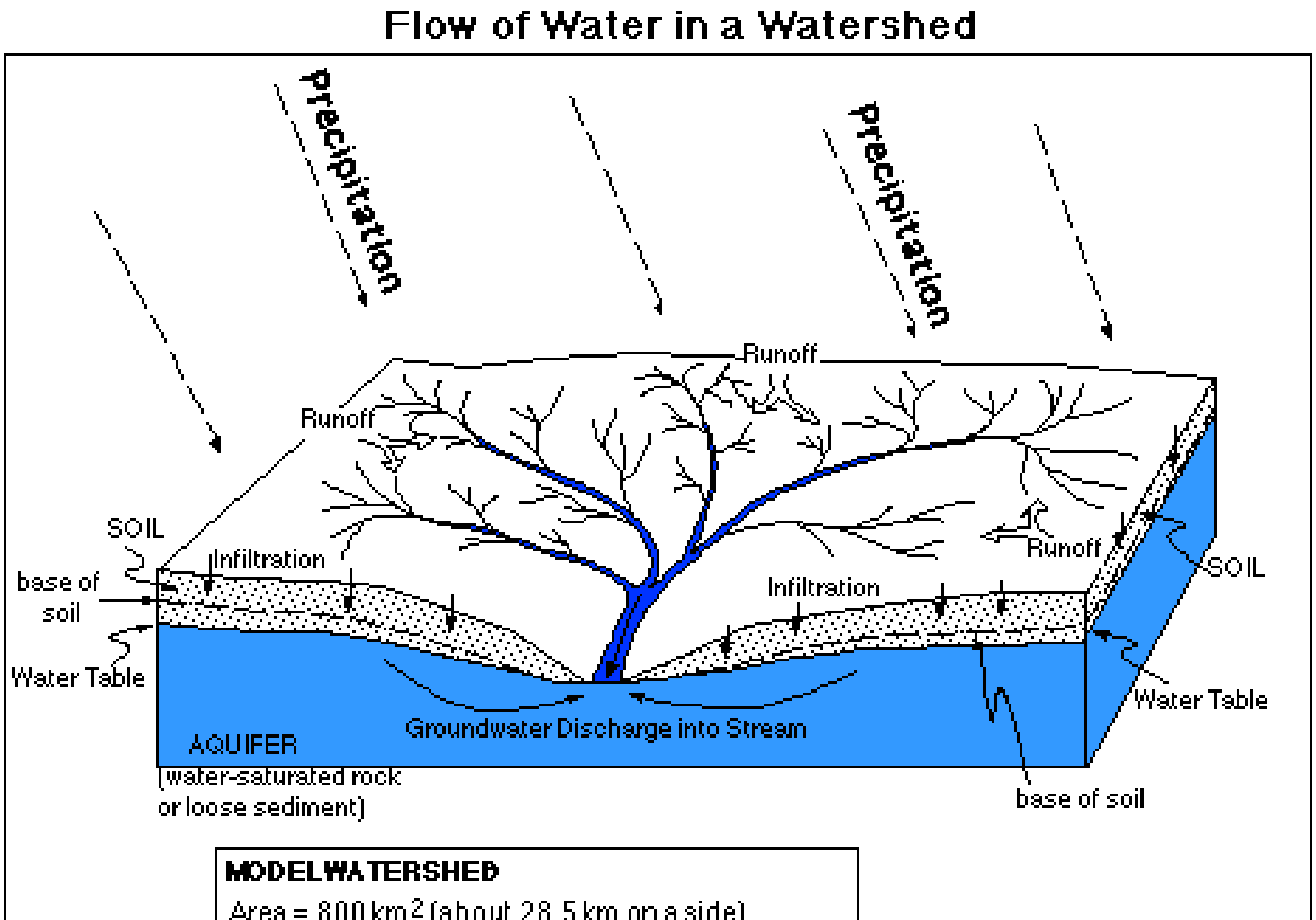




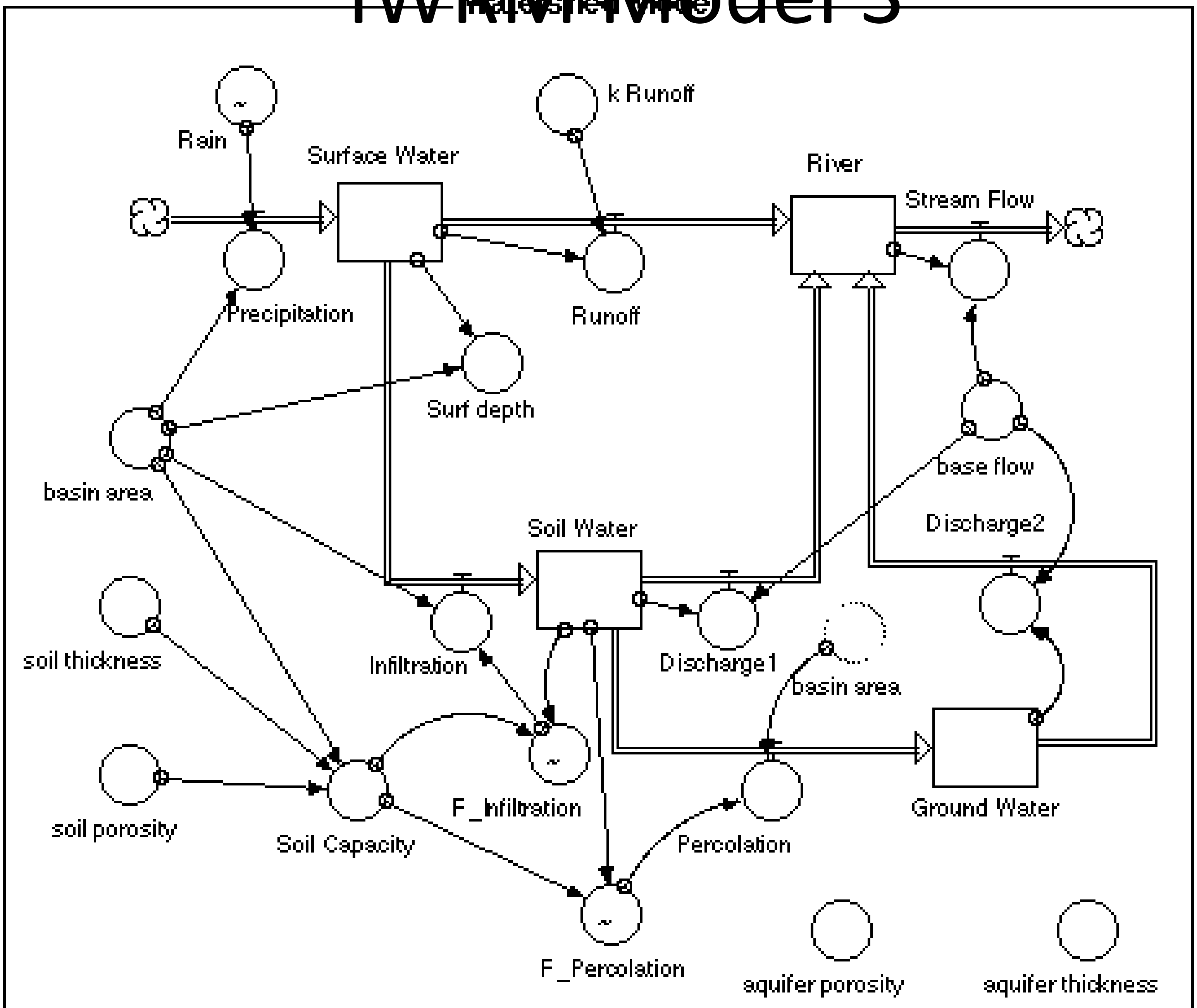
IWRM Model 2



MODEL WATERSHED

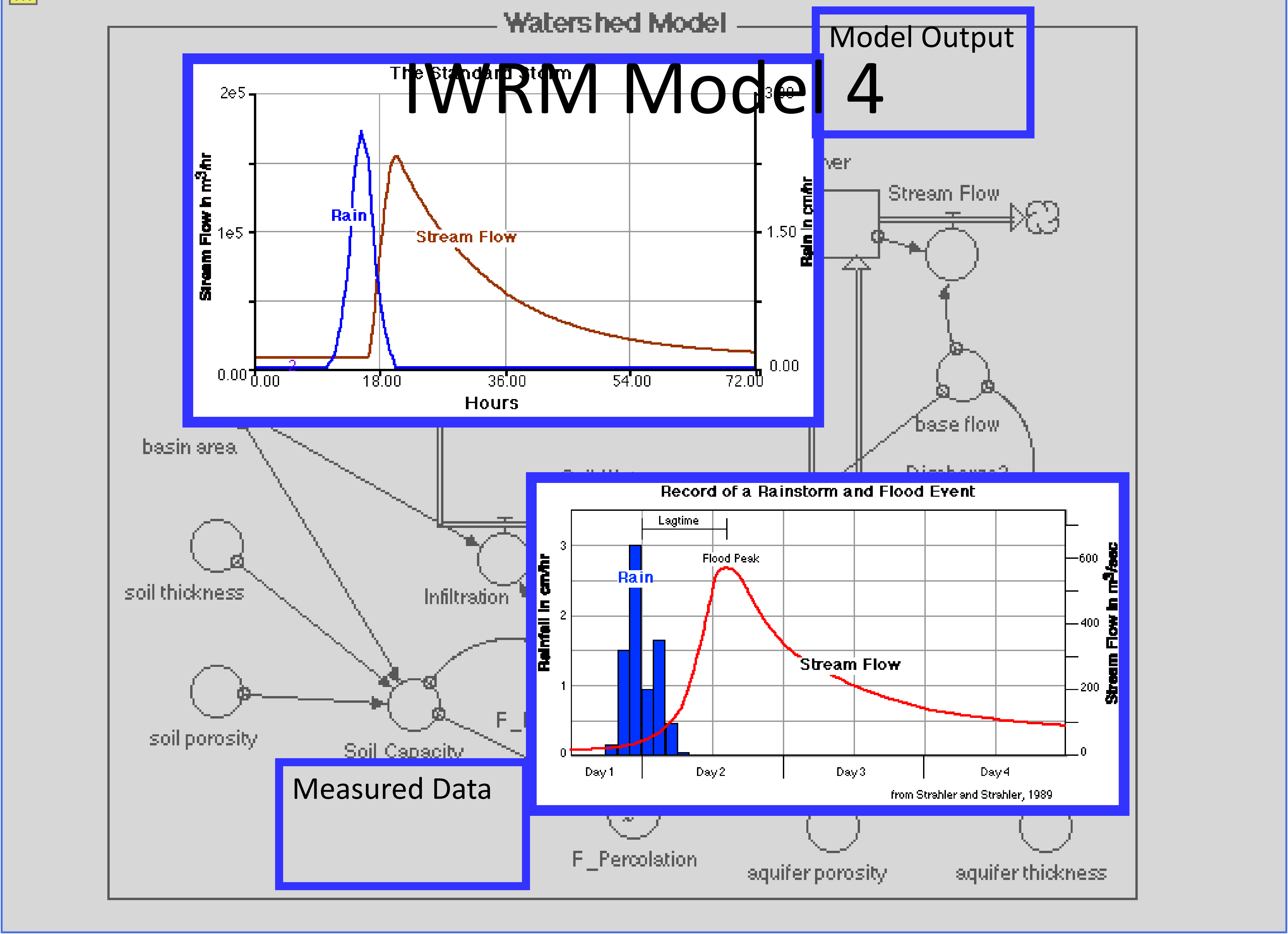
Area = 800 km^2 (about 28.5 km on a side)
Soil Thickness = 2 m Aquifer Thickness = 20 m
Soil Porosity = 10% Aquifer Porosity = 10%
Base Flow = 7200 m^3/hr (= 20 m^3/sec)
Length of Perennial Stream Channel = 20 km
Average Cross-Sectional Area of Channel = 5 m^2

IWRM Model 3



Watershed Model
k Runoff
Rain
Surface Water
River
Stream Flow
Runoff
Precipitation
Surf depth
basin area
base flow
Discharge2
Soil Water
soil thickness
Infiltration
Discharge1
basin area
F_Infiltration
Ground Water
soil porosity
Soil Capacity
Percolation
F_Percolation
aquifer porosity
aquifer thickness

IWRM Model 4



Watershed Model
Model Output
The Standard Storm
2e5
1e5
0.00
3.00
1.50
0.00
Stream Flow in m³/hr
Rain in cm/hr
Rain
Stream Flow
0.00
18.00
36.00
54.00
72.00
Hours
Stream Flow
base flow
basin area
soil thickness
soil porosity
Soil Capacity
Infiltration
F_Percolation
aquifer porosity
aquifer thickness
Measured Data
Record of a Rainstorm and Flood Event
Lagtime
Flood Peak
Rain
Stream Flow
Rainfall in cm/hr
Stream Flow in m³/sec
3
2
1
0
600
400
200
0
Day 1
Day 2
Day 3
Day 4
from Strahler and Strahler, 1989

Development of automatic methods of obtaining the drainage and land cover databases for WATFLOOD

F. Seglenieks, E.D. Soulis and N. Kouwen

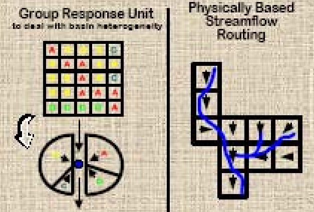
Water Resources Group, Department of Civil Engineering, University of Waterloo

University of Waterloo

Copies of this poster can be downloaded from the WATFLOOD homepage: http://sunburn.uwaterloo.ca/Watflood

INTRODUCTION TO WATFLOOD

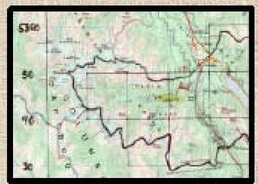
WATFLOOD is a distributed hydrologic model based on the GRU concept. In the GRU method, all similarly vegetated areas (not necessarily contiguous) within a sub-watershed or element are grouped as one response unit and called a GRU. An element has one GRU for each hydrologically significant land cover type. The hydrological response from all GRUs in an element are summed to give its total response. More information on the model can be found at the website: http://sunburn.uwaterloo.ca/Watflood



DRAINAGE DATABASE COLLECTION

MANUAL METHOD

The manual method of deriving the landcover database involves obtaining the appropriate topographic maps, outlining the basin, drawing the correct GRU grid spacing, and then writing down the information needed for WATFLOOD.



AUTOMATIC METHOD

In 1996, the program MapMaker was written to take advantage of the newly available databases containing geophysical information (ie. elevation and landcover). Since then, the program has been updated and will now take in data derived from the above databases and create all the files necessary to run WATFLOOD and even set up an example event.

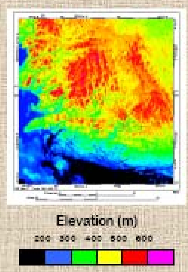
STUDY AREA

The basins chosen to demonstrate the program are the Goulais and Mississagi. They are located in Northern Ontario near the town of Sault St. Marie, with drainage areas of 1160 km² and 9300 km², respectively.

DATA SOURCES

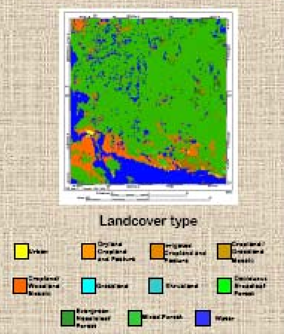
GTOPO30 - Global 30 Arc Second Elevation Data Set

http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html



North America Land Cover Characteristics Data Base

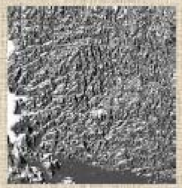
http://edcwww.cr.usgs.gov/landdaac/glcc/na_int.html



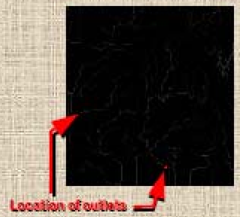
DERIVED DATA

From the above data sources the following products can be derived, we use the EASI/PACE Image Processor and the in the future we hope to link MapMaker with the basin delineation program TOPAZ.

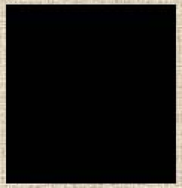
Flow direction



Flow accumulation



Seed values

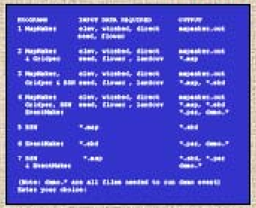


Watershed delineation

MAPMAKER

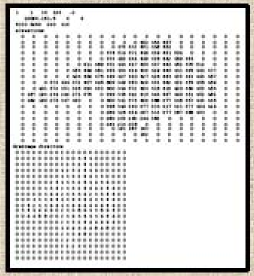
The MapMaker program offers many choices during execution, depending on the available input information and the required output files. If chosen by the user, MapMaker will not only create the required watershed information files for WATFLOOD, but will also create a sample parameter file and a simulated run consisting of a snowmelt and a rainfall event.

INPUT INFORMATION

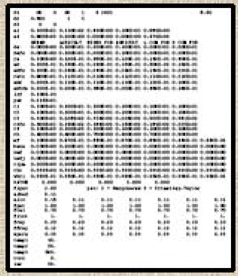


OUTPUT FILES

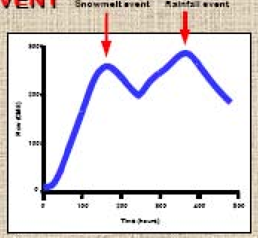
Sample watershed file

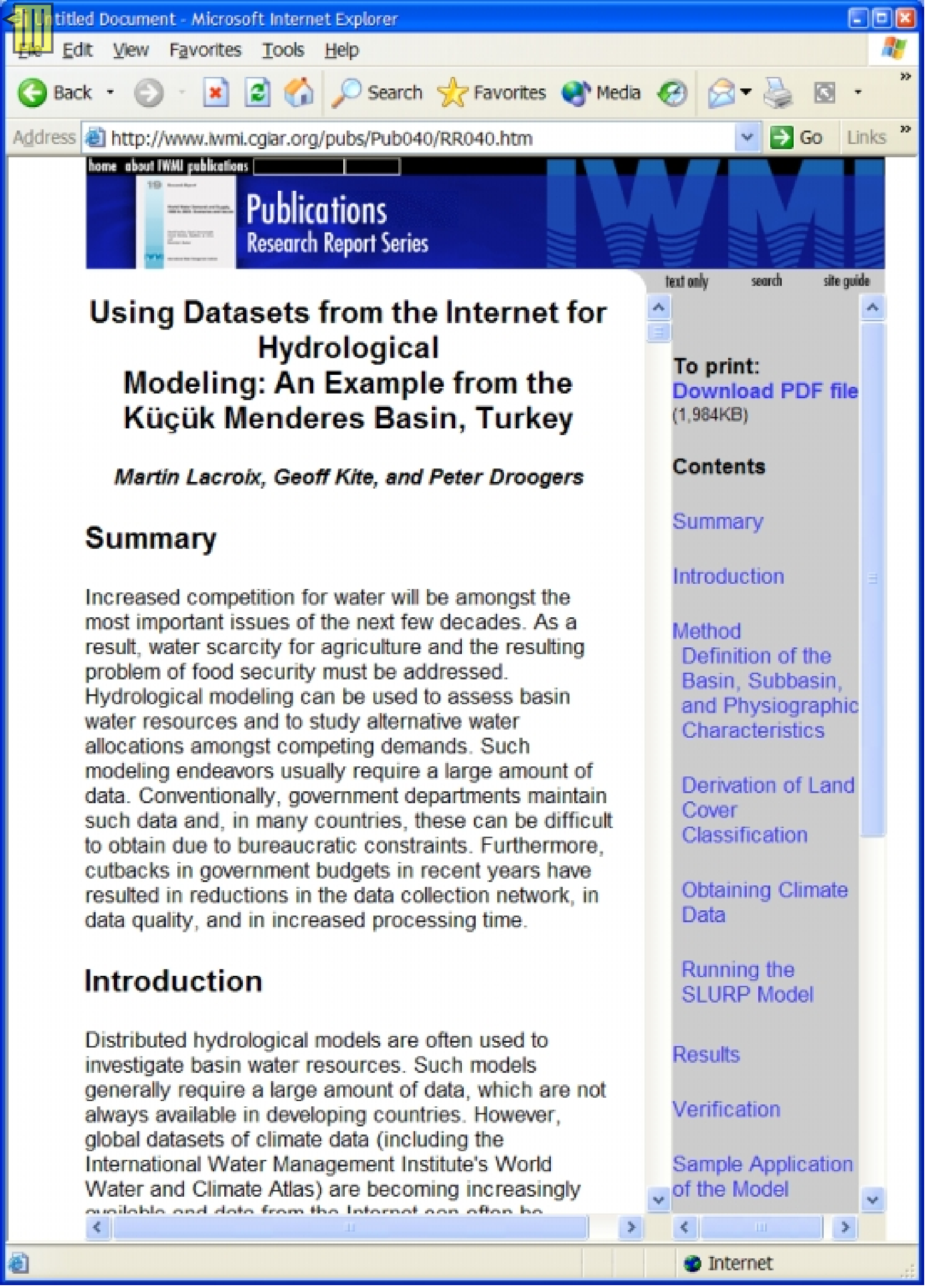


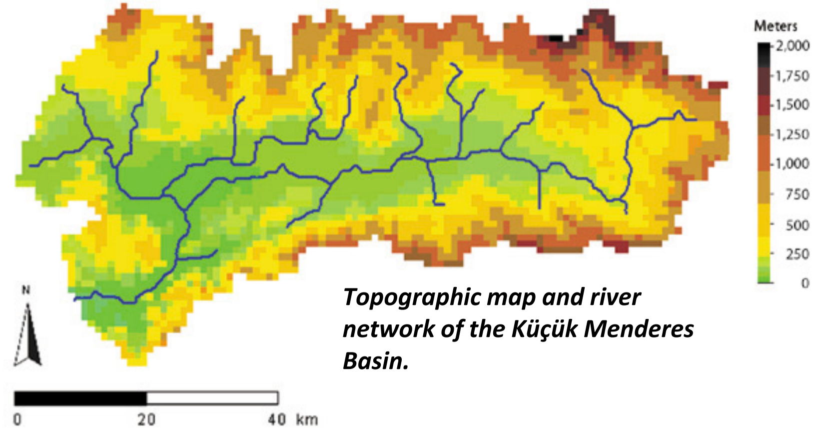
Sample parameter file



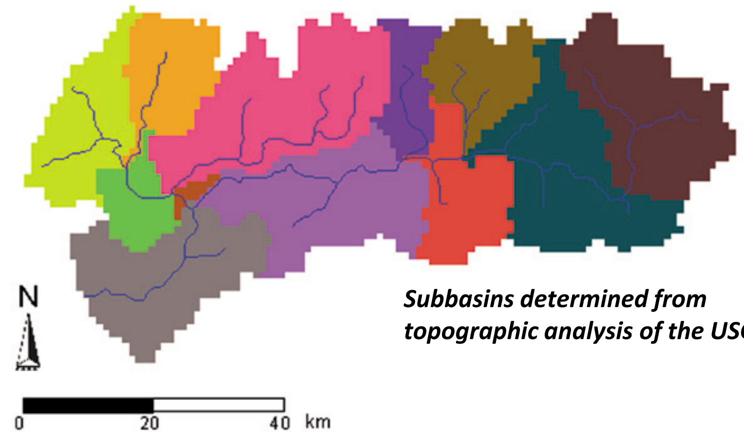
SAMPLE EVENT



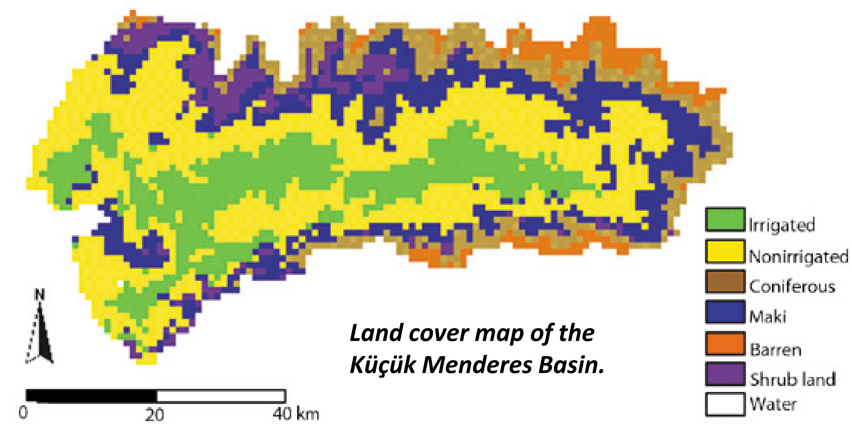




Topographic map and river network of the Küçük Menderes Basin.



Subbasins determined from topographic analysis of the USGS DEM.



Land cover map of the Küçük Menderes Basin.

http://www.iwmi.cgiar.org/pubs/Pub040/RR040.htm

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IWRM - management

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- **Information about the watershed's full hydrological regime.**
- **An analytical system, or model, capable of revealing the full range of impacts that would be produced by particular uses and developments in the watershed**
- **Specified management objectives for the watershed, with criteria for assessing management alternatives in an objective and unbiased way**
- **Participation of all relevant regulatory agencies**
- **Provisions for public participation in determining objectives and in management decisions.**

Evolution of Water Management

Water Management: Phases of Development	Evolution Dates	Conferences
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IWRM - goals

4. Evolution of more complex and complete systems of IWRM: Goal-oriented

If IWRM is defined as “a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (GWP/TAC, 2000), then the focus shifts.

The goals become the most important focus;

Goals for IWRM

- To develop a consensus-based vision of ideal water resources conditions for the area of interest.
- To measure the distance between current and ideal conditions, and thus define one or more water management problems, based on consensus among stakeholders.
- To develop and apply tools for water resources decision making, including demonstration projects, computer simulation models, conflict resolution tools, data management and sharing, and so on.
- To identify appropriate management actions to resolve observed problems.
- To assign responsibility for actions and costs for remedial measures.
- To agree upon acceptable timelines for implementation of management actions.
- To monitor the degree of implementation of management actions, and progress toward water resources goals.
- To build the capacity of regional stakeholders for collaborative, consensus-based management of water resources.
- To build institutional capacity to work across jurisdictional, disciplinary, and sector boundaries.
- To achieve measurable progress toward improved water resources conditions

From Isobel W. Heathcote (2002)

Goals 2 WWC

Another view, similar in scope, is that of the World Water Council.
They state that the three primary objectives of integrated water resource management are to:

- **Empower women, men, and communities to decide on their level of access to safe water and hygienic living conditions and on the types of water-using economic activities they desire–and to organise to achieve them.**

- **Produce more food and create more sustainable livelihoods per unit of water applied, and ensure access for all to the food required for healthy and productive lives.**

- **Manage human water use to conserve the quantity and quality of freshwater and terrestrial ecosystems that provide services to humans and all living things**

Evolution of Water Management

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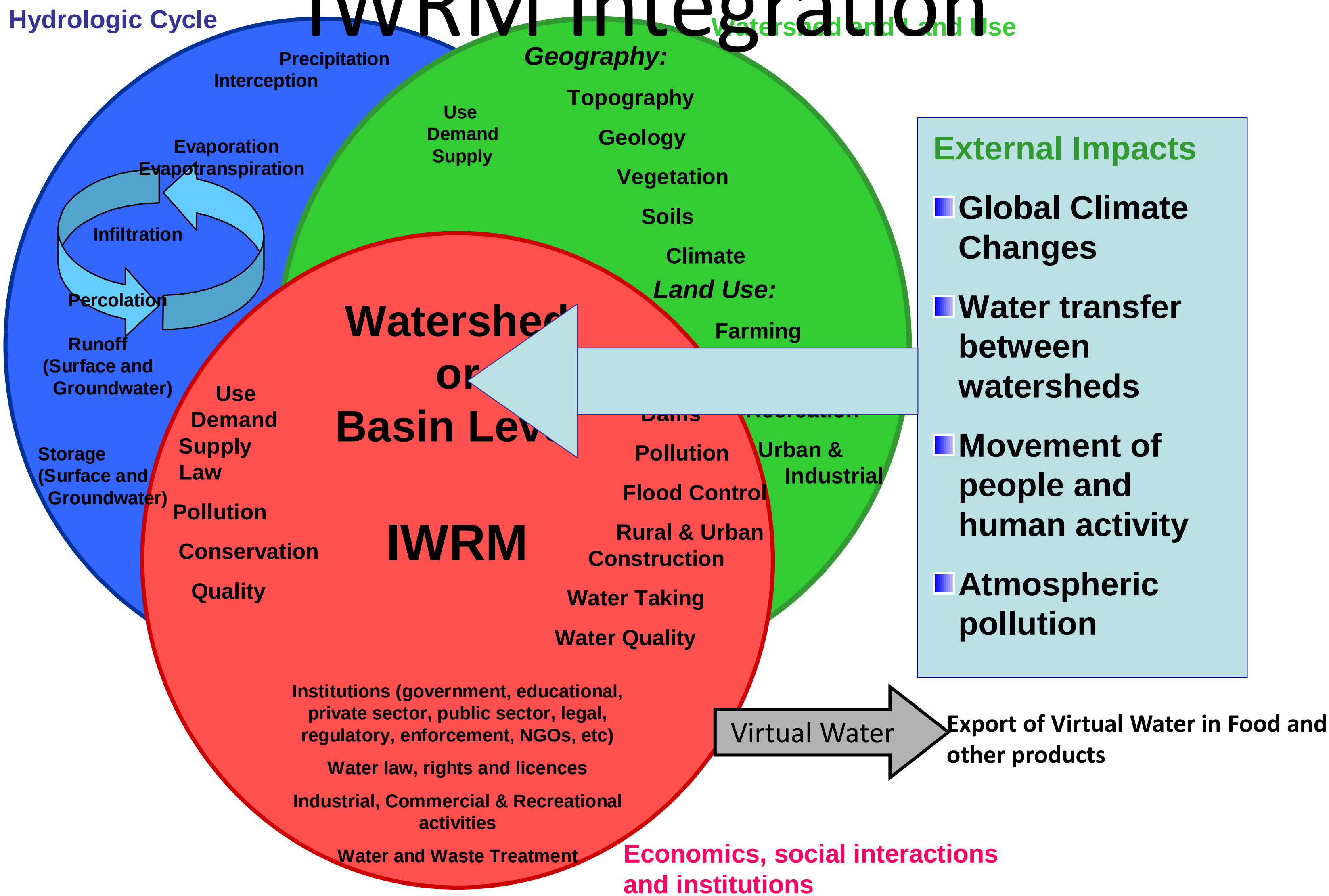
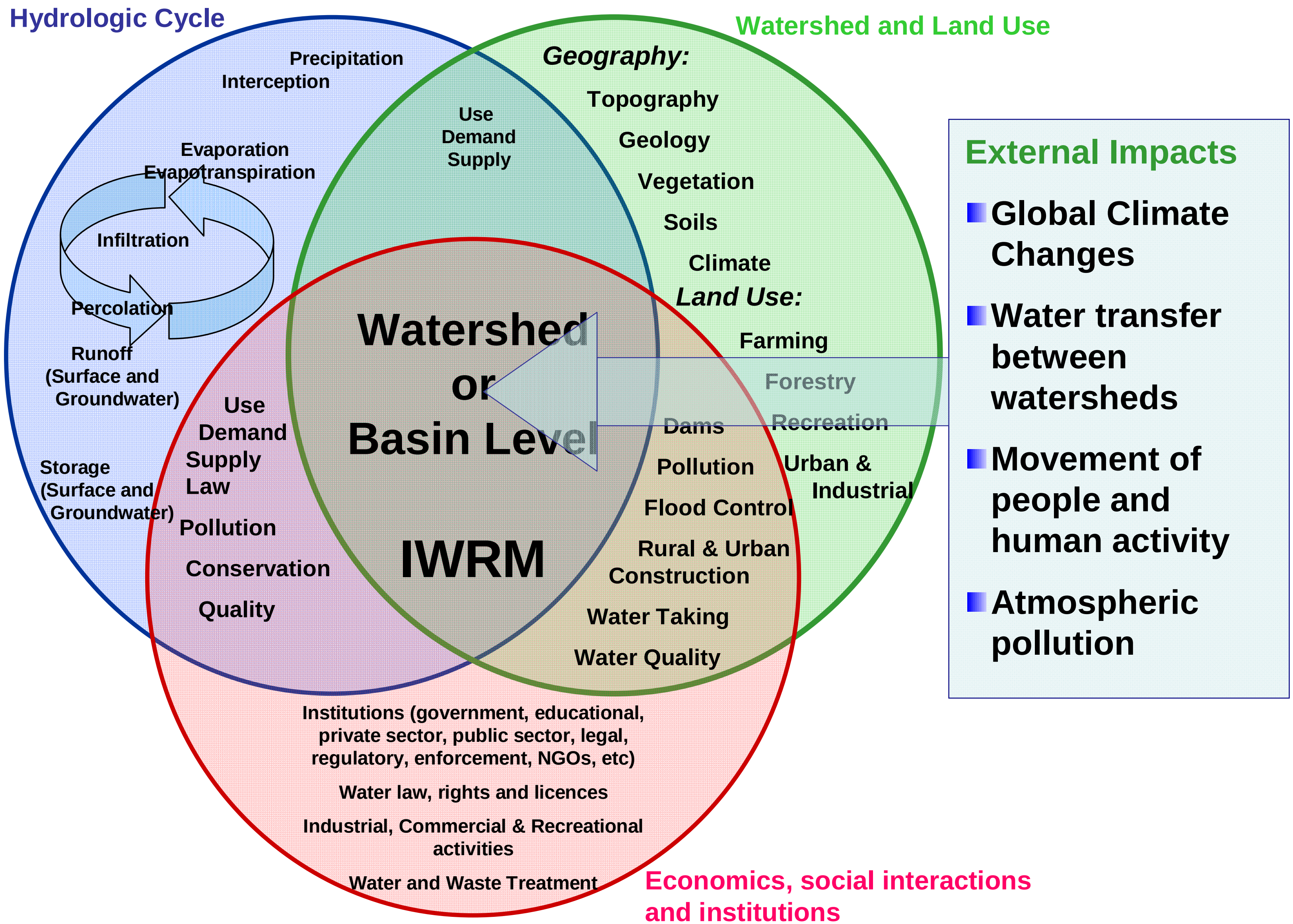
IWRM Integration

IWRM Integration



Mayfield, 2004


Hydrologic Cycle
Watershed and Land Use
Economics, social interactions and institutions
Precipitation
Interception
Evaporation
Evapotranspiration
Infiltration
Percolation
Runoff (Surface and Groundwater)
Storage (Surface and Groundwater)
Use
Demand
Supply
Geography:
Topography
Geology
Vegetation
Soils
Climate
Land Use:
Farming
Forestry
Recreation
Urban & Industrial
Use
Demand
Supply
Law
Pollution
Conservation
Quality
Watershed or Basin Level
IWRM
Dams
Pollution
Flood Control
Rural & Urban Construction
Water Taking
Water Quality
Institutions (government, educational, private sector, public sector, legal, regulatory, enforcement, NGOs, etc)
Water law, rights and licences
Industrial, Commercial & Recreational activities
Water and Waste Treatment
External Impacts
Global Climate Changes
Water transfer between watersheds
Movement of people and human activity
Atmospheric pollution

This overview of IWRM processes shows many of the individual components of IWRM planning. These components are shown in three main areas:

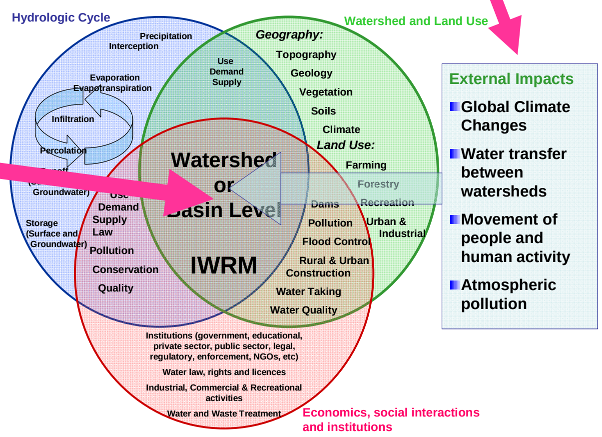
- ❑ *Hydrologic cycle (blue)* - with common hydrological factors listed

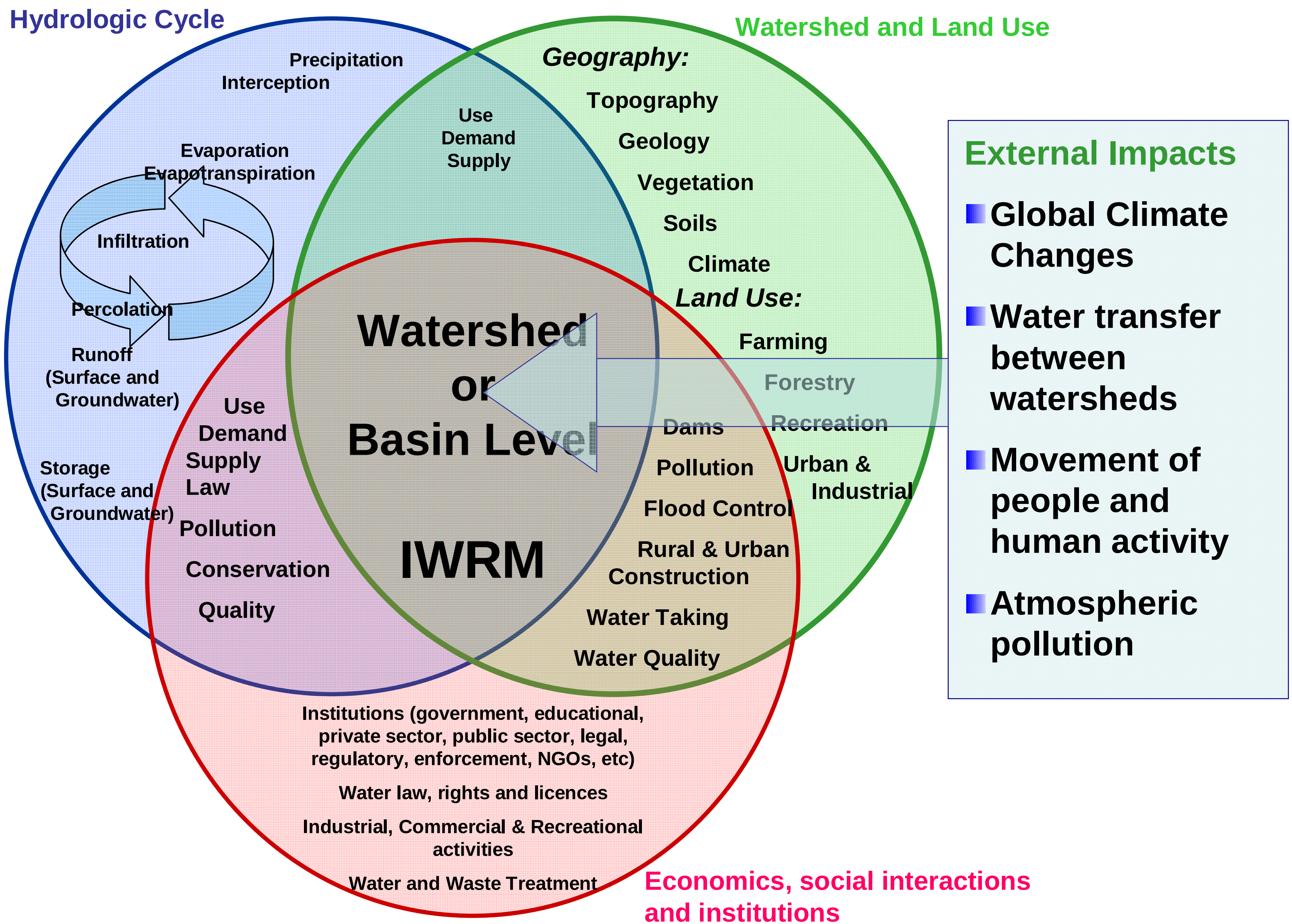
- ❑ *Watershed and land use (green)* - listing factors where land activities affect water

- ❑ *Economics, social interactions and institutions (pink)* - showing the various factors in those areas that bear on water supply and IWRM

- ❑ Outside factors such as global climate changes, water transfers, atmospheric pollution, and movement of people are also listed. These factors cannot be considered only at the watershed or drainage basin level. Water can also be exported from the watershed in food or other products.

- ❑ IWRM lies at the intersection of all of the factors.





Hydrologic Cycle
Watershed and Land Use
Precipitation
Interception
Evaporation
Evapotranspiration
Infiltration
Percolation
Runoff
(Surface and
Groundwater)
Storage
(Surface and
Groundwater)
Use
Demand
Supply
Geography:
Topography
Geology
Vegetation
Soils
Climate
Land Use:
Farming
Forestry
Recreation
Urban &
Industrial
Watershed
or
Basin Level
IWRM
Use
Demand
Supply
Law
Pollution
Conservation
Quality
Dams
Pollution
Flood Control
Rural & Urban
Construction
Water Taking
Water Quality
Institutions (government, educational,
private sector, public sector, legal,
regulatory, enforcement, NGOs, etc)
Water law, rights and licences
Industrial, Commercial & Recreational
activities
Water and Waste Treatment
Economics, social interactions
and institutions
External Impacts
Global Climate Changes
Water transfer between watersheds
Movement of people and human activity
Atmospheric pollution