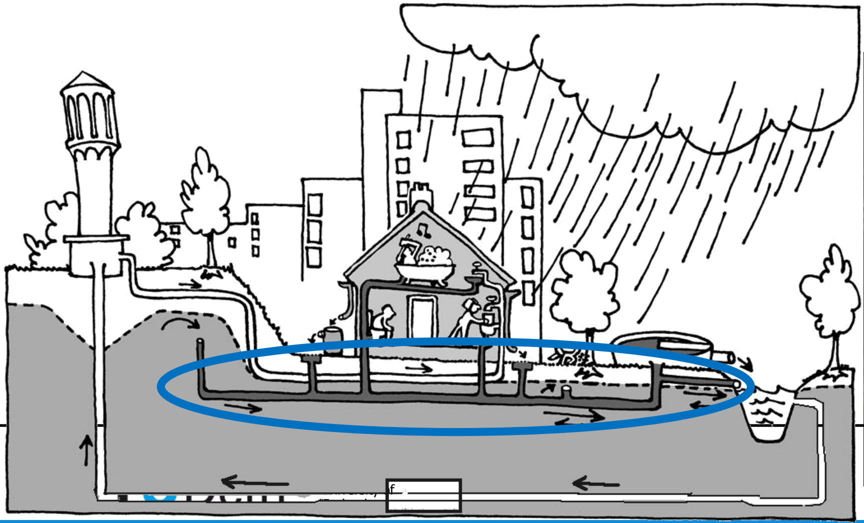
CT4491 Fundamentals of Urban Drainage

Urban drainage in lowland areas

Marie-claire ten Veldhuis,
17-9-2013



Source: news.bbc.co.uk

Source: www.nu.nl

Living in a delta: polder areas and water management challenges

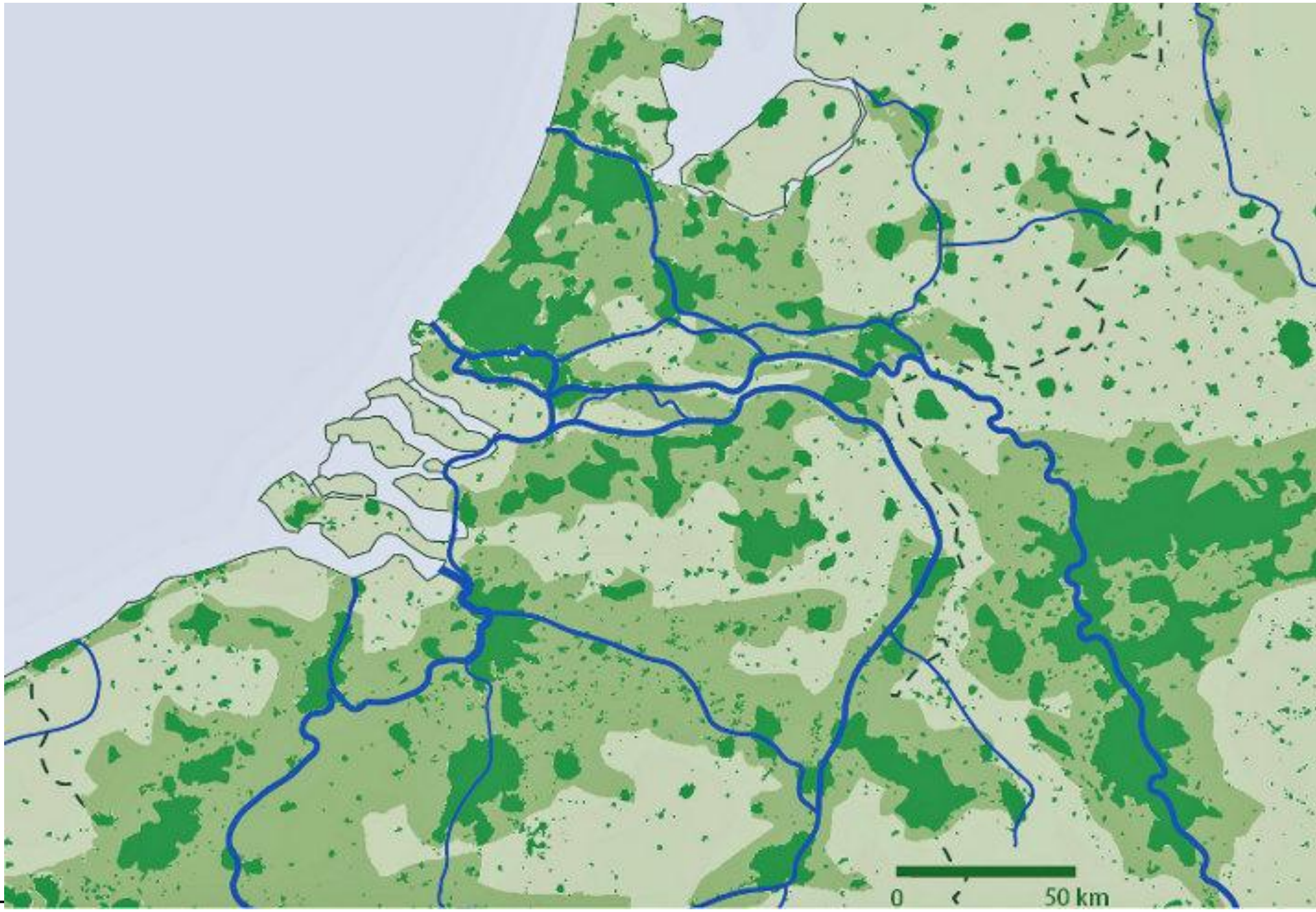
Water management in delta cities

Rotterdam and Jakarta: two examples of delta cities

A. Influence of river and sea on urban water systems
B. Small ground level variations (almost flat)
C. High groundwater tables, salt water intrusion

Rotterdam: moderate climate, annual rainfall ca. 0.9 m/yr
Jakarta: tropical climate, annual rainfall ca. 2 m/yr

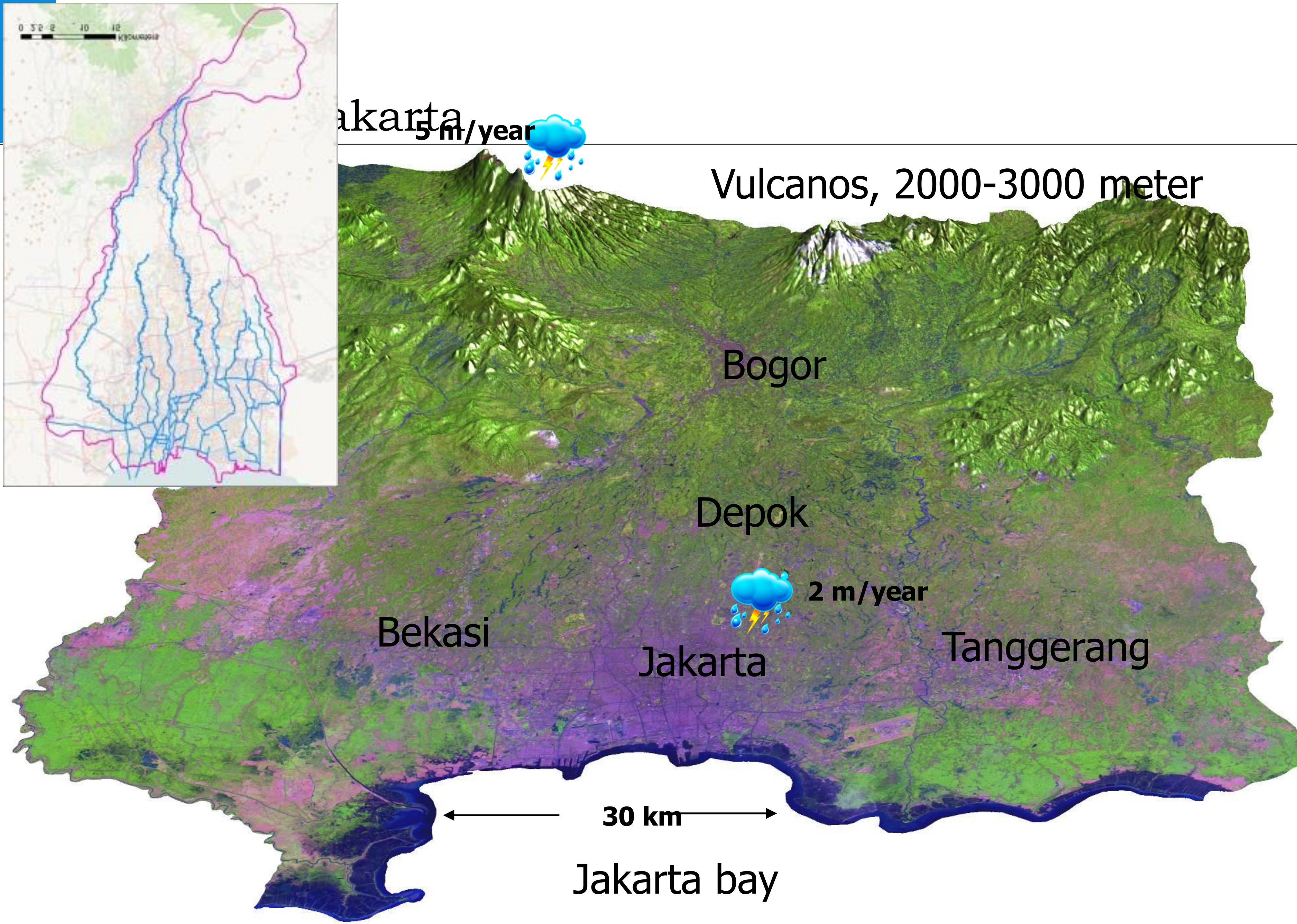
The Netherlands: Rhine, Meuse, Scheldt delta



Darker shades of green indicate higher population density

Source: www.deltanet-project.eu

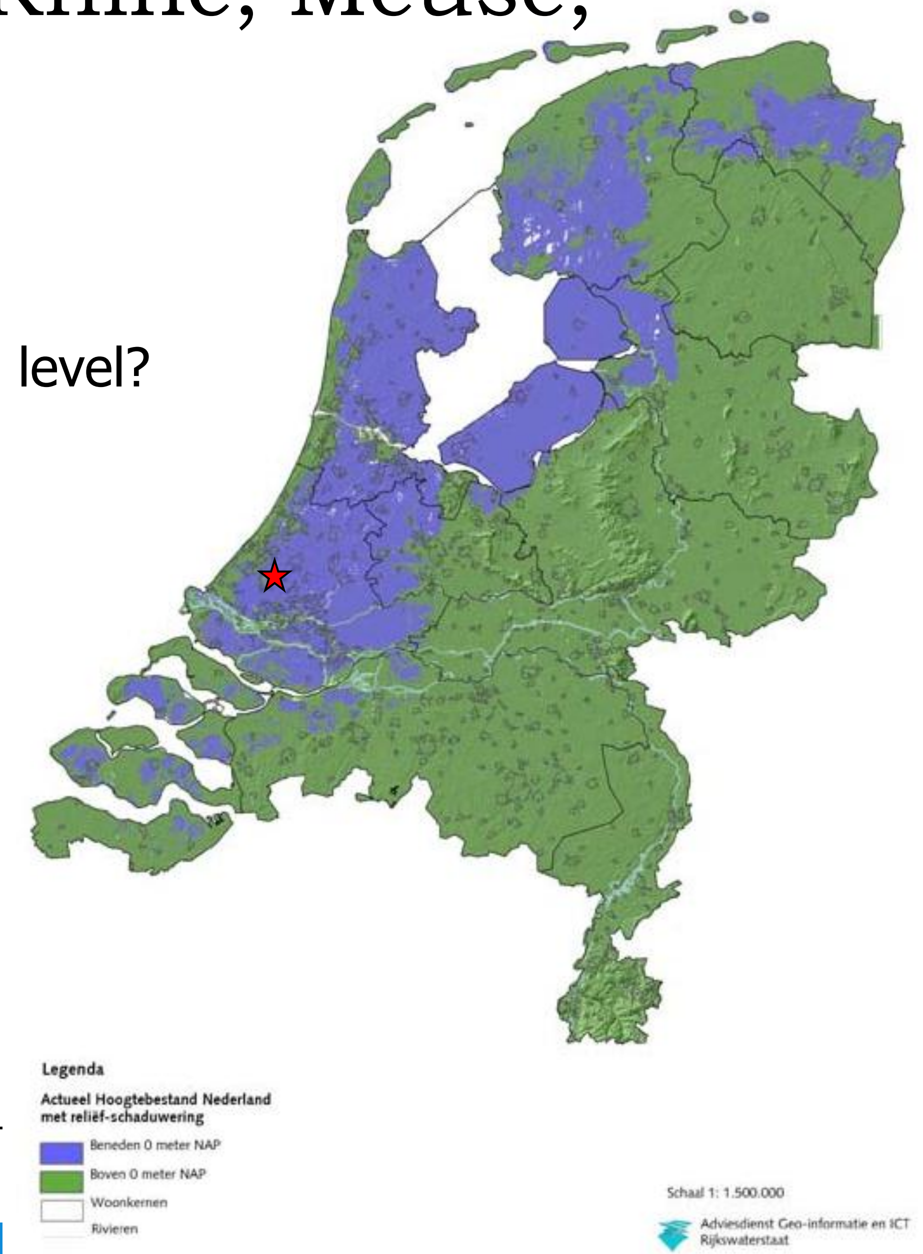
akarta


5 m/year
Vulcanos, 2000-3000 meter
Bogor
Depok
2 m/year
Bekasi
Jakarta
Tanggerang
30 km
Jakarta bay

The Netherlands: Rhine, Meuse, Scheldt delta

Delft: ground level relative to sea level?

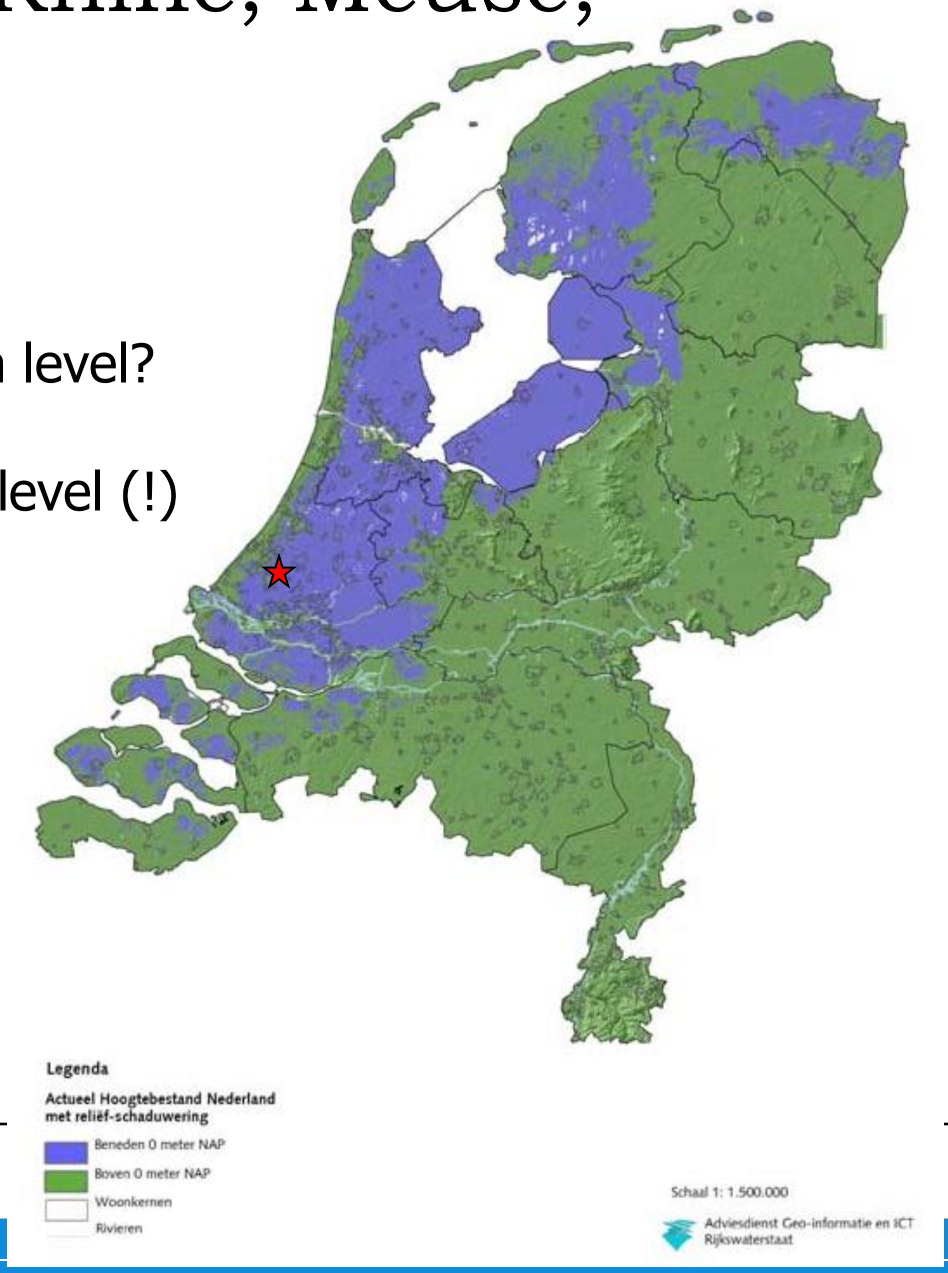
A: +10m
B: +5 m
C: 0 m
D: -5 m
E: -10 m
F: Other



The Netherlands: Rhine, Meuse, Scheldt delta

Delft: ground level relative to sea level?

0.5 to 5 meters below mean sea level (!)

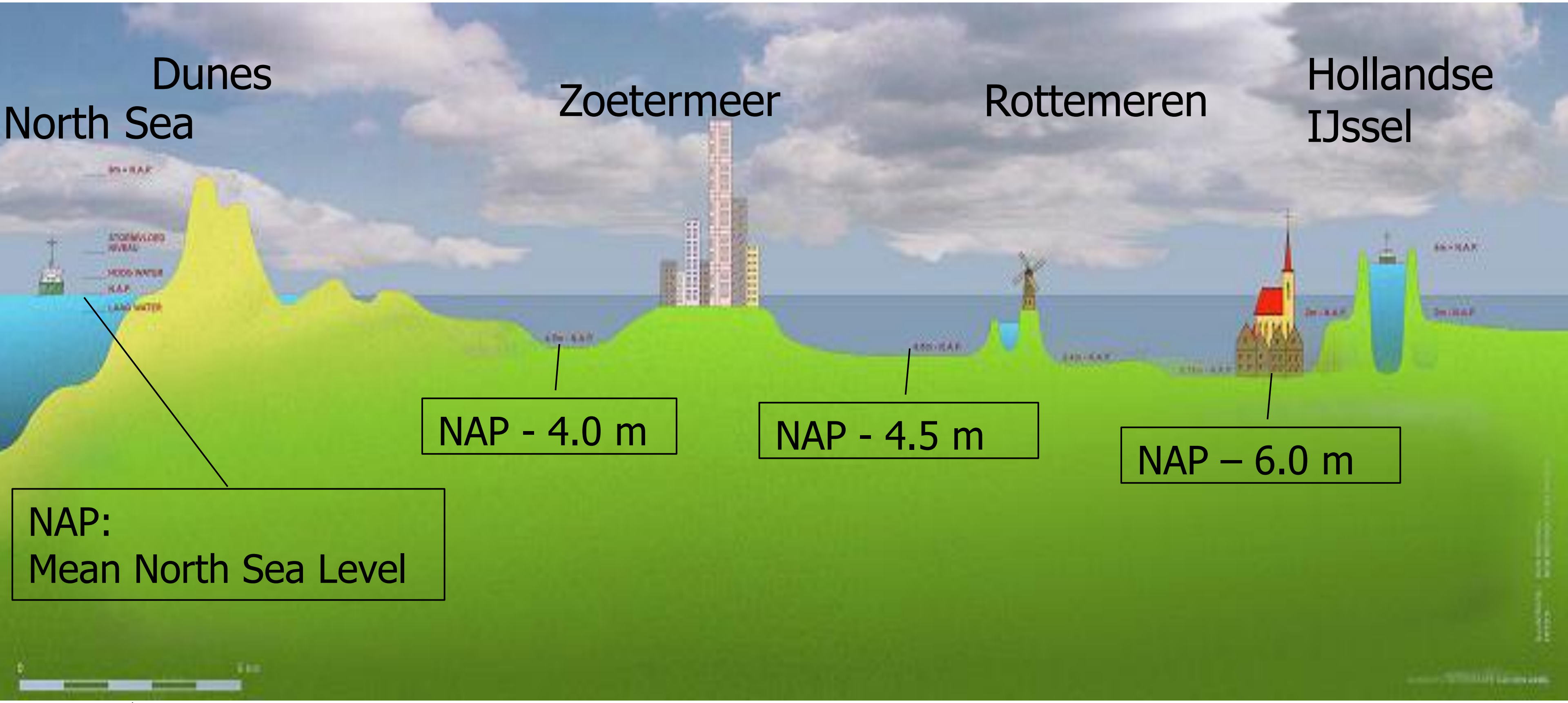


Deltas, if dikes do not protect

Influence of sea level

Influence of sea + river levels

Watersystems in the Dutch delta



Jakarta

Pluit - November 26, 2007

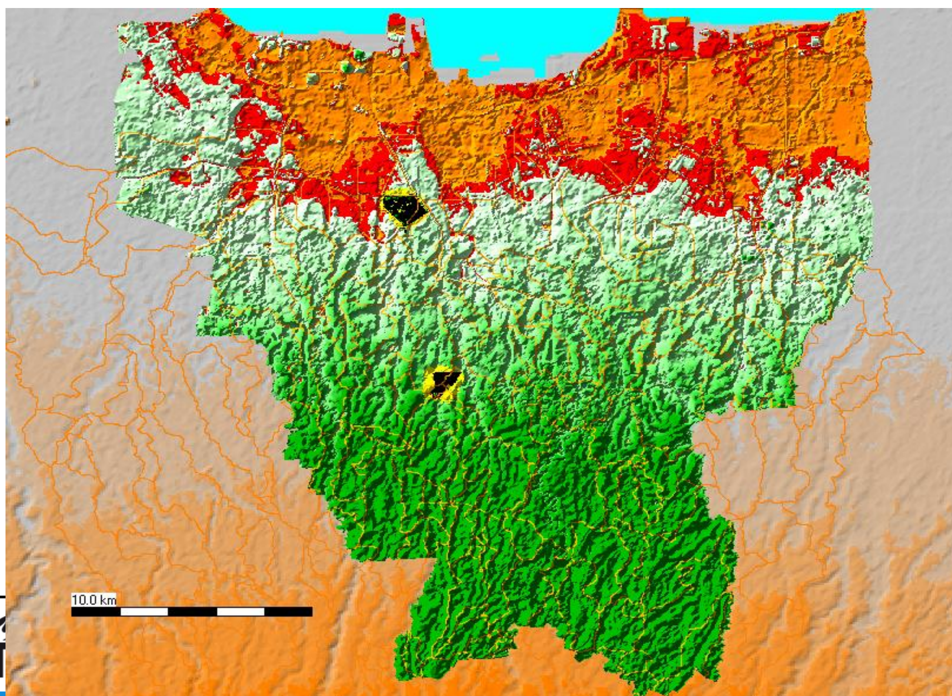
Jakarta
Pluit - February 2011
(Water level 2.28m)

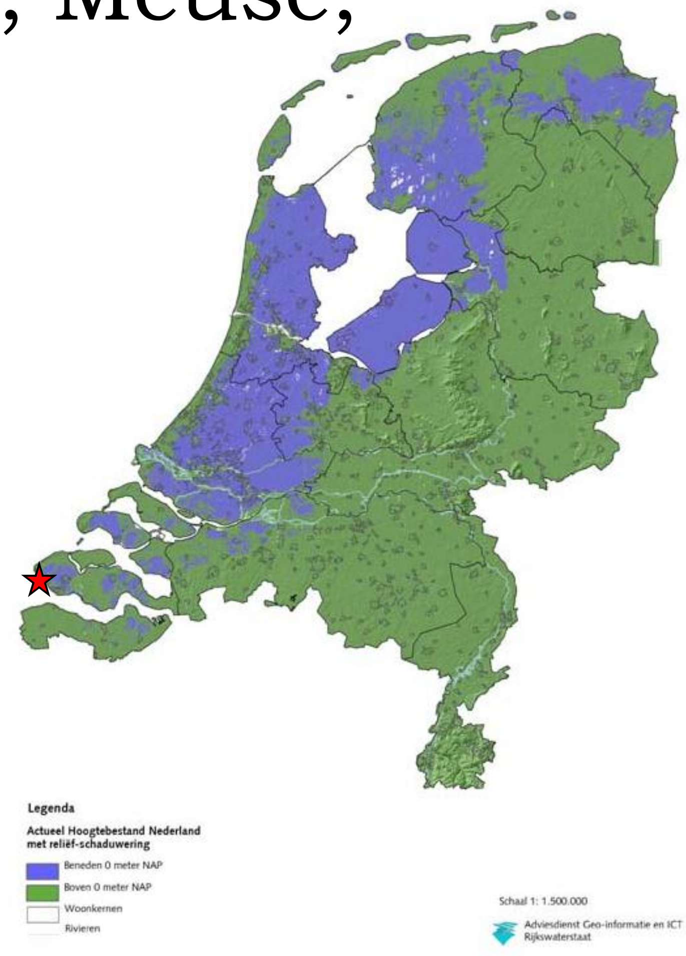
- ➢ Jakarta: ground level relative to sea level?

The Netherlands: Rhine, Meuse, Scheldt delta

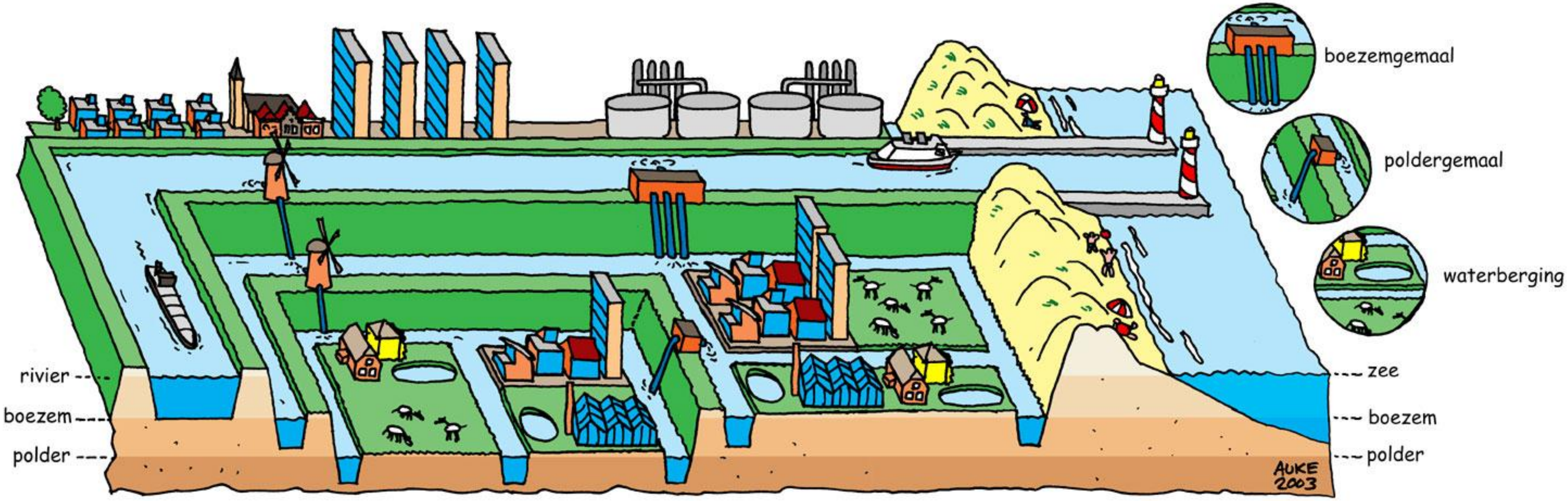
Delft: ground level relative to sea level?
0.5 to 5 meters below mean sea level

Jakarta: average 7 m + sea level
➢ 40% of Jakarta below sea level

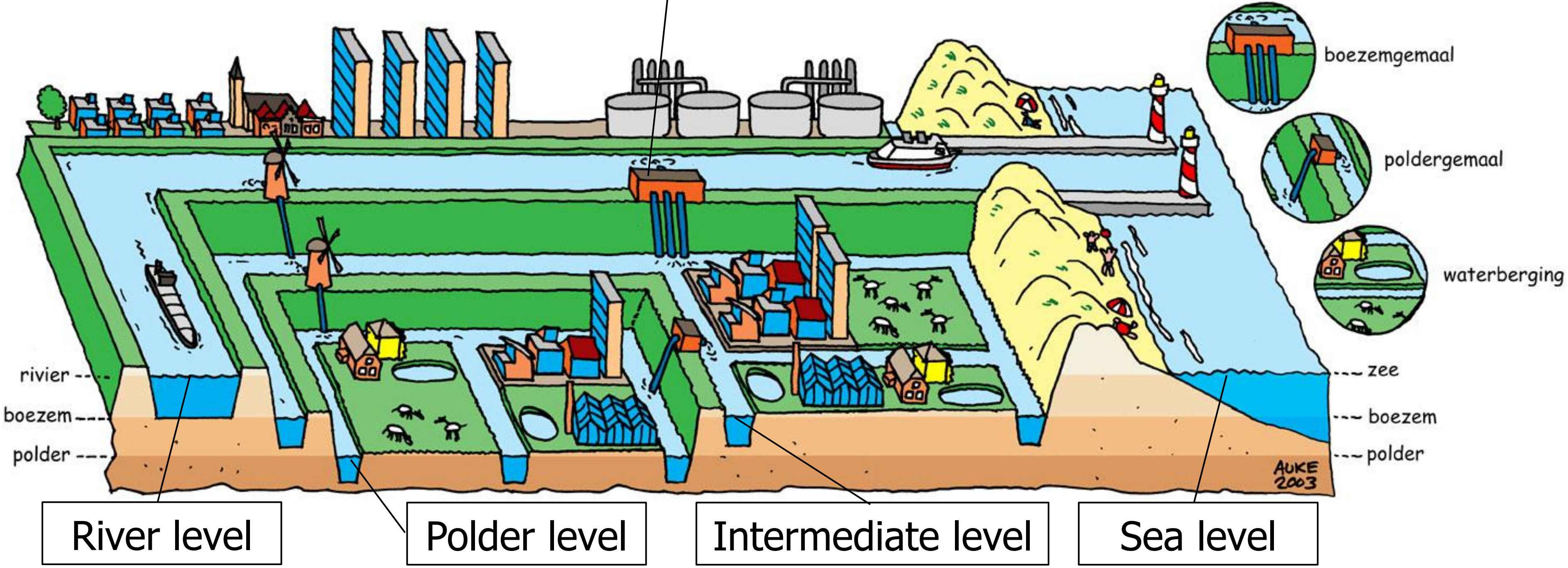


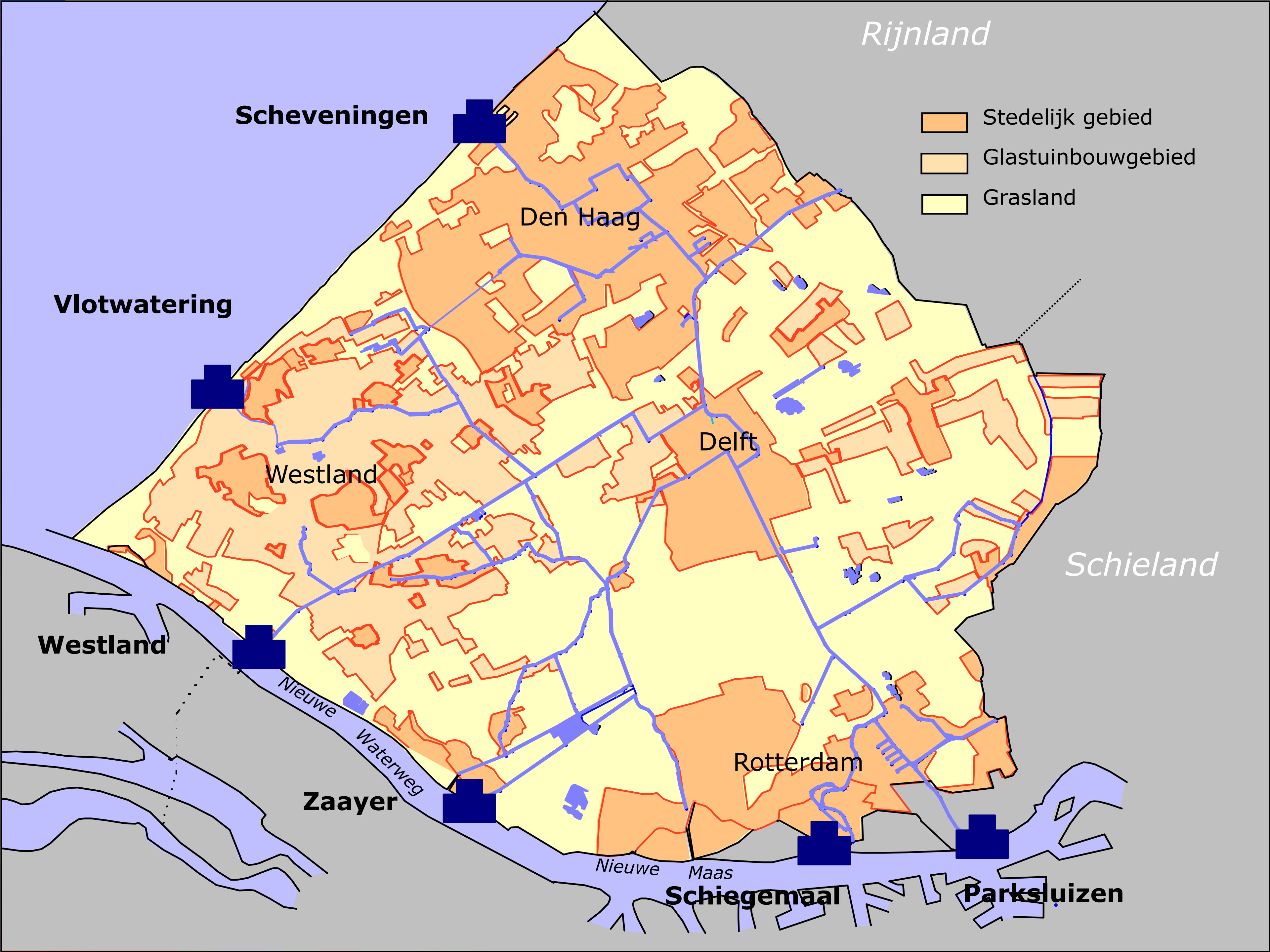


Deltas with protection: dikes and polders



Deltas with protection: dikes and polders




Rijnland
Stedelijk gebied
Glastuinbouwgebied
Grasland
Scheveningen
Den Haag
Vlotwatering
Westland
Delft
Schieland
Westland
Nieuwe Waterweg
Zaayer
Rotterdam
Nieuwe Maas
Schiegemaal
Parksluizen

Delft area, dikes for flood protection:

- Sea defence works (23 km)
- River dikes (31 km)
- Polder dikes (655 km)

If this were 1 continuous straight line of dikes, what European capitals could we reach?

Delft area, dikes for flood protection:

- Sea defence works (23 km)
- River dikes (31 km)
- Polder dikes (655 km)

Total: 709km

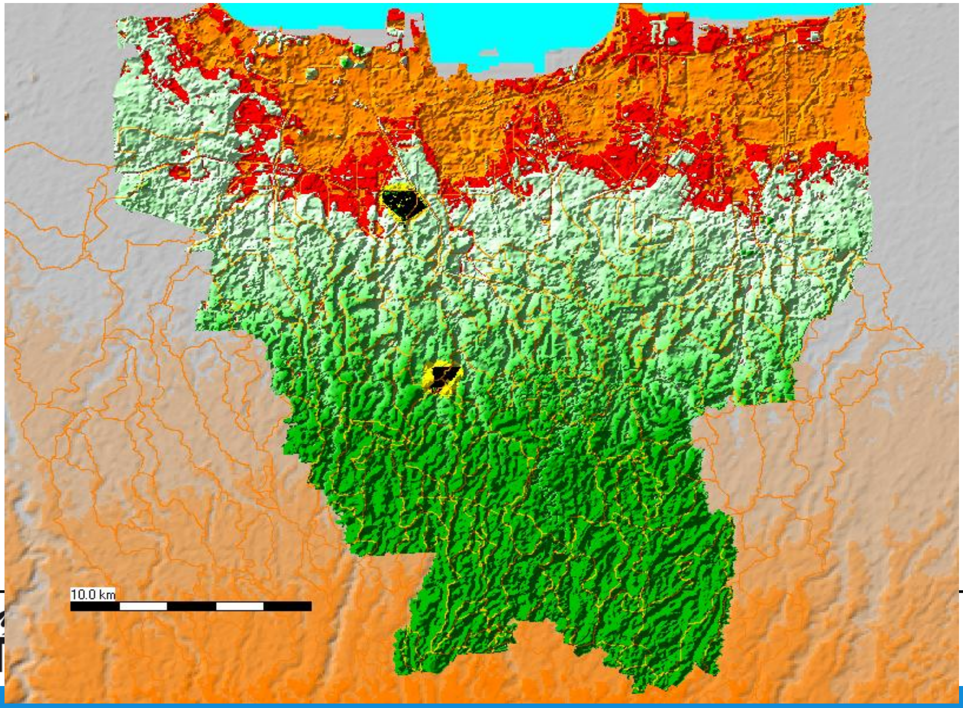
- Delft-Paris: 463 km
- Delft-Berlin: 702 km
- Delft-London: 492 km

A lot of dikes to maintain or enlarge!

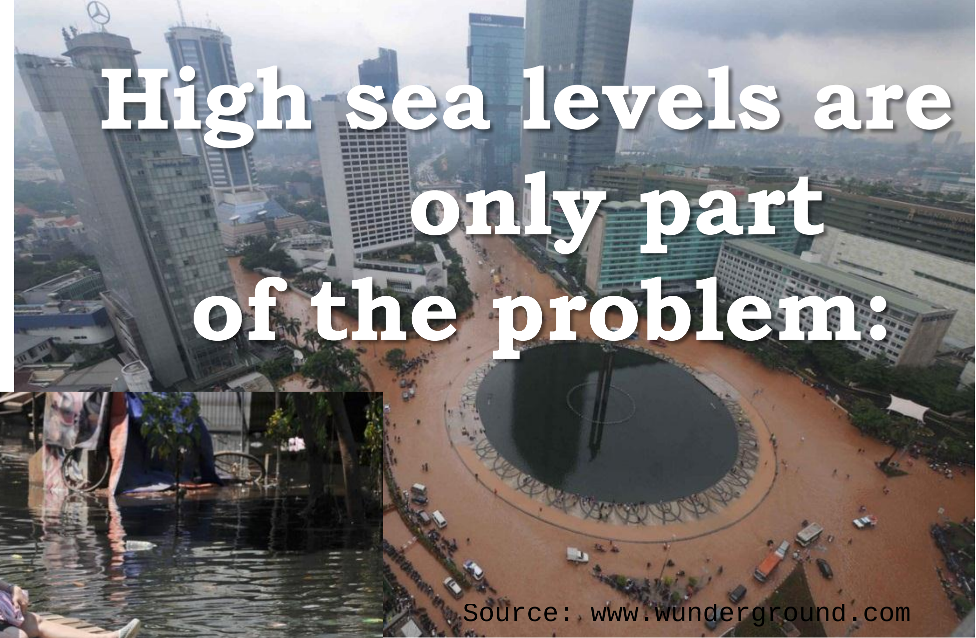
Dikes for flood protection

Delft: 0.5 to 5 meters below mean sea level
709 km of dikes to protect surrounding delta area

Jakarta: 40% or urbanised area below sea level
➢ Should a similar solution be implemented here?



High sea levels are only part of the problem:

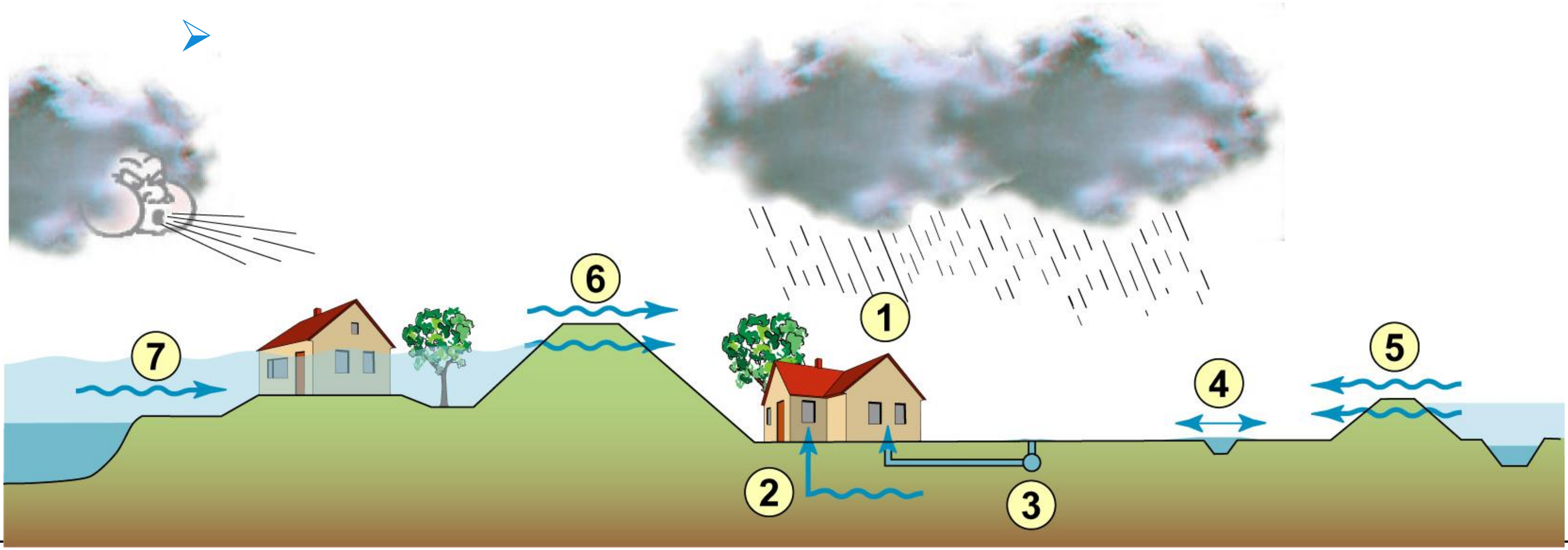


Jakarta, Jan 2013:
extreme rainfall

Water management challenges in deltas

Water comes from all sides:

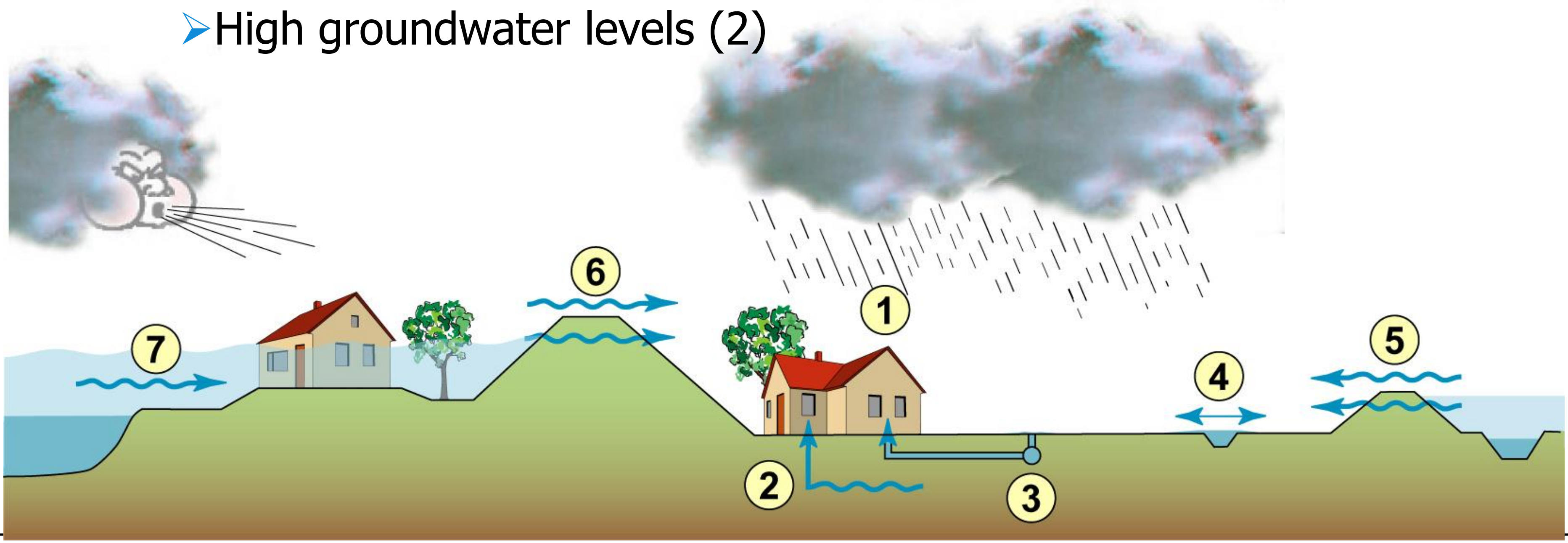
-
-
- Make a list: 7 water problems in deltas
-
-
-



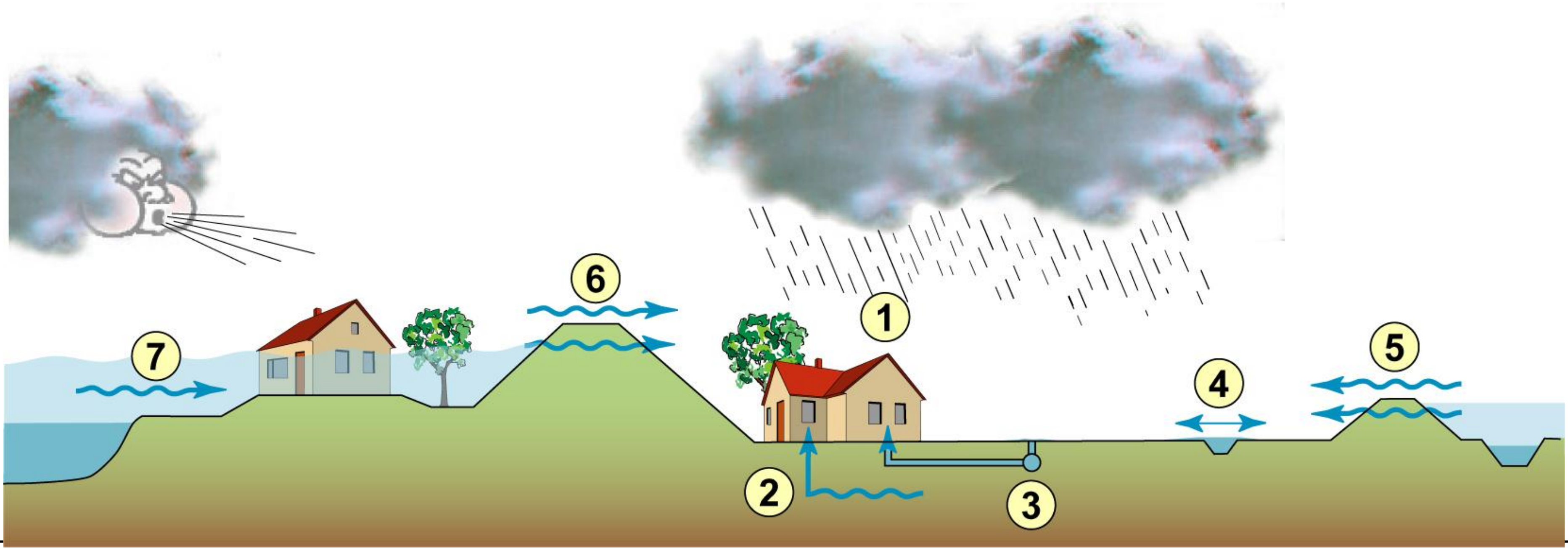
Water management challenges in deltas

Water comes from all sides:

- High sea levels (6, 7)
- High river levels (5)
- Heavy rainfall (1)
- High surface water levels (in polder and regional water system) (4)
- Urban drainage system overloading (3)
- High groundwater levels (2)



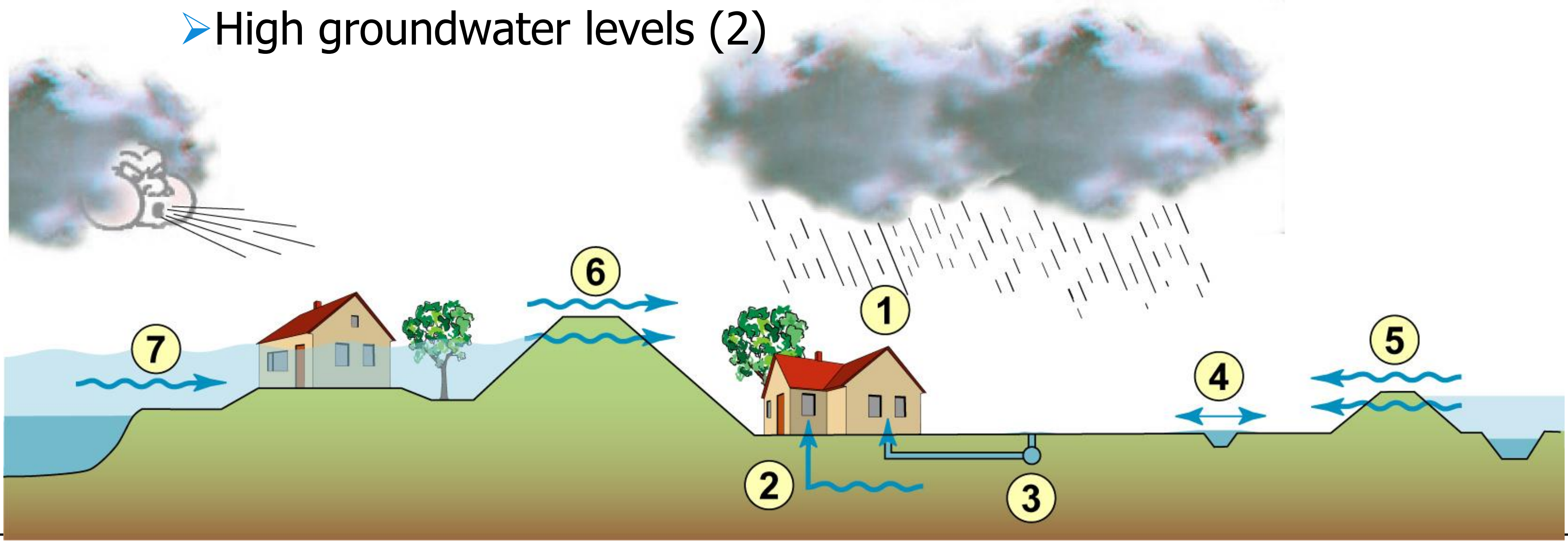
Climate change: growing challenges



Climate change: growing challenges

What growing challenges due to climate change for:

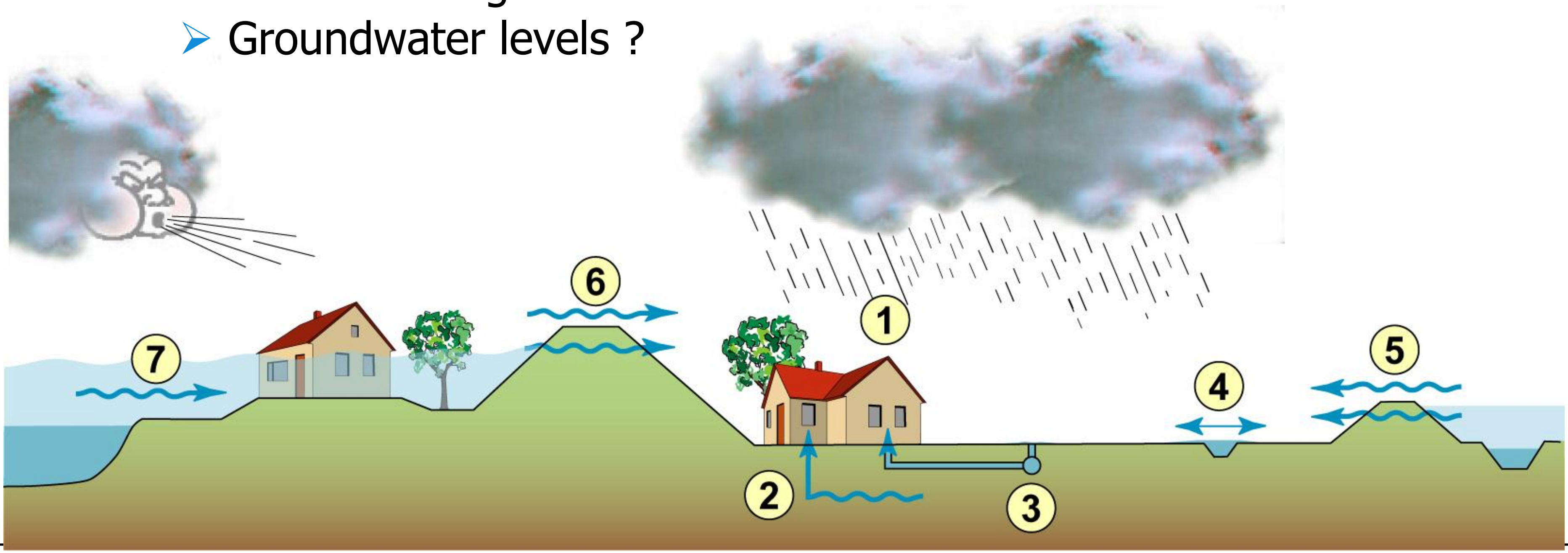
- High sea levels (6, 7)
- High river levels (5)
- Heavy rainfall (1)
- High surface water levels (in polder and regional water system) (4)
- Urban drainage system overloading (3)
- High groundwater levels (2)



Climate change: growing challenges

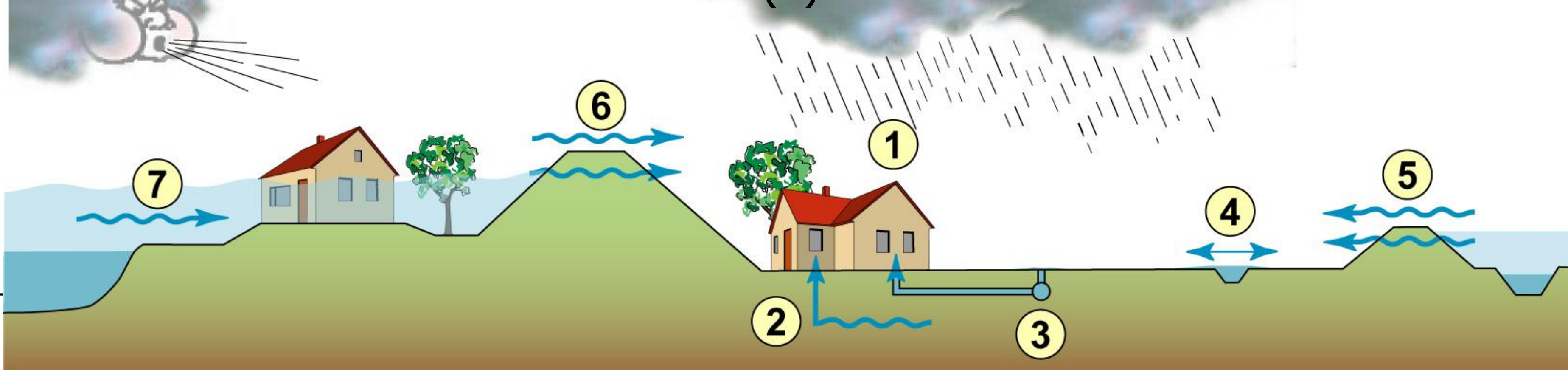
What growing challenges due to climate change for:

- Sea levels ?
- River levels ?
- Rainfall ?
- Surface water levels ?
- Urban drainage ?
- Groundwater levels ?



Climate change: growing challenges

- Rising sea levels (6,7)
  - Rising river levels (5)
- More extreme rainfall (1)
  - High surface water levels (in polder and regional water system) (4)
  - Urban drainage system overloading (5)
- Longer droughts
  - Subsiding soils
  - Salt water intrusion (2)



The challenge: coping with more extreme rainfall in cities

Source: www.wunderground.com

Jakarta, Jan 2013: extreme rainfall

Aerial view of Delft and elevation levels

Dark blue is level of main surface waters (water level Schie: NAP-0.43)

Delft city centre: canals

Note: street level only cm-s above water level

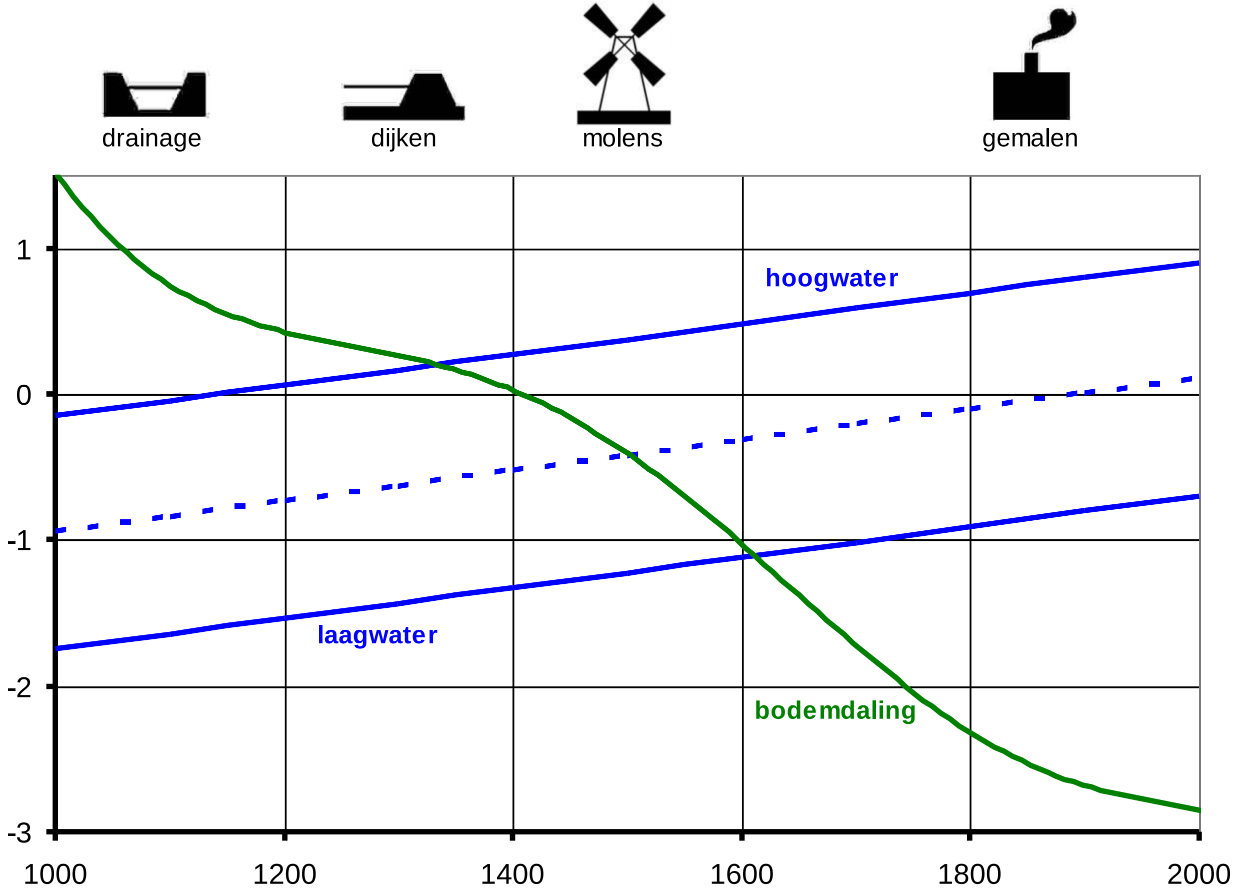
Rietveld en Raam blank na hoosbuien

Street level only cm-s above water level: susceptible to flooding

Deltas , an additional challenge: land subsidence

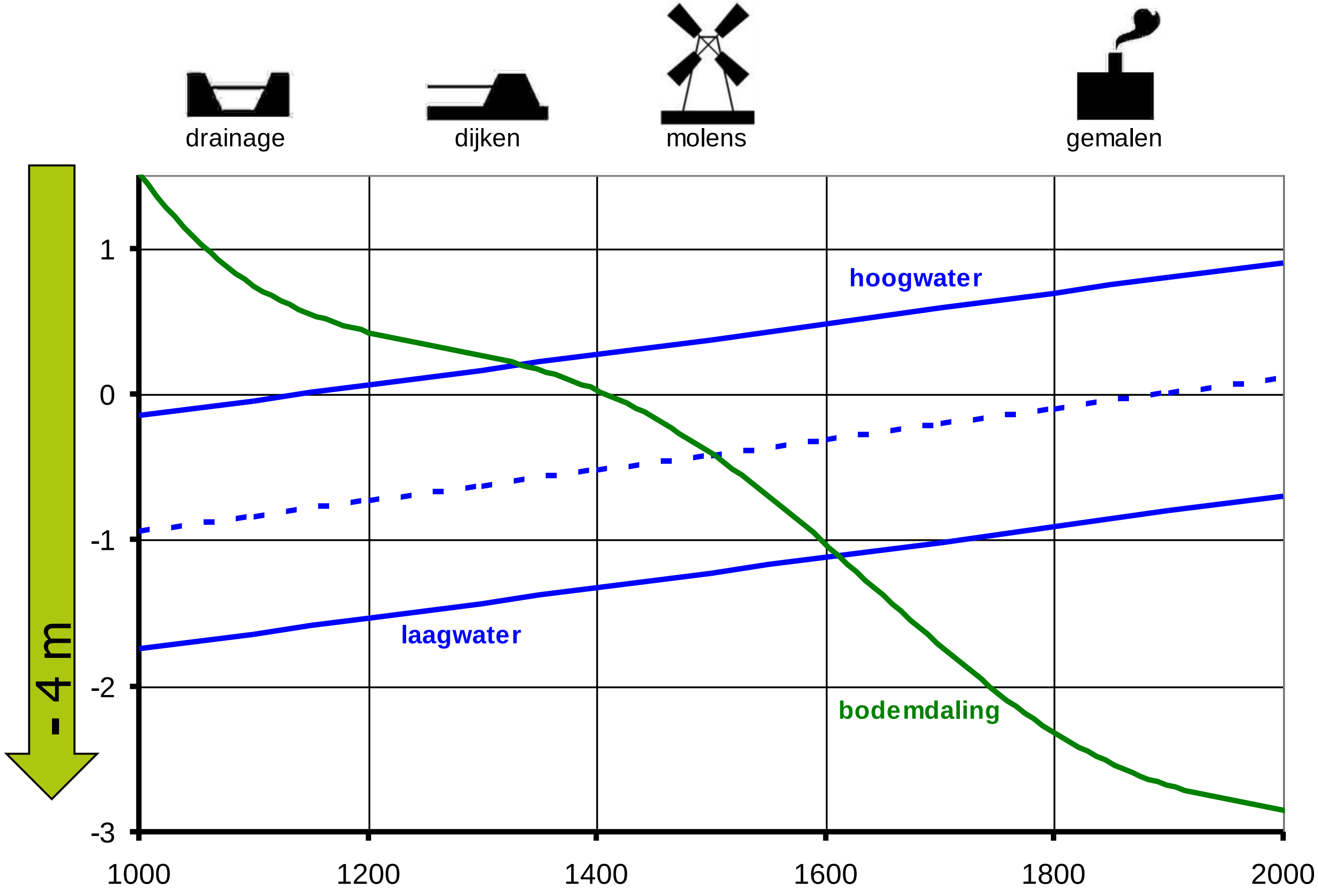
Land reclamation: subsidence

Historical development of water and ground levels in polders

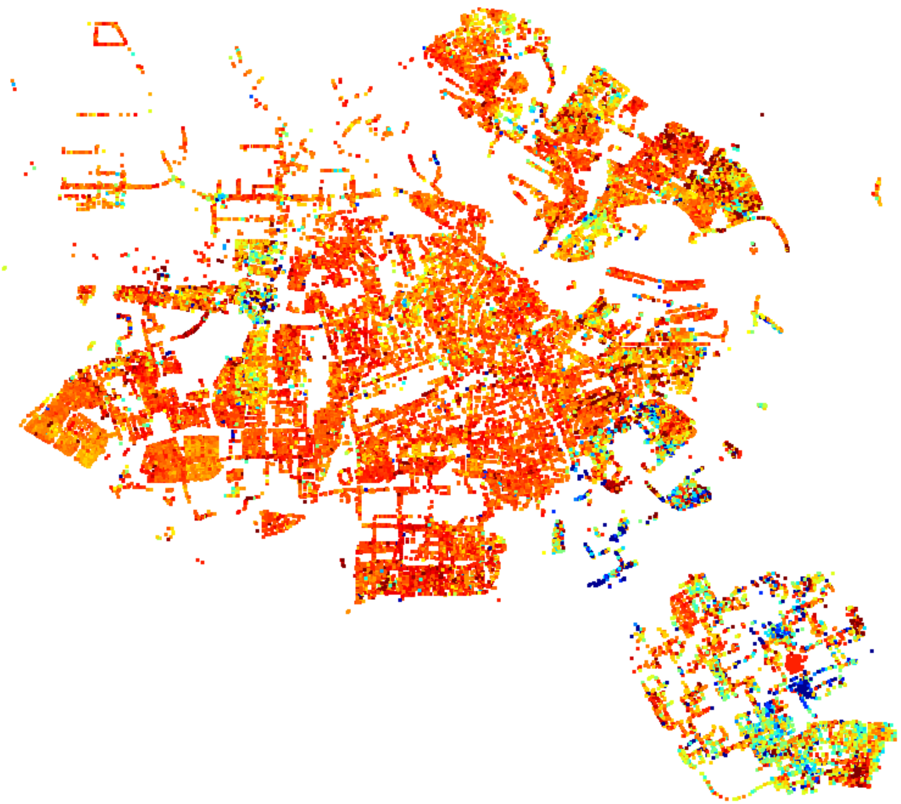


Land reclamation

Historical development of water level and ground levels in polders



Subsidence in polders

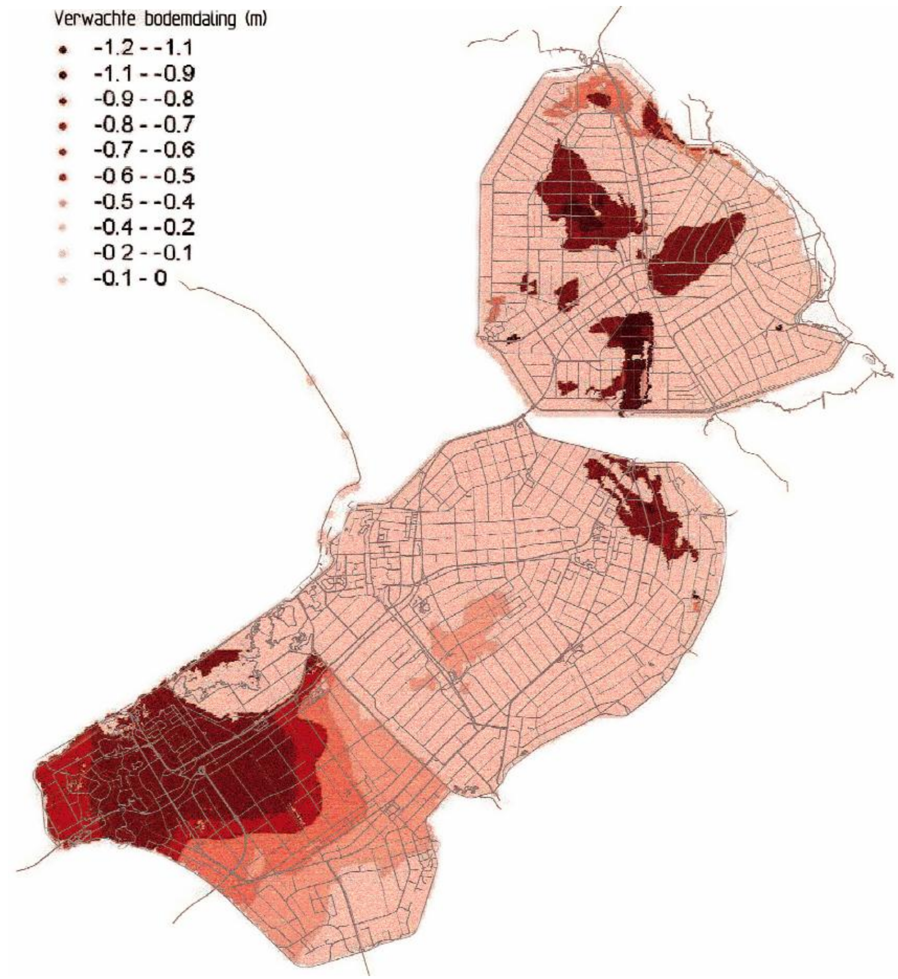


Amsterdam: Settlement rate in mm/yr

Scale: -20mm/yr (dark blue) to 0mm/yr (red)

Expected subsidence

(Flevopolders: range 0 to 1.2 m)



Subsidence in polders


Photo credit: Foter / CC BY-SA

Jakarta: Settlement rate in mm/yr:
Up to 25 cm /year

So… we build higher and higher buildings and will be safe?

Amsterdam: Settlement rate in mm/yr:
Up to 2 cm/year

Well,
only if you do not want
to go anywhere…

Water management challenges in deltas

Water comes from all sides:

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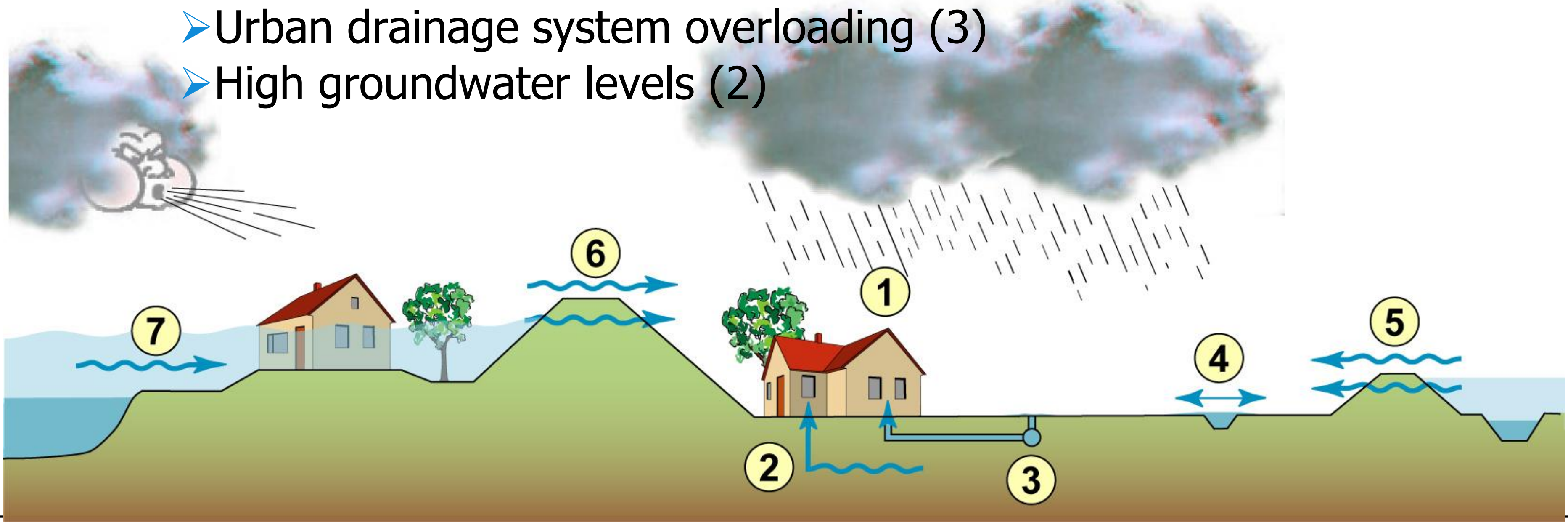
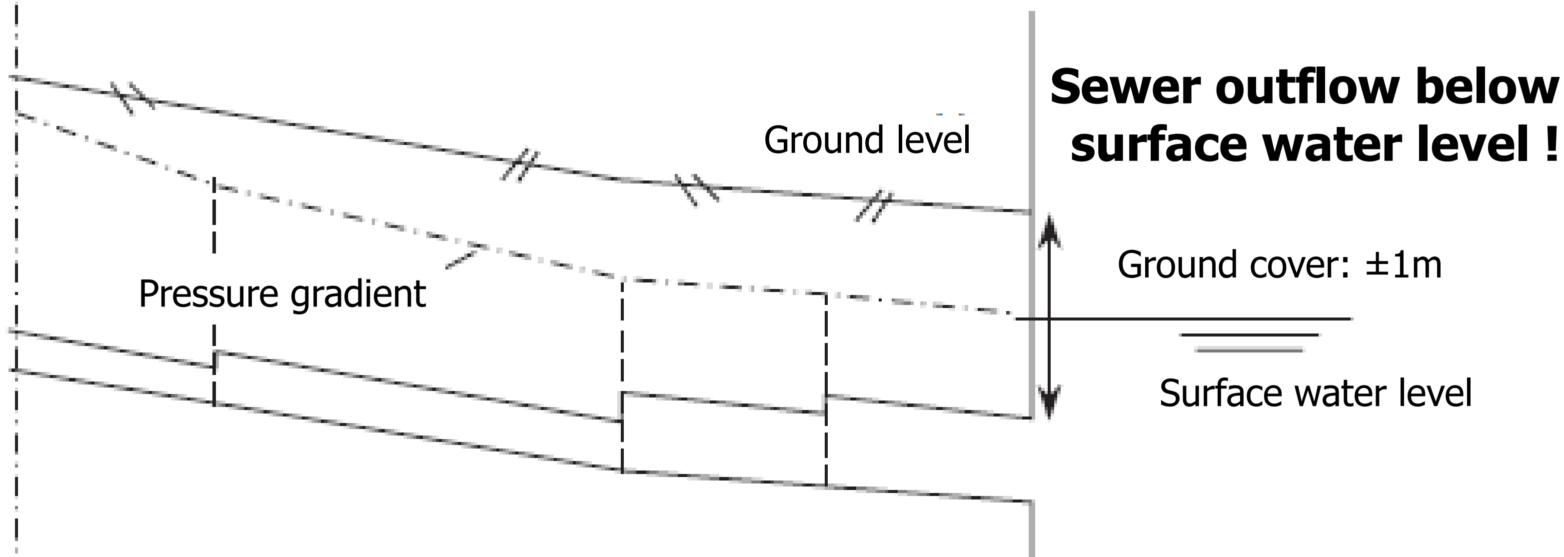


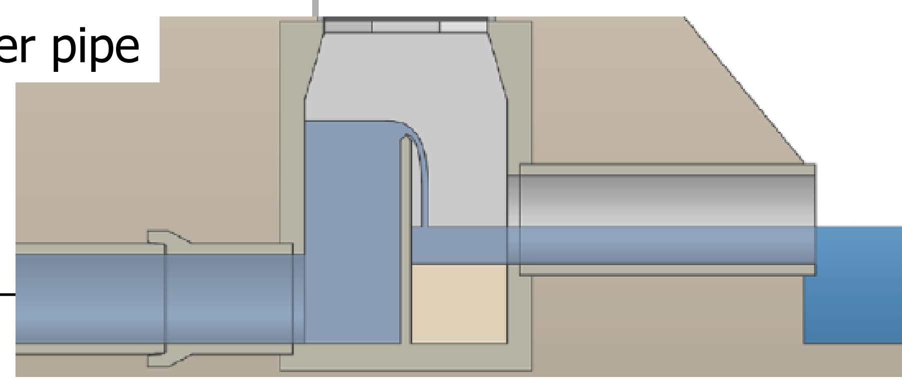
Sewer systems in lowland areas, where there is no natural slope

Sewers in flat urban catchments

Small distance between ground level and surface water level:

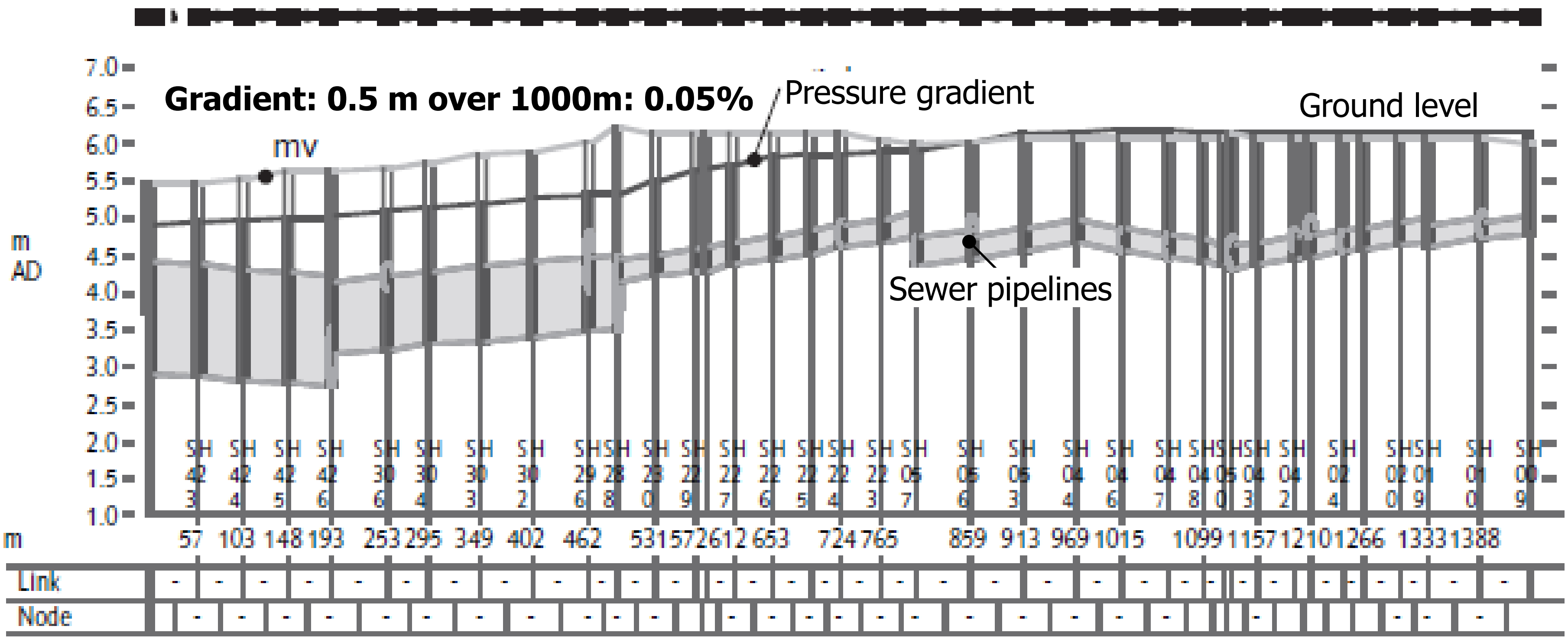


Side-view of underground sewer pipe



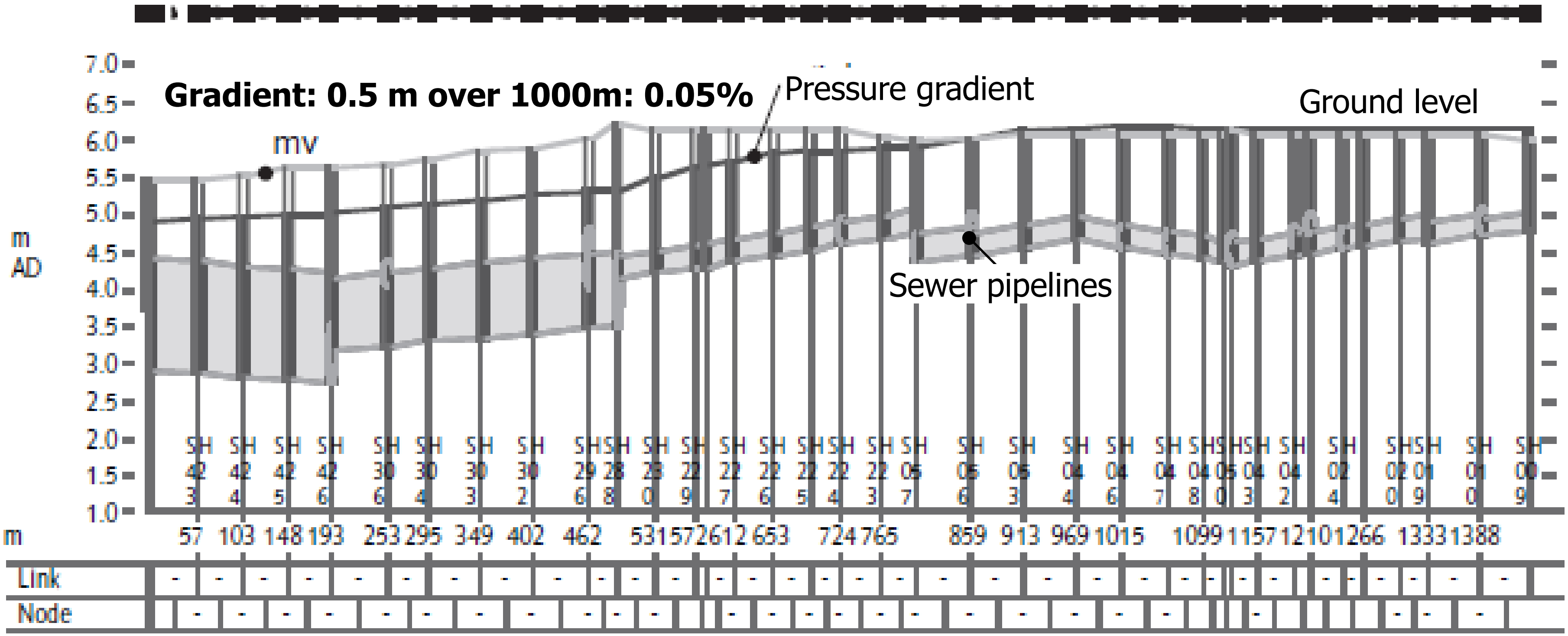
Sewers in flat urban catchments

Side view of small-gradient sewer

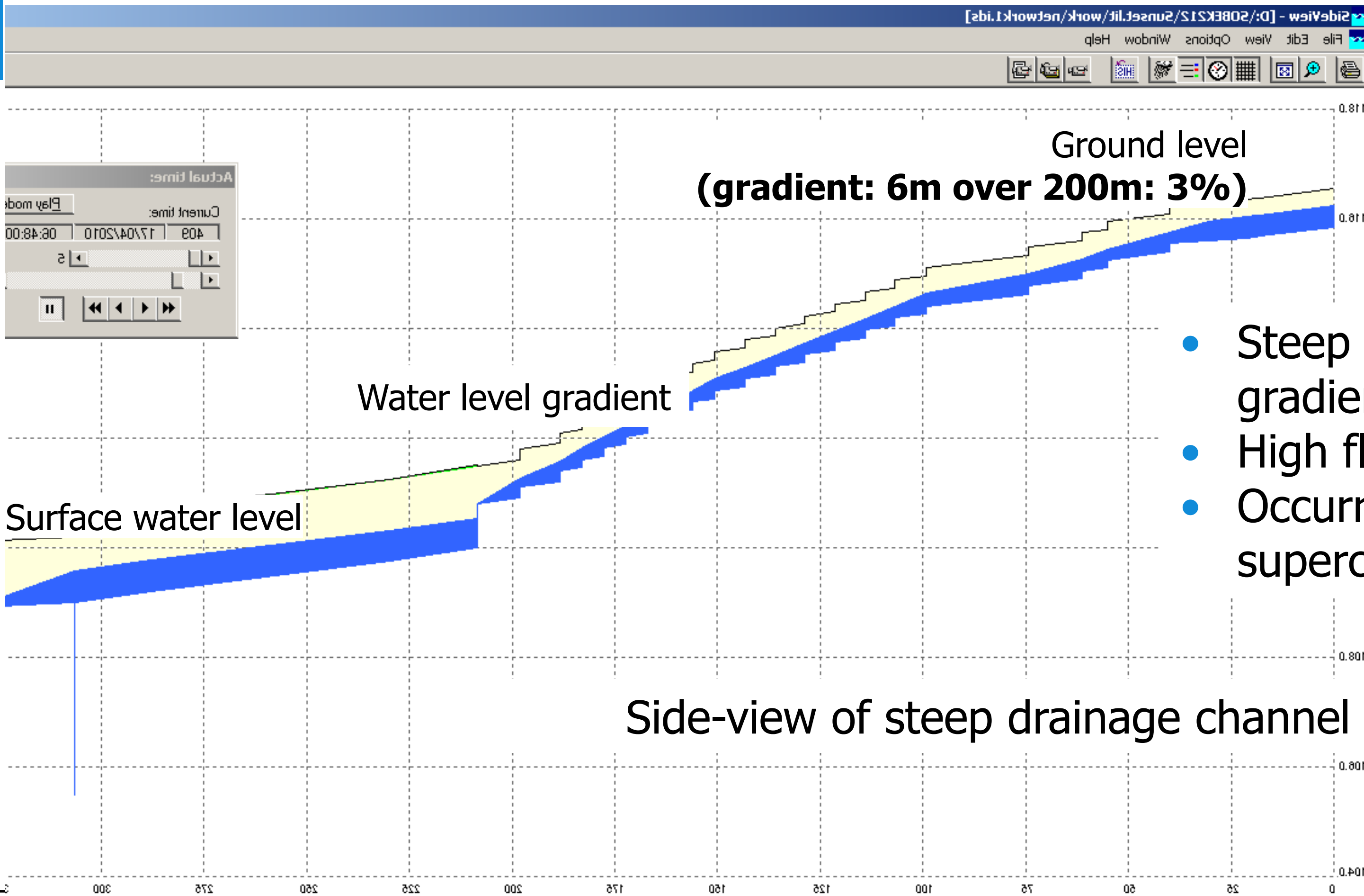


Sewers in flat urban catchments

- Small ground level gradient; small sewer pipe gradients
- Low flow velocities
- Subcritical flow



Sewers in steep urban catchments



- Steep ground level gradient;
- High flow velocities
- Occurrence of supercritical flow

Water management in delta cities

Main differences between urban water systems in sloping versus flat catchments:

Feature	Sloping	Flat

First, a few questions:

Water management in delta cities

Q: What is level of sewer outflow (bottom level pipe) compared to surface water level ?

Water management in delta cities

Q: What is level of sewer outflow (bottom level pipe) compared to surface water level ?

Q: How deep are sewers below ground level ?

Water management in delta cities

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Q: How deep are sewers below ground level ?

A: typically 1 m to 4 m below ground level

Water management in delta cities

Q: What is level of sewer outflow (bottom level pipe) compared to surface water level ?

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A: typically 1 m to 4 m below ground level

Q: What is distance between ground level and surface water level?

Water management in delta cities

Q: What is level of sewer outflow (bottom level pipe) compared to surface water level ?

Q: How deep are sewers below ground level ?

A: typically 1 m to 4 m below ground level

Q: What is distance between ground level and surface water level?

A: Typically 0.5 m – 2.5 m

Water management in delta cities

Q: What is level of sewer outflow (bottom level pipe) compared to surface water level ?
A: typically 0.3 m tot 1 m below surface water level

Q: How deep are sewers below ground level ?

A: typically 1 m to 4 m below ground level

Q: What is distance between ground level and surface water level?

A: Typically 0.5 m – 2.5 m

Water management in delta cities

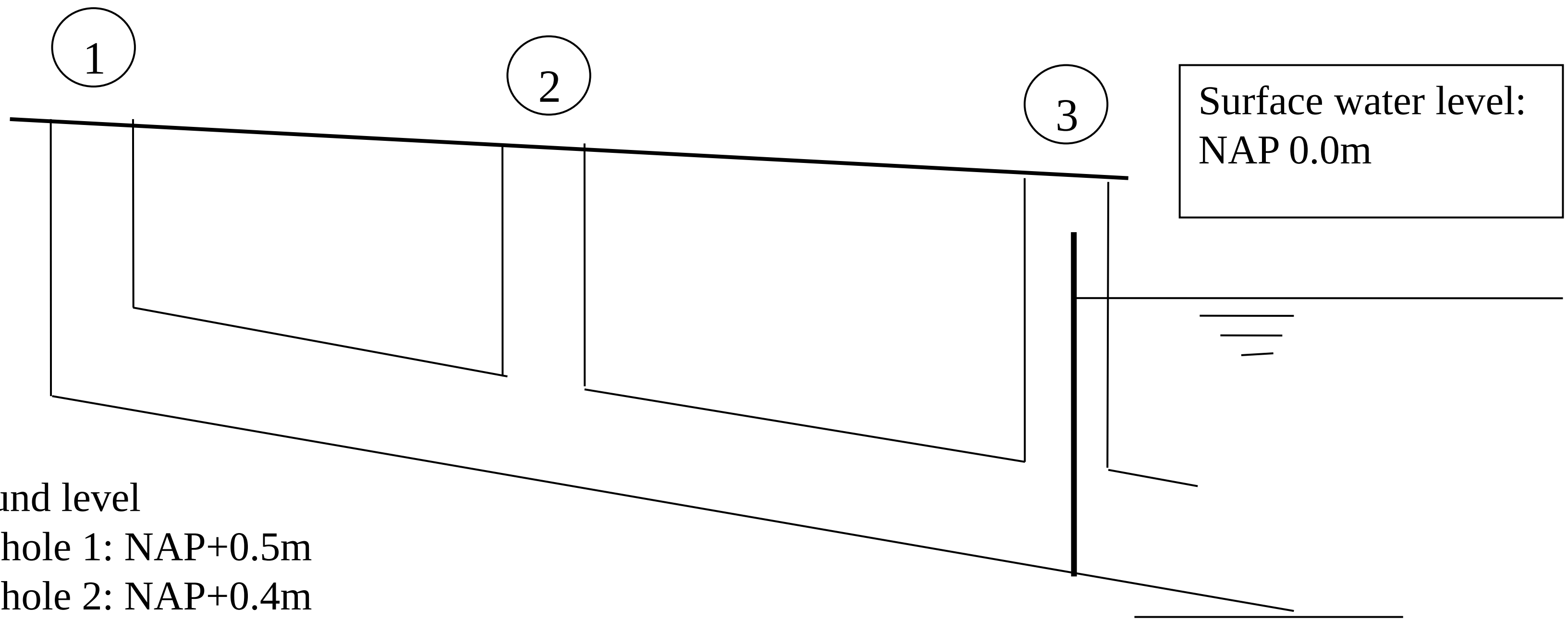
Main differences between urban water systems in sloping versus flat catchments:

Feature	Sloping	Flat
Distance ground level to surface water level	0 – 10s of meters Pipe outflow point above surface water level Pipes above groundwater	0 – 10s of centimeters Pipe outflow point below surface water level Pipes below groundwater
Water conveyance gradient	Natural gradient	Create gradient by digger deeper+adding pumping stations
Flow velocities	High flow velocities	Low flow velocities
Design conditions	Pipes partially filled	Pipes surcharged =pressurised flow

Example: Longitudinal profile of a combined sewer pipeline

Sketch the hydraulic gradient in the sewers during design rainfall

Rainfall intensity: 60 l/s/ha
Connected surface per manhole: 4 ha; 50/50 paved/unpaved
Distance between manholes: 400 m



Ground level
Manhole 1: NAP+0.5m
Manhole 2: NAP+0.4m
Manhole 3: NAP+0.3m

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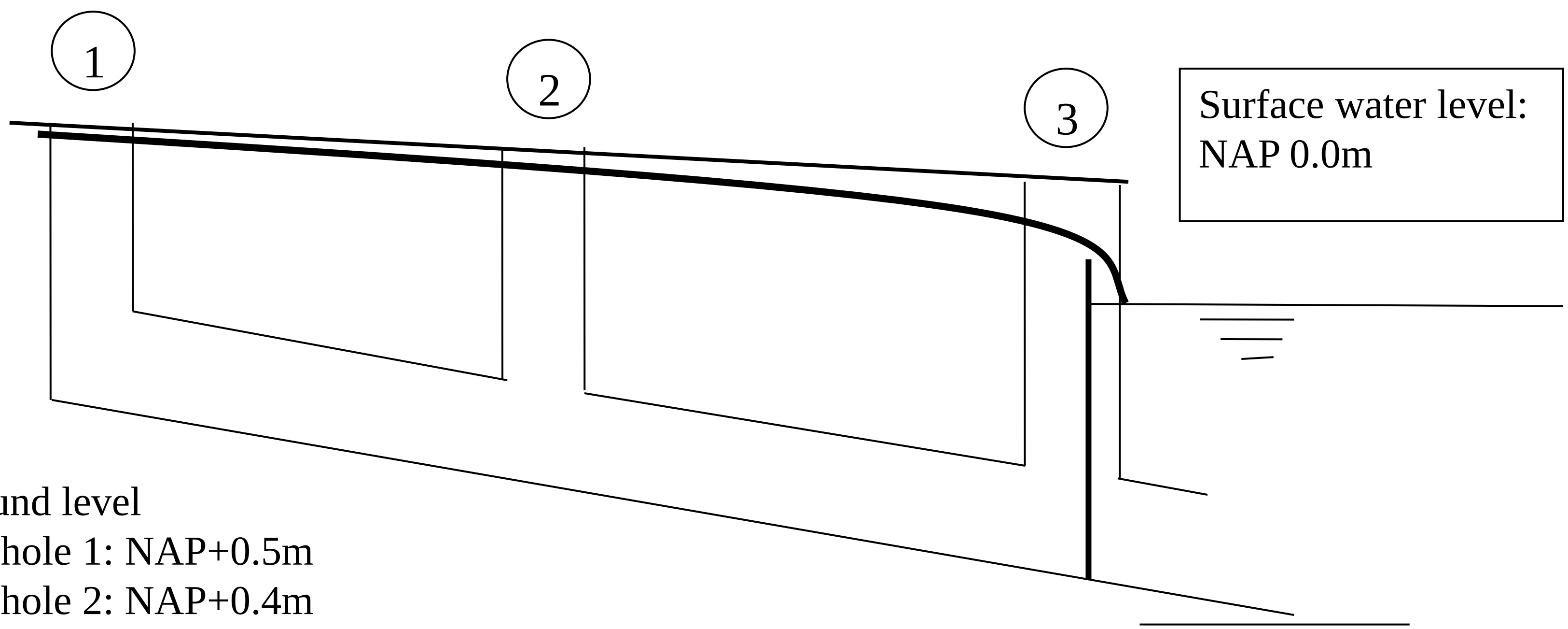

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Example: Longitudinal profile of a stormwater sewer line

Same question:

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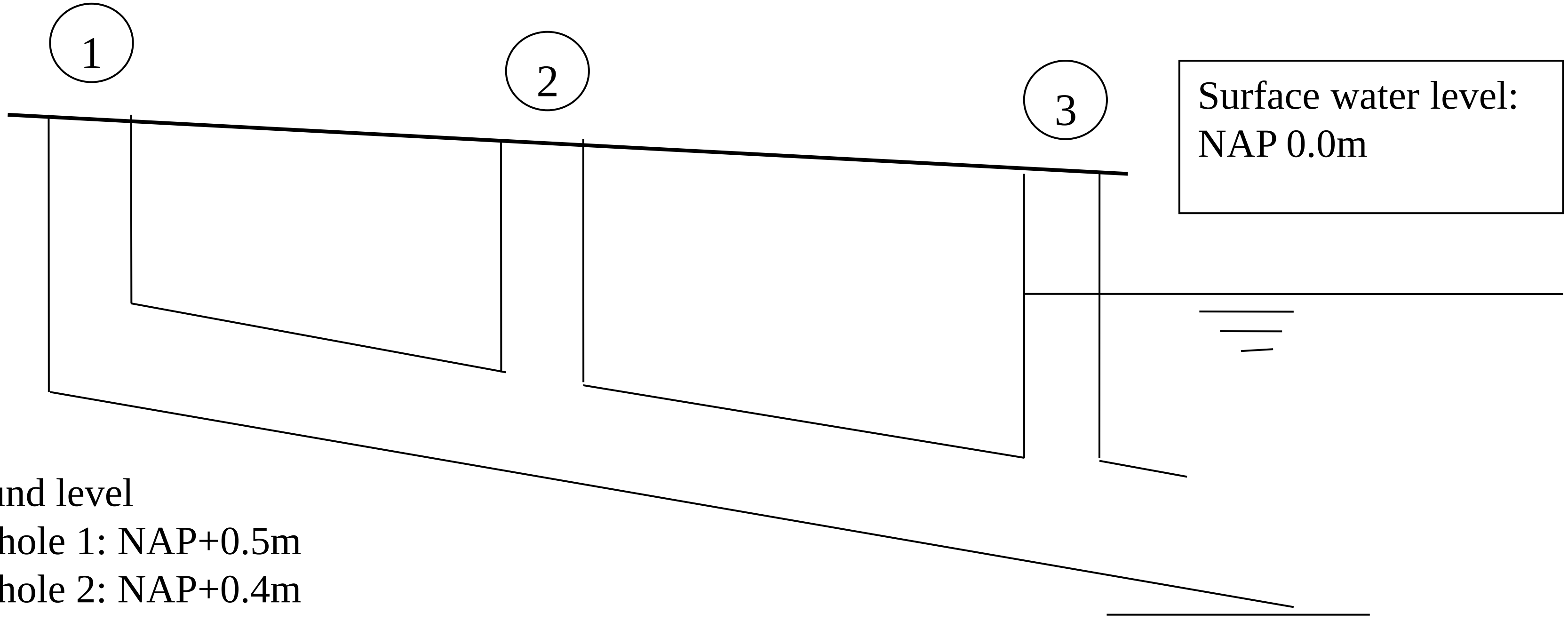

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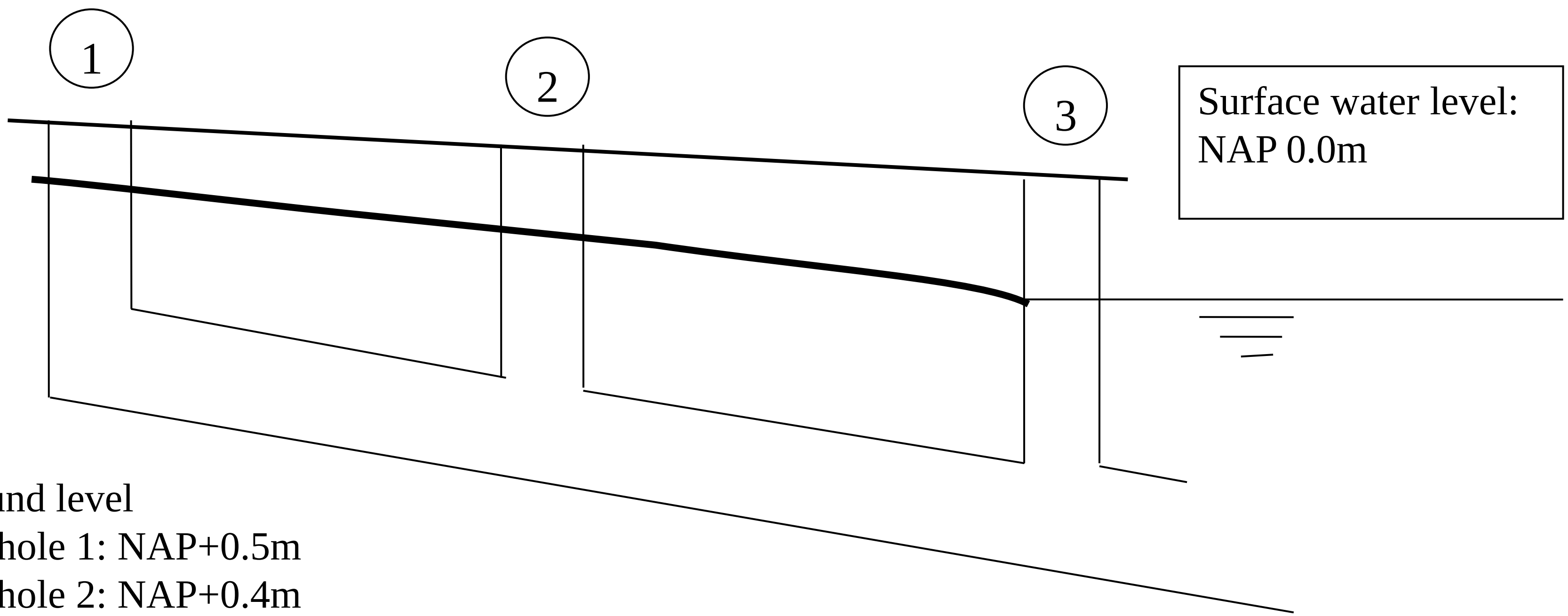

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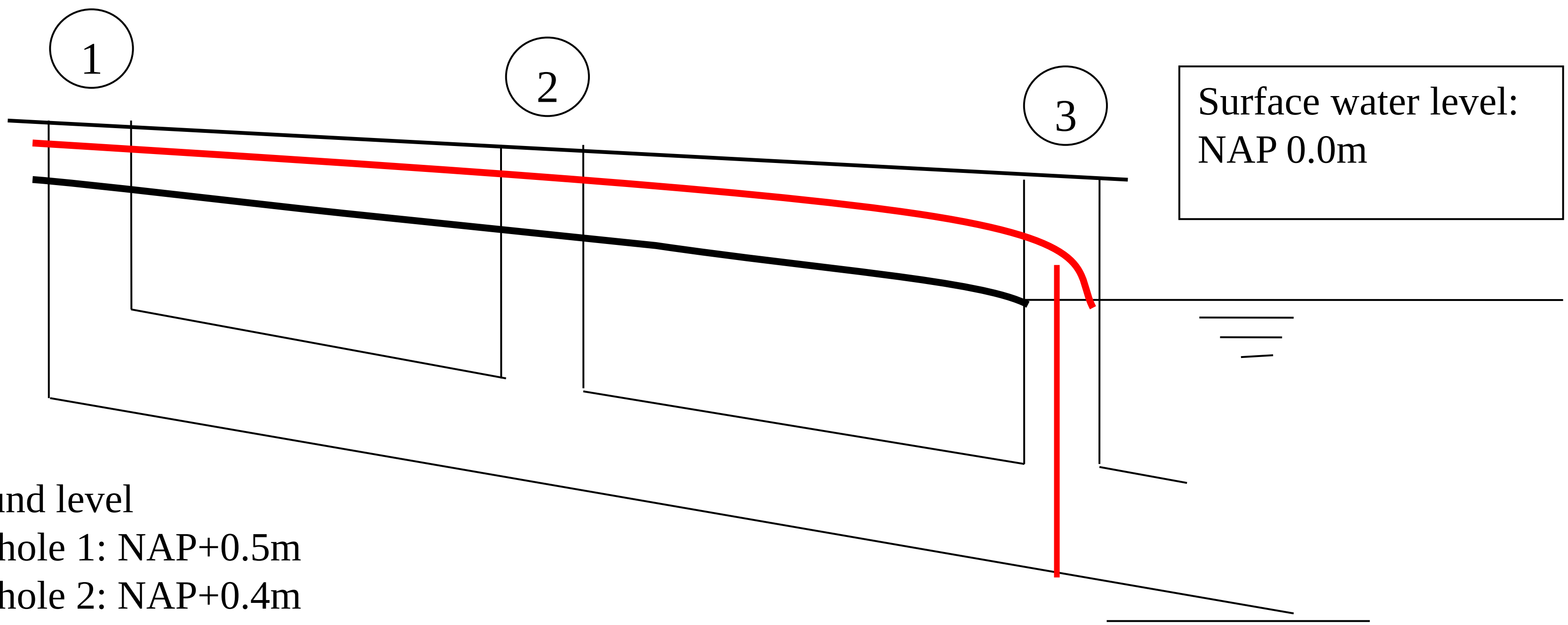

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Manhole 1: NAP+0.5m
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