



**stowa**

**Deltares**  
Enabling Delta Life



# JIP Energiebesparing Gemalen #Slim\_Malen

Klaudia Hováth  
Gebruikersgroep, Delft  
17 March 2017

**TU/e** Technische Universiteit  
Eindhoven  
University of Technology

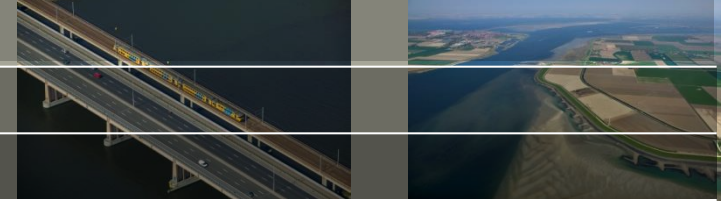
Nelen & Schuurmans



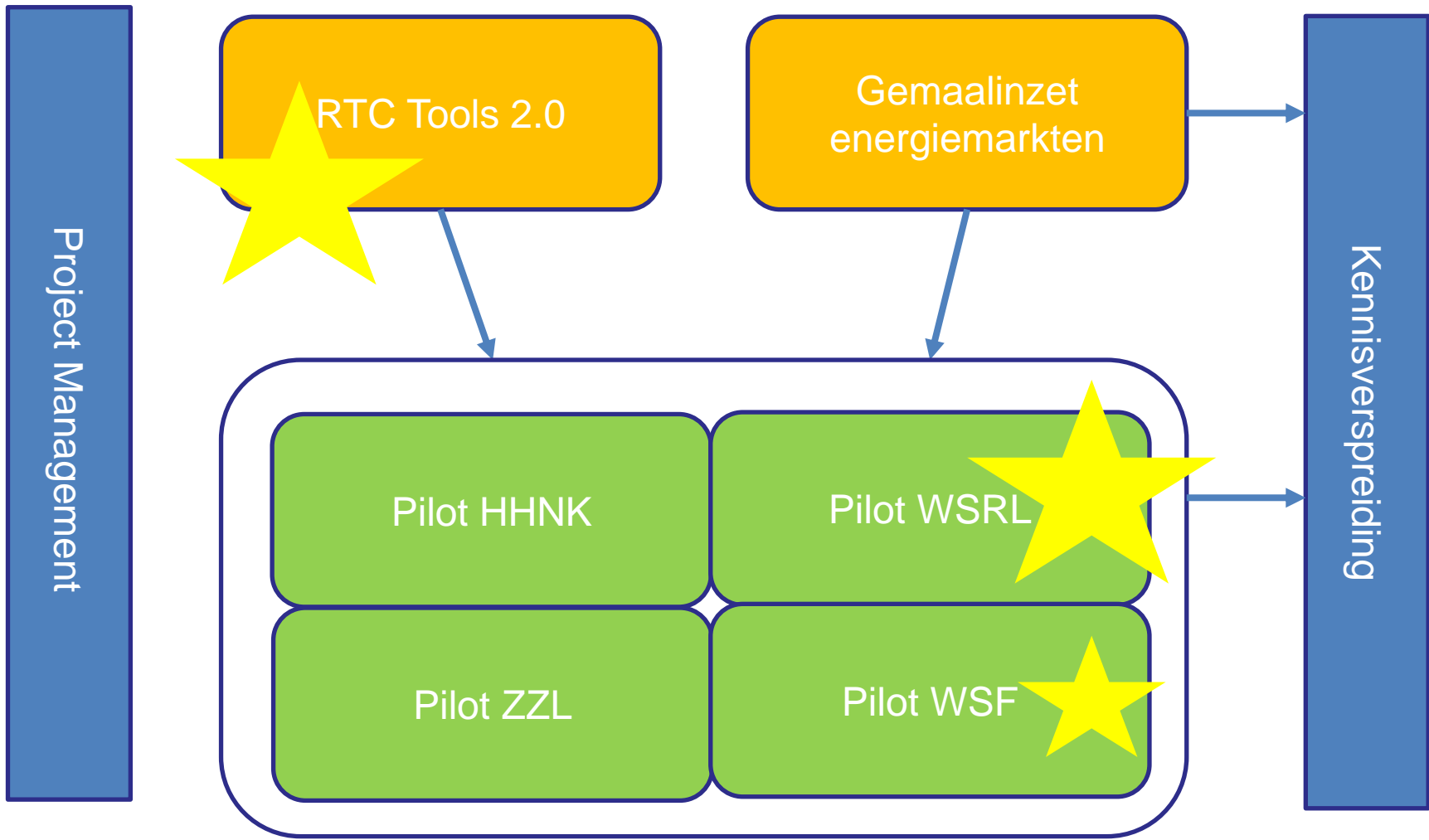
WATERSCHAP  
**ZUIDERZEE** LAND  
UW WATERSCHAP

 **eRisk Group**  
Energy & Finance

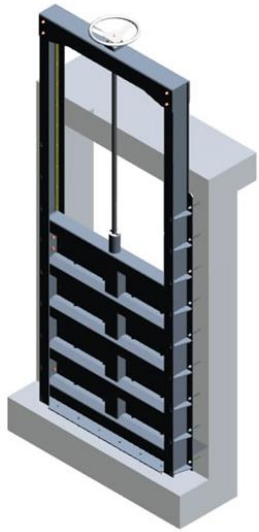
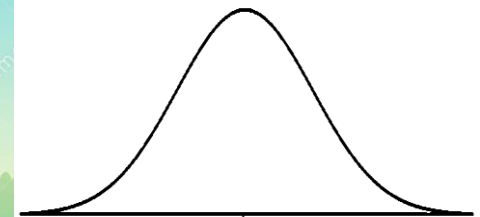
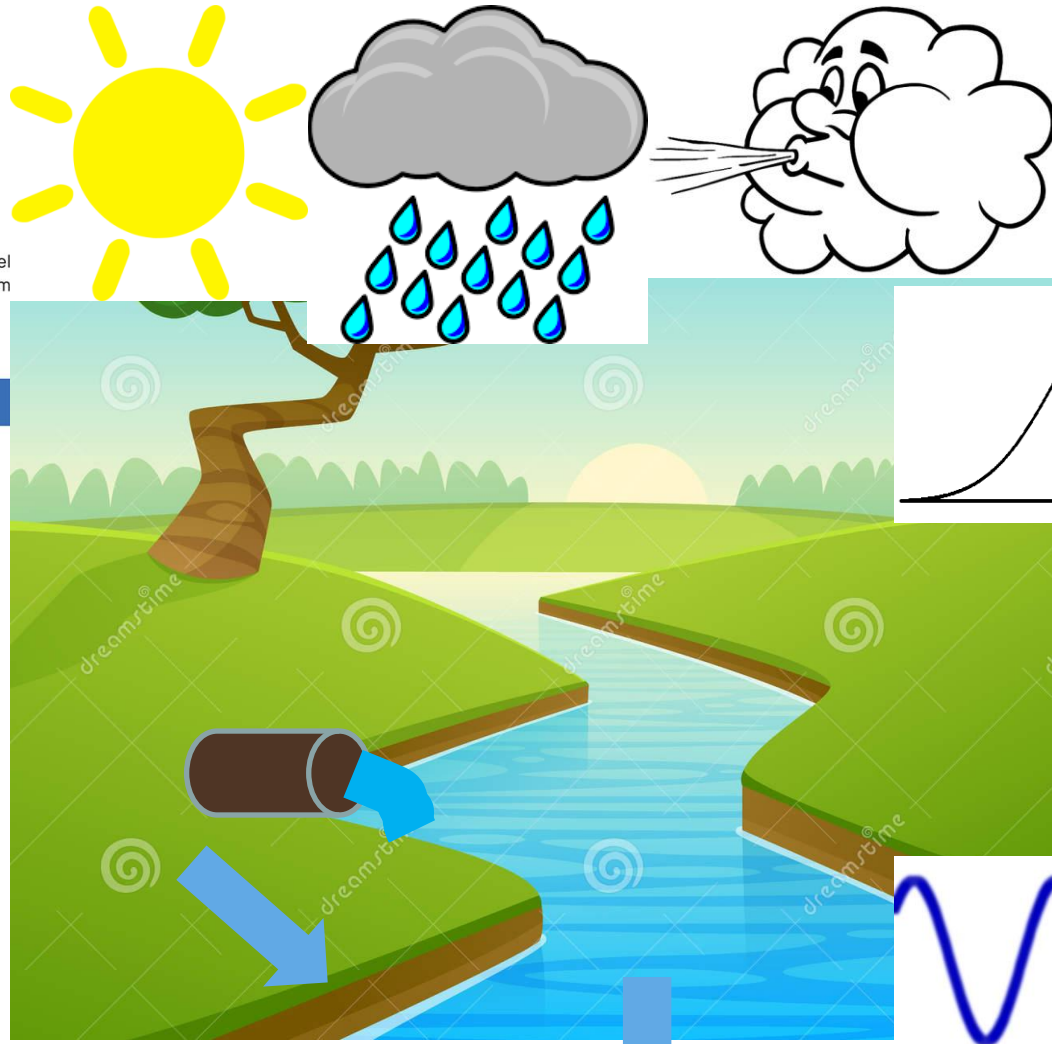
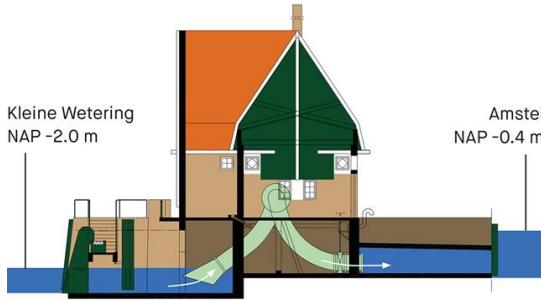
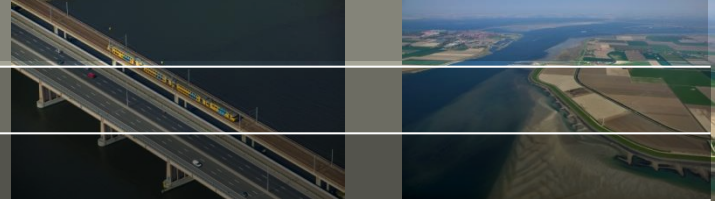
# Introduction



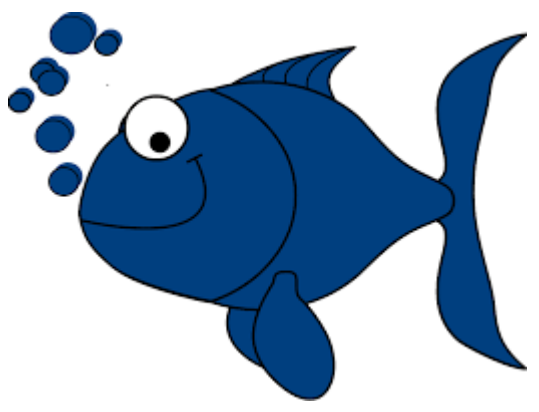
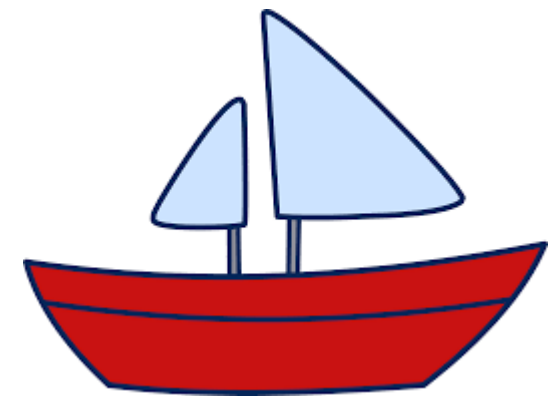
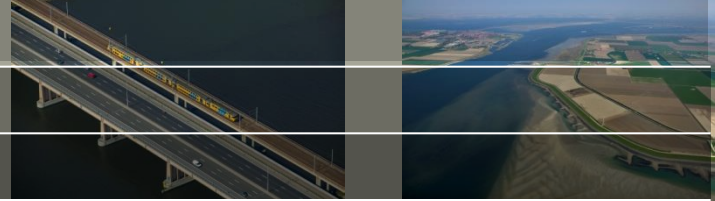
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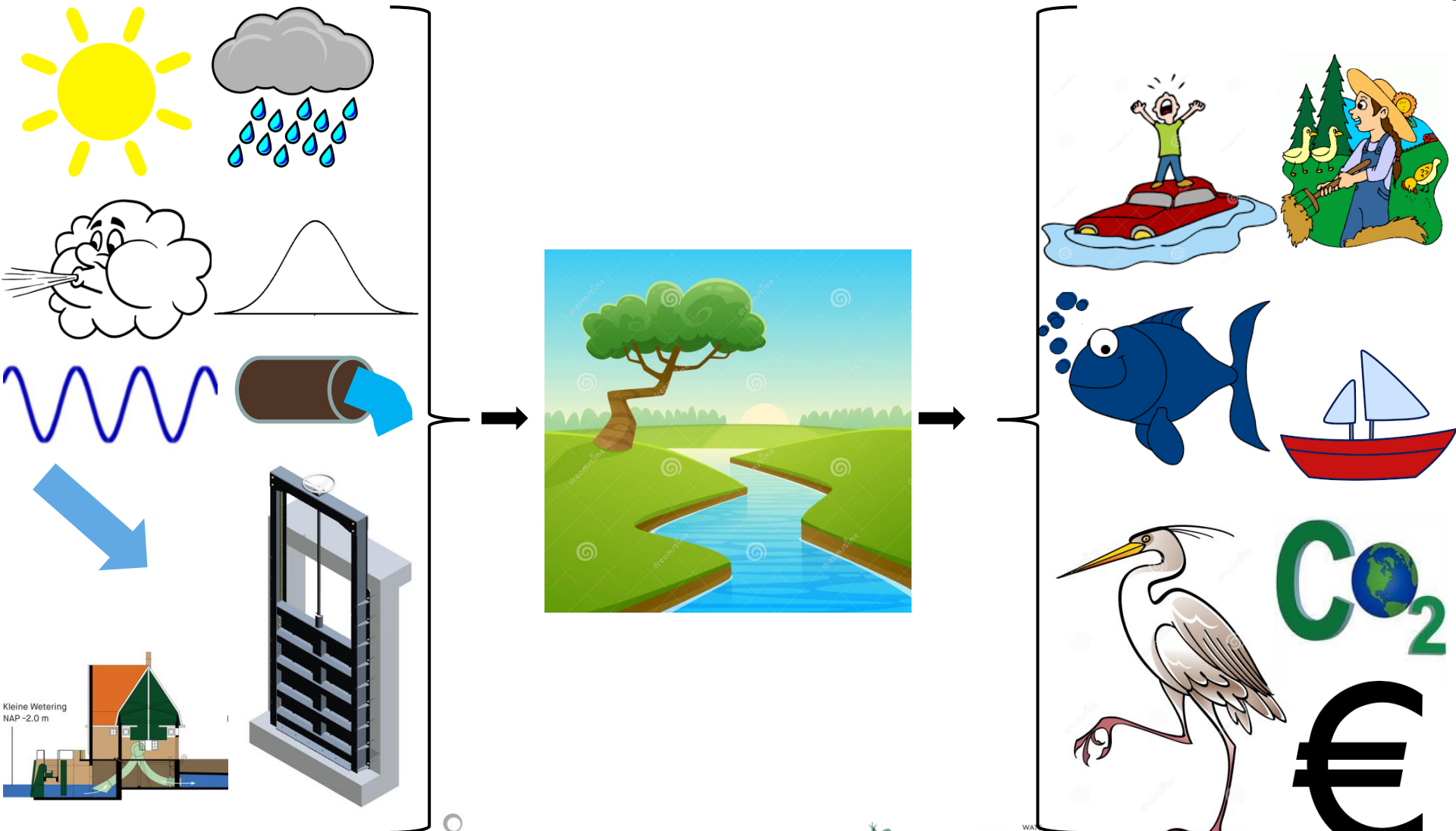
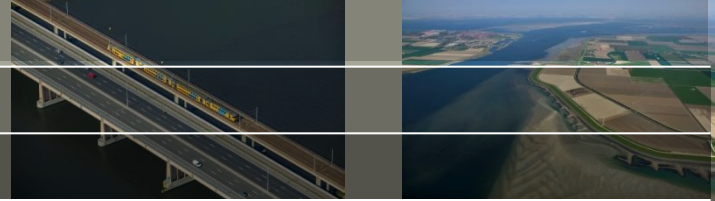
# Water system



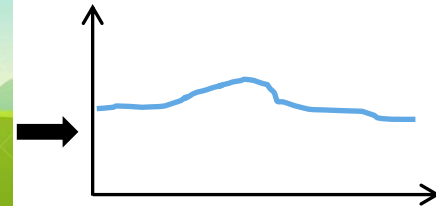
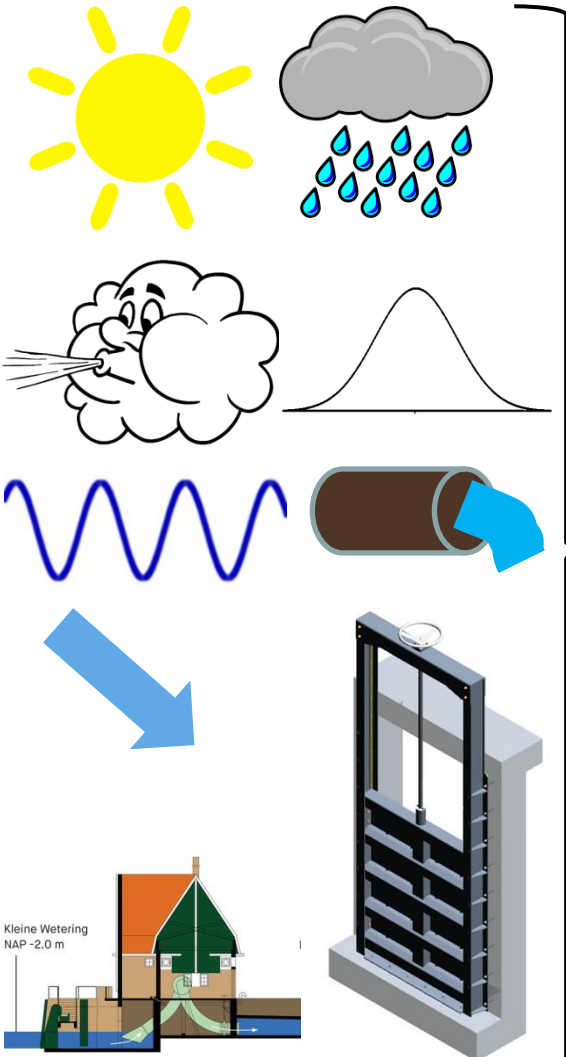
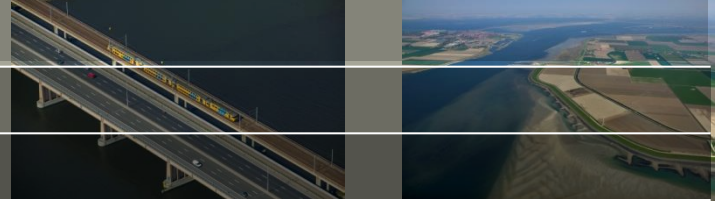
# Goals



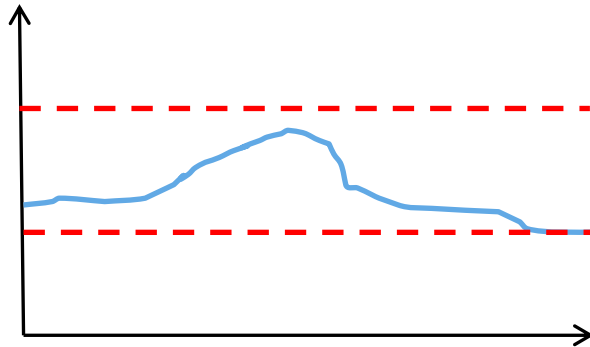
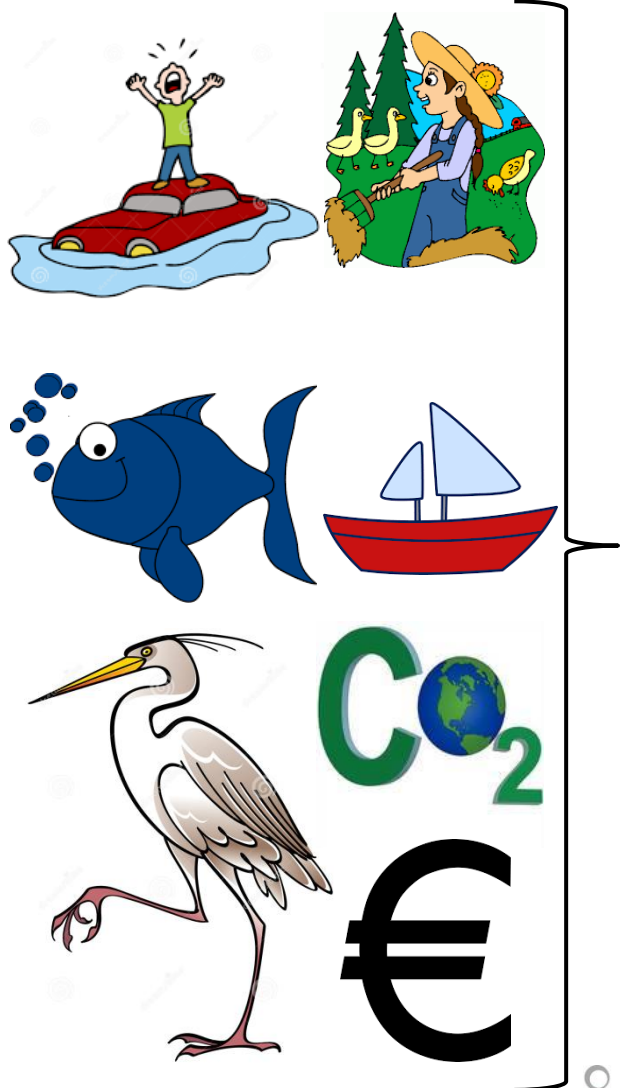
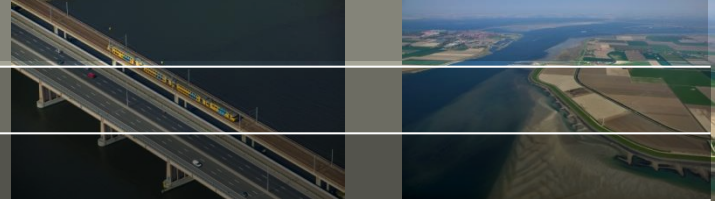
# Water system



# Water system



# Goals

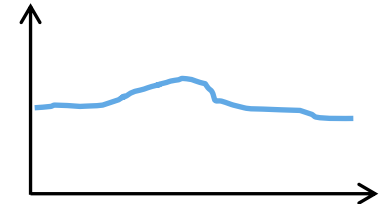
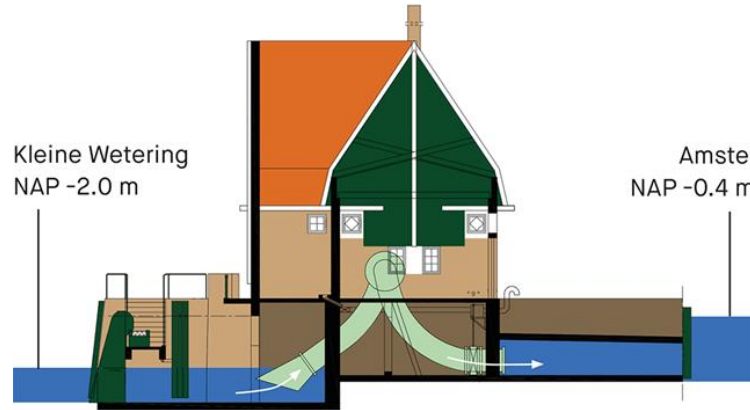
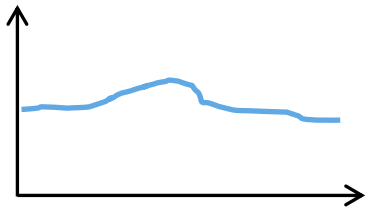
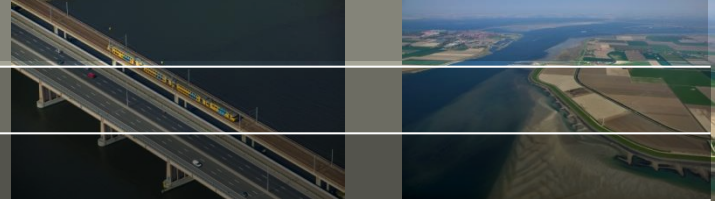


$$Q_{\min} < Q < Q_{\max}$$

€ ?

CO<sub>2</sub> ?



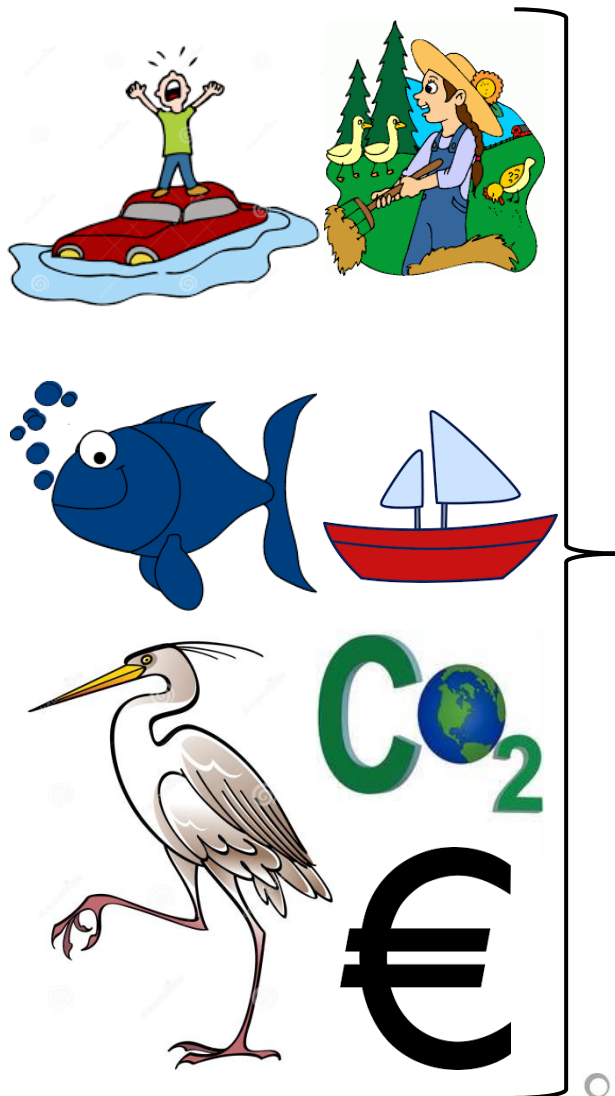
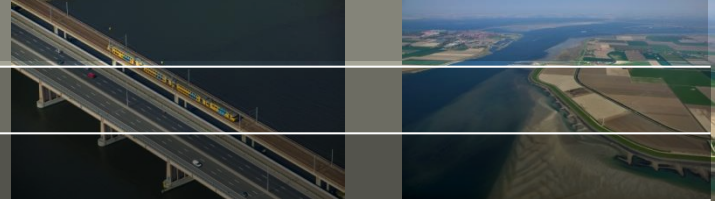


€

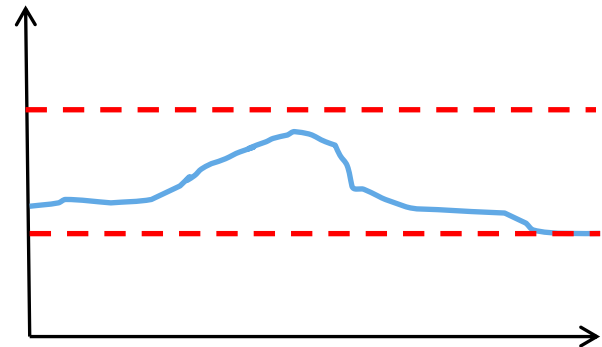
CO<sub>2</sub>



# Goals

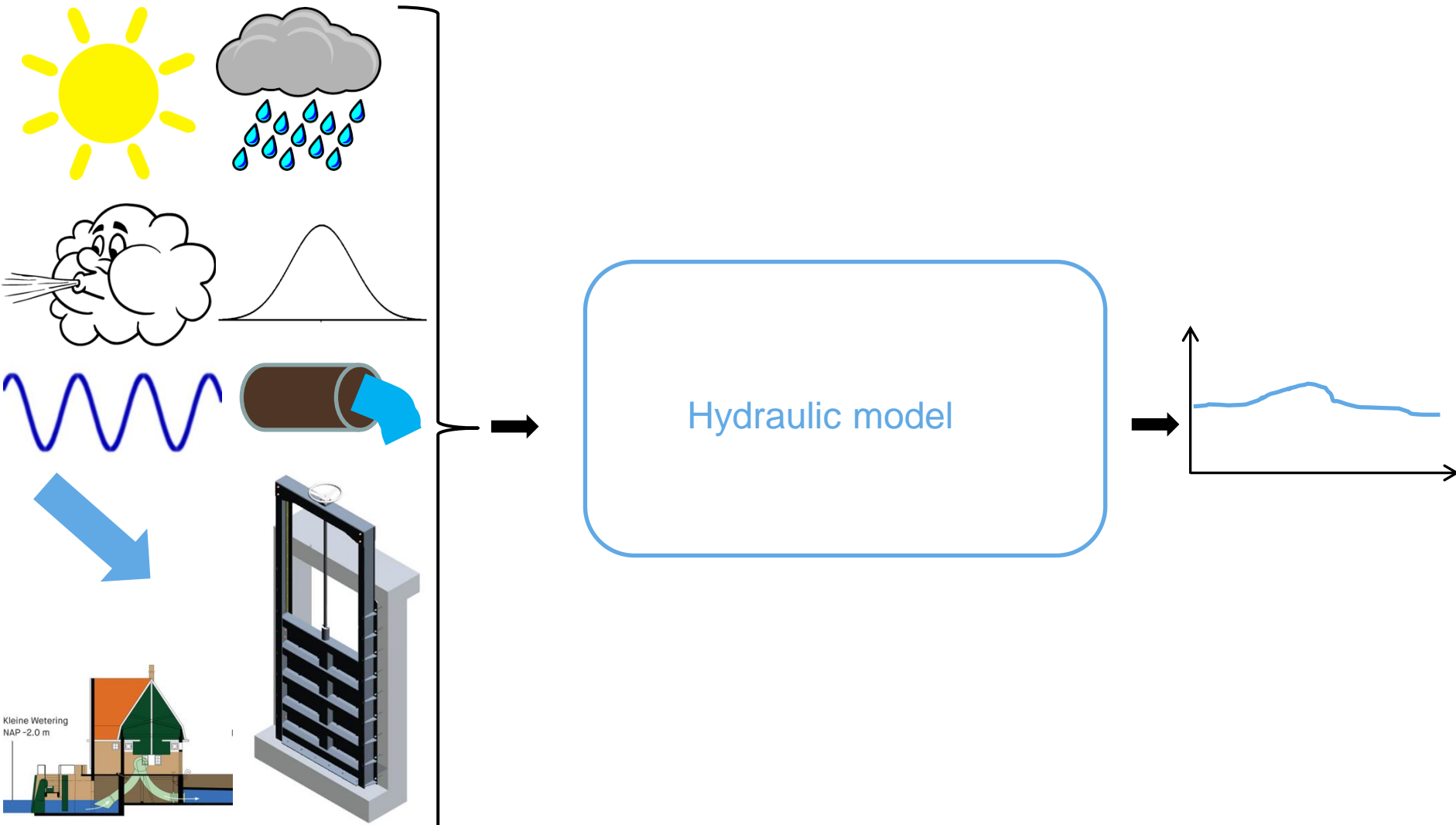
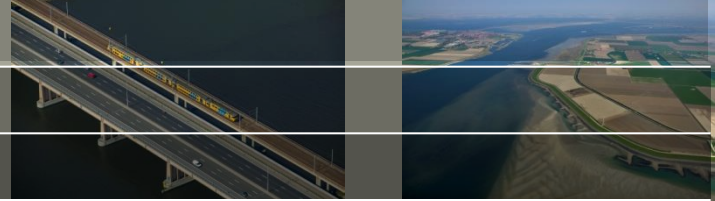


Pump model



$$Q_{\min} < Q < Q_{\max}$$

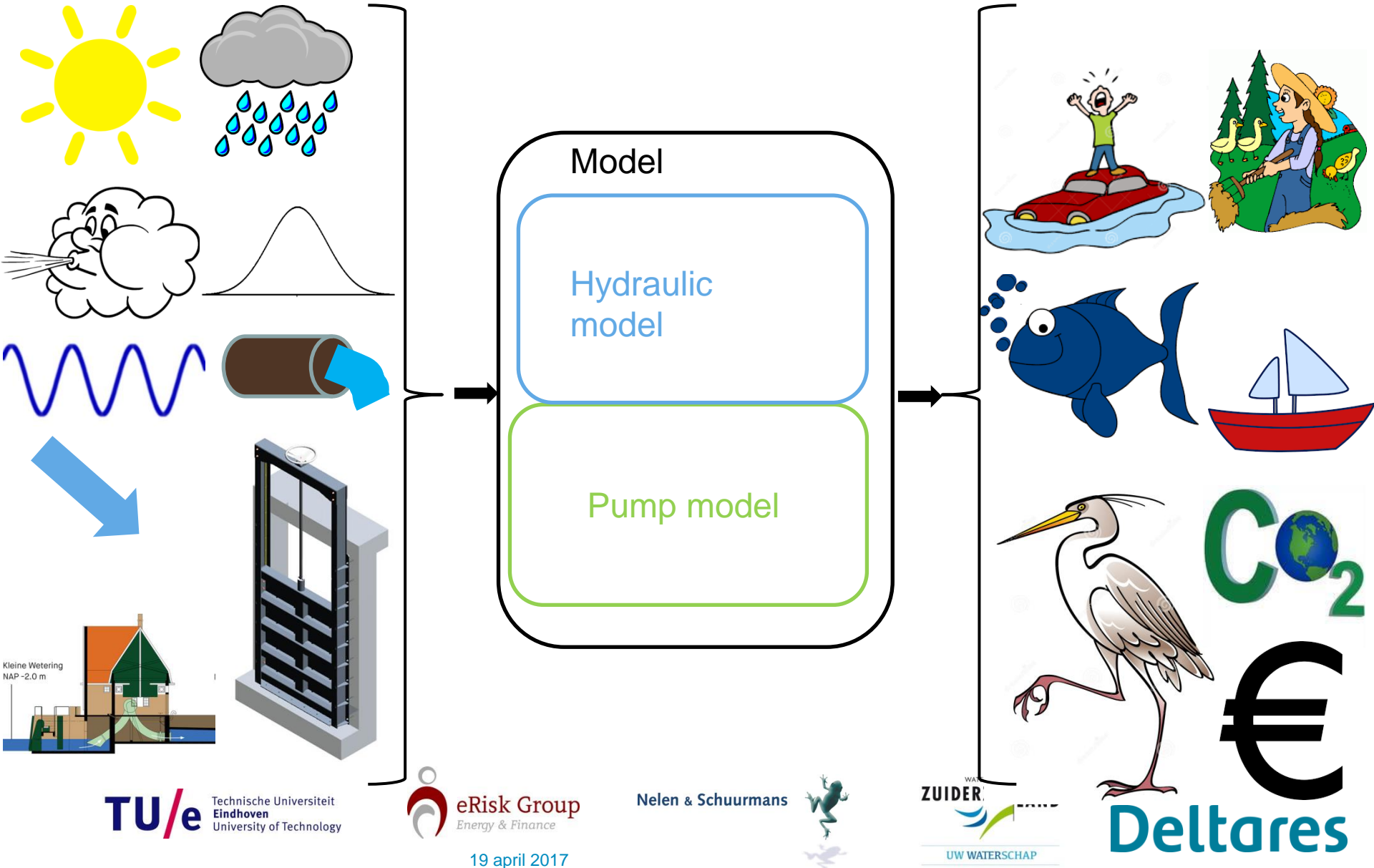
# Model



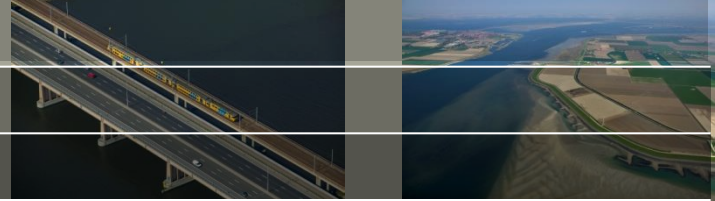
Kleine Wetering  
NAP -2.0 m



# Water system



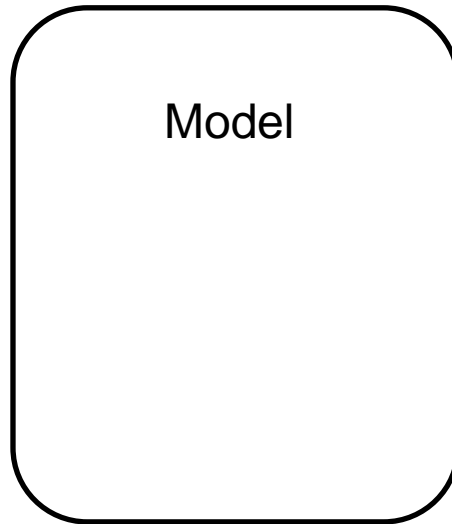
# Water system



Input



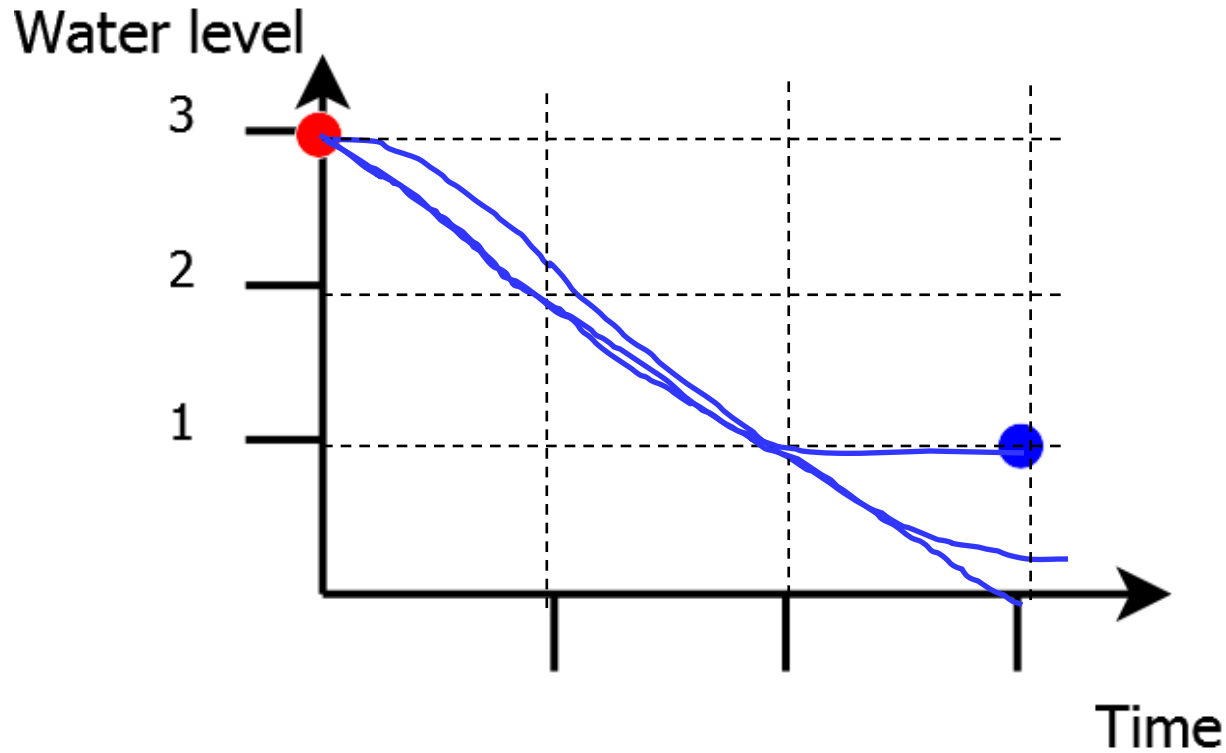
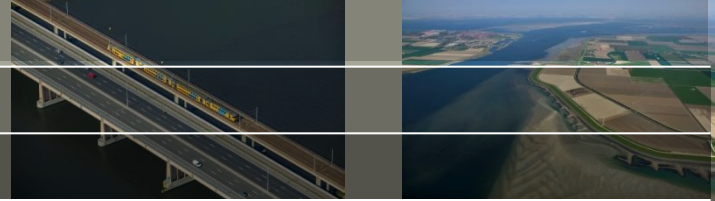
Model

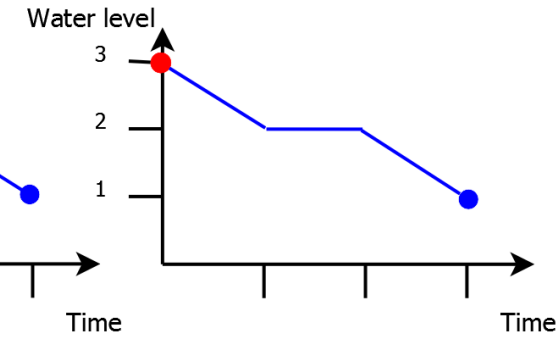
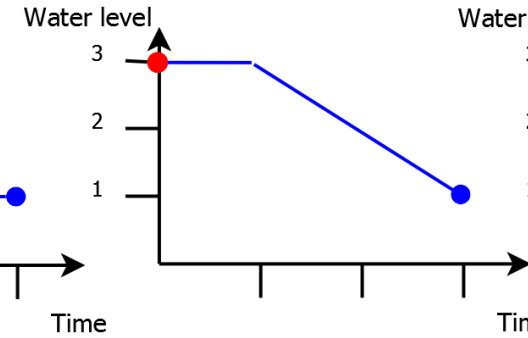
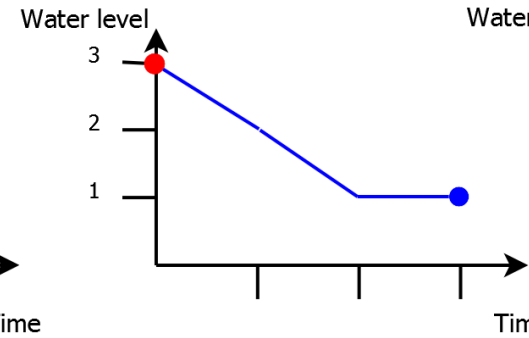
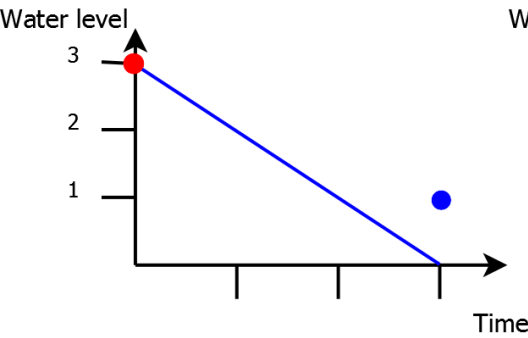
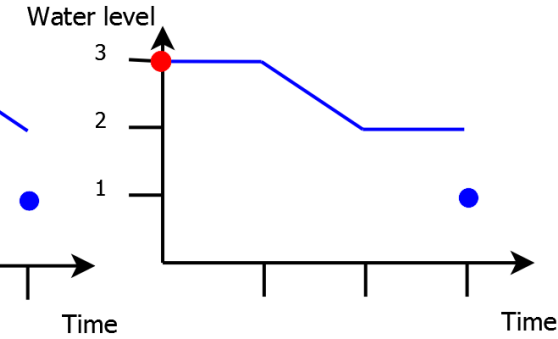
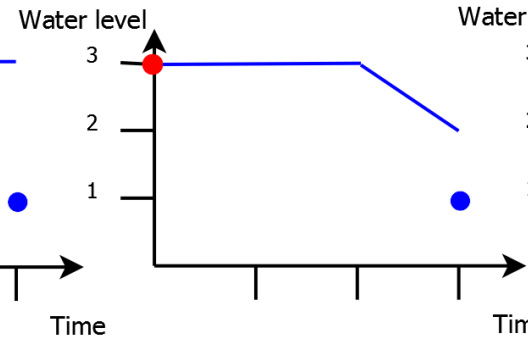
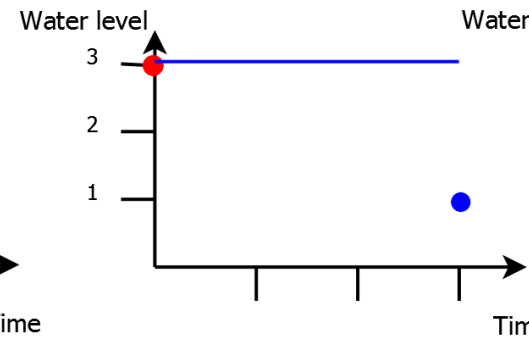
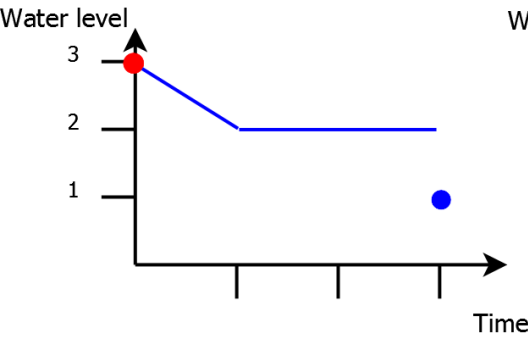
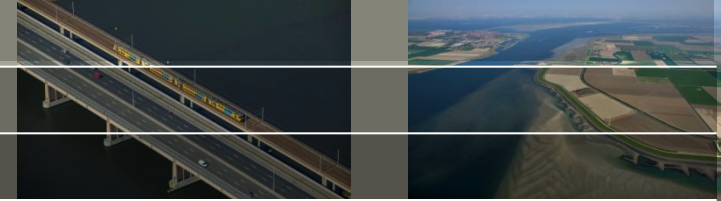


Output



# Example





# Possibilities

$$2^{24} \approx 1.7 * 10^7$$

3 pumps, no interaction

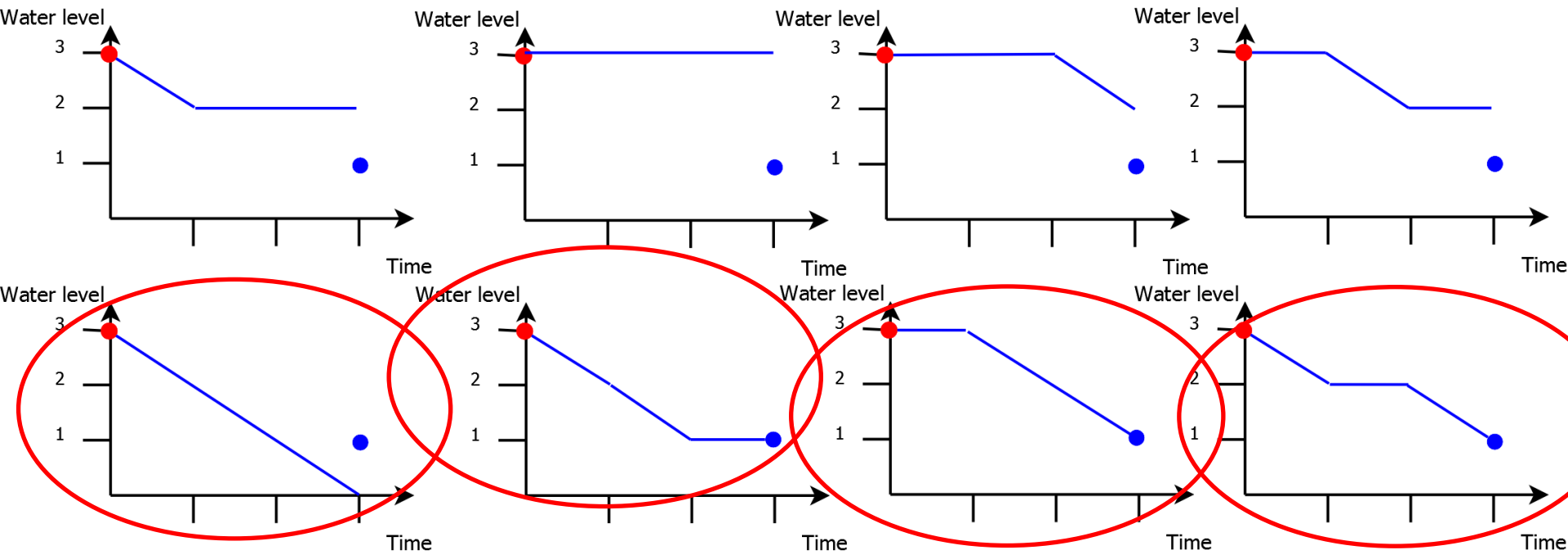
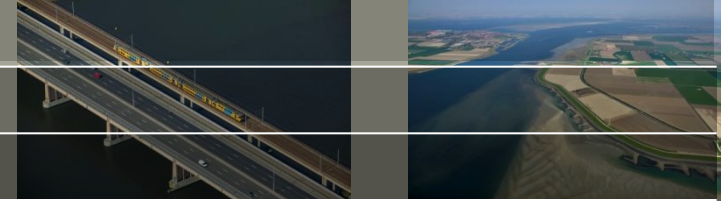
$$\left(2^{24}\right)^3 \approx 5 * 10^{21}$$

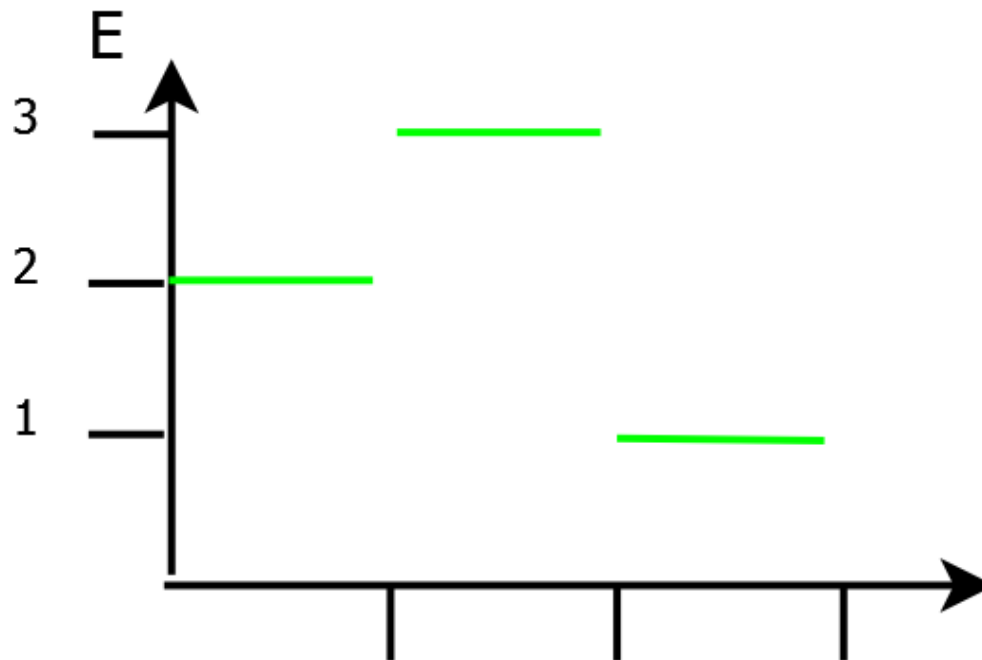
5000 trillion

$1.5 * 10^{14}$  years: 100 billion years, 100 000 000 million years

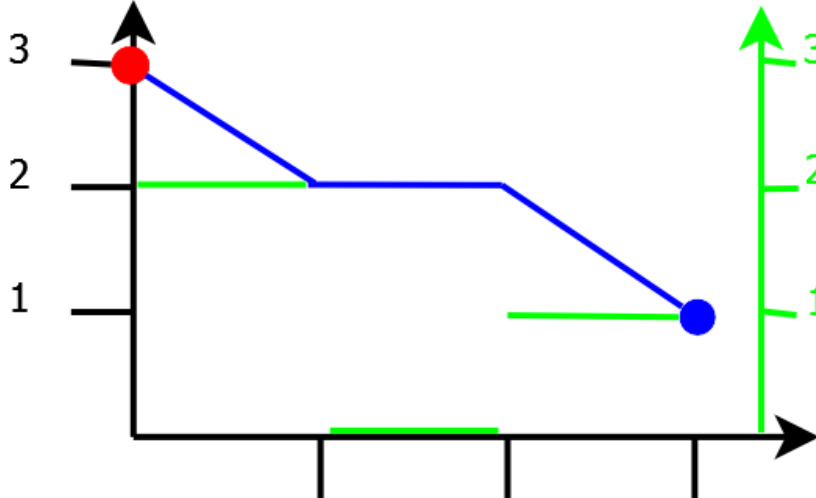




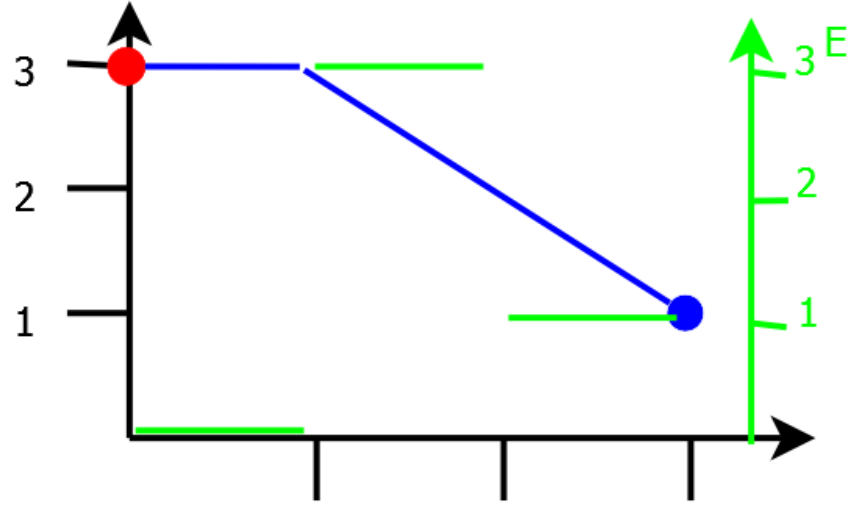




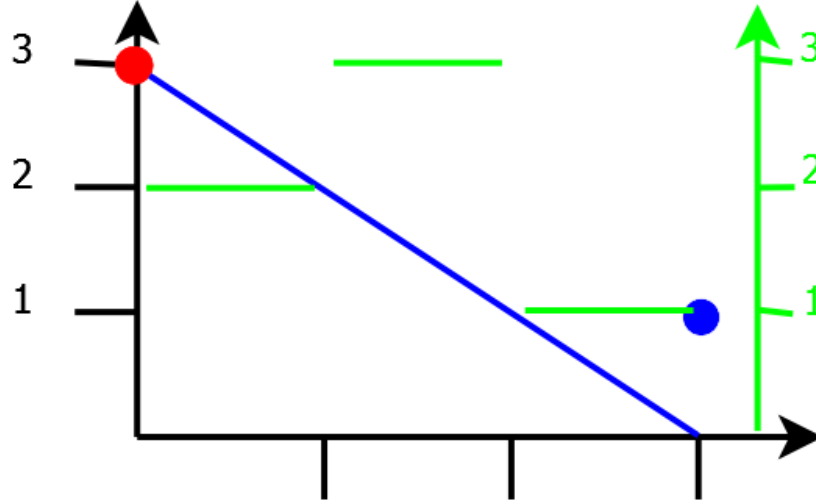
Water level



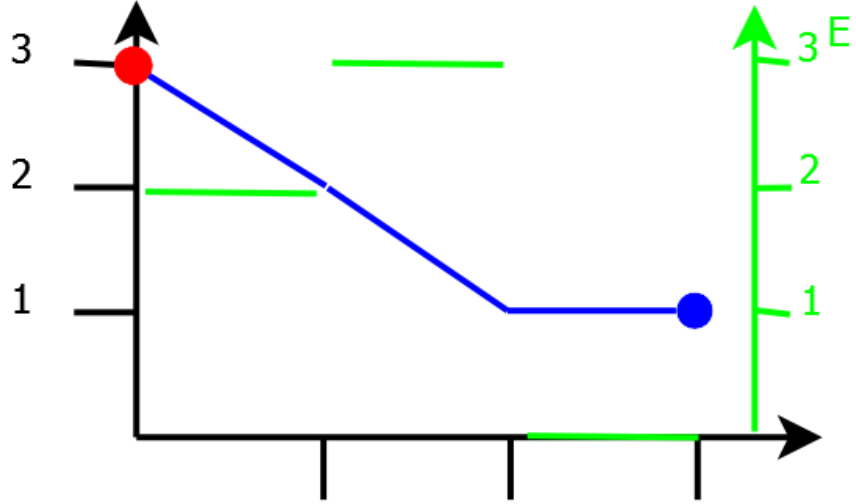
Water level



Water level



Water level



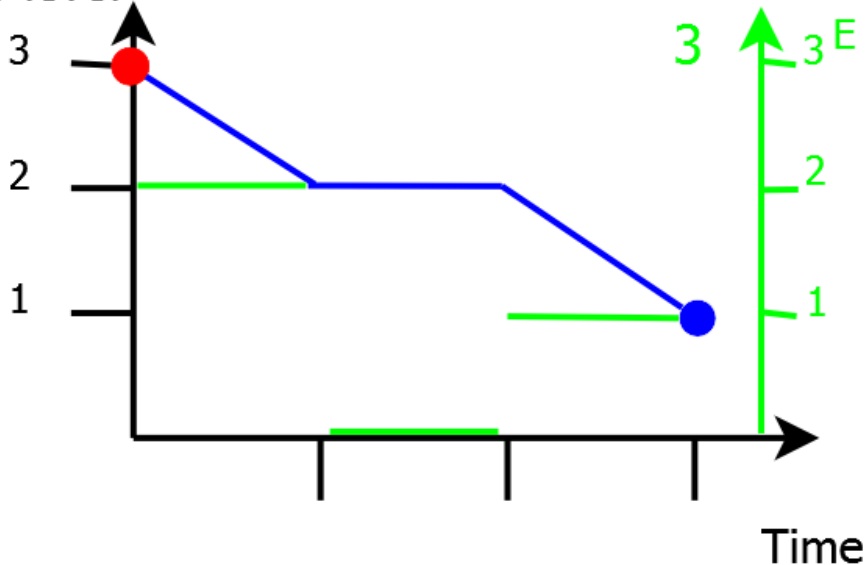
Time

Time

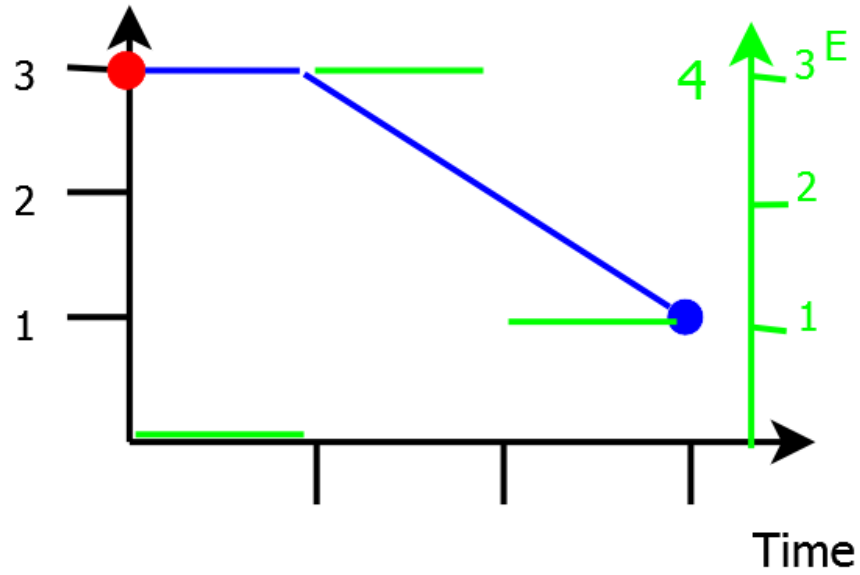
Time

Time

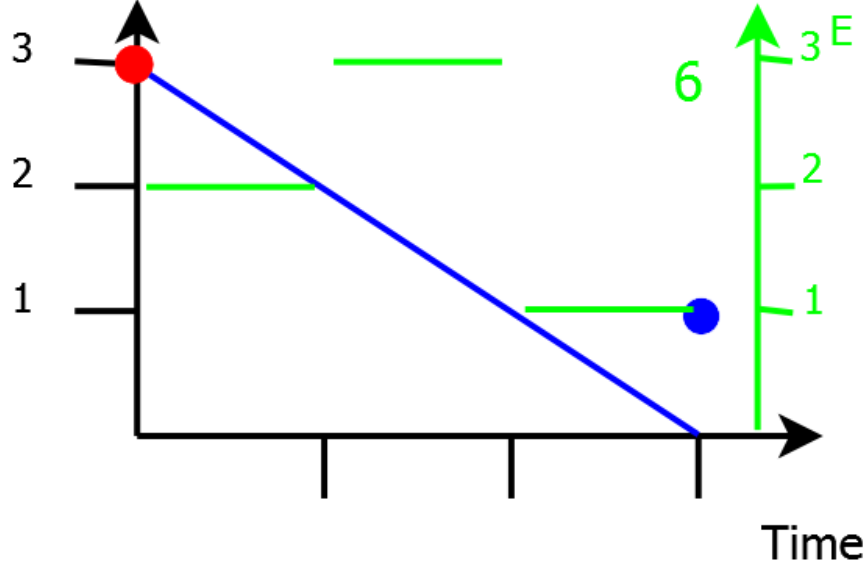
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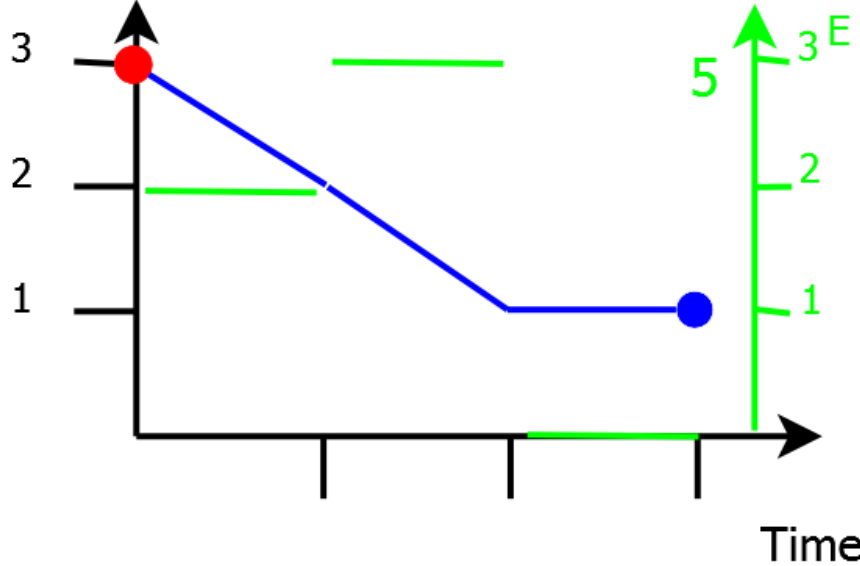
Water level

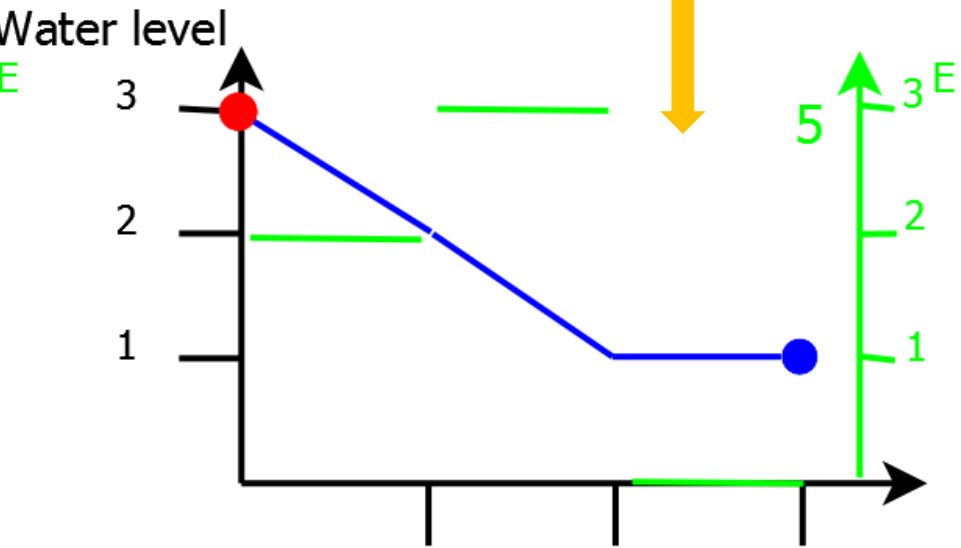
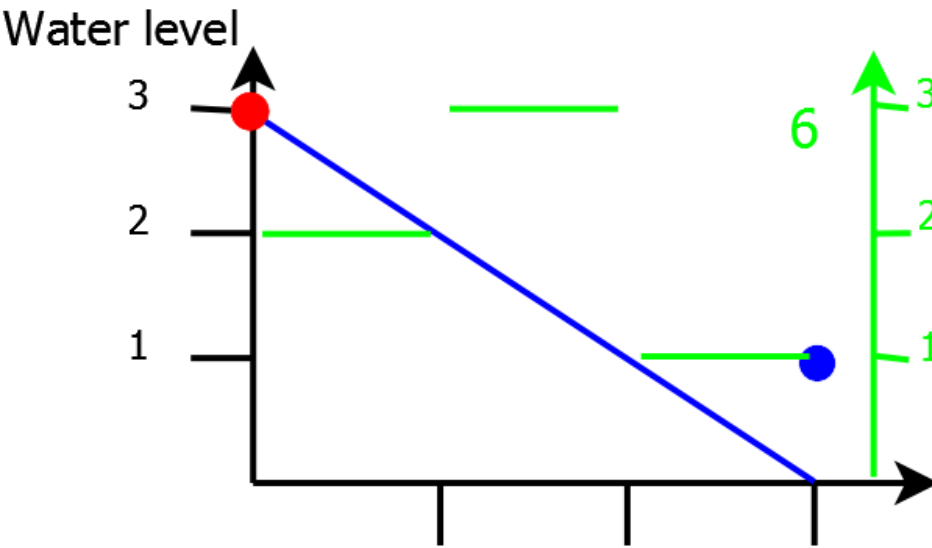
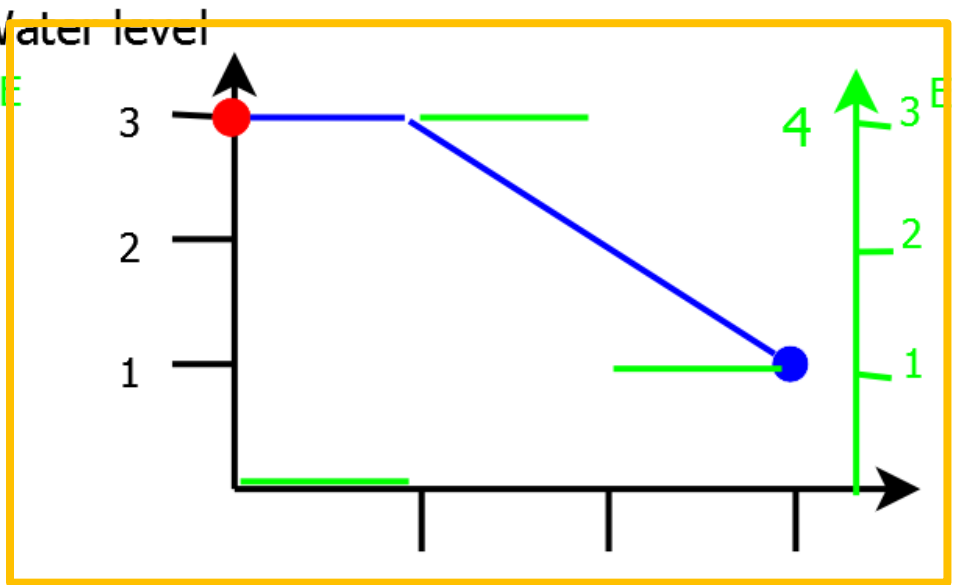
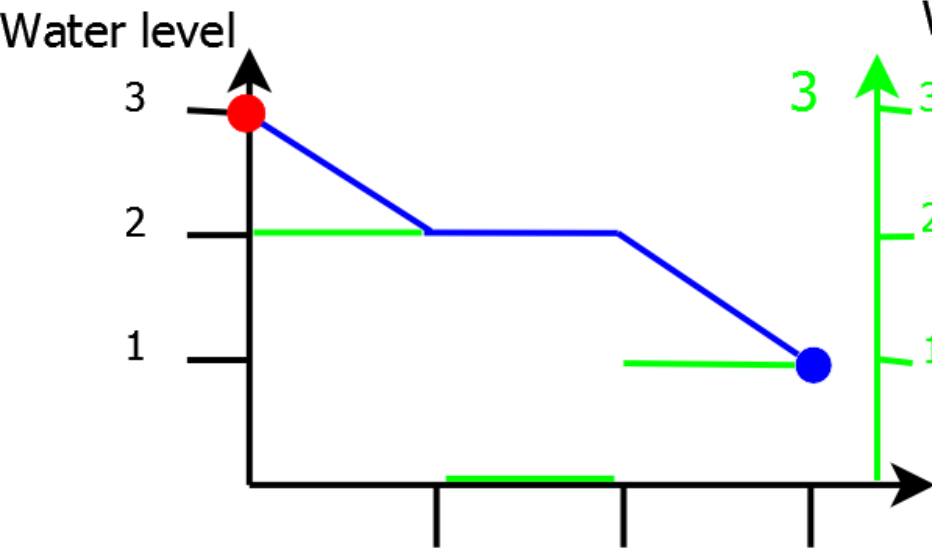


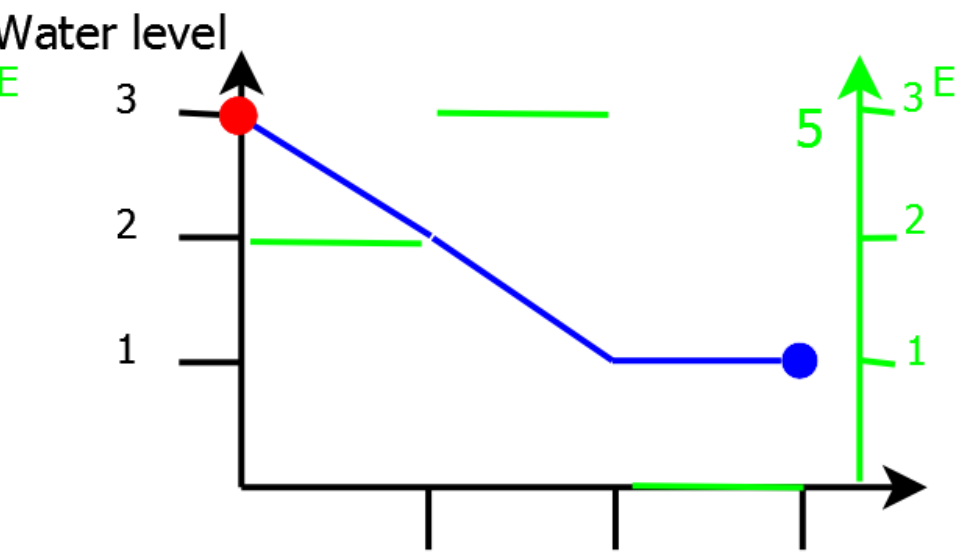
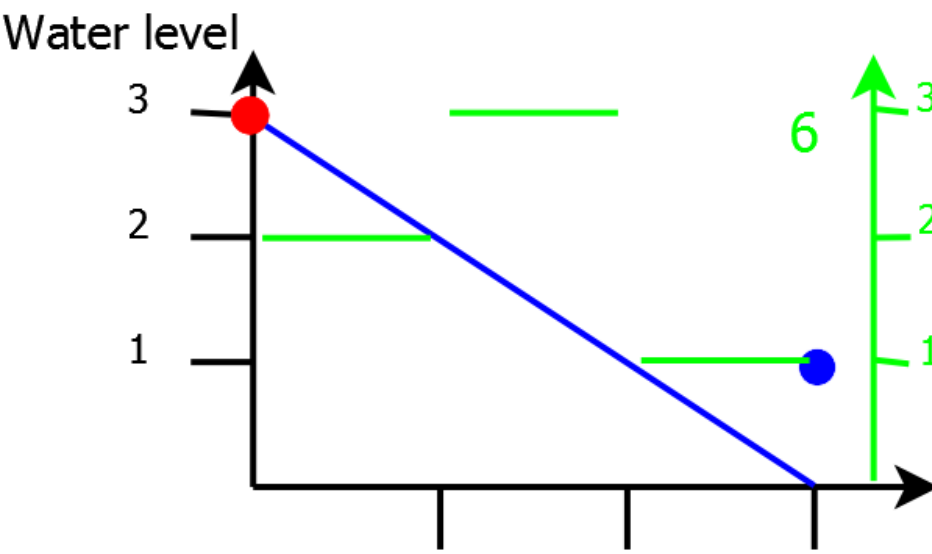
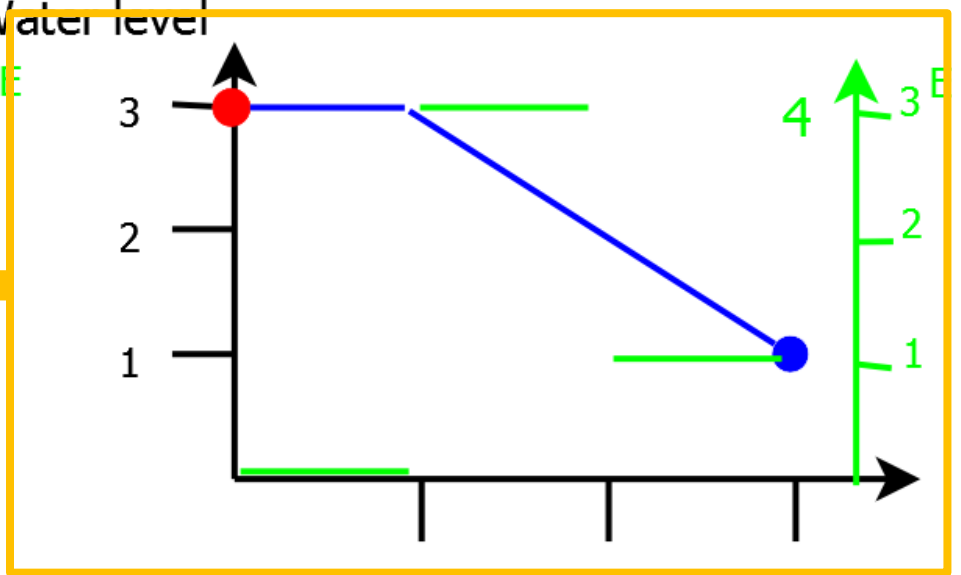
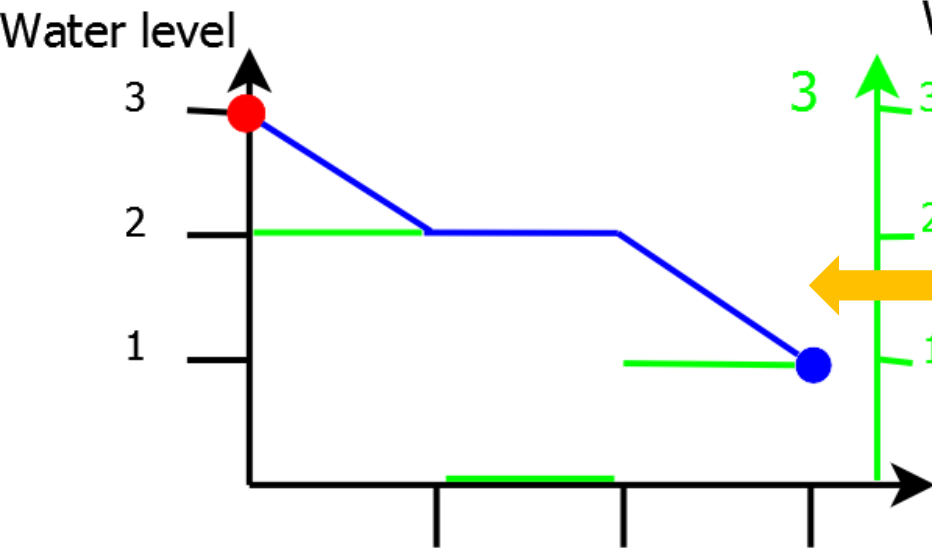
Water level



Water level







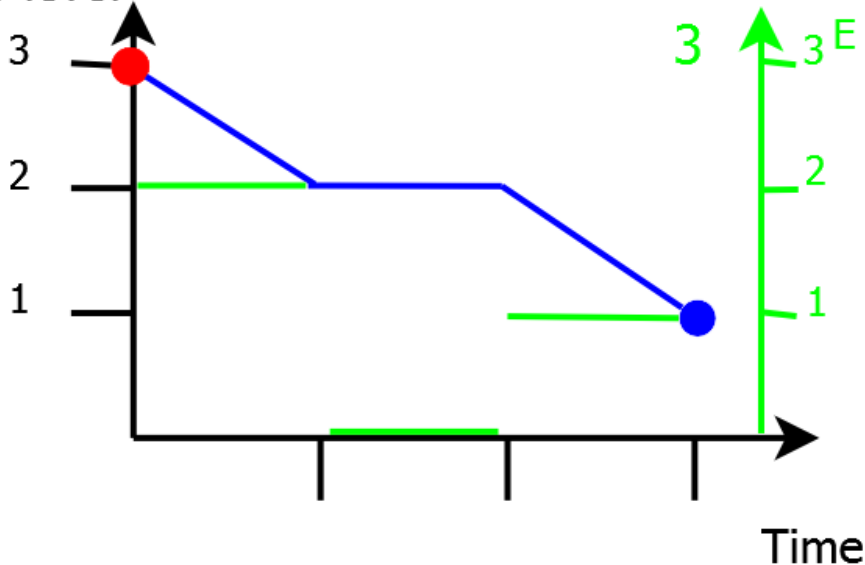
Time

Time

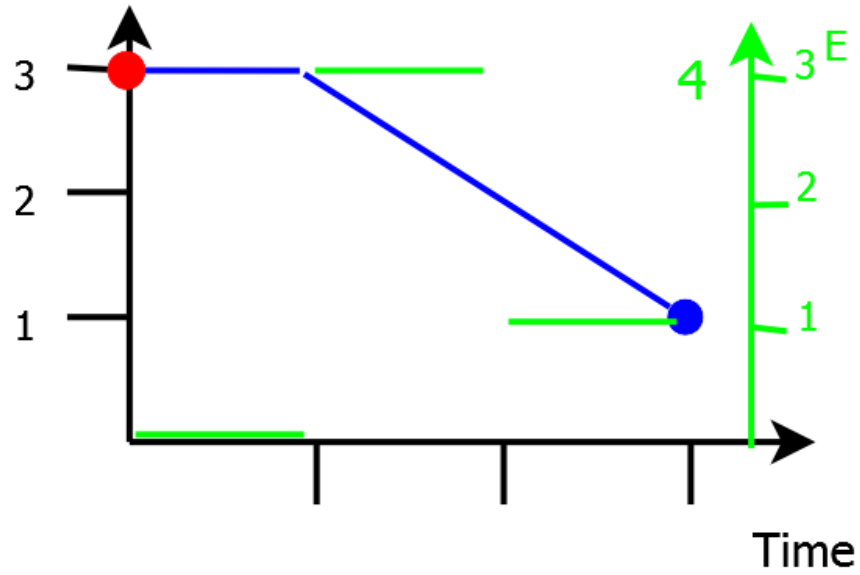
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Time

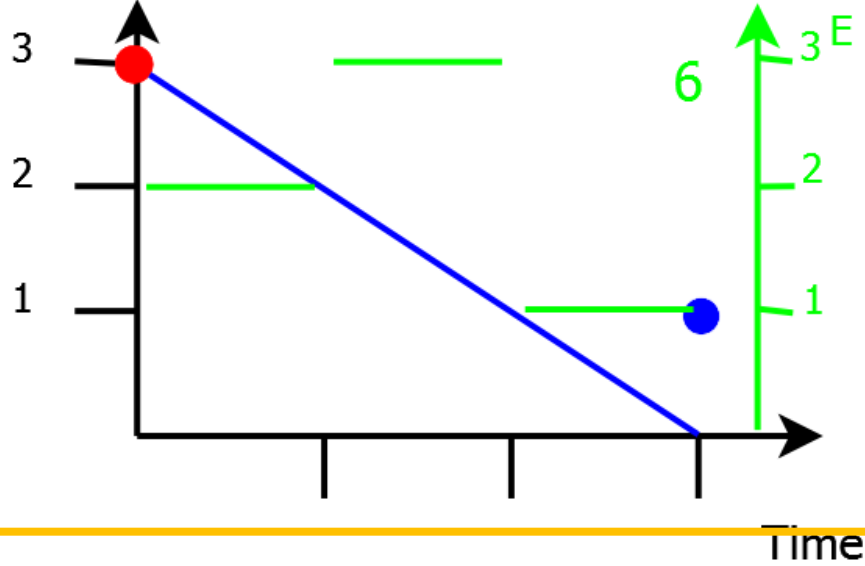
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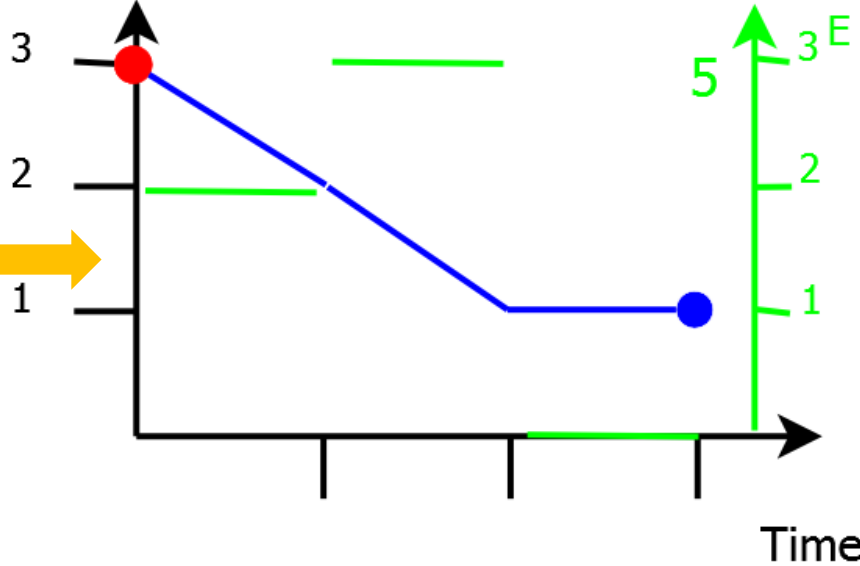
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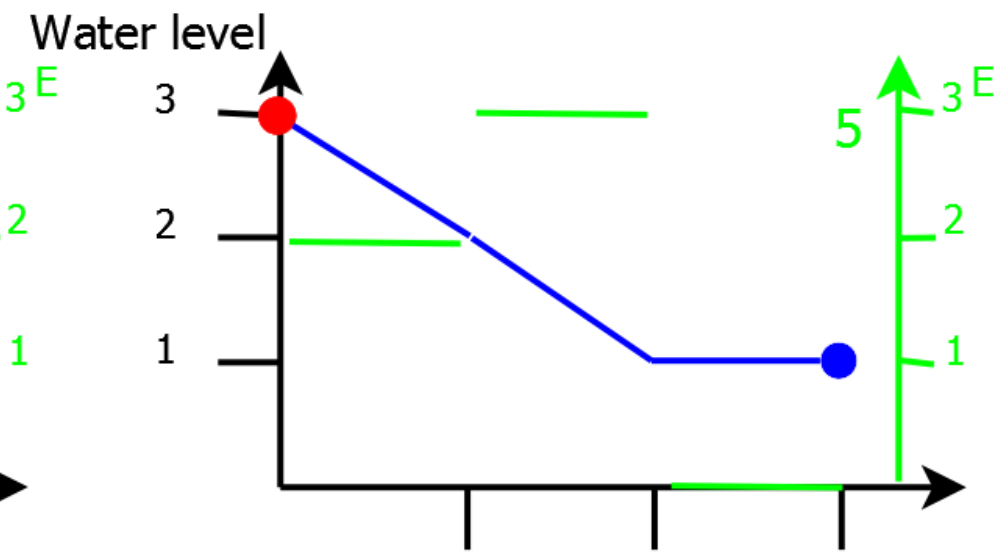
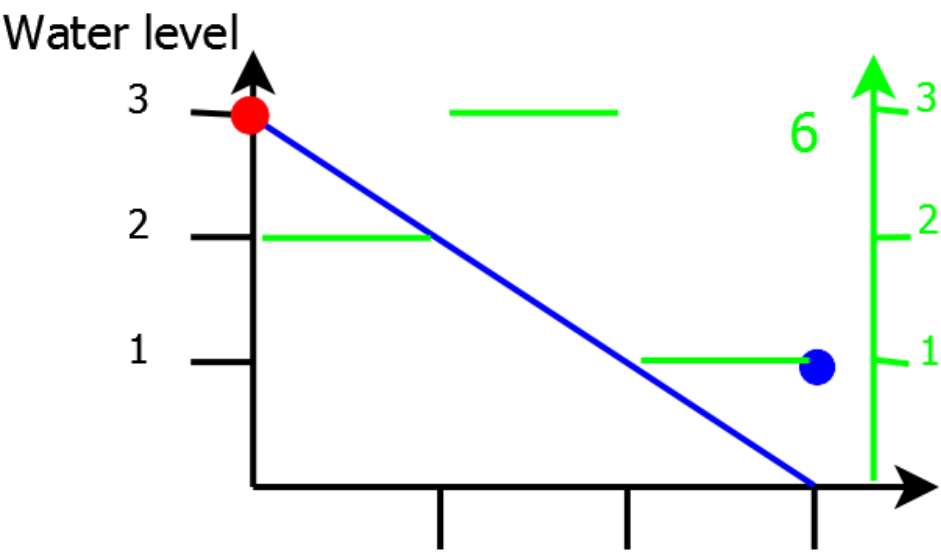
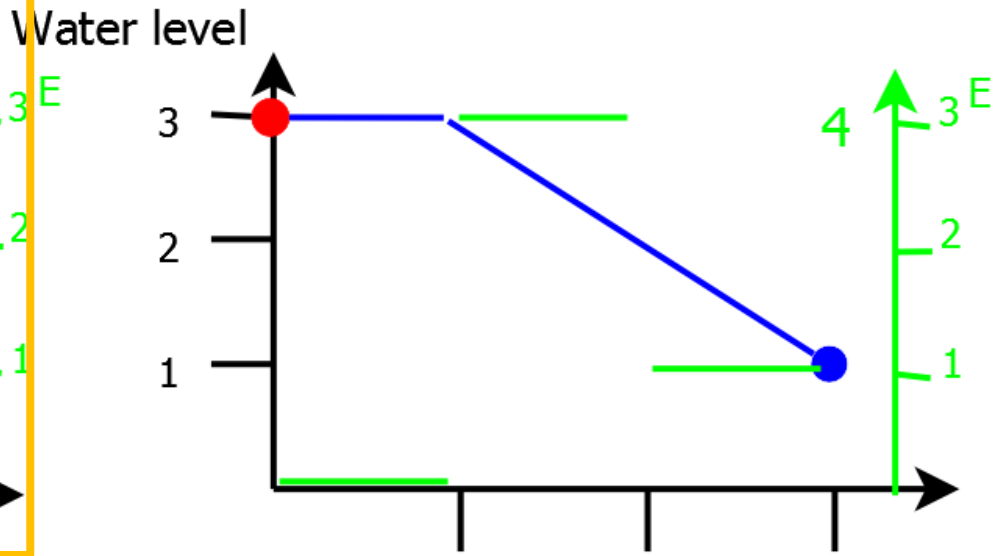
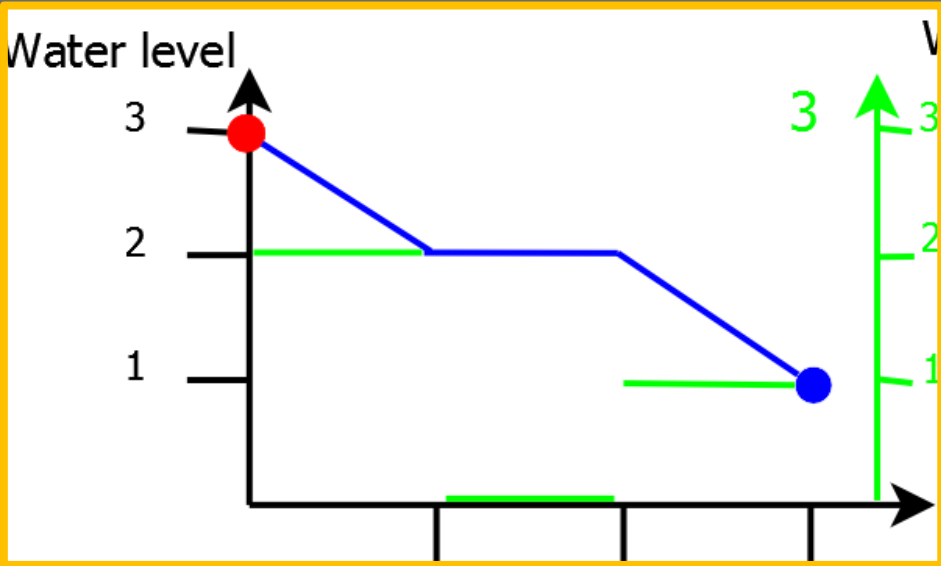


Water level

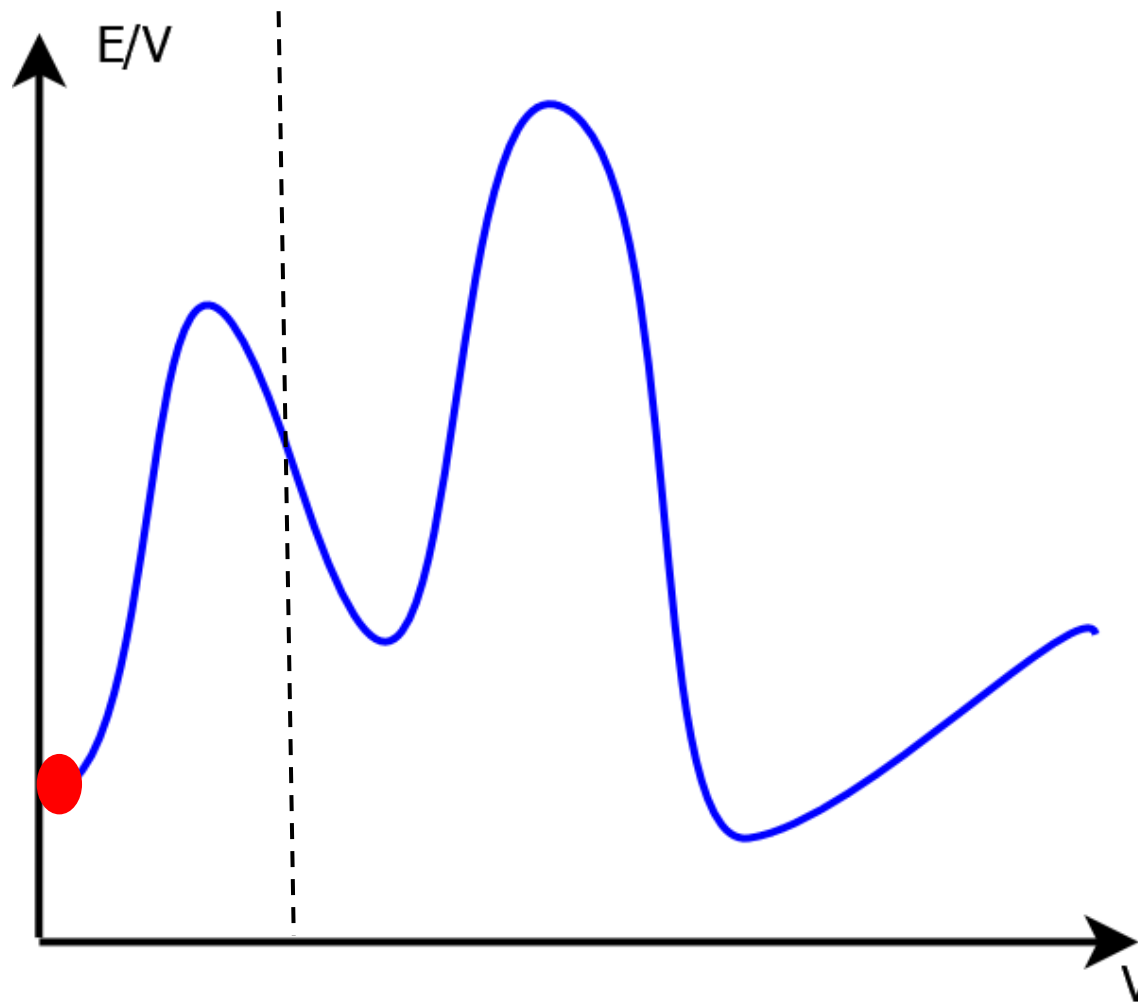


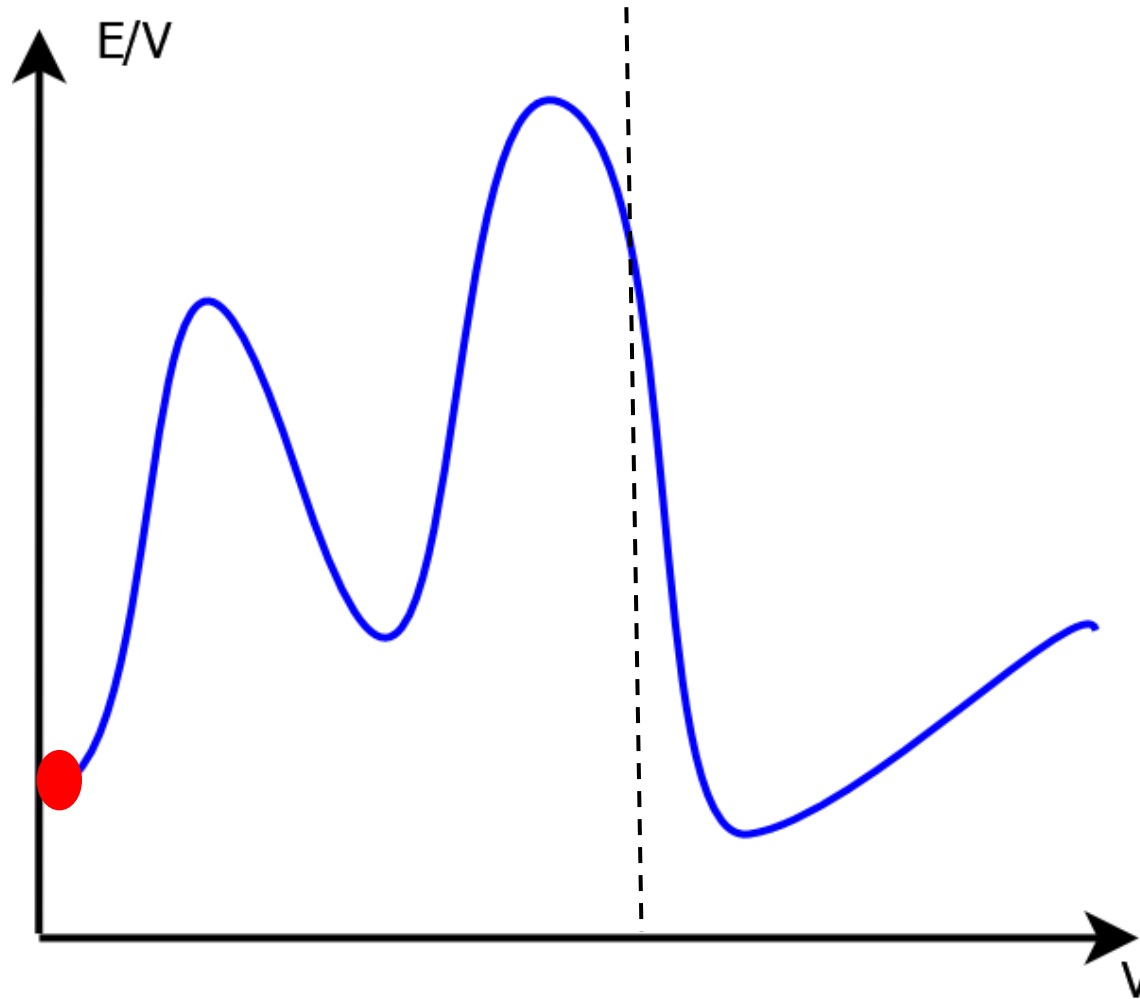
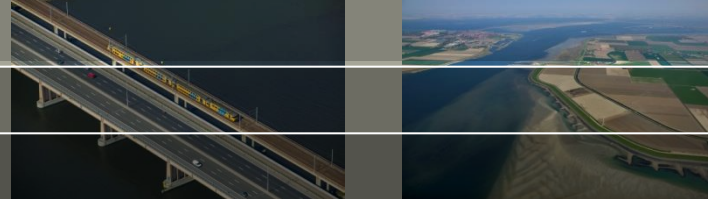
Water level



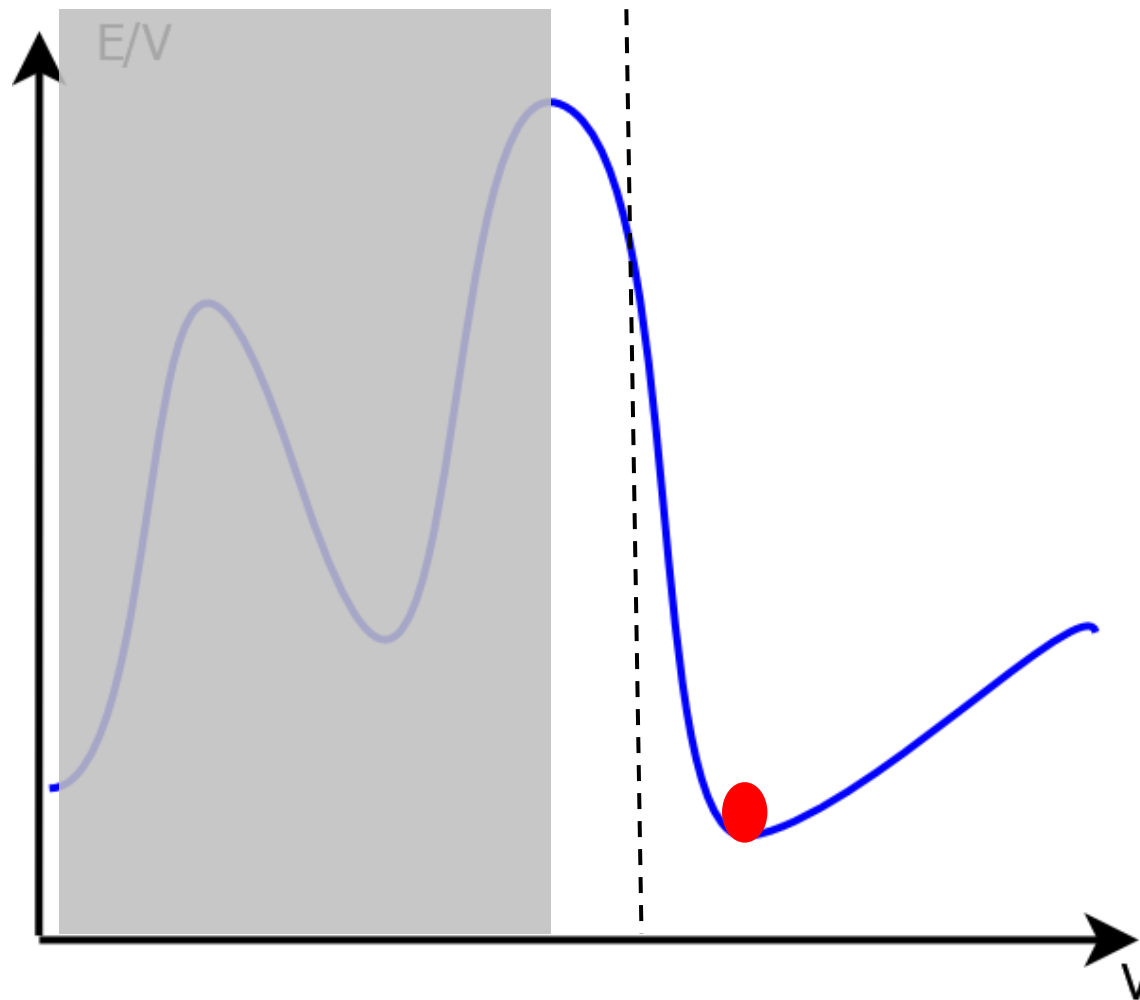
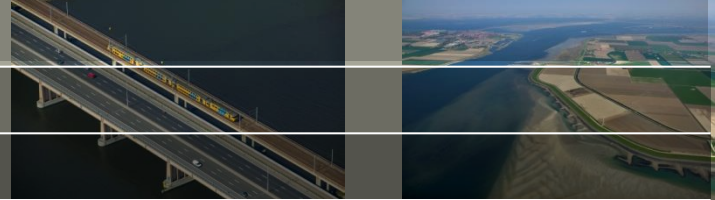








# Convexity



# Convex functions

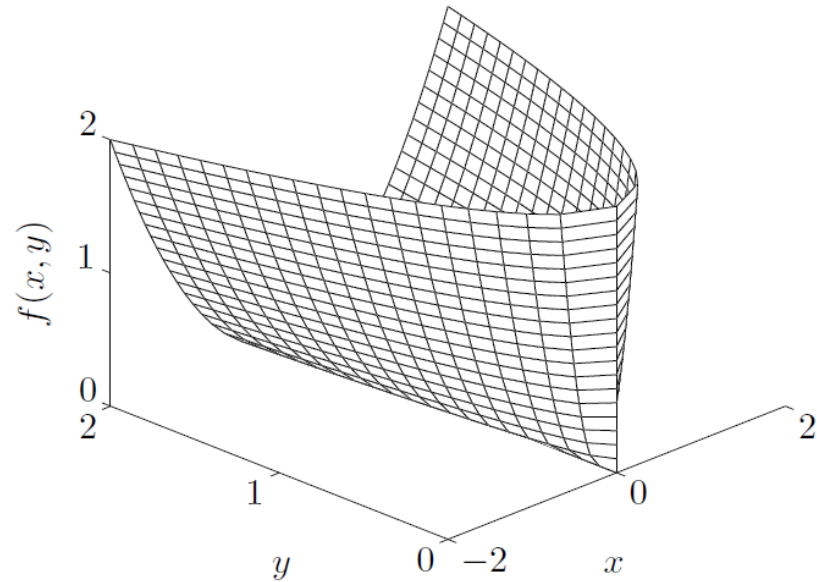
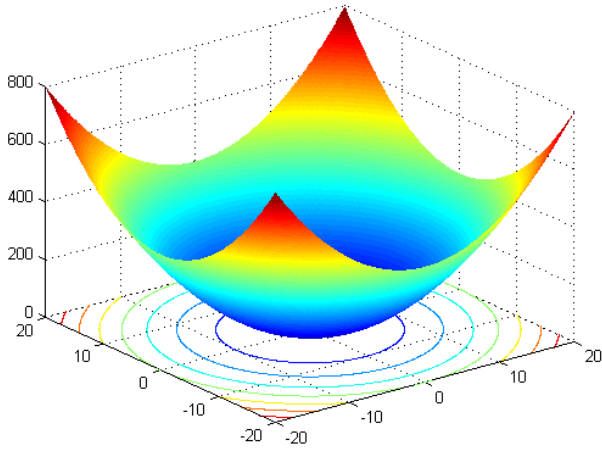
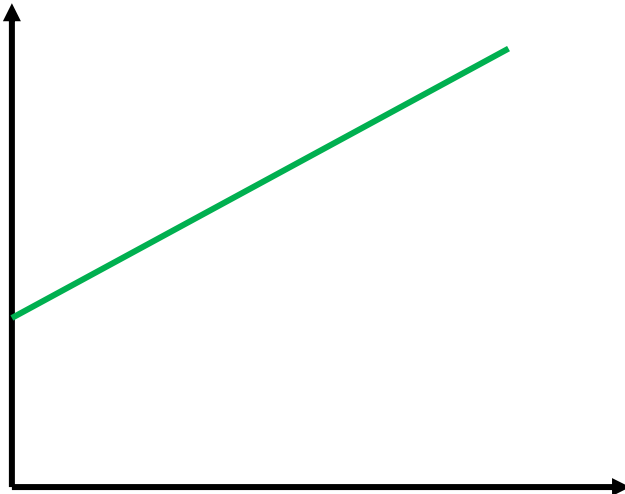
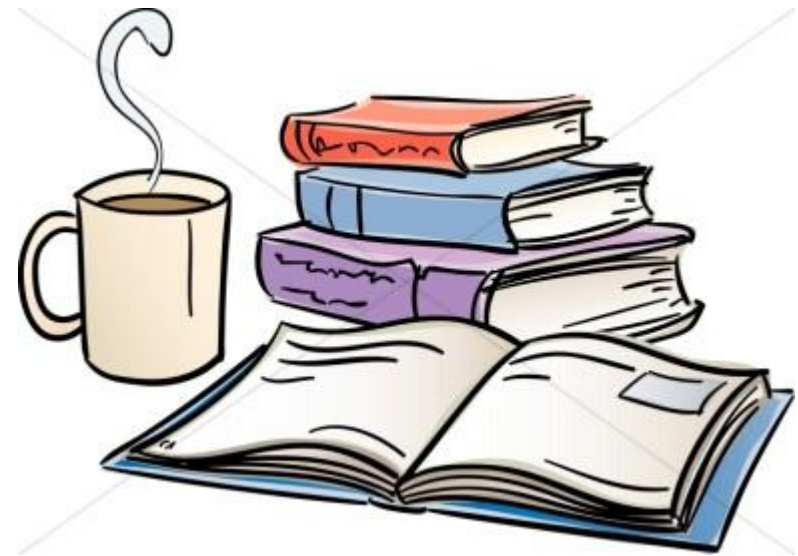
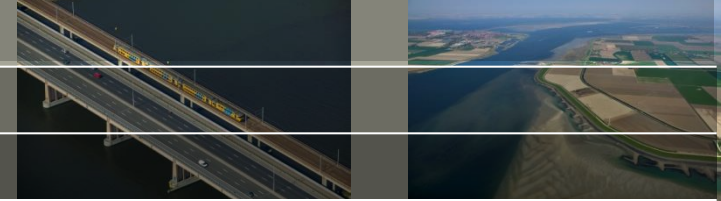


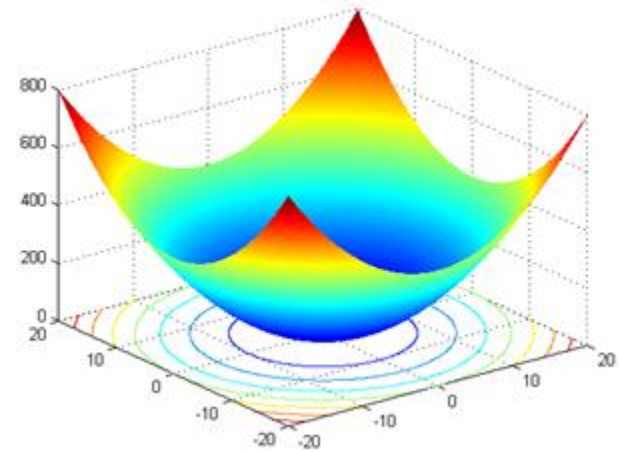
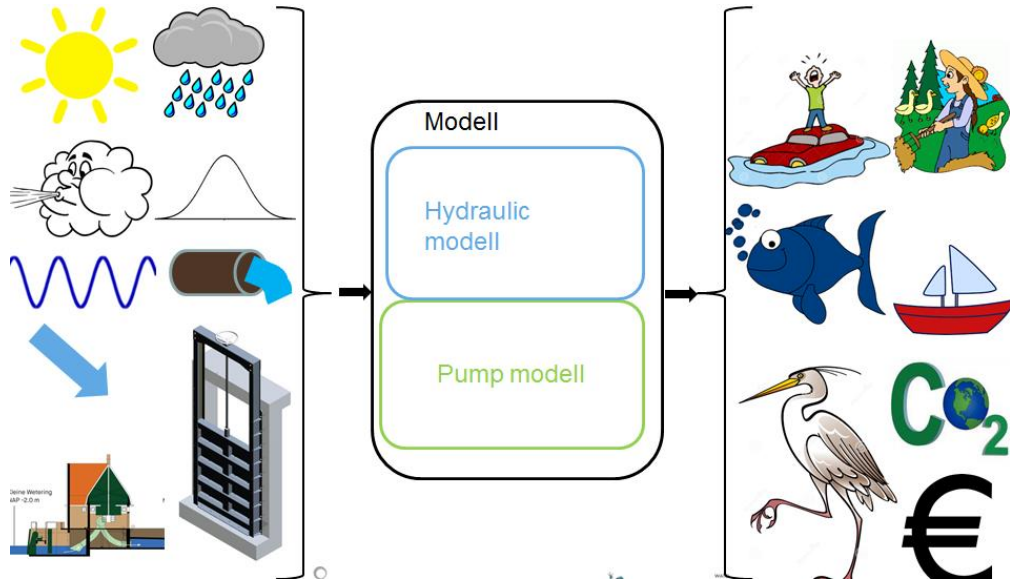
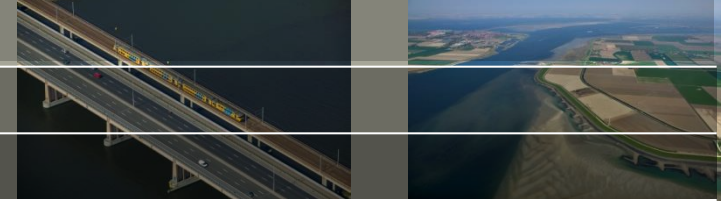
Figure 3.3 Graph of  $f(x, y) = x^2/y$ .



# Convexity



# What have we seen so far?



3 pumps, no interaction

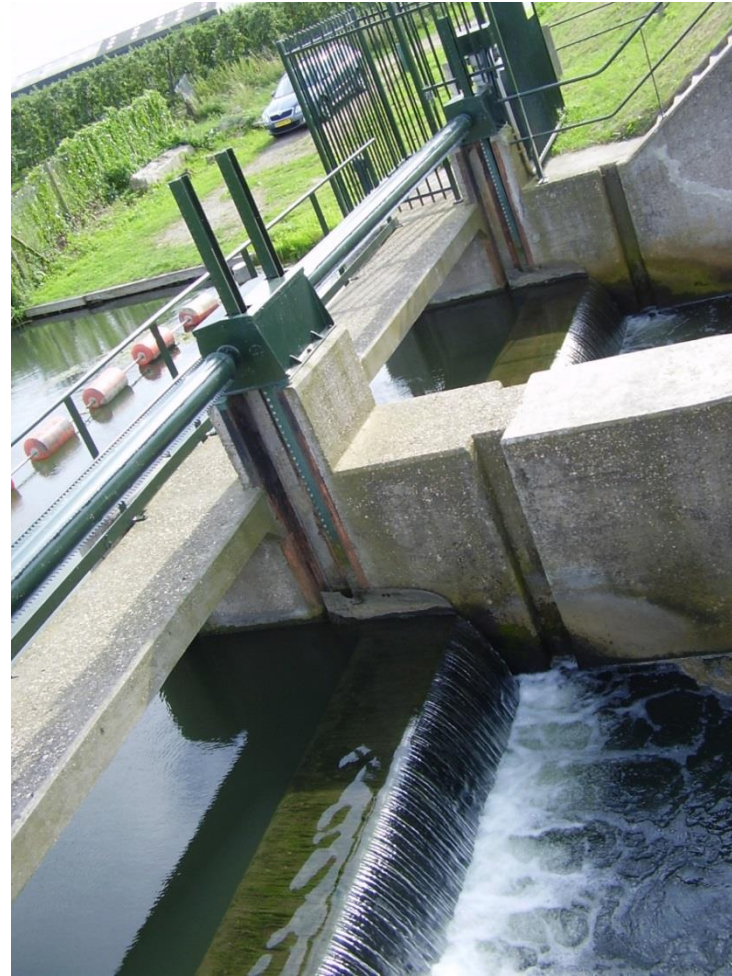
$$(2^{24})^3 \approx 5 * 10^{21}$$



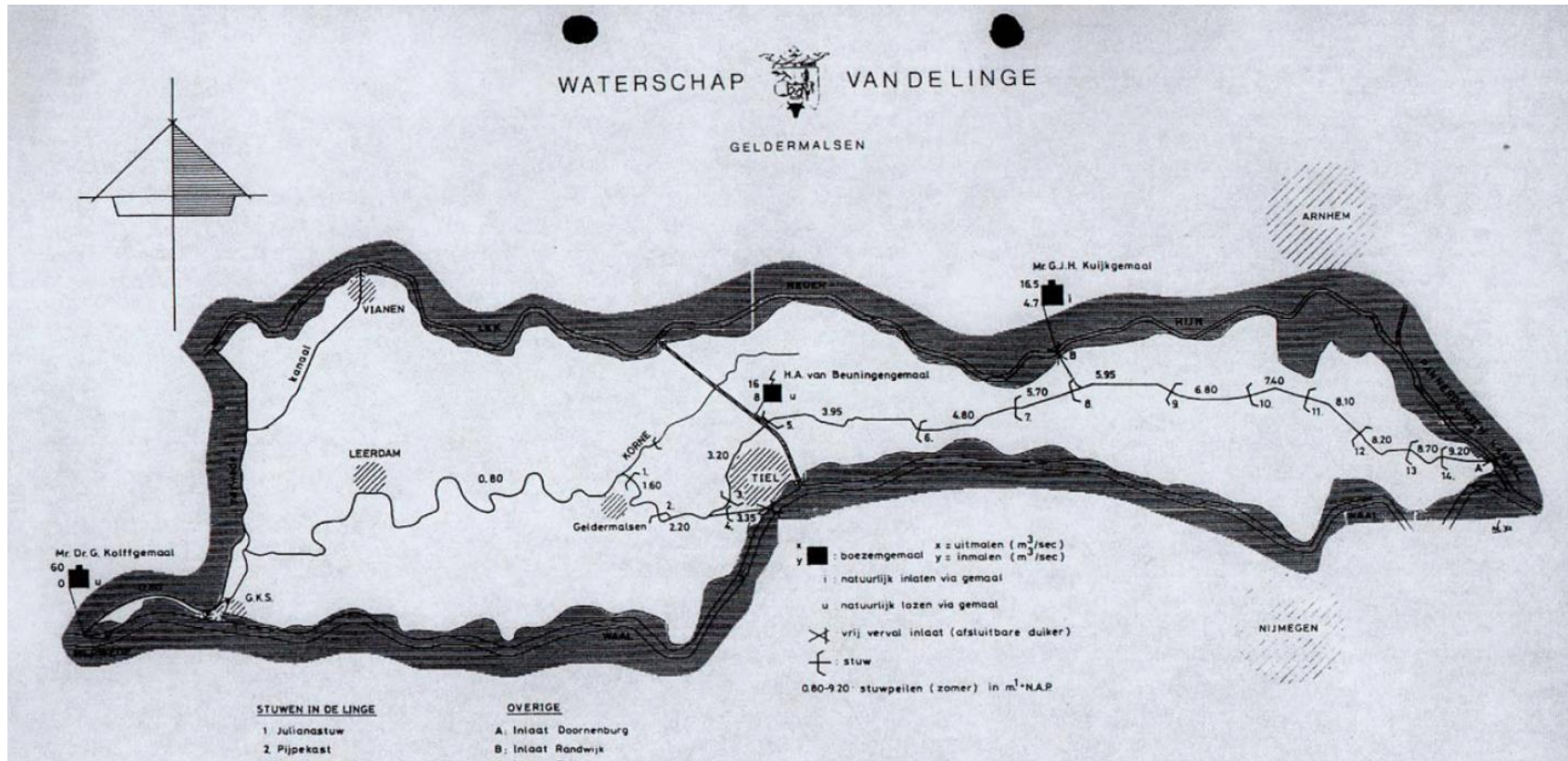
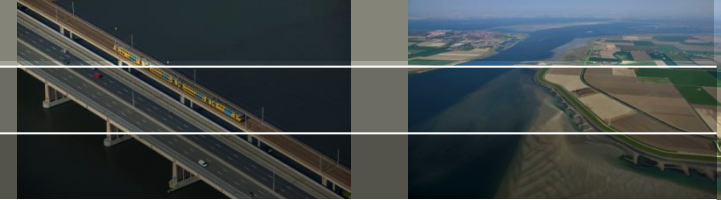
5000 trillion



# What is coming?

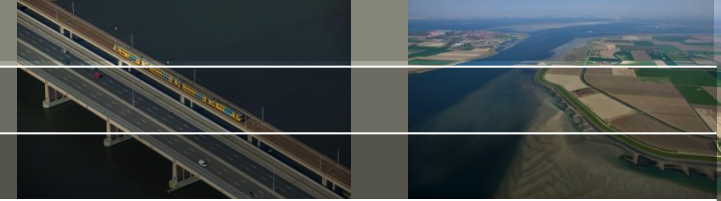


# Pilot Rivierenland

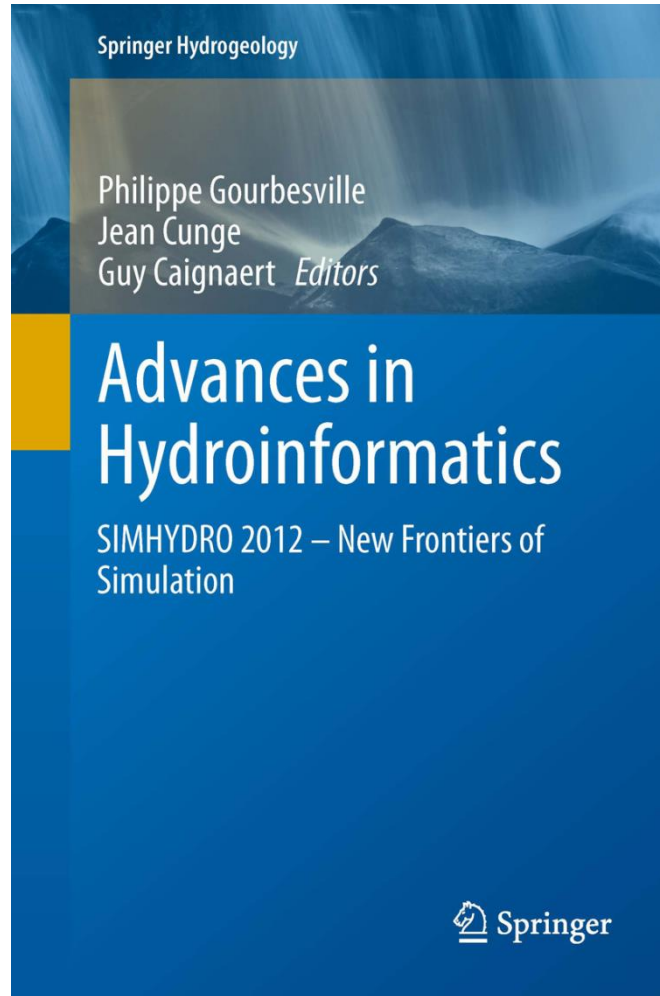




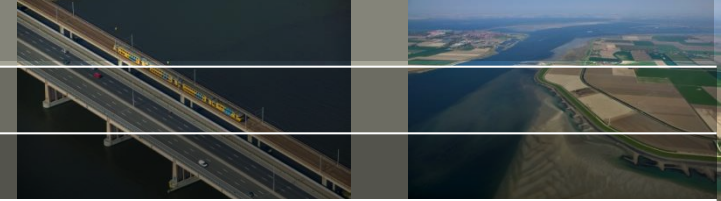
# Hydraulics



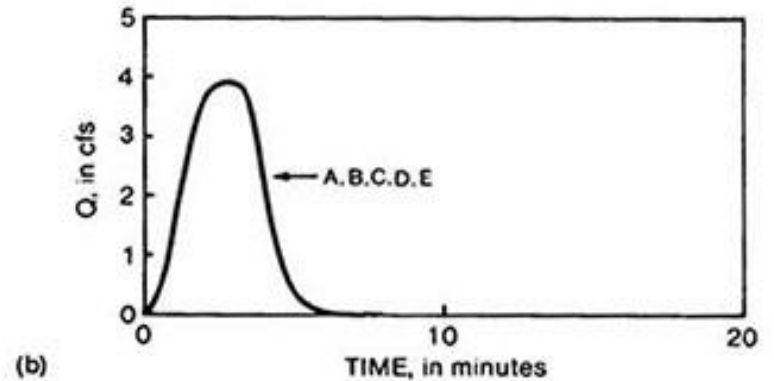
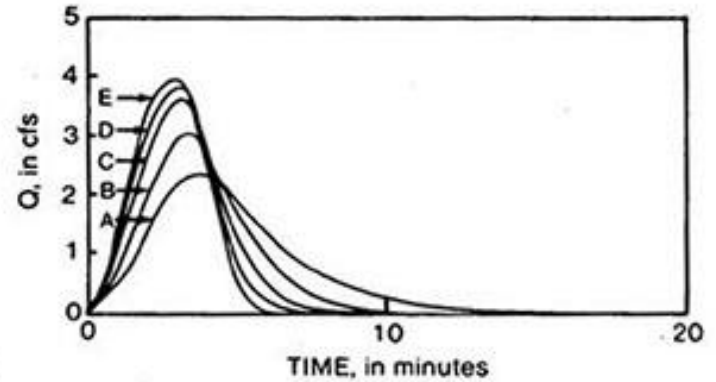
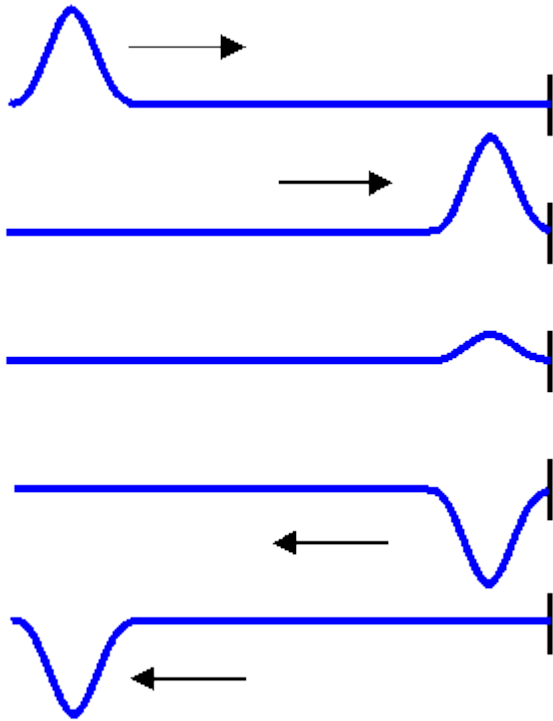
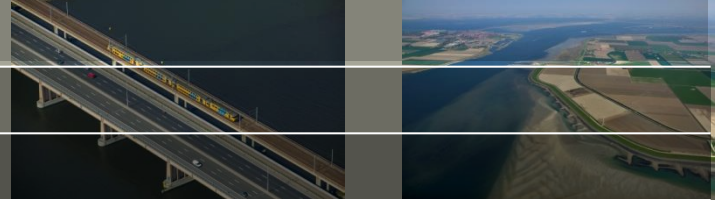
# Publication

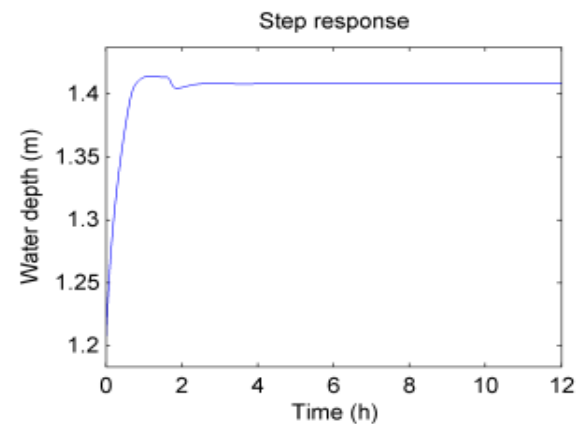
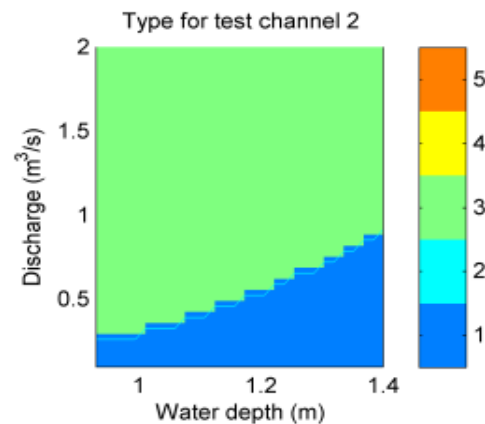
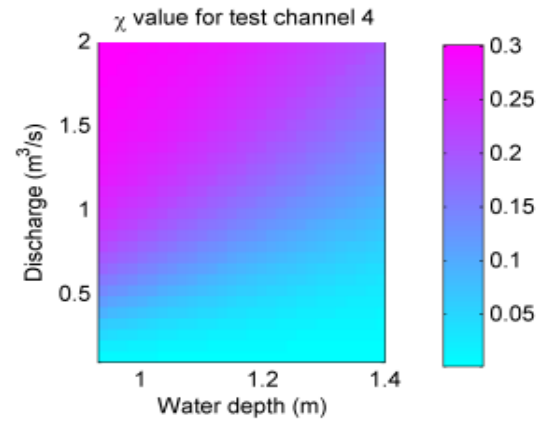
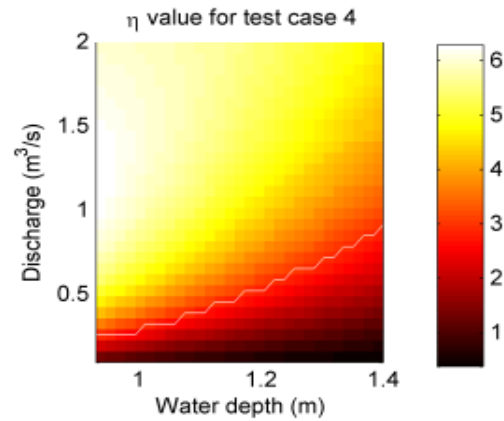
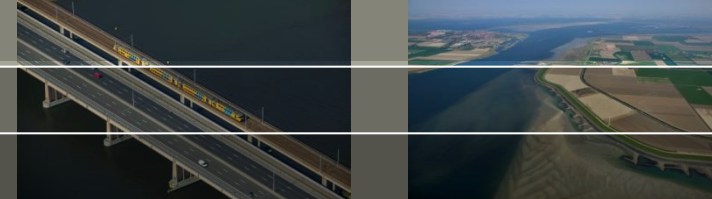


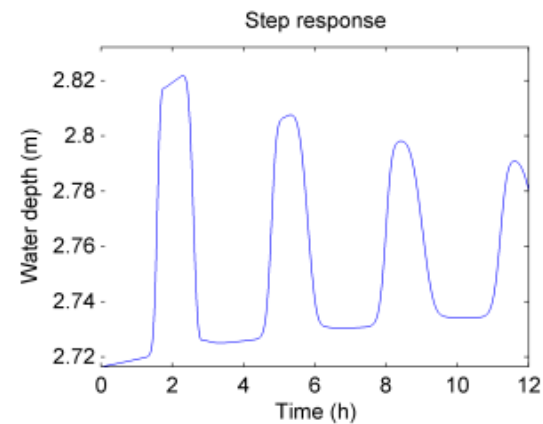
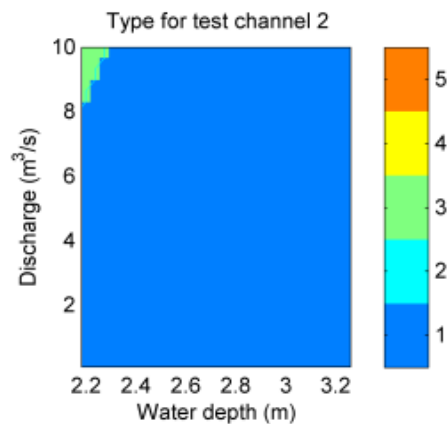
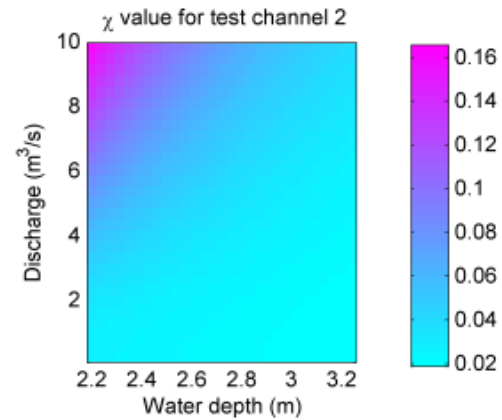
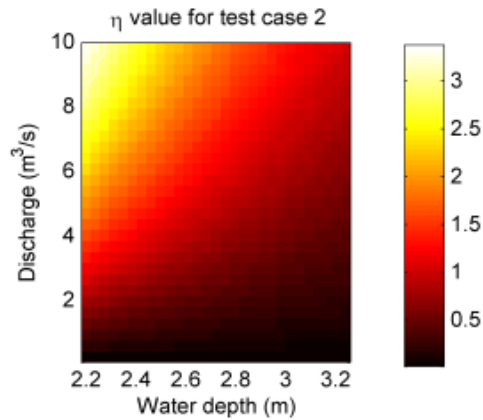
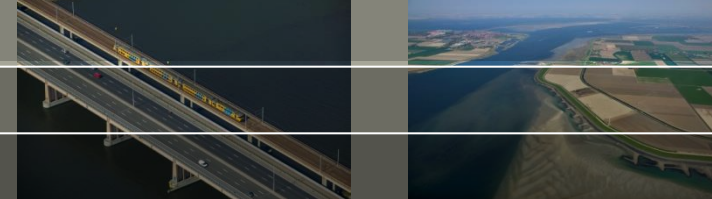
# Open water channels



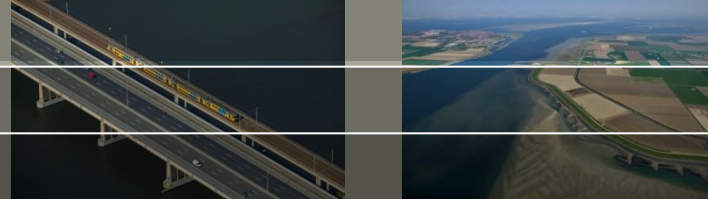
# Caterorisation







# Application



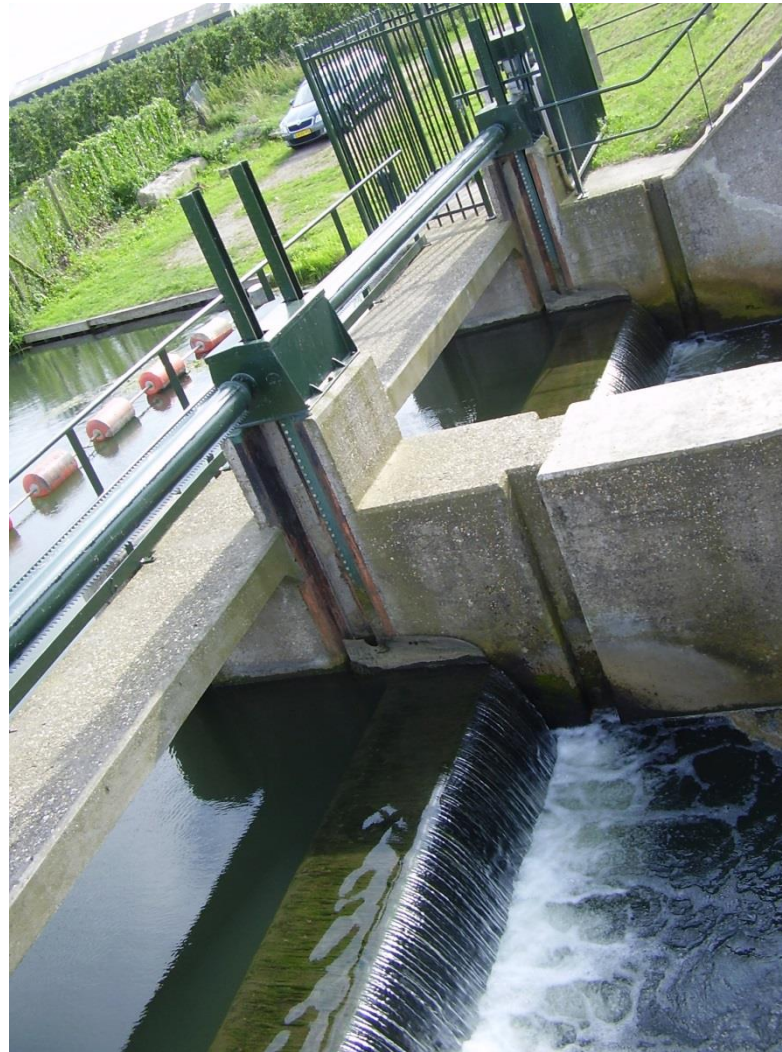
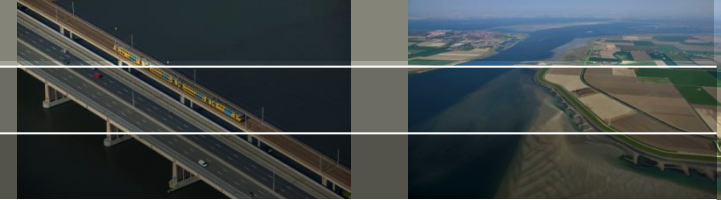
Geometry,  $Q$ ,  $H$

Category

Model choice

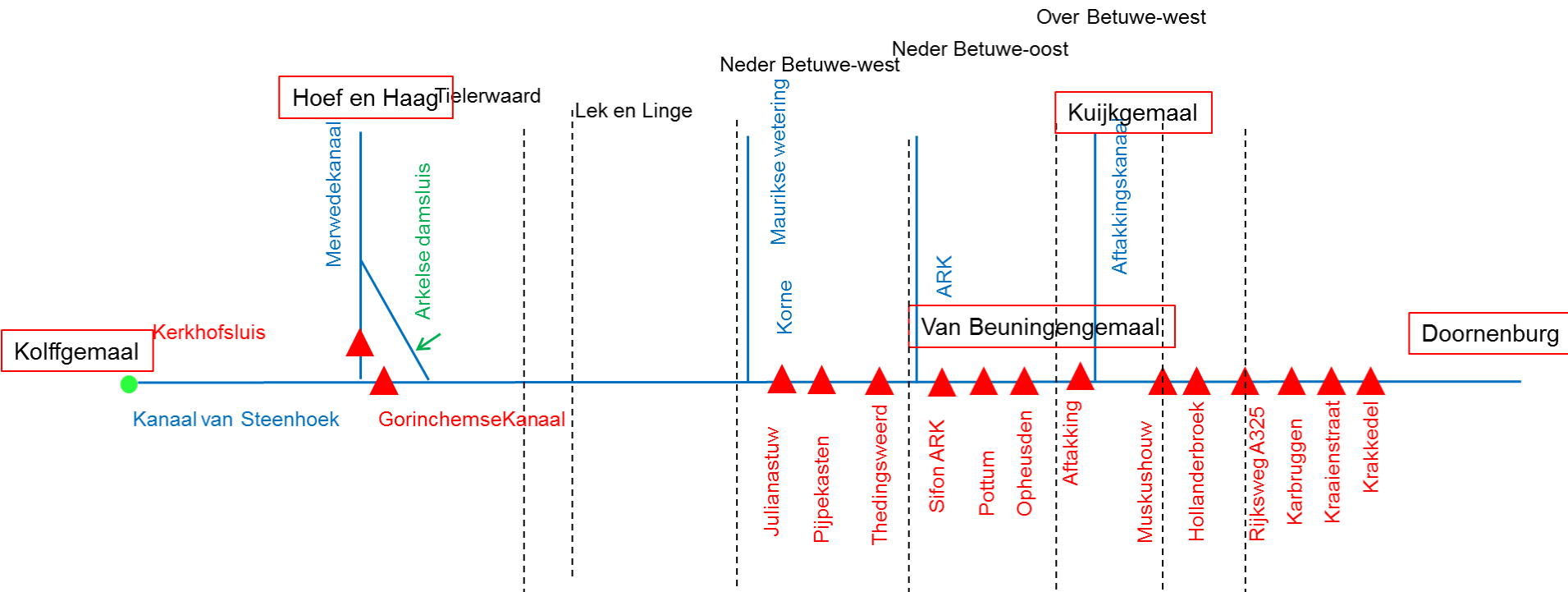
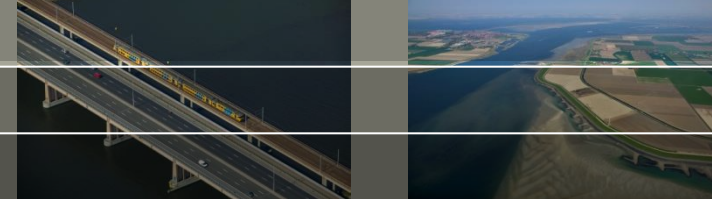


# Hydraulic structures

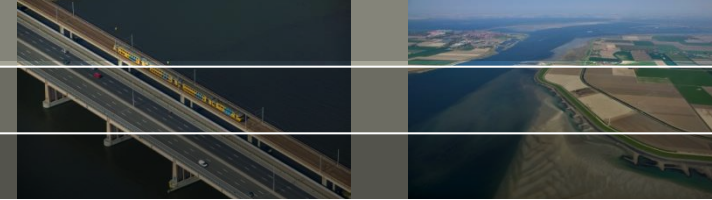




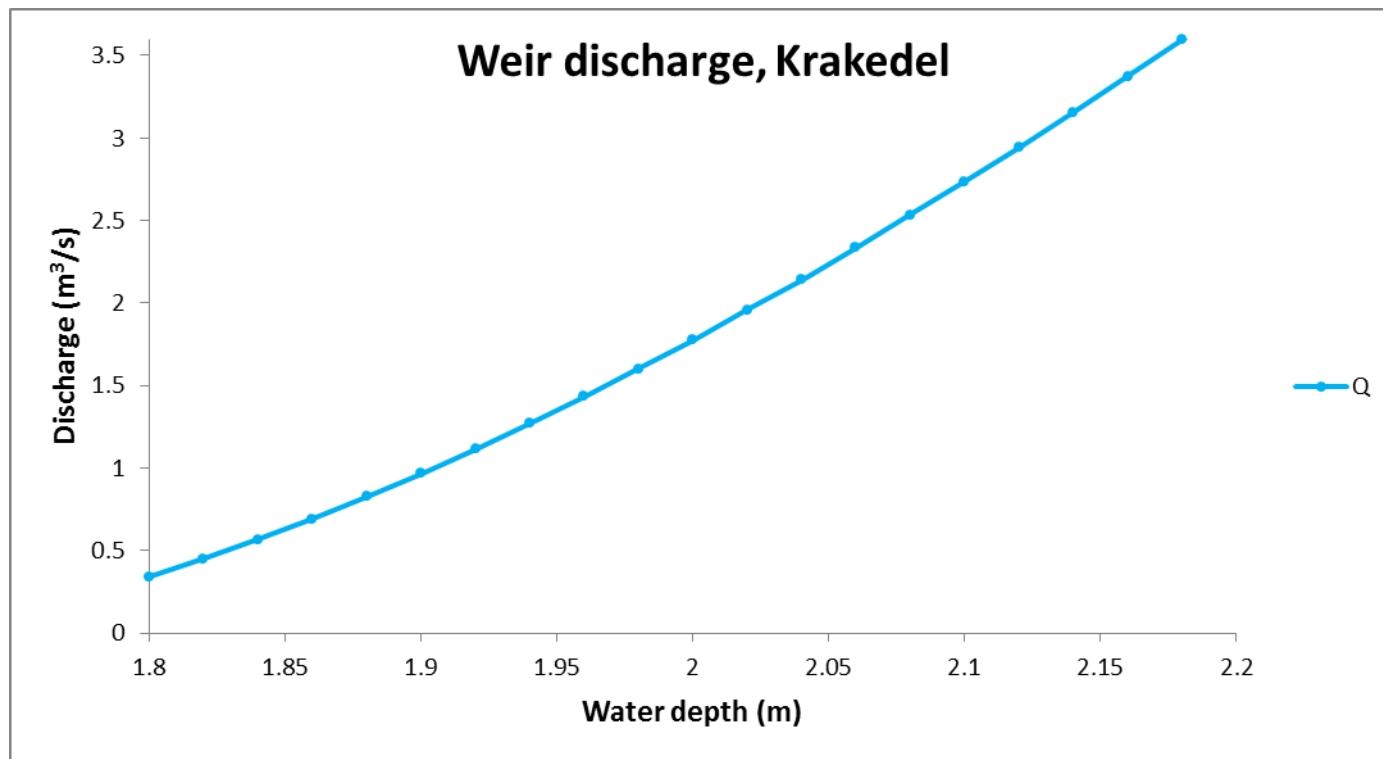
# Linge



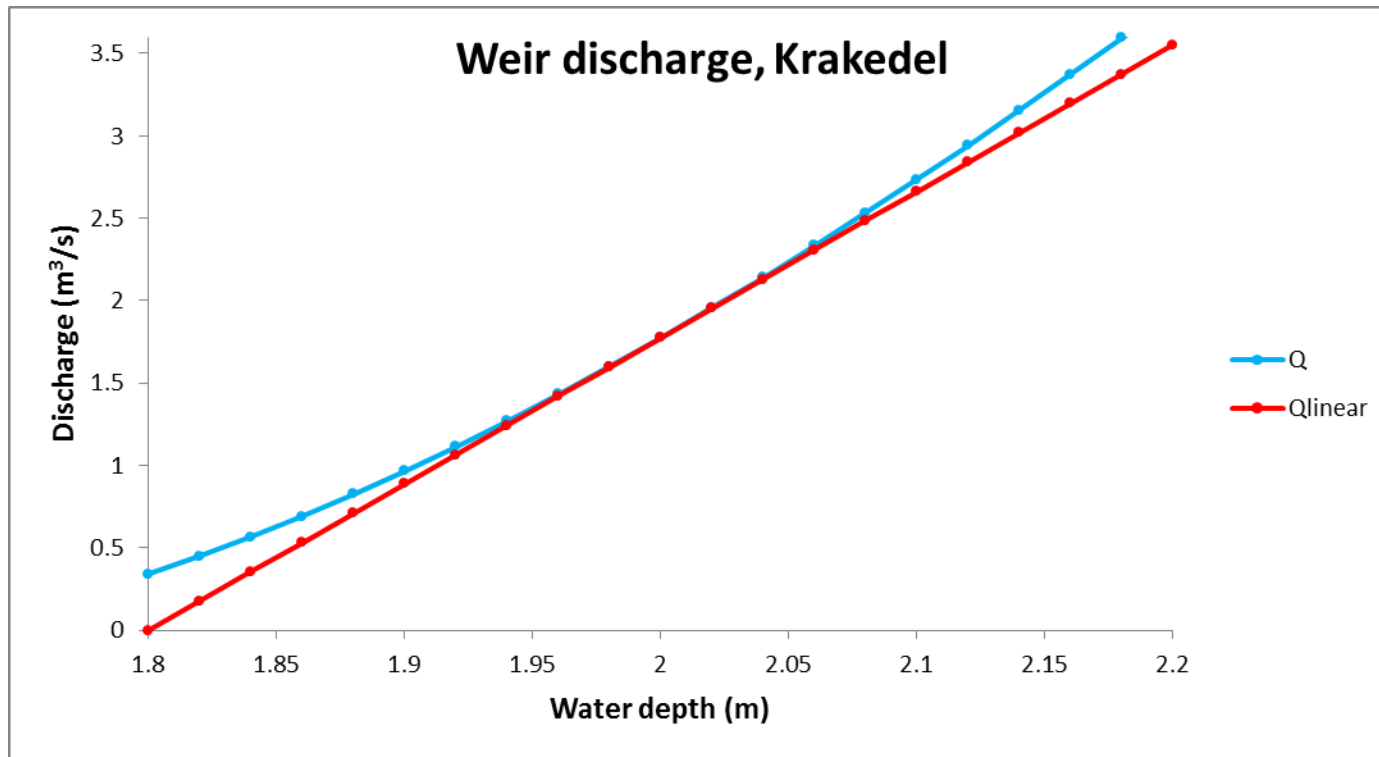
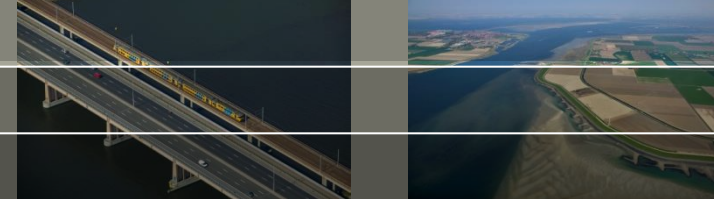
# Krakedel



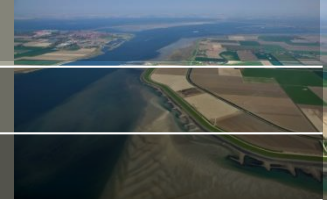
$$Q = 0.61B \frac{2}{3} \sqrt{2g} (H_{up} - H_{weir})^{3/2}$$

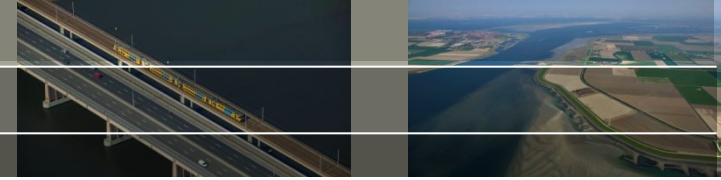


# Weirs

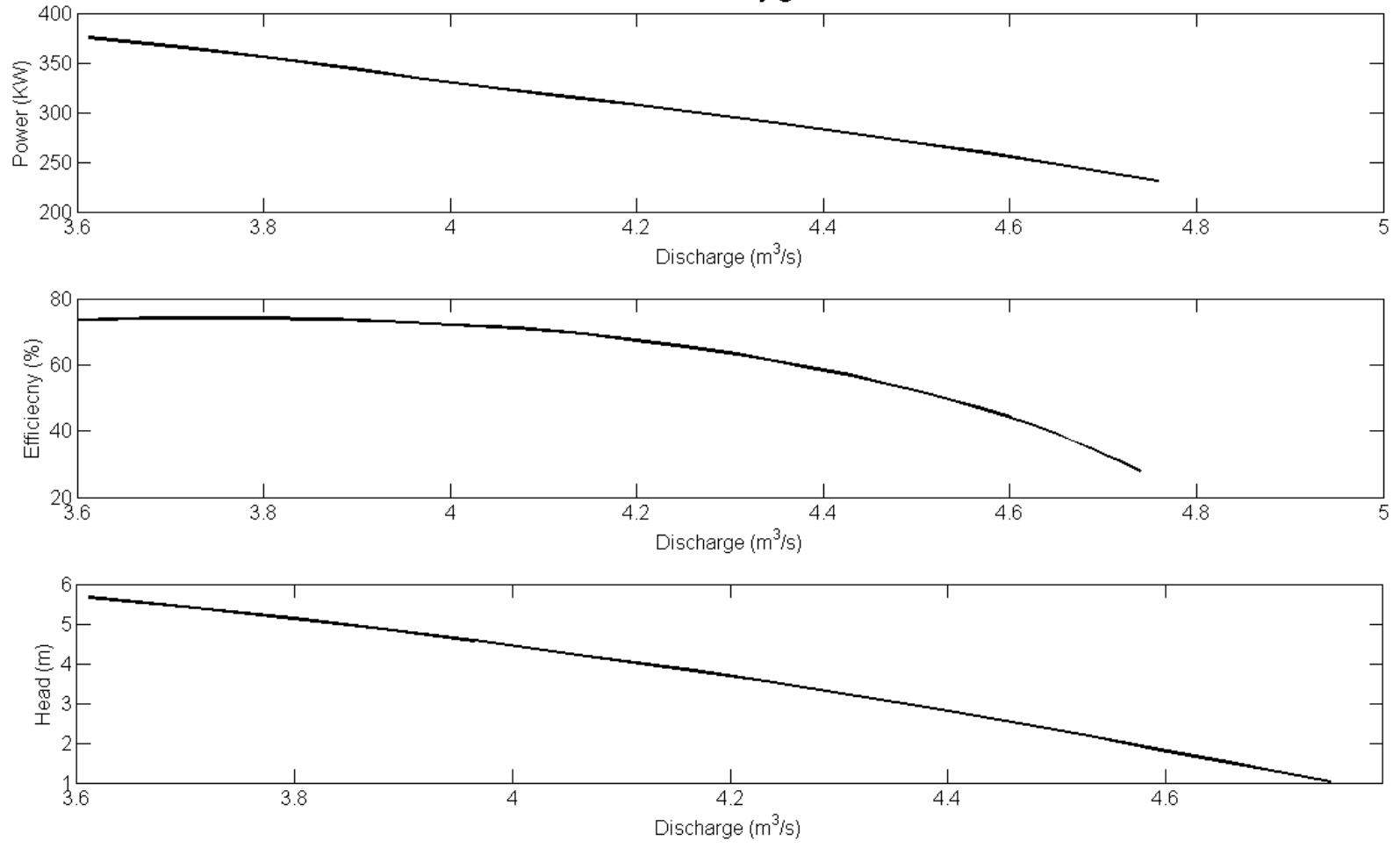


# Pumps

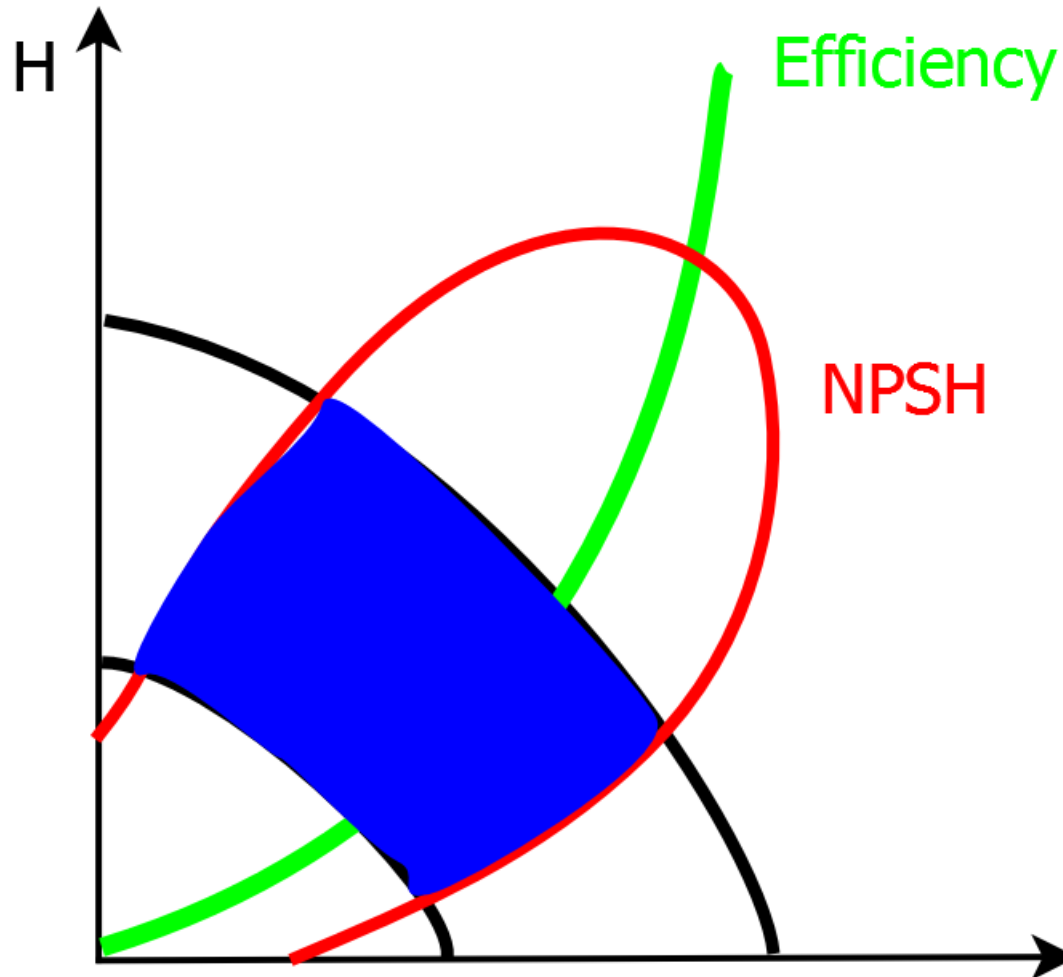
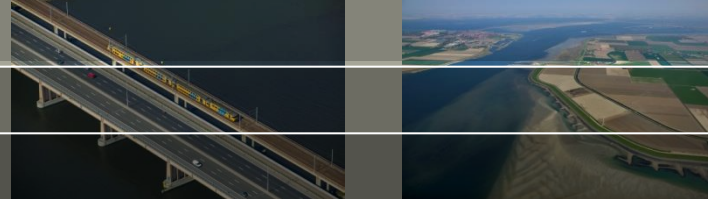




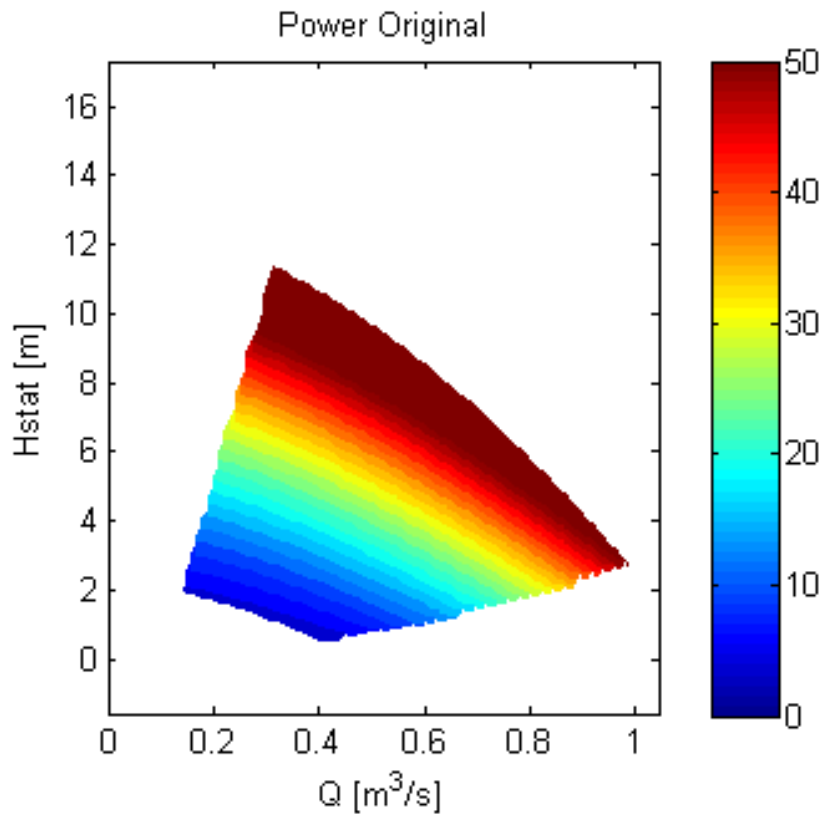
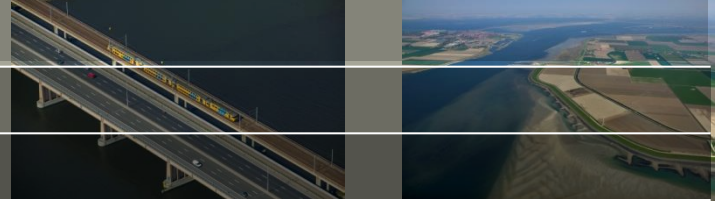
### Mr. G.J.H. Kuijkgemaal



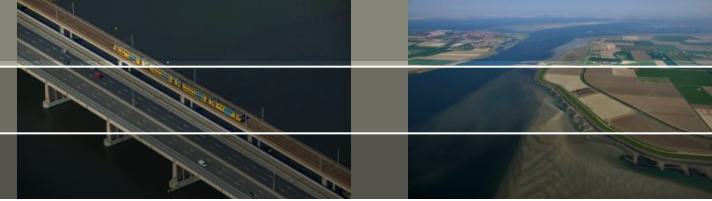
# Working area approximation



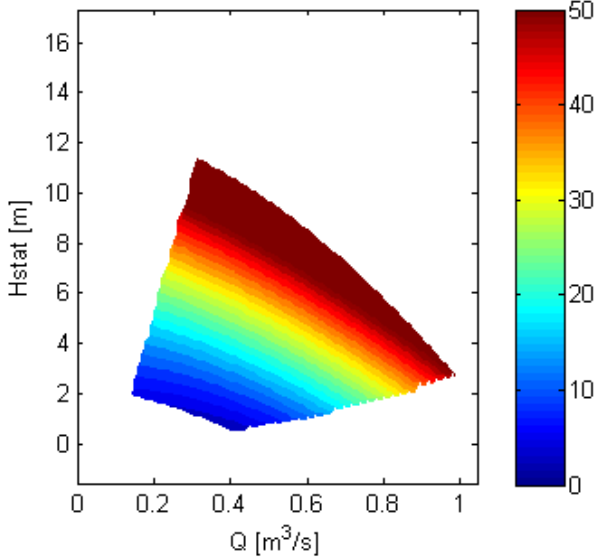
# Power



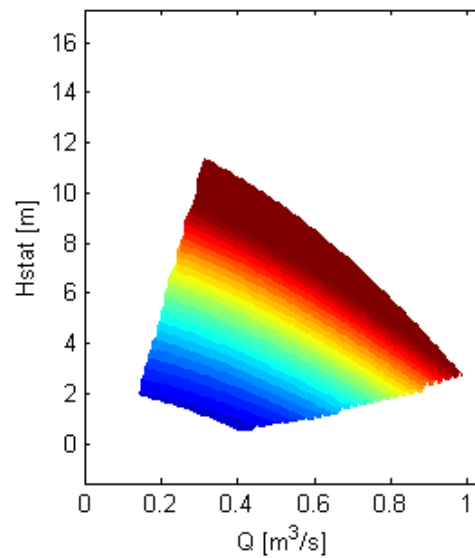
# Power approximation



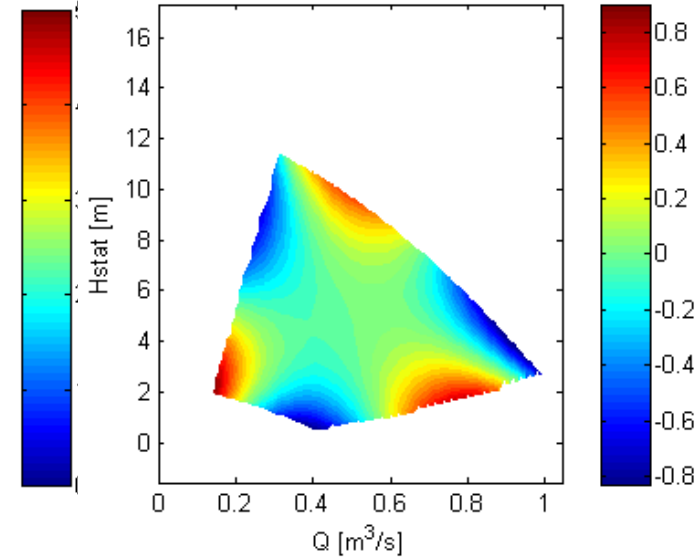
Power Approximation (VWF Liessluis)



Power Original

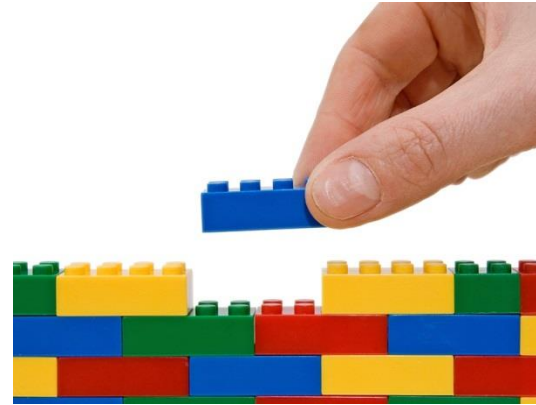
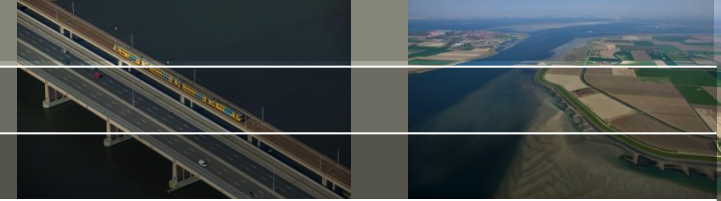


Power Error

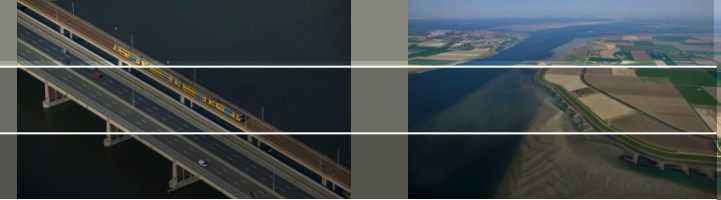




# And next...



# Summary



# Summary

