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The Study on Urban Stormwater Management using Low Impact Development (LID)

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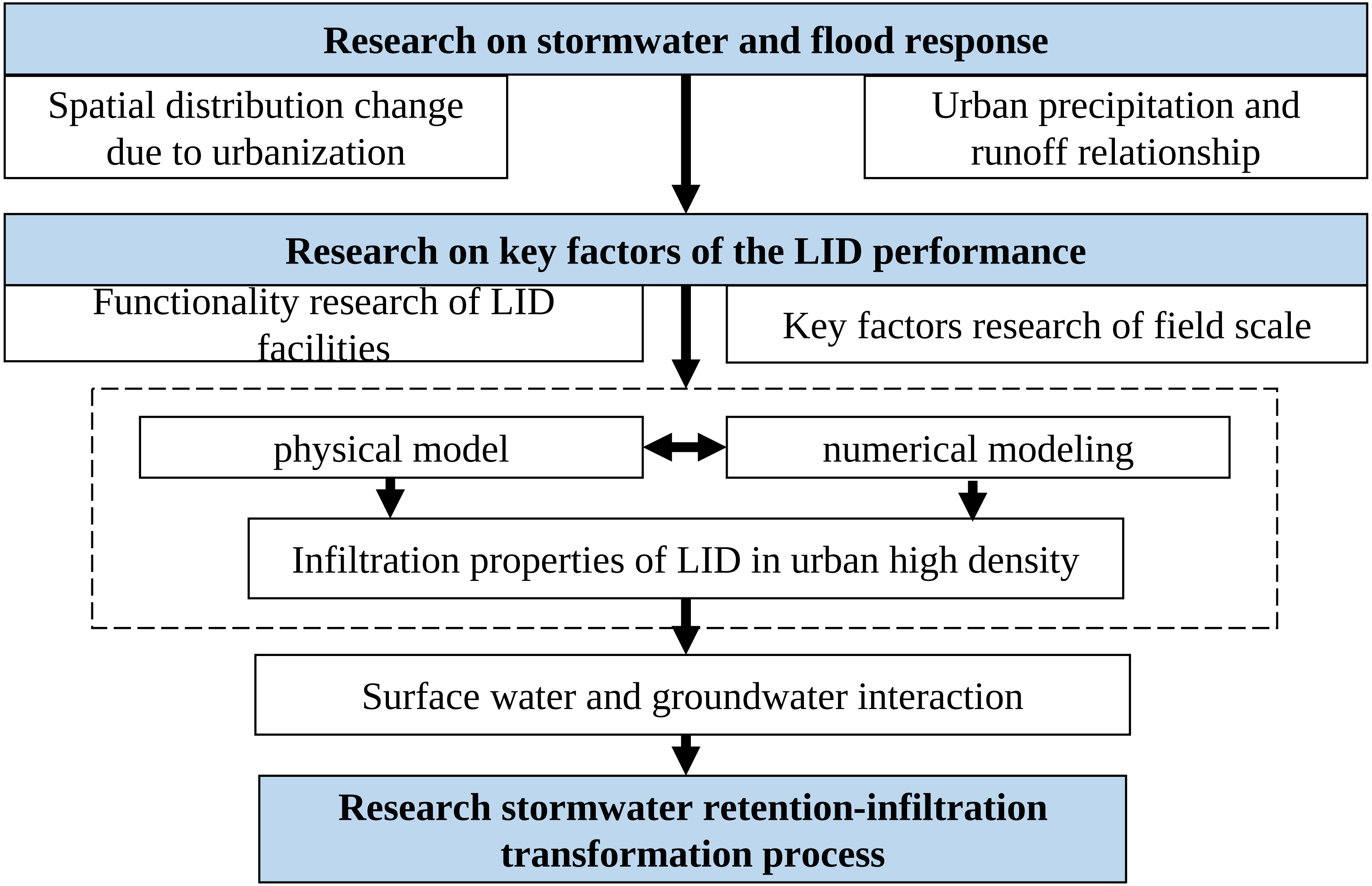
Roadmap of our research

1. Research on stormwater and flood response
2. Research on key factors of the LID performance
3. Research stormwater retention-infiltration transformation process
4. Practical use of LID in urban high density

Roadmap of our research



Main problems


High-rise buildings


Urban stormwater


Anthropogenic pollution


Urban flood

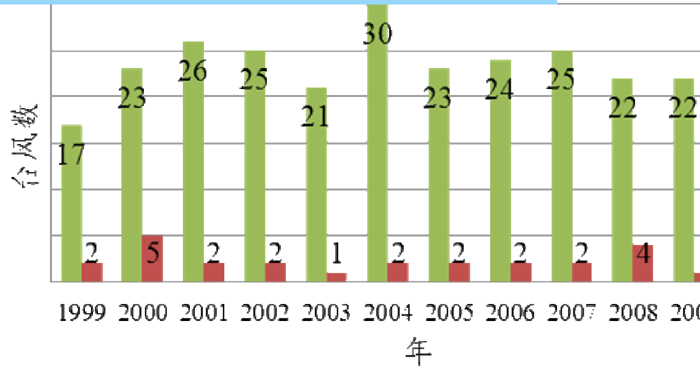
- **High-rise buildings induc regional climate change;**
- **Urban stormwater occur more frequently;**
- **Anthropogenic pollution a threat on the environme**
- **Urban flood impact on ci development negatively.**

Reasons

■ Climate Change

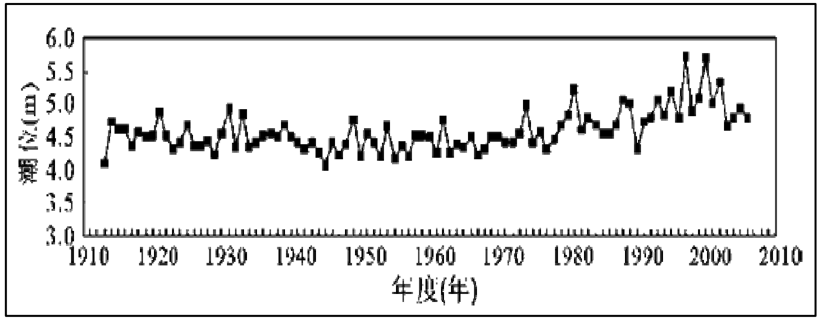
Typhoon

Violent typhoon in Shanghai (1913-2006)



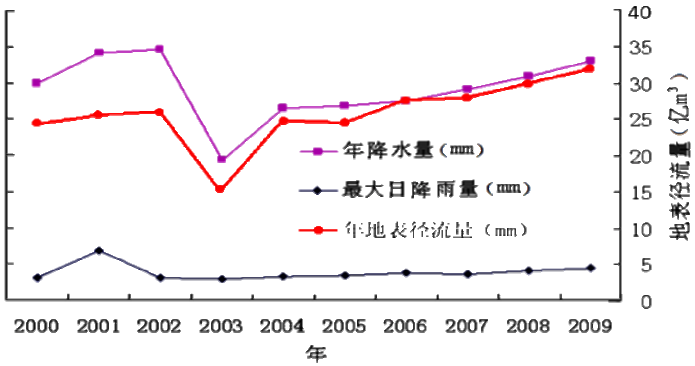
Tide Level

The highest tide level of Huangpu River (1913-2006)



Extreme rainfall

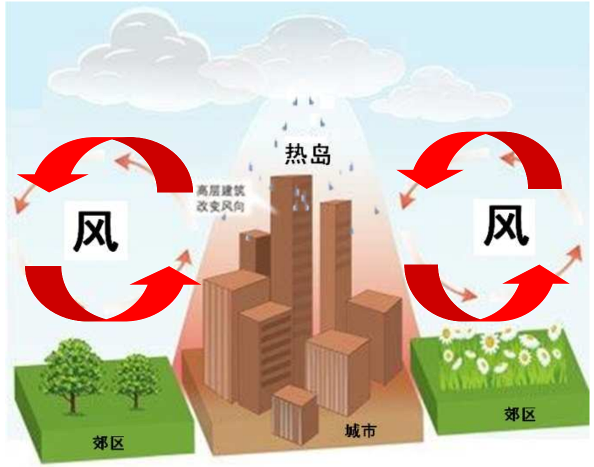
Annual maximum daily rainfall series, annula rainfall series and annual surface runoff (2000-2009)



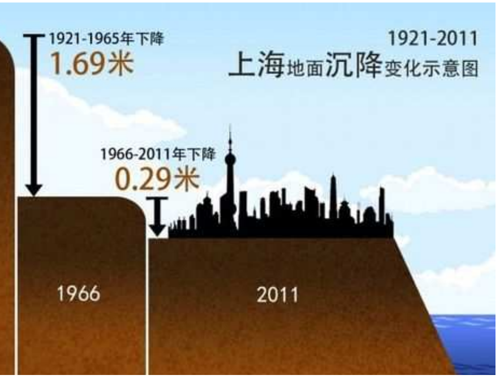
Reasons

- Human Activity

Heat Island



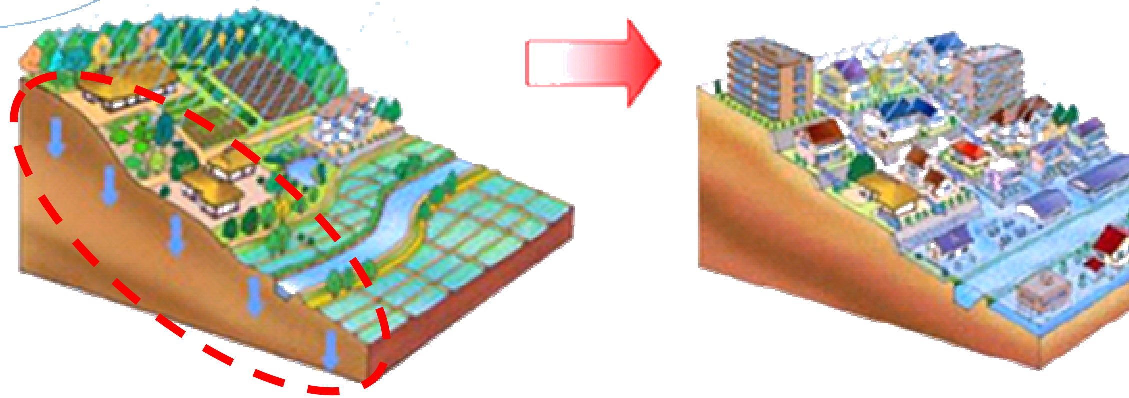
Ground Settlement



er-extraction of Groundwater
ep Foundation Construction

Underlying Surface Changes

Increase of impermeable area

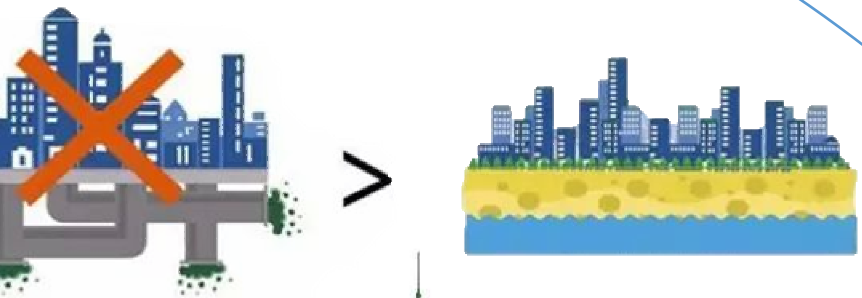


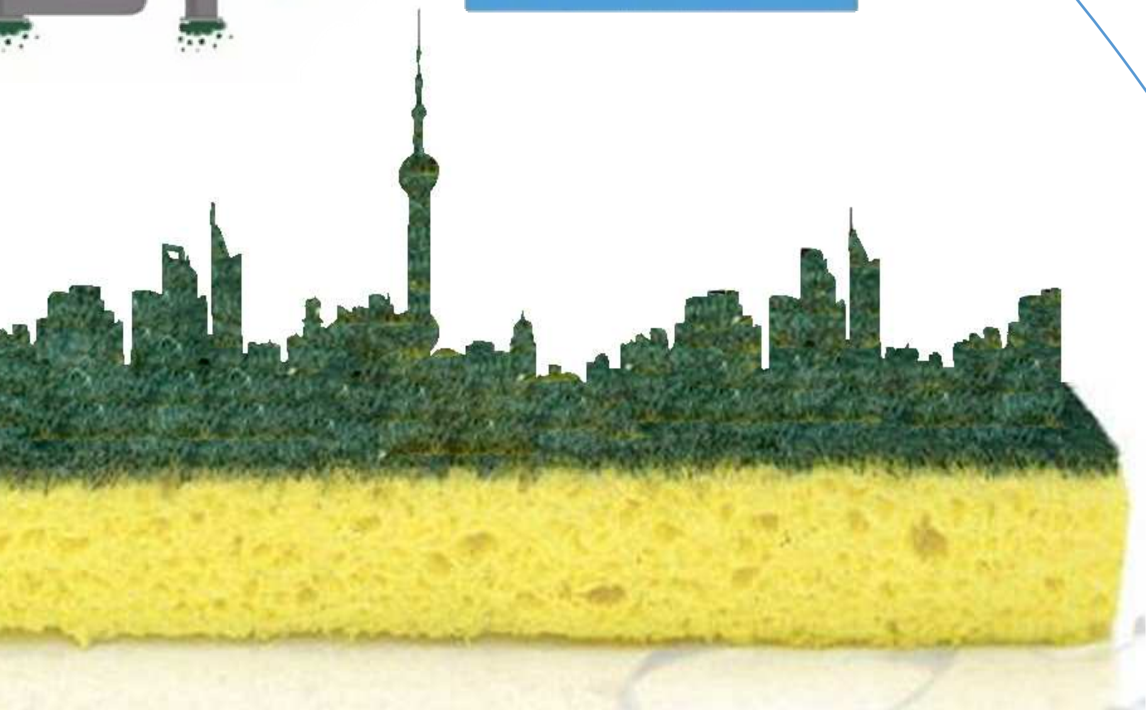
Urban impermeable surface

Drainage system

Development of underground space

Solve the problems



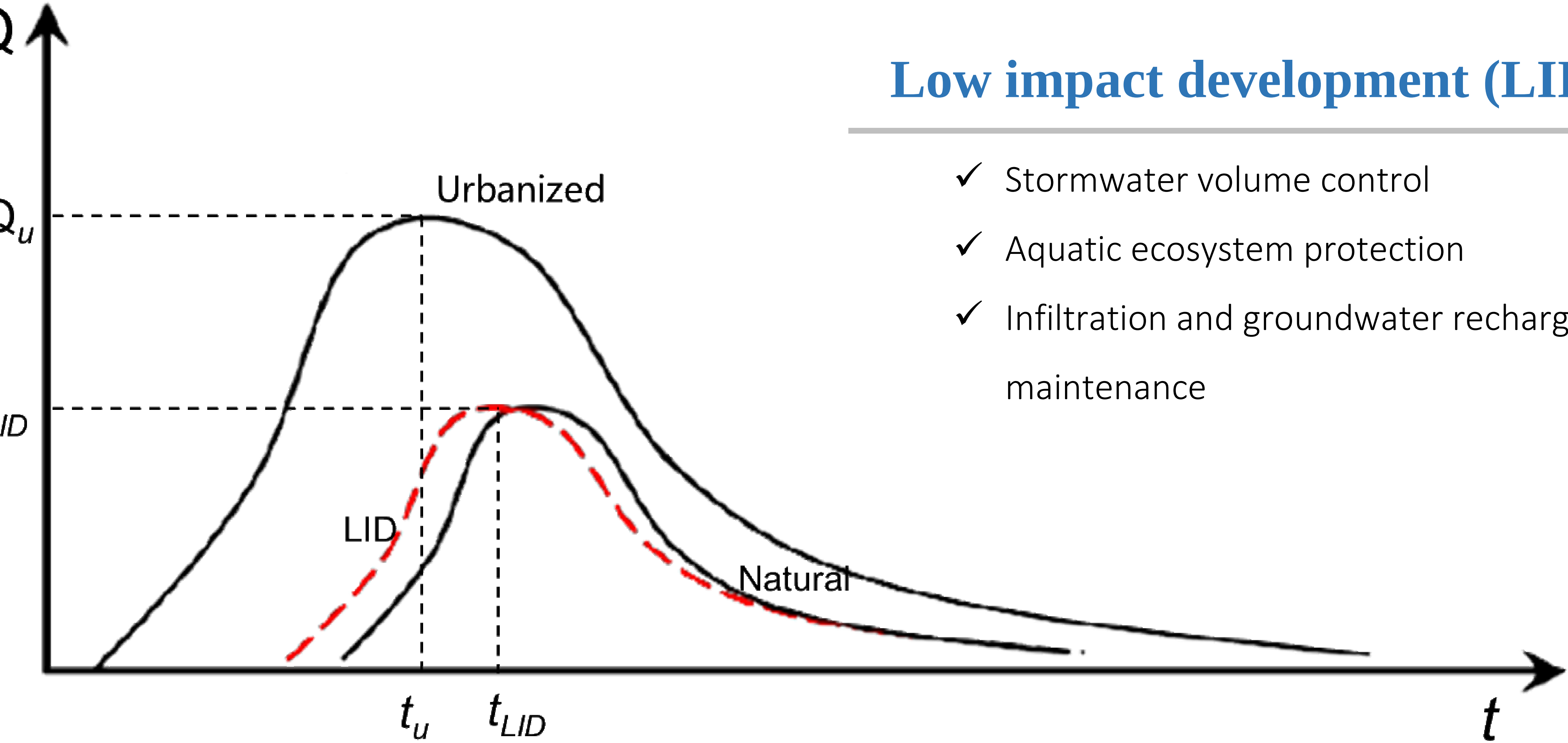


April, 2012 - The concept of “Sponge City”

October, 2014 - Technical manual for “Sponge City” construction

April, 2015 – 16 cities for “Sponge construction

April, 2016 – 14 cities for “Sponge City” construction

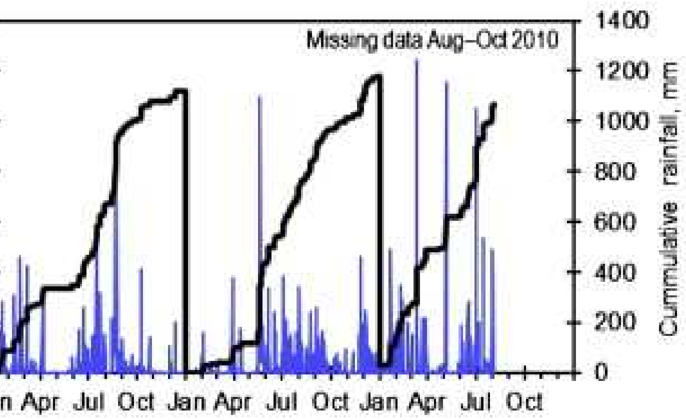


Low impact development (LID)

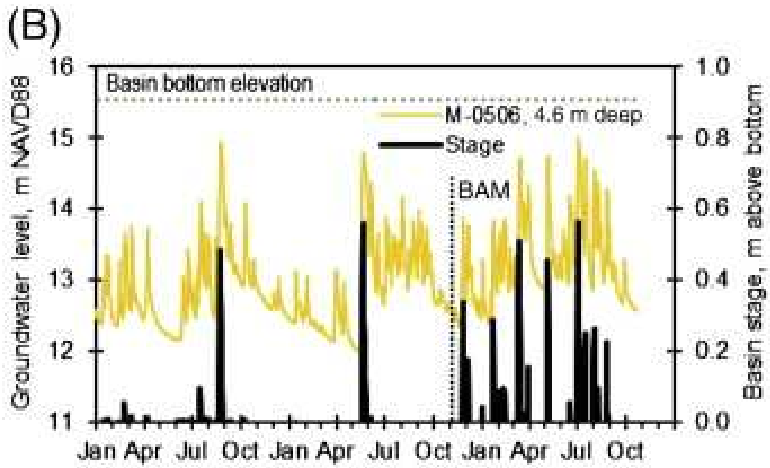
- ✓ Stormwater volume control
- ✓ Aquatic ecosystem protection
- ✓ Infiltration and groundwater recharge maintenance

Study on stormwater and flood response

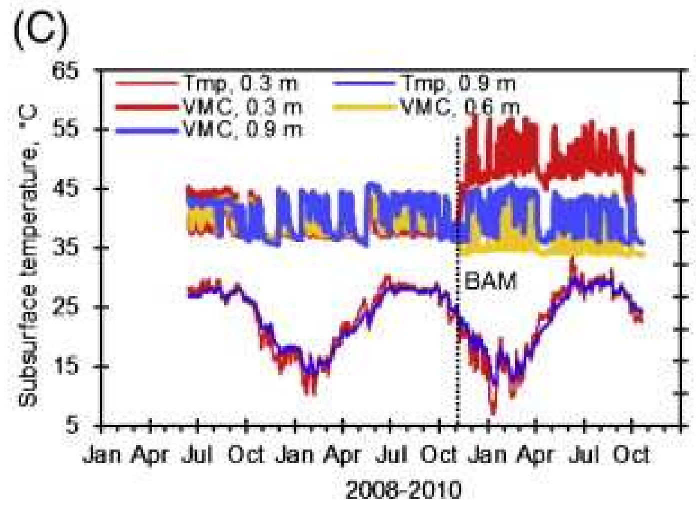
Hydrologic monitoring at the stormwater infiltration basin



A) rainfall



(B) basin stage and groundwater level



(C) soil moisture content (VMC) and subsurf

temperature (Tmp).

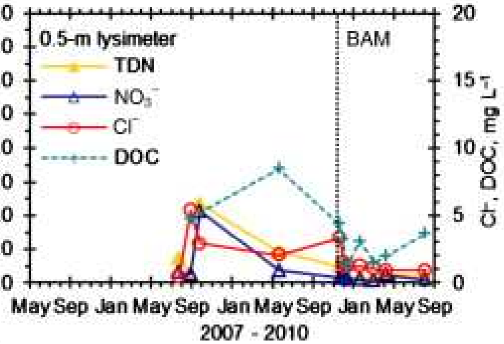
Spatial distribution existed in short duration precipitation;

High correlation was found in stormwater and flood in urban area;

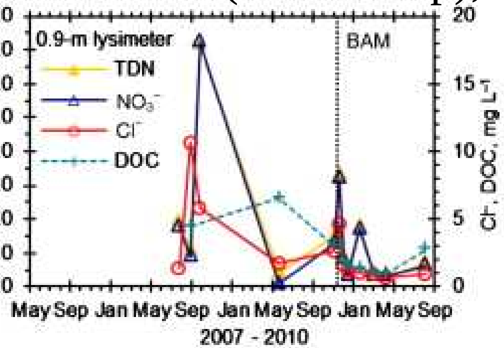
Stormwater and flood response rapidly due to urban pavement impermeable.

Temporal variations in phosphorus species and chloride concentrations and pH before and after placement of biosorption activated media

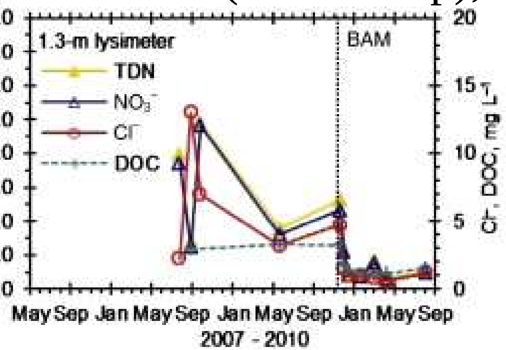
) soil water (0.5-m deep);



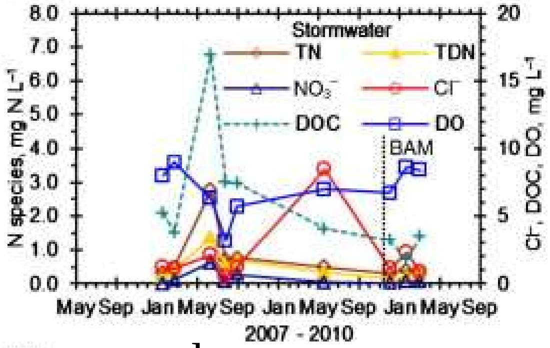
) soil water (0.9-m deep);



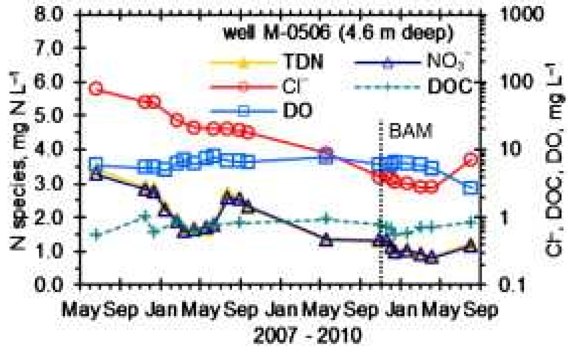
) soil water (1.3-m deep);



(D) stormwater;



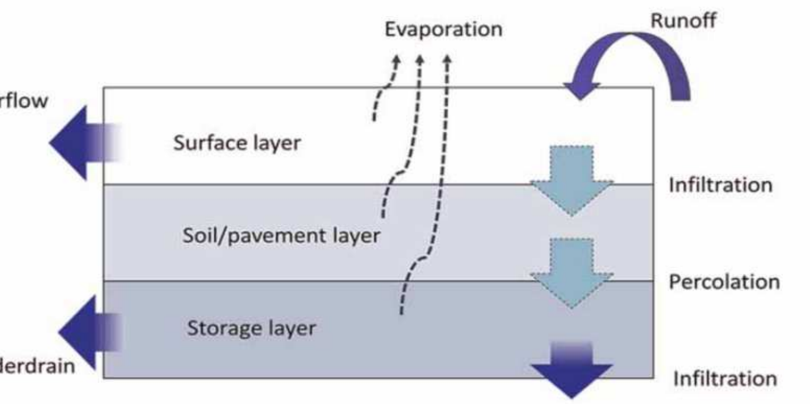
(E) groundwater



- **Contaminant infiltration in different LID layers have specific characteristics;**
- **High correlation was found in surface water and groundwater interaction;**
- **Pollution degraded in the pathway of infiltration in LID configuration**

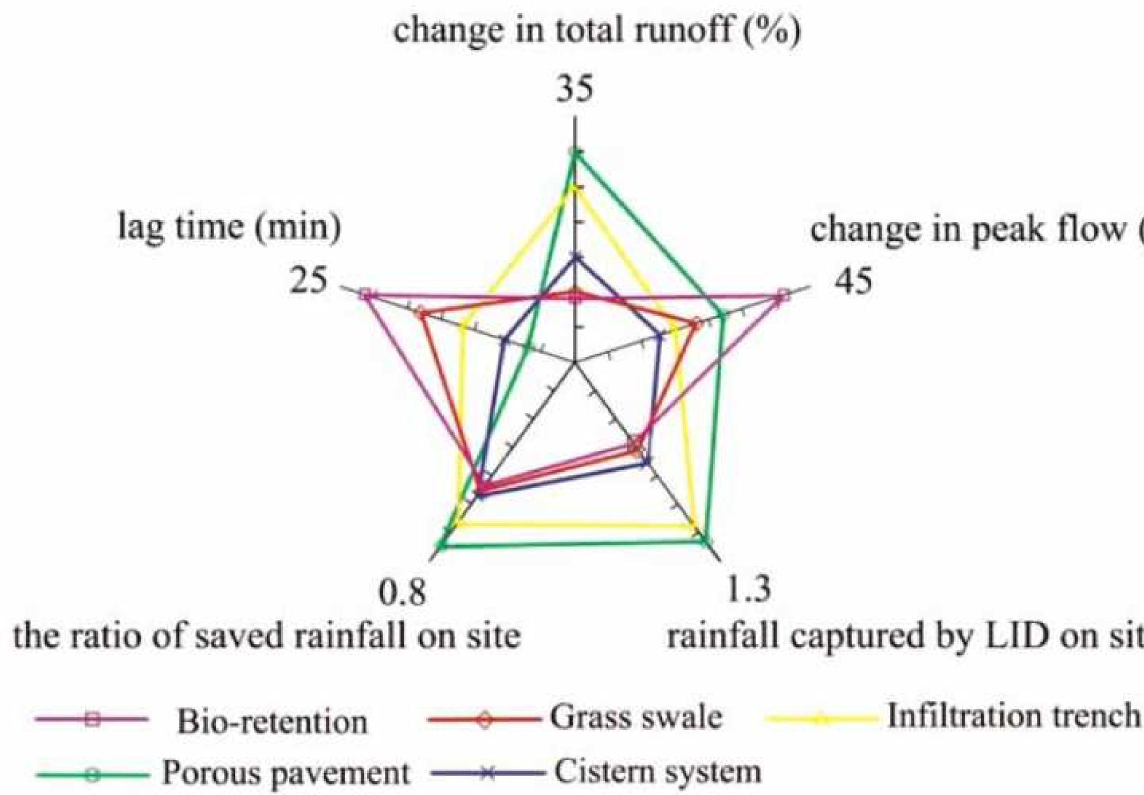
Key factors of the LID performance

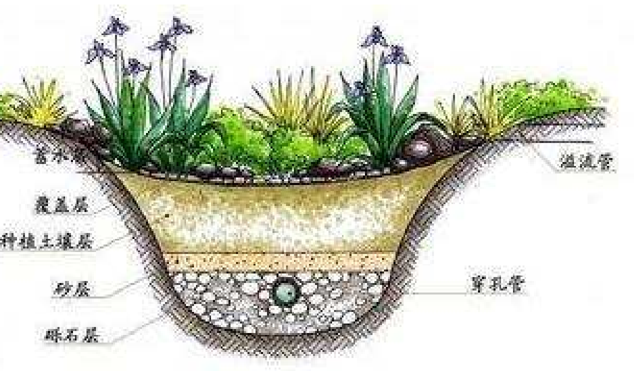
LID performance radar chart for small storm events. (<25.4 mm)



Bio-retention performed the best in the change of lag time and peak flow for flood control;

Grass swale functioned poorly in the reduction of average runoff and all water balance indices.

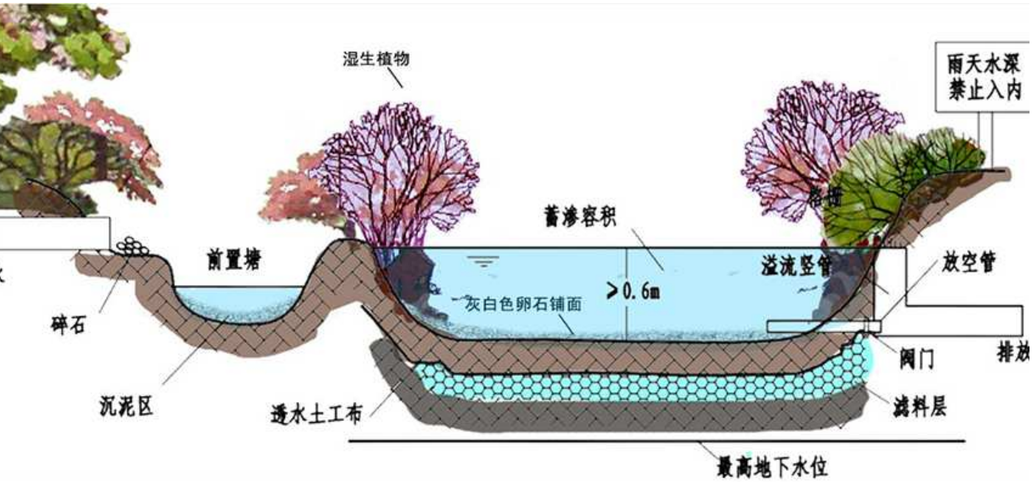




Section of grassed swales

Practical use of the grassed swales

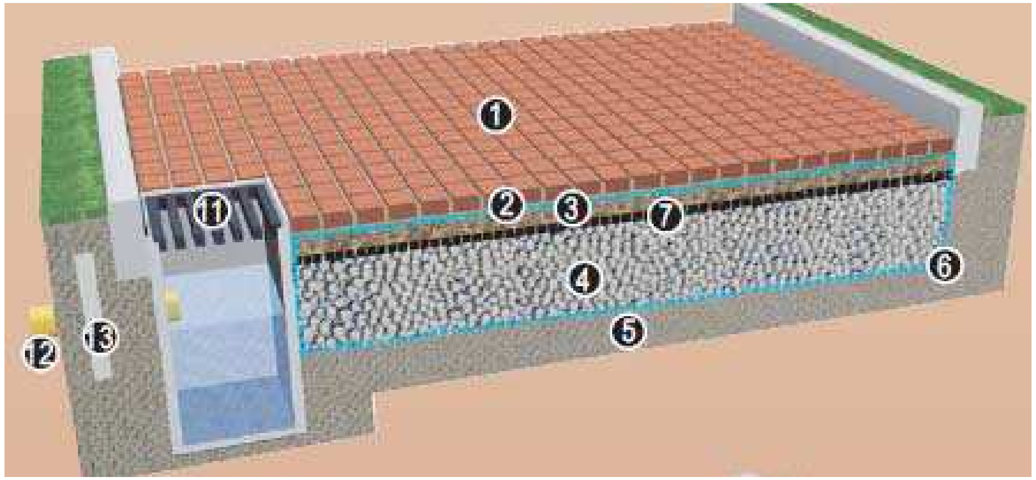
Practical use of the grassed swales



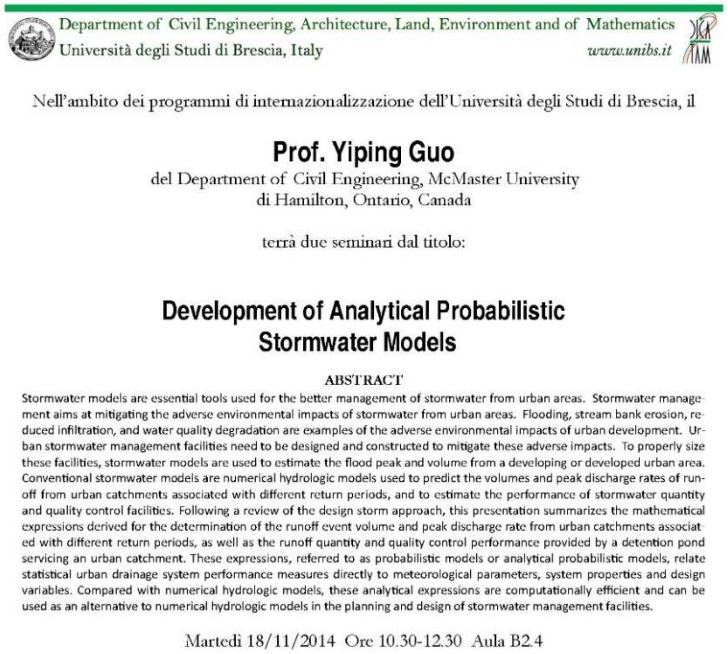
Practices of bio-retention

Schematic diagram of bio-retention

Permeable pavement



Stormwater retention-infiltration transformation process



Department of Civil Engineering, Architecture, Land, Environment and of Mathematics
Università degli Studi di Brescia, Italy
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Nell'ambito dei programmi di internazionalizzazione dell'Università degli Studi di Brescia, il

Prof. Yiping Guo
del Department of Civil Engineering, McMaster University
di Hamilton, Ontario, Canada

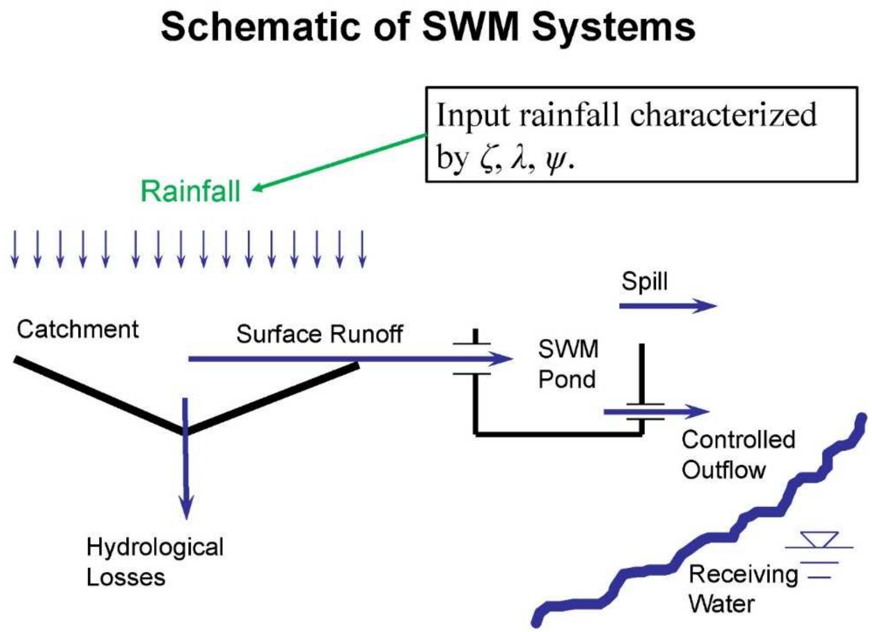
terrà due seminari dal titolo:

Development of Analytical Probabilistic Stormwater Models

ABSTRACT

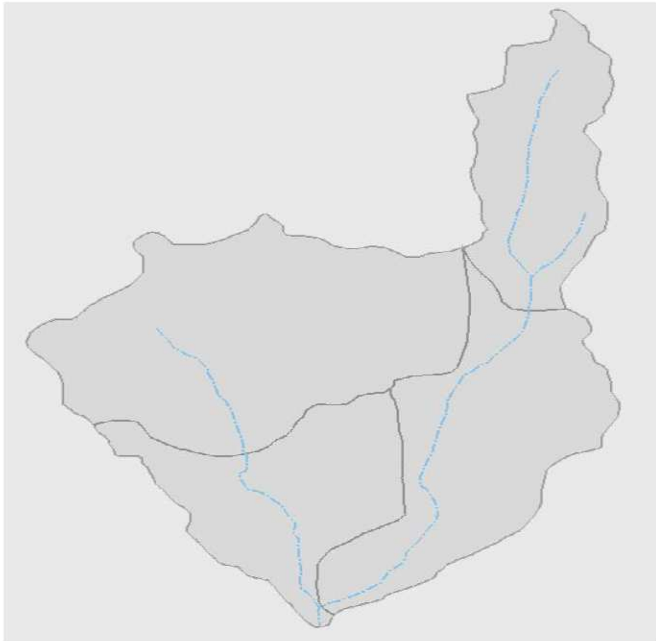
Stormwater models are essential tools used for the better management of stormwater from urban areas. Stormwater management aims at mitigating the adverse environmental impacts of stormwater from urban areas. Flooding, stream bank erosion, reduced infiltration, and water quality degradation are examples of the adverse environmental impacts of urban development. Urban stormwater management facilities need to be designed and constructed to mitigate these adverse impacts. To properly size these facilities, stormwater models are used to estimate the flood peak and volume from a developing or developed urban area. Conventional stormwater models are numerical hydrologic models used to predict the volumes and peak discharge rates of runoff from urban catchments associated with different return periods, and to estimate the performance of stormwater quantity and quality control facilities. Following a review of the design storm approach, this presentation summarizes the mathematical expressions derived for the determination of the runoff event volume and peak discharge rate from urban catchments associated with different return periods, as well as the runoff quantity and quality control performance provided by a detention pond servicing an urban catchment. These expressions, referred to as probabilistic models or analytical probabilistic models, relate statistical urban drainage system performance measures directly to meteorological parameters, system properties and design variables. Compared with numerical hydrologic models, these analytical expressions are computationally efficient and can be used as an alternative to numerical hydrologic models in the planning and design of stormwater management facilities.

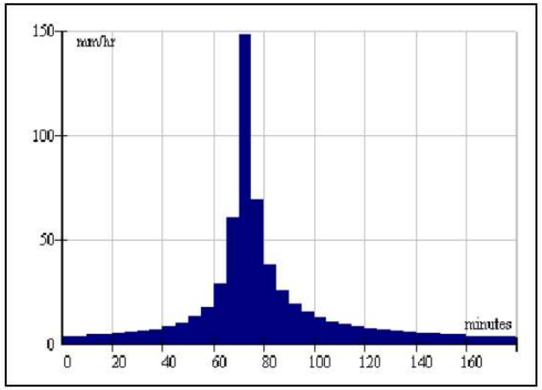
Martedì 18/11/2014 Ore 10.30-12.30 Aula B2.4



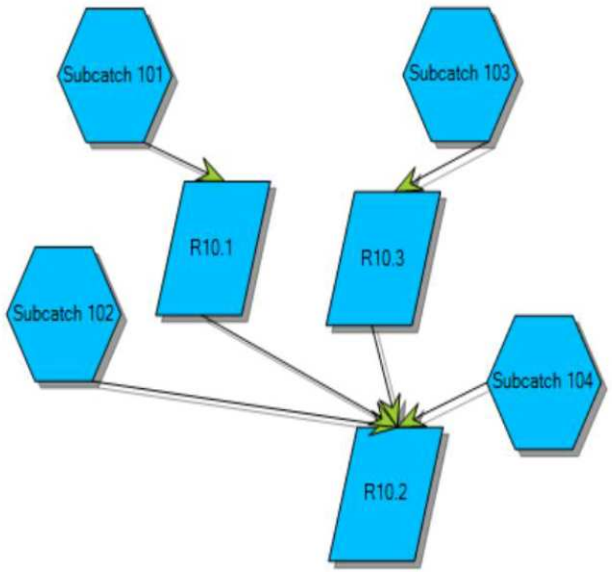
- Expanded from previous results of **probabilistic rainfall-runoff transformation**.
- Analytical equations transforming **the input rainfall frequency distribution** to **output runo frequency distribution**.
- Can be used to calculate the **average annual runoff volume and runoff event volume return perio**

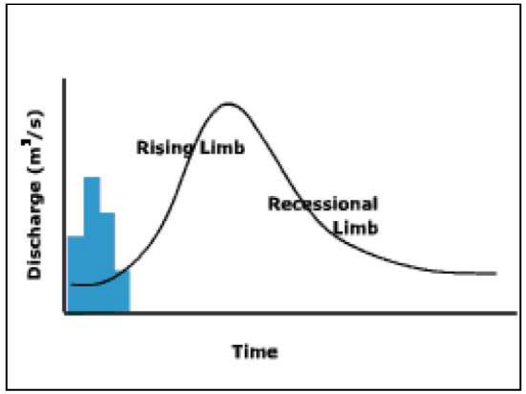
Design Storm Approach





Input Design
Storm
Hyetograph





Output Runoff
Hydrograph

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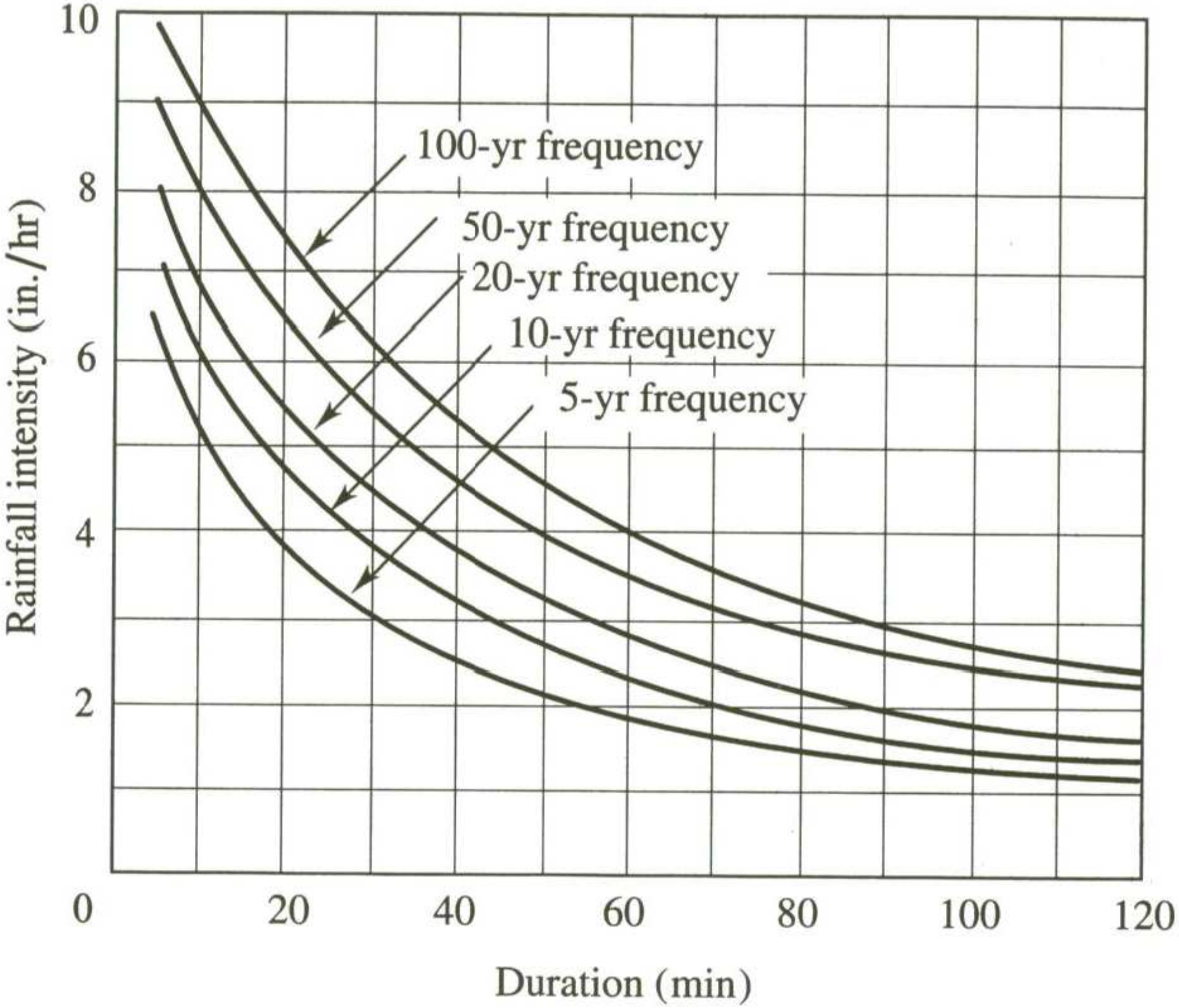
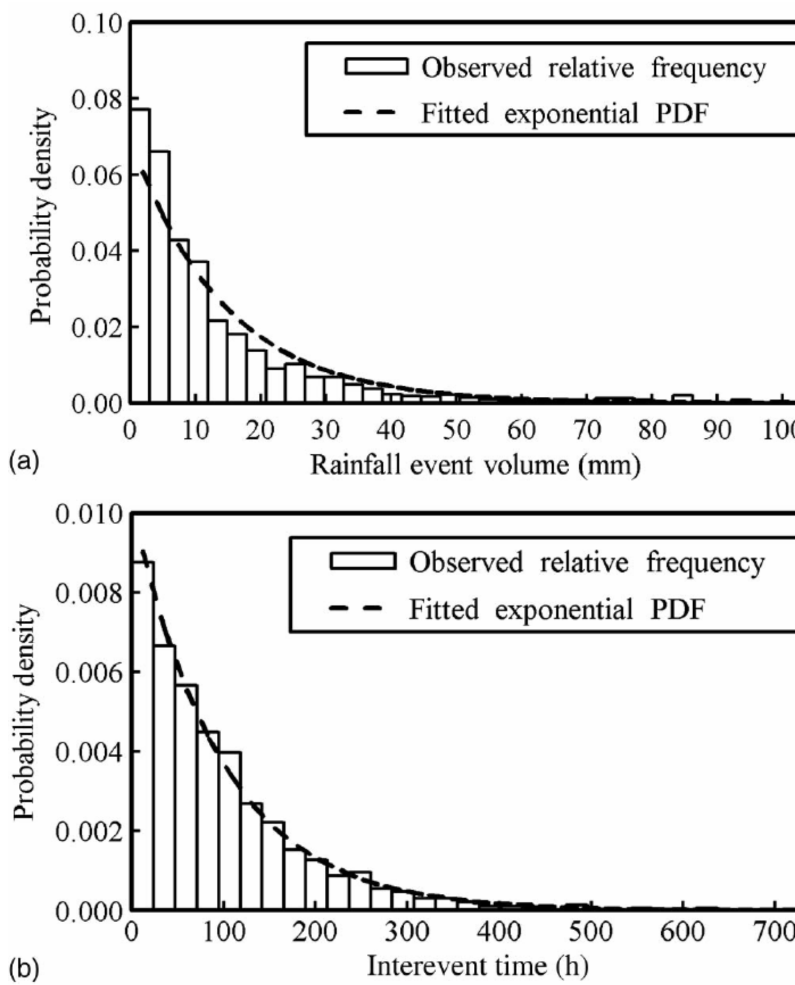
IDF
urves





Frequency distributions of rainfall event volume and interevent time

Probabilistic Models of Point Rainfall Characteristics

Rainfall Event Characteristic	Exponential Probability Density Function	Distribution Parameter
Depth, v (mm)	$f_V(v) = \zeta \exp(-\zeta v)$	$\zeta = \frac{1}{\bar{v}}$
Duration, t (h)	$f_T(t) = \lambda \exp(-\lambda t)$	$\lambda = \frac{1}{\bar{t}}$
Inter-event Time, b (h)	$f_B(b) = \psi \exp(-\psi b)$	$\psi = \frac{1}{\bar{b}}$

erivation Results: Runoff event volume probability distribution

$$
] = \begin{cases}
\exp(-\zeta S_{di}) & , \quad v_r = 0 \\
\exp(-\zeta S_{di} - \frac{\zeta}{h} v_r) & , \quad 0 < v_r \le hS_{dd} \\
\frac{\lambda}{\lambda + \zeta f_c - \zeta f_c h} \exp(-\zeta S_d - \zeta v_r) & \\
+ \frac{\zeta f_c (1-h)}{\lambda + \zeta f_c - \zeta f_c h} \exp\left[-\zeta S_{di} + \frac{\lambda}{f_c} S_{dd} - \frac{1}{h} (\zeta + \frac{\lambda}{f_c}) v_r \right] & , \quad v_r > hS_{dd}
\end{cases}
$$

$$
T_R = \frac{1}{\theta P[V_R > v_r]}
$$

(Where θ is the average annual number of rainfall events.)

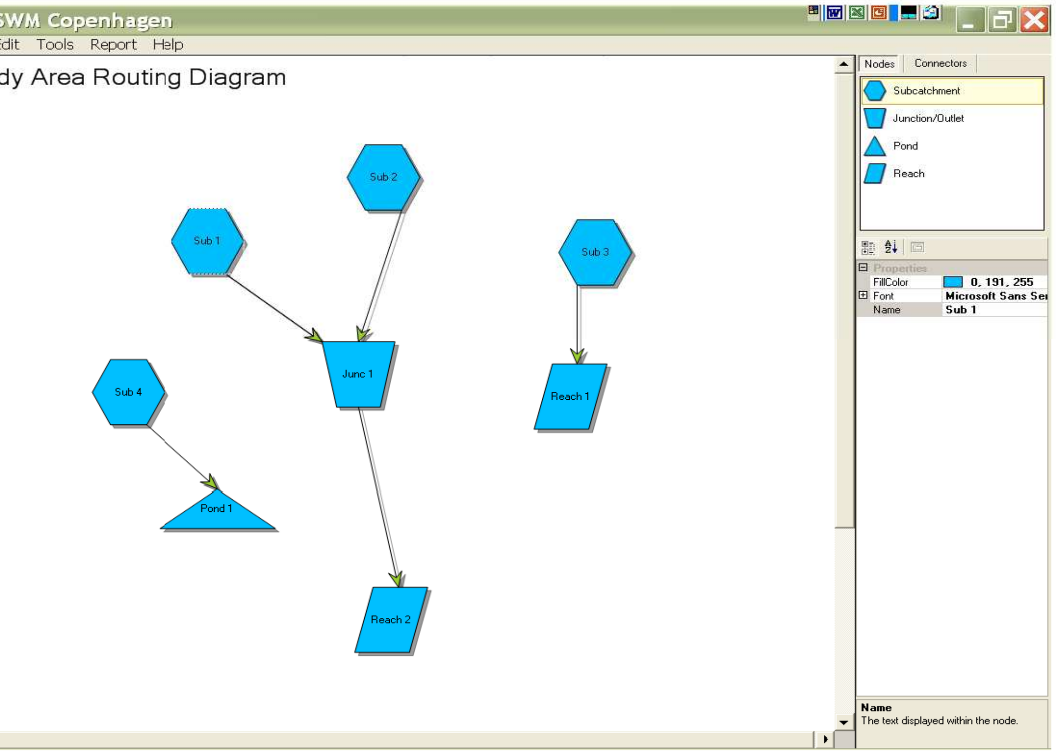
$$
\text{age Annual Runoff} = \theta \left[\frac{h}{\zeta} \exp(-\zeta S_{di}) + \frac{\lambda (1-h)}{\zeta (\zeta f_c + \lambda)} \exp(-\zeta S_{il}) \right]
$$

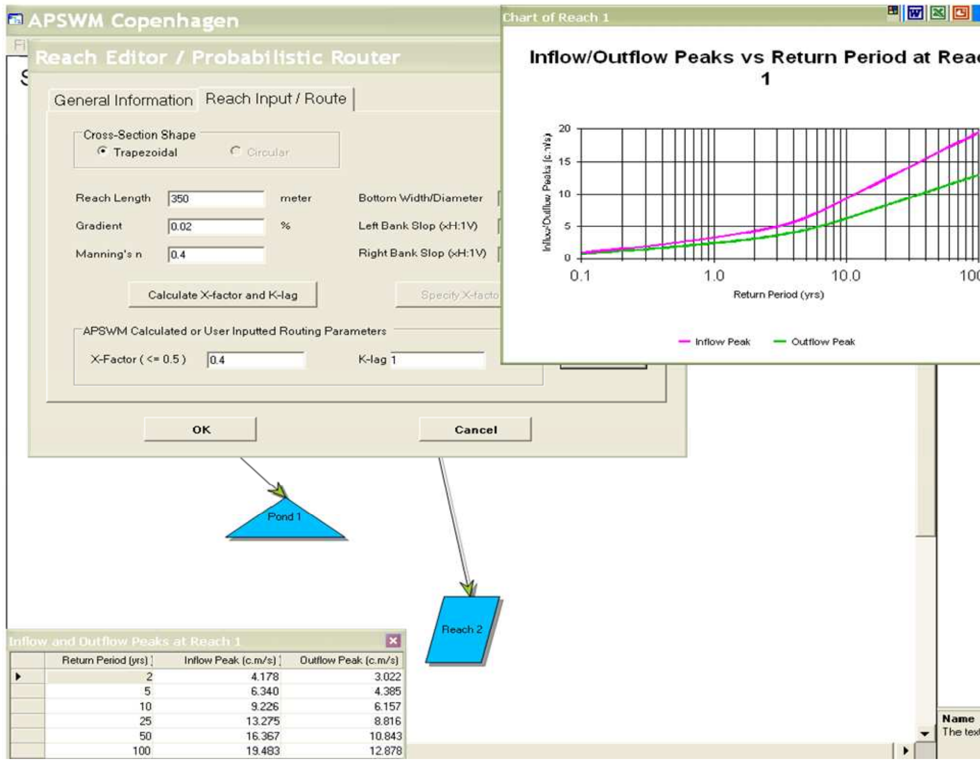
Derivation Results: Peak Discharge Rate Retur Period:

$$
P\left[Q_p > q_p\right] = \begin{cases}
\frac{2h\lambda}{2h\lambda + \zeta q_p} \exp\left(-\zeta S_{di} - \frac{\zeta t_c}{2h} q_p \right) & , \quad q_p < \\
\frac{2\lambda \zeta (1-h)(2 f_c h - q_p)}{(2h\lambda + \zeta q_p)(2\lambda + \zeta q_p + 2 f_c \zeta - 2h f_c \zeta)} \exp\left[- \frac{\left(\zeta S_{il} - \lambda t_c - f_c \zeta t_c\right) q_p - 2 f_c \zeta h S_{di} + 2\lambda h S_{dd}}{q_p - 2 f_c h} \right] & \\
+ \frac{2\lambda}{2\lambda + \zeta\left(q_p + 2 f_c - 2 f_c h\right)} \exp\left(-\zeta S_d - \frac{\zeta t_c}{2} q_p \right) & , \quad \frac{2hS_{dd}}{t_c} \\
\frac{\lambda}{\lambda + \zeta\left(\frac{q_p}{2} + f_c - f_c h\right)} \exp\left(-\zeta S_d - \frac{\zeta t_c}{2} q_p \right) & , \quad q_p \ge 2
\end{cases}
$$

$$
T_R = \frac{1}{\theta P\left[Q_p > q_p\right]}
$$

APSWM as a Software:



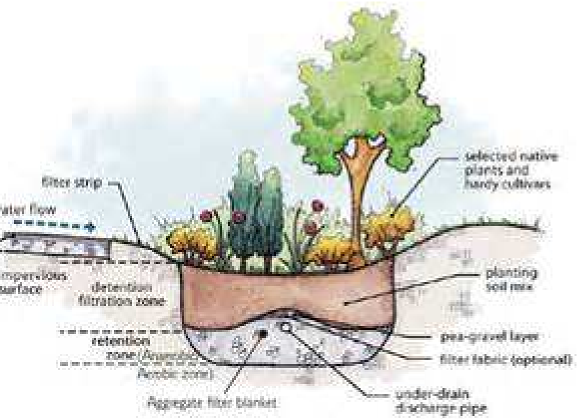


- interface-visualization
- controllable parameters
- open source code

Practical use of LID in urban high density

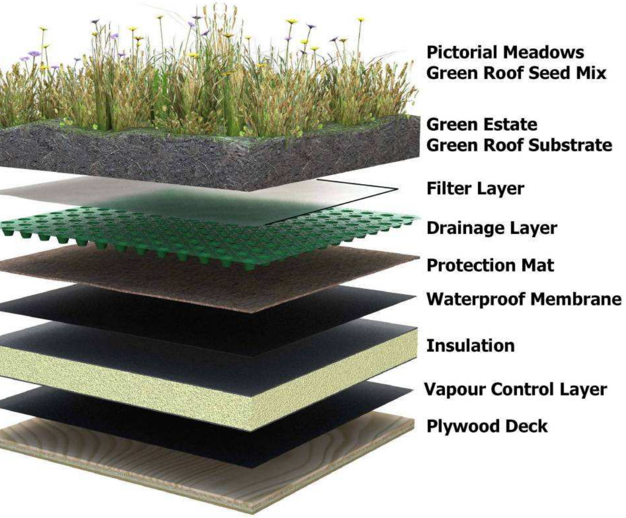
Water tank and drainage system

Practical use of LID in urban high density



Grassed swales in urban high density

Practical use of LID in urban high density



reen roof in urban high density

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Thank you!