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Water & Urban Initiative

Quantitative microbial risk assessment of waterborne infectious diseases

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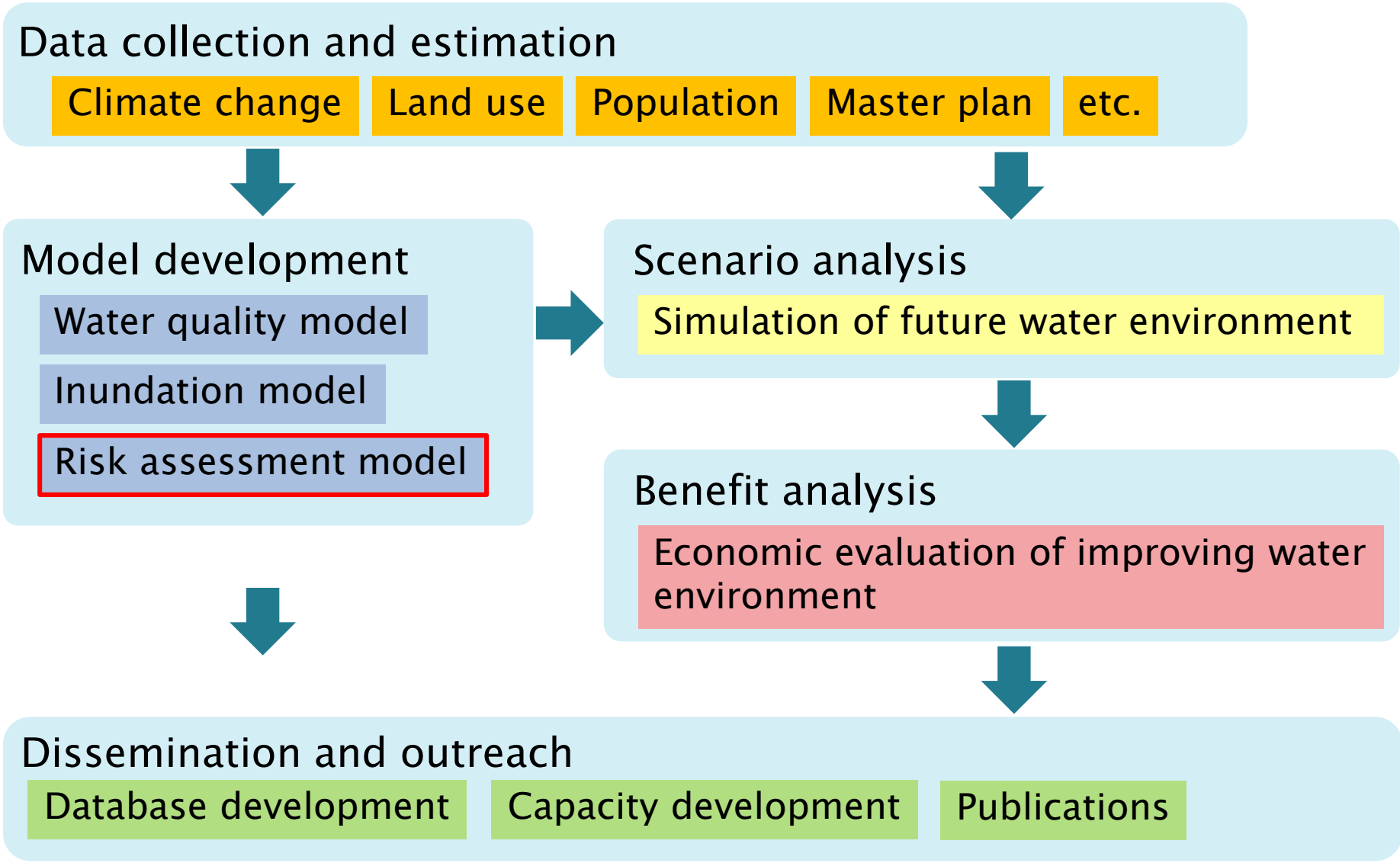
Project research framework



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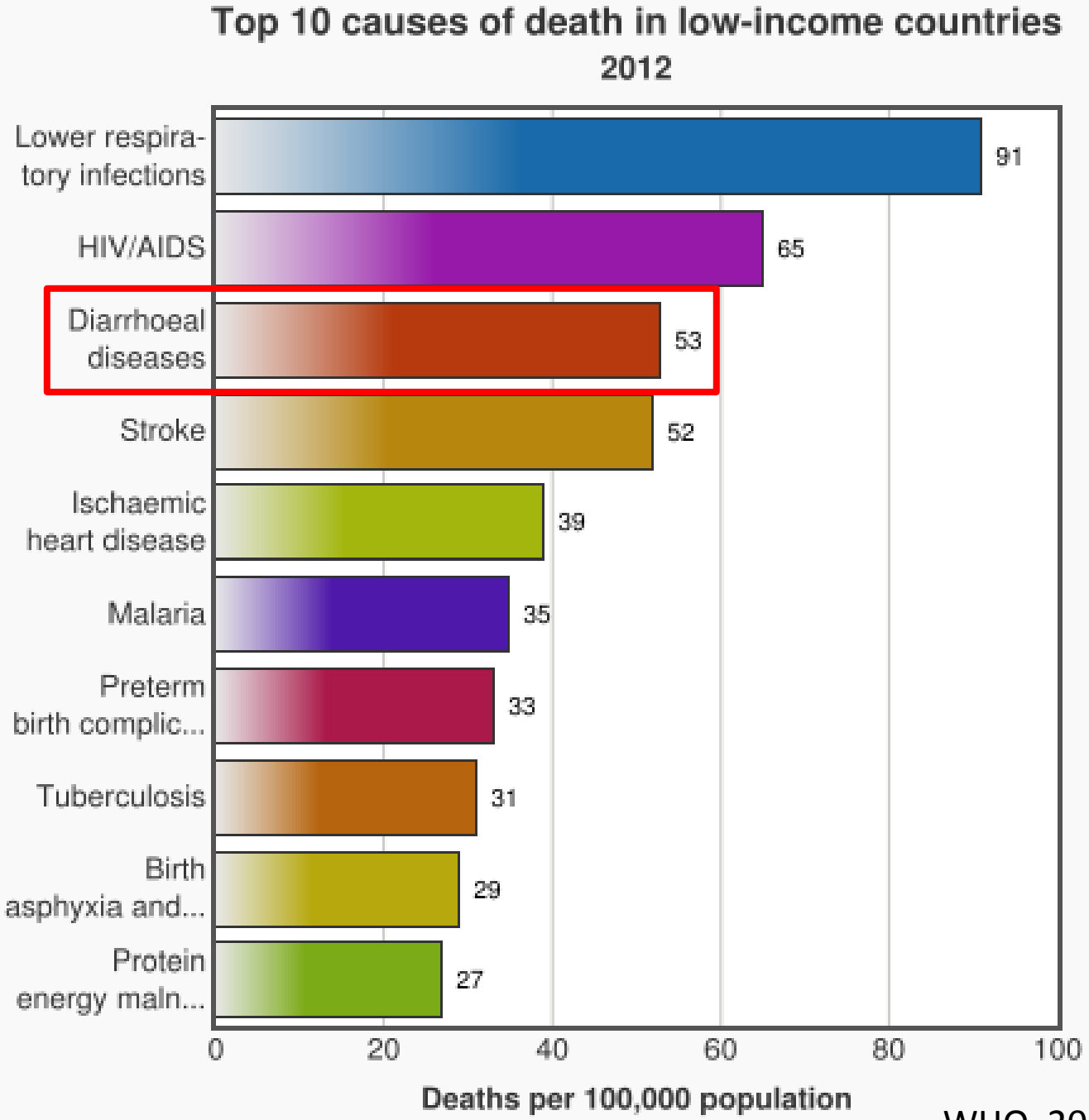
Facts about water and health

- In 2015, there were 2.4 billion (32%) people who lacked access to an improved sanitation facility.
- An estimated 663 million (9%) people do not use an improved source for drinking-water in 2015.
  - WHO/UNISEF, 2015.
- 88% of cases of diarrhea are attributable to unsafe water, inadequate sanitation or insufficient hygiene.
- These cases result in 1.5 million deaths each year, most being the deaths of children.
- Almost one tenth of the global disease burden could be prevented by improving water supply, sanitation, hygiene and management of water resources.
  - Prss-Üstün *et al*., 2008


Top 10 causes of death in low-income countries
2012
Lower respira-tory infections
91
HIV/AIDS
65
Diarrhoeal diseases
53
Stroke
52
Ischaemic heart disease
39
Malaria
35
Preterm birth complic...
33
Tuberculosis
31
Birth asphyxia and...
29
Protein energy maln...
27
0
20
40
60
80
100
Deaths per 100,000 population

WHO, 2012

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Quantitative microbial risk assessment (QMRA)

Quantitative Microbial **Risk Assessment**

- Health risk assessment
  - A method to qualitatively or quantitatively characterize and estimate potential adverse health effects (risks) associated with exposure of individuals or populations to hazards (materials or situations, physical, chemical and or microbial agents).

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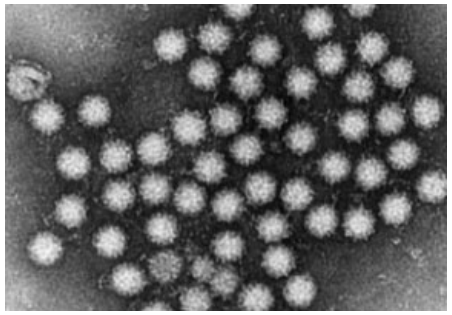
Quantitative microbial risk assessment (QMRA)

Quantitative **Microbial Risk** Assessment

- Health risks caused by microbial pathogens
- Pathogens of concern

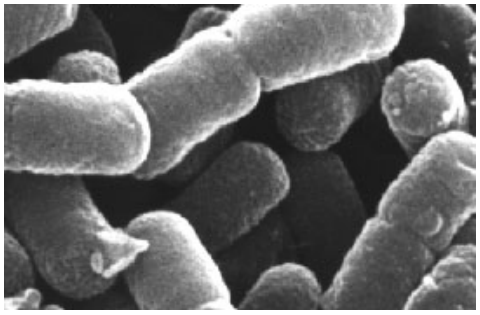
Viruses (<100nm)

Norovirus
Enterovirus
Adenoviruses



Bacteria (~1µm)

Campylobacter
Helicobacter
Escherichia coli



Protozoa (5-10µm)

Cryptosporidium
Giardia
Cyclospora

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Quantitative microbial risk assessment (QMRA)

Quantitative Microbial Risk Assessment

- Is this hazardous?

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Case study: 2007 flood in Jakarta

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2007 Jakarta flood

- The 2007 Jakarta flood was a major flood in Jakarta, the capital of Indonesia and affected several other areas around the city
  - Date: 2 February – 12 February 2007
  - Deaths: 80
  - Property damage: $400 million
- 1,066 patients treated by hospitals due to diarrhea and 329 due to dengue fever (Standard Newswire, 2007)

A Jakarta taxi submerged by flooded water. See en:2007 Jakarta flood.

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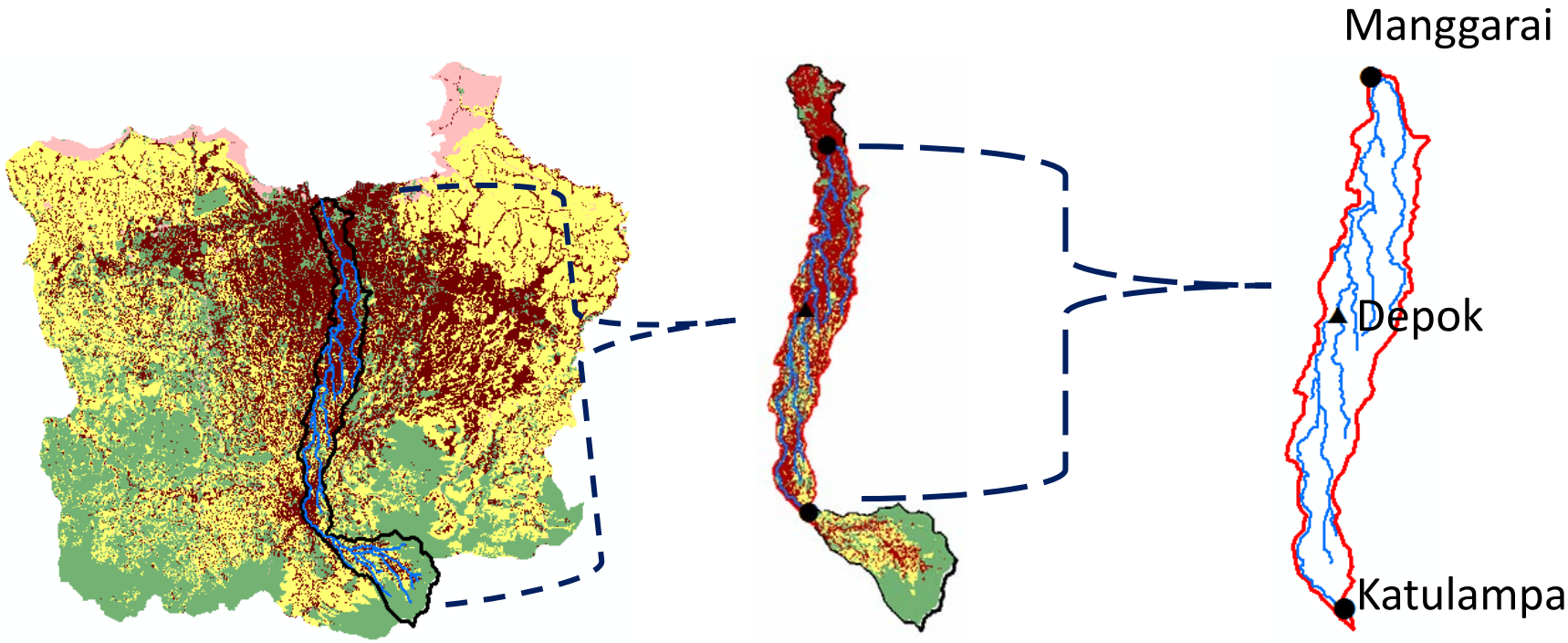
Study area



Greater Jakarta

Ciliwung river basin
Catchment area = 438 km^2

Assessment area = 238 km^2
Elevation: 9 to 403 m

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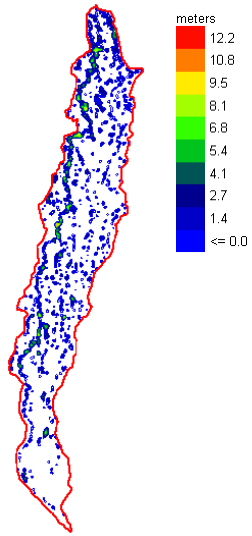
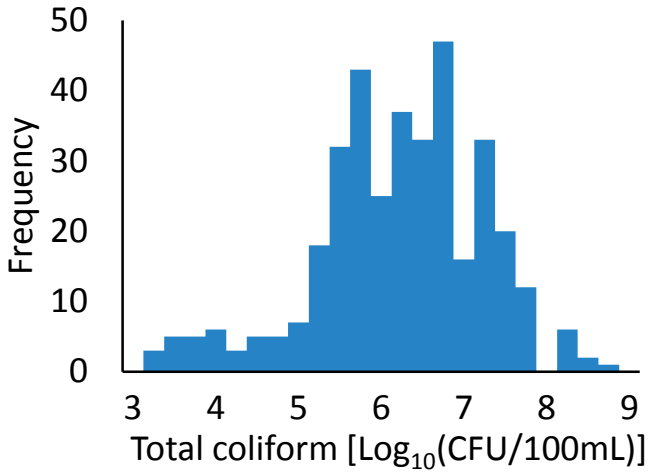
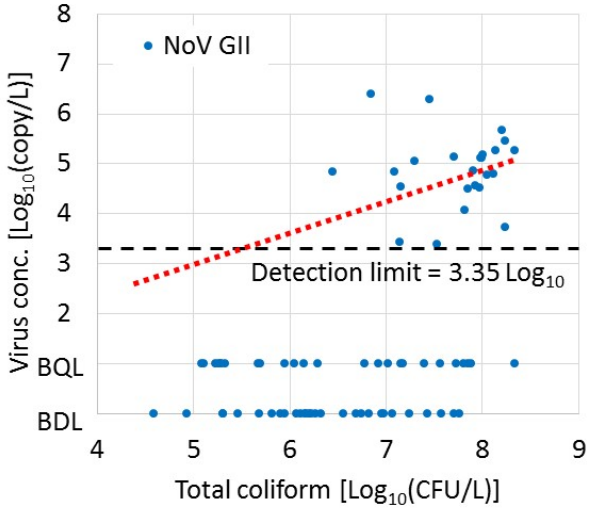
Model development: noroviruses in flood water







Flood simulation results

Total coliform concentration

Convert to noroviruses conc.

Water ingestion

Norovirus concentration in flood water

Health risk (probability of infection)

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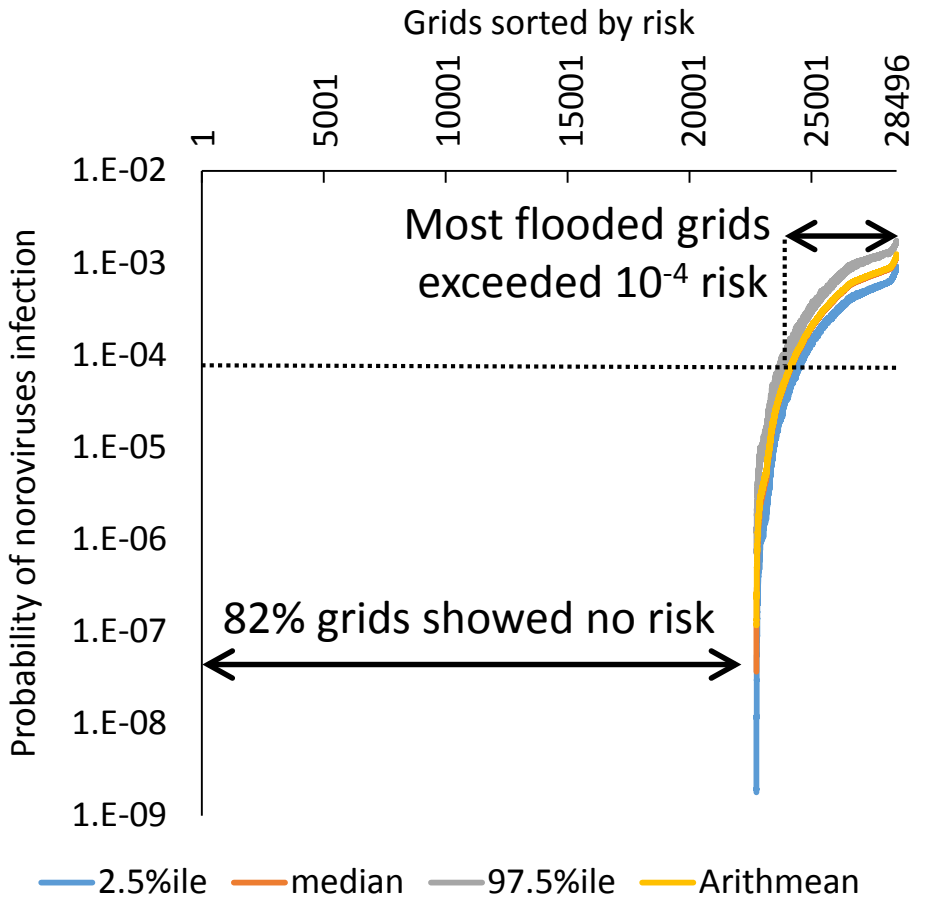
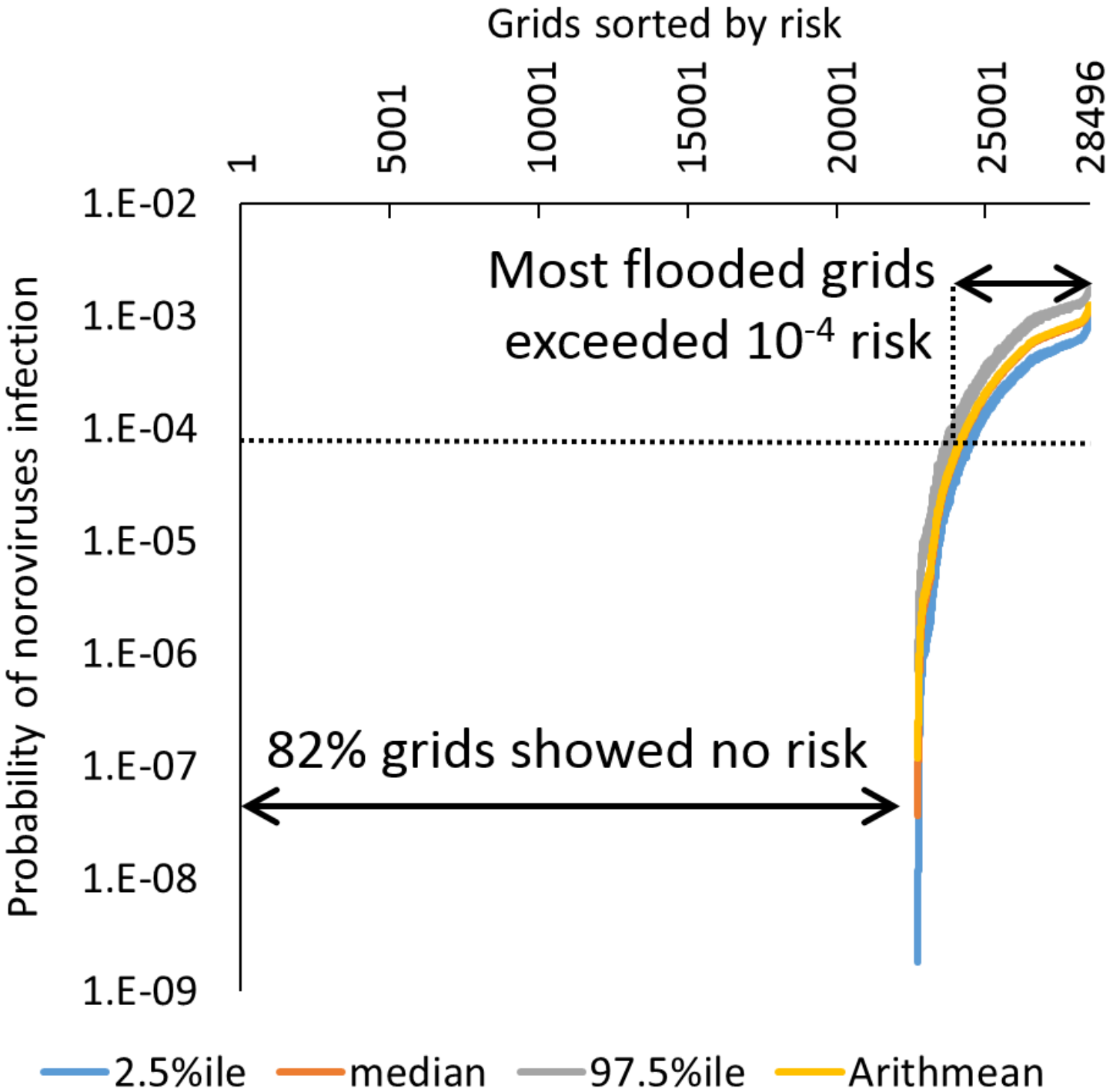
Health risk of norovirus infection

- Flo-2D result = inundation depth in each grid at each time (hour)
  - 28,496 grids x 312 hours = 8.9 M data
  - 82% of the grids (23,228 / 28,496) had no flood = no risk

- Risk assessment
  - Norovirus as target pathogen
  - QMRA w/ Monte Carlo simulation (x 10,000 iteration)

- Results
  - Flooded grid showed relatively high risk of infection
    - 4,146 grids (72% of flooded grids) showed > 10^{-4} risk




Grids sorted by risk
1
5001
10001
15001
20001
25001
28496
Probability of noroviruses infection
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
Most flooded grids exceeded 10-4 risk
82% grids showed no risk
2.5%ile
median
97.5%ile
Arithmean

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Conclusion

- The health risk assessment model using the QMRA approach can estimate potential health outcomes (probability of noroviruses infection) caused by being exposed to flood water
  - 72% of flooded grids showed relatively high (> 10^{-4}) risk
- The model can be used to estimate health risks in what-if scenarios
  - Urban flooding in the future (population growth, climate change)
  - Effect of flood control measures
  - Effect of sewage management measures