

# Sustainable Stormwater Management: A Case Study for the Urban Expansion of Kavala City

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**LEGEND**

-  City Limits (1970)
-  Approved City Limits (1987)
-  Approved City Limits (2013)
-  Egnatia Motorway



#### LEGEND

-  Kavala City Catchment Area
-  Areas of Potential Significant Flood Risk
-  Egnatia Motorway

The study area belongs to the Water Department of East Macedonia (EL11). There is only one the Strymonas River Basin (EL1106).

According to the Management Plan of the Water Basin of East Macedonia Water District, that was elaborated in 2011, approved in 2013 and revised in 2017, the ecological status of the Coastal Water Body of Western Kavala Gulf (EL1106C0004N) is 'moderate'.

Many studies have shown that pollution may come from transportation (Egnatia Motorway, etc.). Furthermore, the authorities propose a perimeter road that may compound the problem.

So, the problem in this case is not the floods (water quantity), but the water quality in the Coastal Water Body of Western Kavala Gulf.

The Management Plan proposes a Sampling Program at the stormwater sewers outfall, as well as at other point sources of pollution.



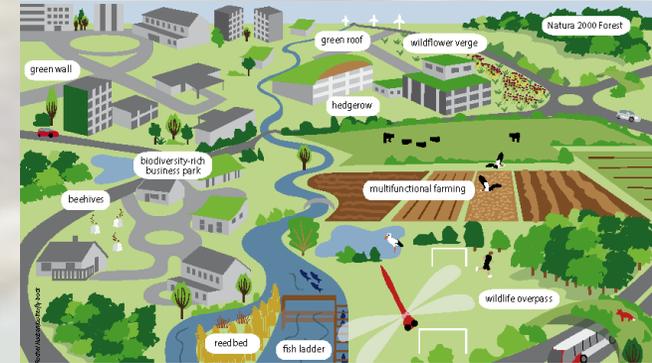
# The Problem

In the future, water quantity (flood) and additional quality problems may also occur due to the **Soil Sealing** that will come from the urbanization of the study area.



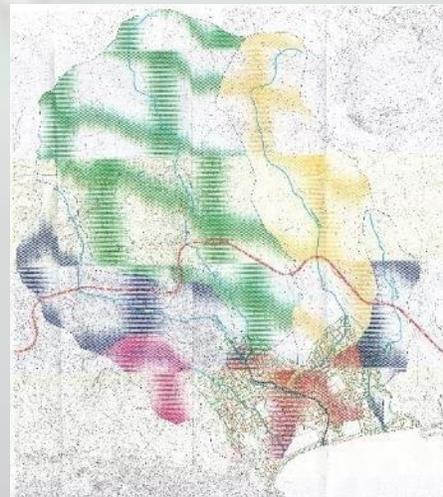
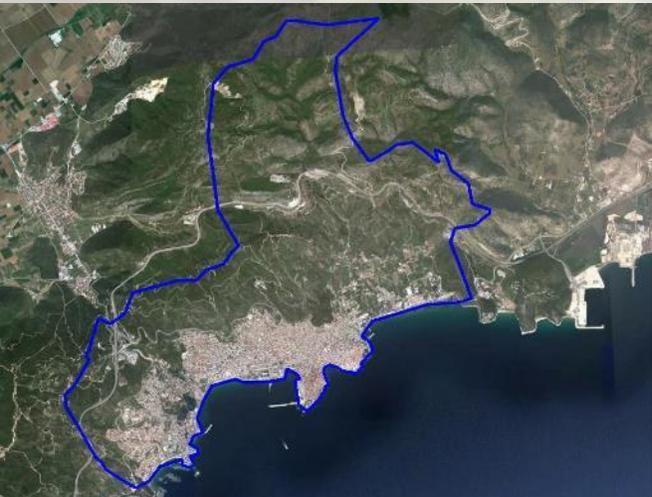
We propose - along with the Sampling Program - an Innovative Stormwater Management Plan (ISMP) relying on the principles of Sustainable Development in this sector, like:

- Best Management Practices (BMPs) / EPA
- Green Infrastructure (GI) / EEA
- Low Impact Development (LID) / EPA
- Natural Water Retention Measures (NWRM) / EC
- Sustainable Drainage Systems (SuDS) / CIRIA



The implementation of the ISMP may will be able - along with the implementation of other measures or same measures at the whole of the City - to change the ecological status from 'moderate' to 'good'.

- Satellite Images
- Topographic Diagrams of Hellenic Military Geographical Service (scale 1:5,000) for the determination of basin limits
- Topographic Diagram of the Study Area (scale 1:1,000) for the design of the proposed measures



IDF Curves given by the Flood Risk Management Plan



SCS Method



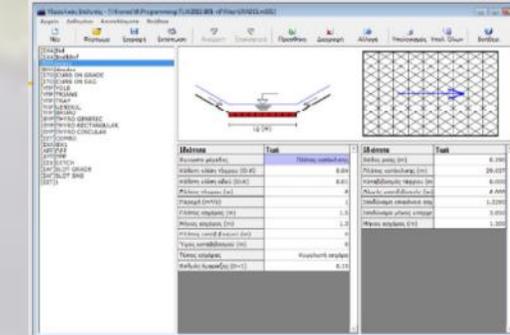
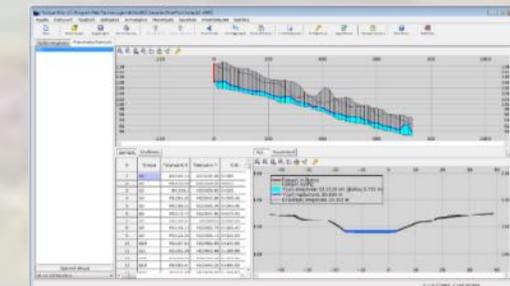
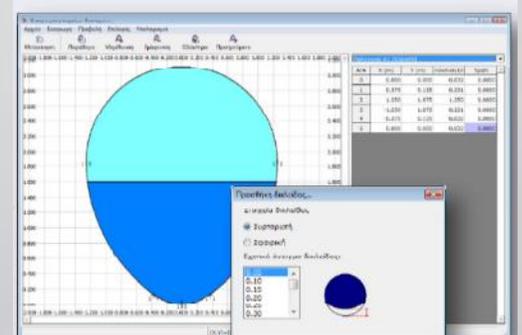
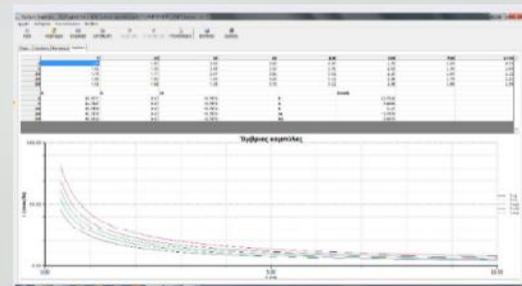
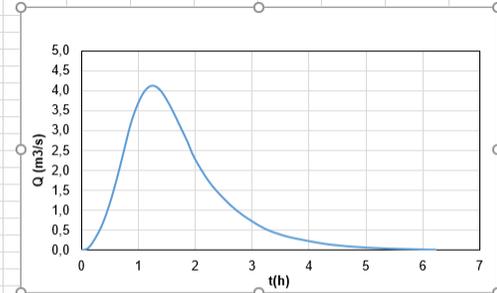
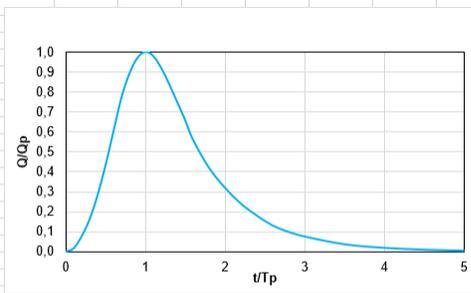
Design Discharge

## Bibliography

↓  
Spreadsheets

↓  
Specialized Software

t/Tp	Q/Qp	t (h)	Q (m³/s)
0.0	0.000	0.0	0.000
0.1	0.015	0.1	0.062
0.2	0.075	0.2	0.309
0.3	0.160	0.4	0.660
0.4	0.280	0.5	1.155
0.5	0.430	0.6	1.773
0.6	0.600	0.7	2.474
0.7	0.770	0.9	3.176
0.8	0.890	1.0	3.670
0.9	0.970	1.1	4.000
1.0	1.000	1.2	4.124
1.1	0.980	1.4	4.042
1.2	0.920	1.5	3.794
1.3	0.840	1.6	3.464
1.4	0.750	1.7	3.093
1.5	0.660	1.9	2.722
1.6	0.560	2.0	2.310
1.8	0.420	2.2	1.732
2.0	0.320	2.5	1.320
2.2	0.240	2.7	0.990
2.4	0.180	3.0	0.742
2.6	0.130	3.2	0.536
2.8	0.098	3.5	0.404
3.0	0.075	3.7	0.309
3.5	0.036	4.4	0.148
4.0	0.018	5.0	0.074
4.5	0.009	5.6	0.037
5.0	0.004	6.2	0.016



By spreadsheets, using input parameters and equations from bibliography

Table 2.7 Mean annual pollutant concentrations and loading rates in rainwater in France

Parameters	Mean concentration (mg/l)	Maximum concentration for potable water (mg/l)	Range of loading rates (mg/m <sup>2</sup> /year)
Sulphates	0.5	150 - 250	100 - 1000
Nitrates	0.3	25 - 50	10 - 400
Ammonium	0.3 - 0.6	0.1	100 - 1400
Potassium	0.05 - 0.25		30 - 250
Calcium	0.2 - 0.8		100 - 800
Magnesium	0.05 - 0.9		30 - 700
Chloride	0.2 - 10	250	200 - 10000
Sodium	0.2 - 6	200	100 - 6000
pH	5	6.5 - 8.5	4.8 - 5.6

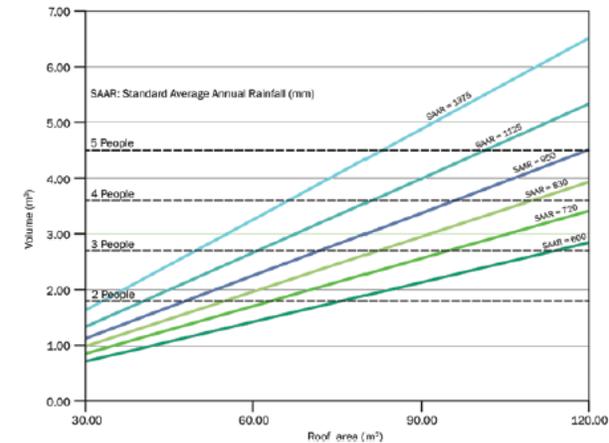
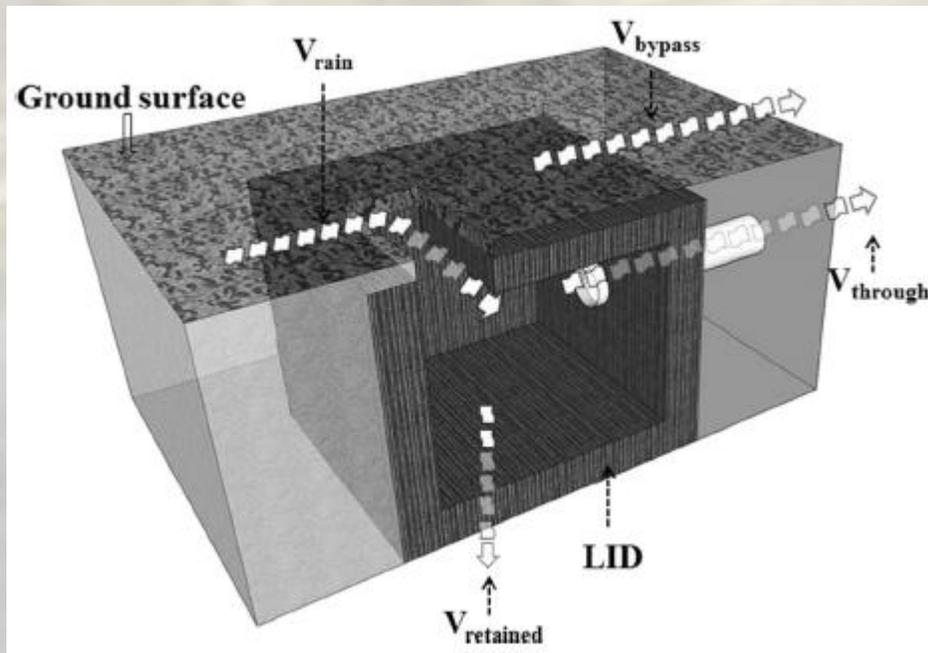


Figure 11.8 The simple look-up approach for sizing RWH tanks – aggregated for various occupancy rates

The intermediate method

The intermediate method is based on calculating the lesser of "5% of the annual runoff yield" and "5% of the annual property demand" as set out in the following sections. The 5% represents approximately 18 days of supply/demand and is required to ensure that sufficient storage is available, being suitably conservative so as to take account of the variability in rainfall/demand patterns.

**BOX 11.2** Runoff yield calculation (intermediate method: water supply only)

Five per cent of the average annual runoff from the contributing area is calculated using the following equation:

$$Y_R = A e AAR \eta \times 0.05$$

where:

- $Y_R$  = runoff volume (yield) (l)
- $A$  = collecting runoff area (m<sup>2</sup>)
- $e$  = runoff (yield) coefficient
- $AAR$  = average annual rainfall depth (mm) (Figure 11.4)
- $\eta$  = hydraulic filter efficiency (ratio)

An alternative formula, which takes into account the number of events in the year and the initial losses, is:

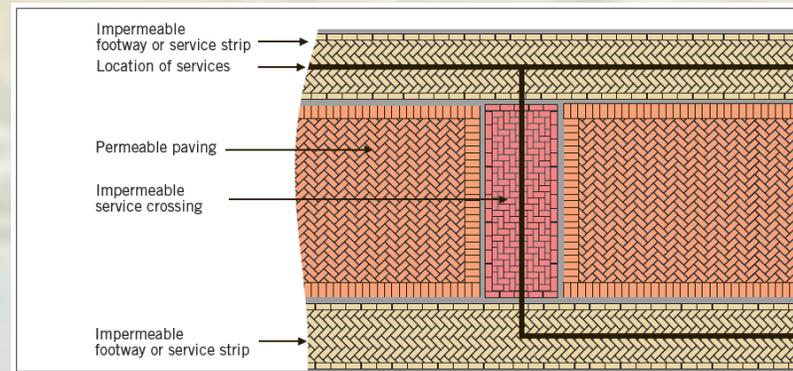
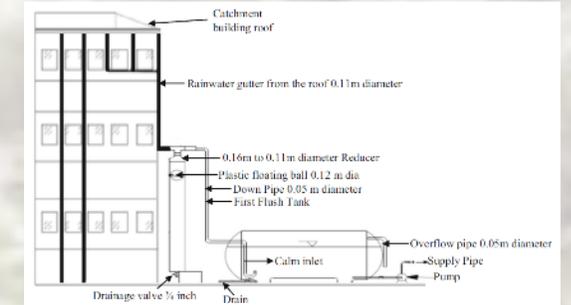
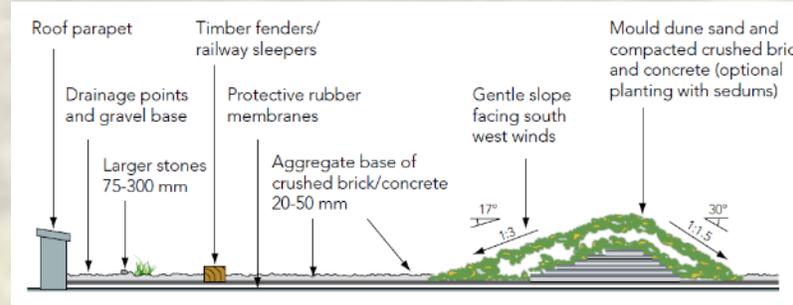
$$Y_R = [AAR - (150 ds)] e_2 \eta A \times 0.05$$

where:

- $d_s$  = depression storage (mm)
- $e_2$  = runoff (yield) coefficient (after depression storage has been filled)

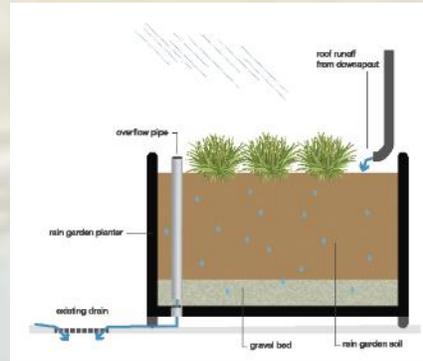
# Proposed Measures

- Green Roofs
- Rainwater Harvesting
- Permeable Paving
- Swales
- Channels and Rills
- Filter Strips



# Proposed Measures

- Soakaways
- Infiltration Trenches
- Rain Gardens
- Detention Basins
- Retention Ponds
- Infiltration Basins



# Conclusions

- Urban expansion of Kavala City is proposed by the approved General Urban Plan of 2003
- The ecological status of the Coastal Water Body of Western Kavala Gulf (EL1106C0004N), according to the Management Plan of the Water Basin of East Macedonia Water District, is 'moderate'
- The Management Plan proposes a Sampling Program at the stormwater sewers outfall, as well as at other point sources of pollution
- An Innovative Stormwater Management Plan (ISMP) relying on the principles of Sustainable Development is proposed, along with the Sampling Program, that may will be able - along with the implementation of other measures or same measures at the whole of the City - to change the ecological status from 'moderate' to 'good'

I should like to extend my special thanks to:

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Thank you!!  
Happy Summer Vacations!!