

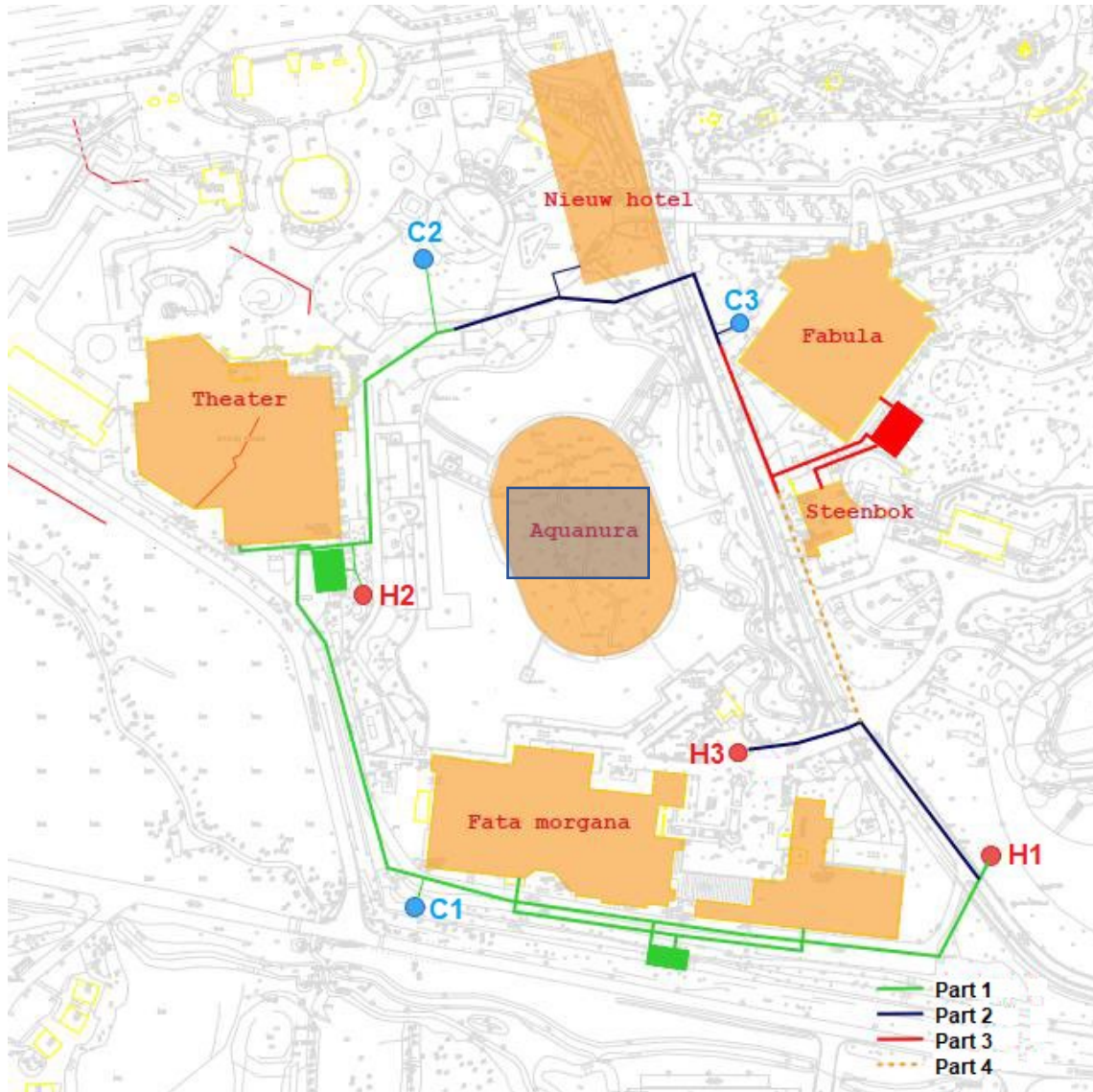
# Efteling Aquathermal Potential

*Effects of heat extraction from Aquanura water pond*

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Tom Niemark  
David Smeulders



## Park area Anderrijk



## Anderrijk facilities

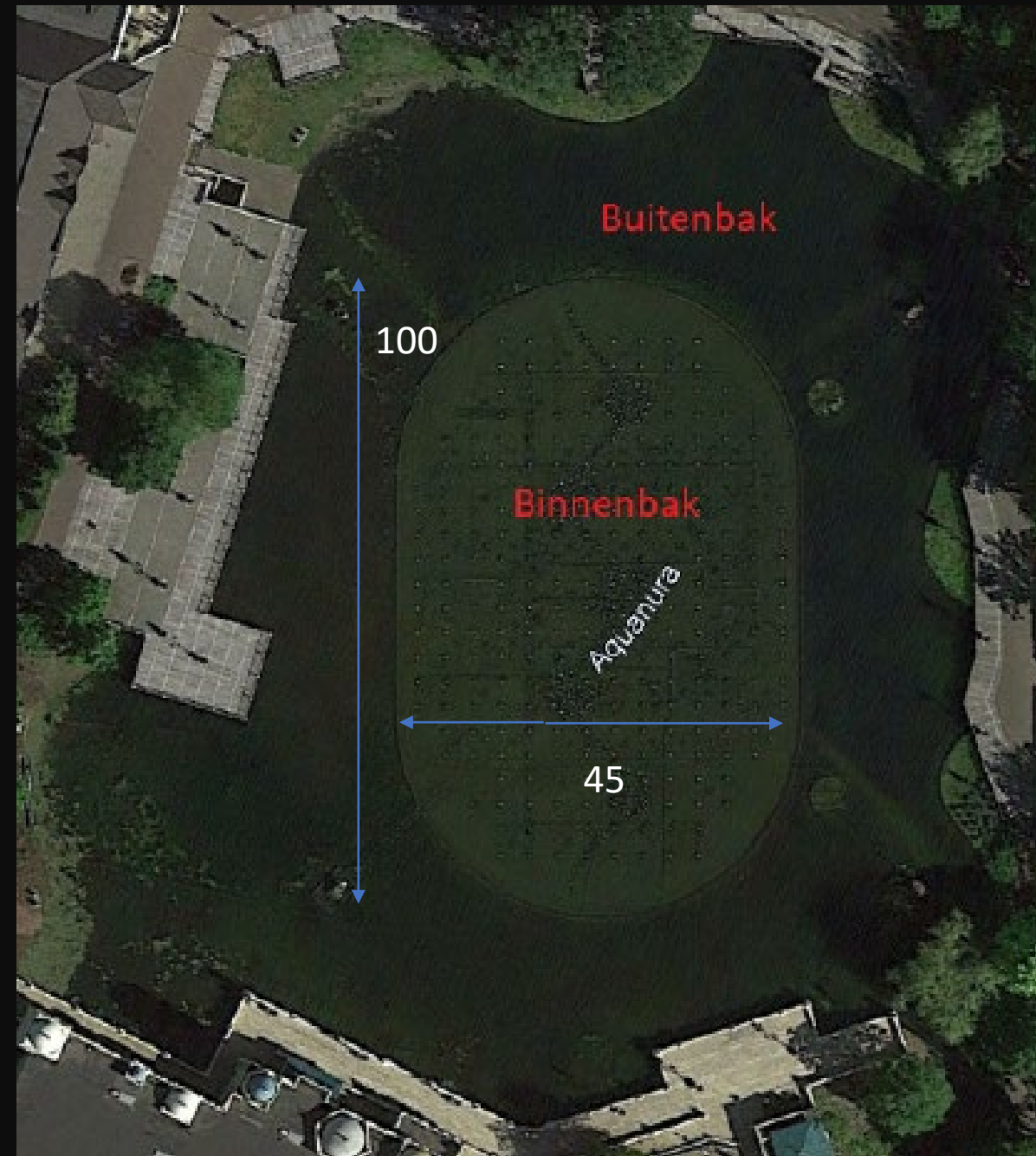
|   |                     | Power [kW] |      |           | Demand [MWh] |      |
|---|---------------------|------------|------|-----------|--------------|------|
|   |                     | Heat       | Cold | Tap Water | Heat         | Cold |
| 1 | Theater             | 1500       | 500  | 40        | 849          | 66   |
|   | Aquanura            |            | -    | -         | 365          | -    |
| 2 | Fata Morgana        | 580        | 0    | -         | 627          | 0    |
|   | Fata Morgana Palace |            | 0    | 7,6       | 116          | 0    |
|   | Bazaar              |            | 50   | 6         | 57           | 33   |
| 3 | Fabula              | 400        | 155  | 16,8      | 634          | 35   |
| 4 | New Hotel           | 500        | 650  | 80        | 487          | 550  |

- 4 facilities considered (see Table)
- 3.13 MW total heat demand (incl. hot tap water)
- 1,36 MW total cold demand
- Heat extraction from Aquarura pond
- Connected via newly build heat grid
- 3 ATES hot storage wells, 3 cold wells
- Expected start operations: summer 2023

# Aquanura pond

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- 17,700 m<sup>2</sup>
  - 1.1 m water depth
  - Separate inner pond
    - 4,400 m<sup>2</sup>
    - 0.6 m water depth
    - Concrete construction
    - Fountains for water shows
    - Pipelines for water shows
    - Pipelines for anti-ice system
- 





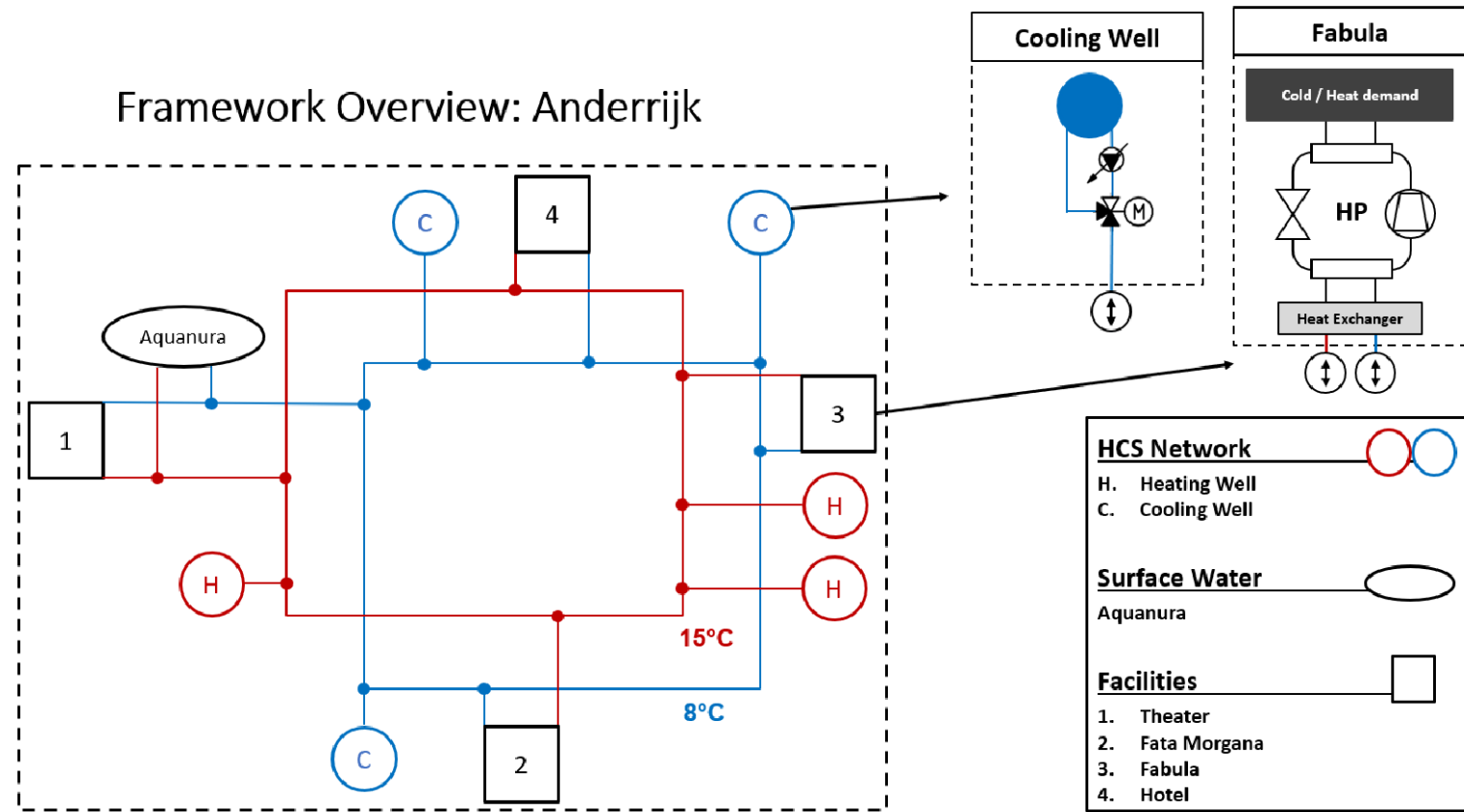
# Aquanura inner pond pumped dry for maintenance



Fountains and pipeline systems

Outer pond

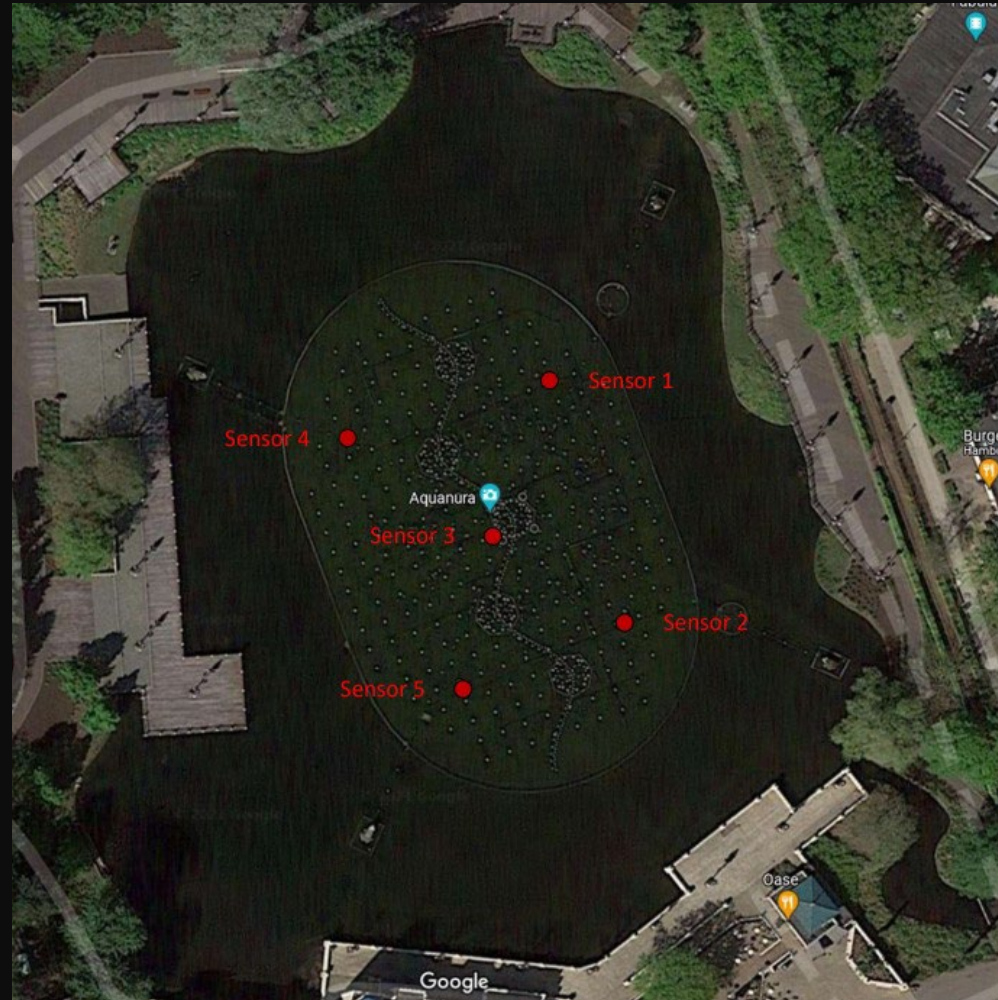
# Previous work: dynamic modeling of Anderrijk heat grid (Tom Niemark thesis report)



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## My work: heat extraction from- and temperature prediction of Aquanura pond

- 5 temperature sensors available
  - 15 mins interval
  - Start 15 July 2021



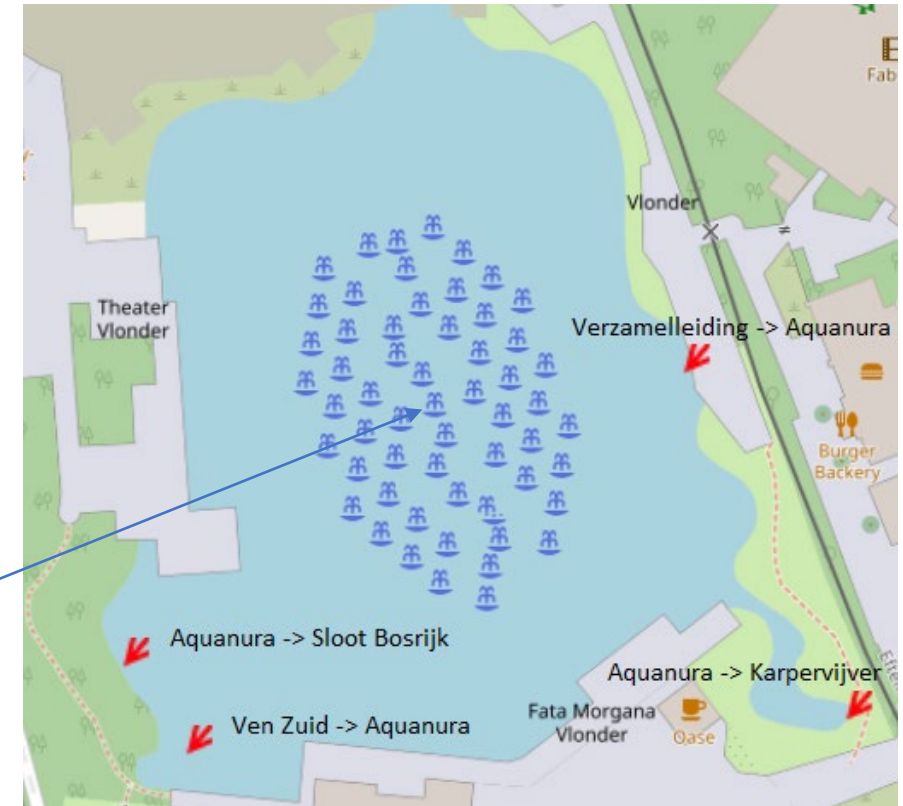
# Existing water pipelines to and from Aquanura pond

| Water  | Leidingnummer | Diameter (mm) | Lengte(m) |
|--|---------------|---------------|-----------|
| <b><i>Inkomend</i></b>   |               |               |           |
| Ven Zuid   | L10           | 200           | 2100      |
| Afvoer verzamelleiding Gondoletta, Boulevard & hemelwaterafvoer(HWA) van Witte Paard, Anton Pieckplein & Carrousel Complex | L20           | 400           | 20        |
| HWA leiding hoofdparking   | L28           | 200           | 360       |
| HWA leiding Dwarrelplein   | L29           | 1000          | 130       |
| <b><i>Uitgaand</i></b>   |               |               |           |
| Zuigleiding sprinklersysteem Theater   | L30           | NVT           | NVT       |
| Karpervijver   | L62           |               |           |
| - Aanvoerleiding naar Karpervijver   | L62.1         | 800           | 5         |
| - Vernauwing vanwege kruising met gasleiding   | L62.2         | 200           | 35        |
| - Leiding na verdunning richting Karpervijver  | L62.3         | 800           | 10        |
| Sloot Bosrijk S4   | L66           | 315           | 185       |



# Existing extraction and inlet points

| Water   | Debiet (m <sup>3</sup> /h) |
|---|----------------------------|
| <i>Inkomend buitenbak</i>                       | <b>110</b>                 |
| Ven Zuid  | 35                         |
| Afvoer verzamelleiding Gondoletta,<br>Boulevard | 50                         |
| Overstort van binnenbak naar buitenbak          | 25                         |
| <b>Uitgaand buitenbak</b>                       | <b>110</b>                 |
| Karpervijver                                    | 73                         |
| Sloot Bosrijk S4                                | 37                         |

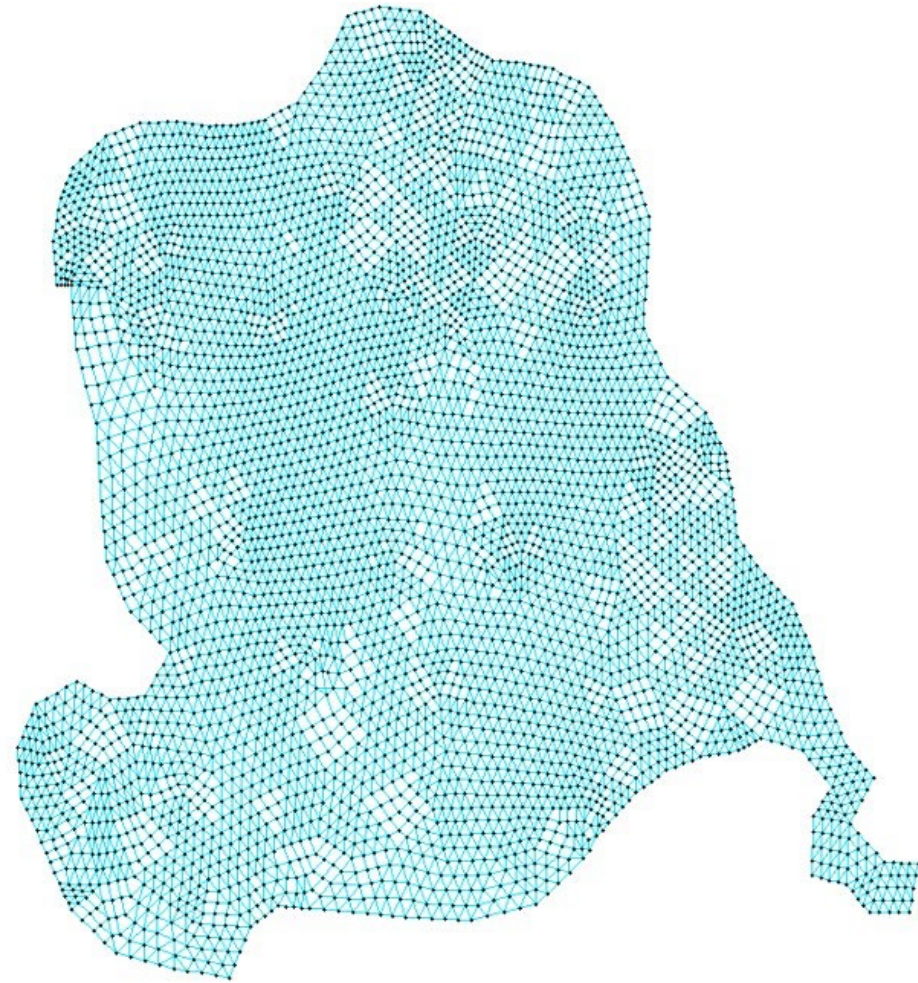


Fountains not taken into account  
Rainfall and evaporation not considered



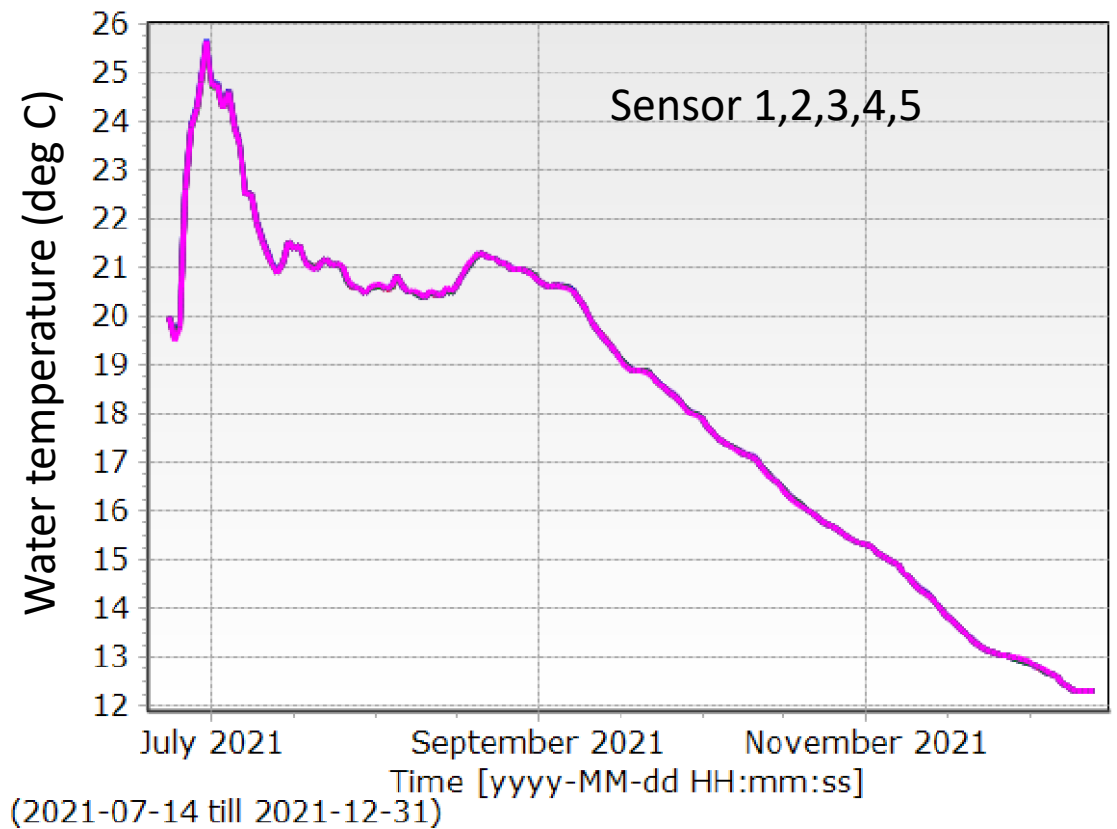
# Delft3D Model

- Uniform water initial temperature
- KNMI Wind input data
- KNMI cloud information
- KNMI air temperature
- Water transparency
- Existing water inlet/outlet flow rates
- Inlet/outlet water temperatures
- Water depth



Aquanure computational grid

# Calibration of the model: perfect agreement

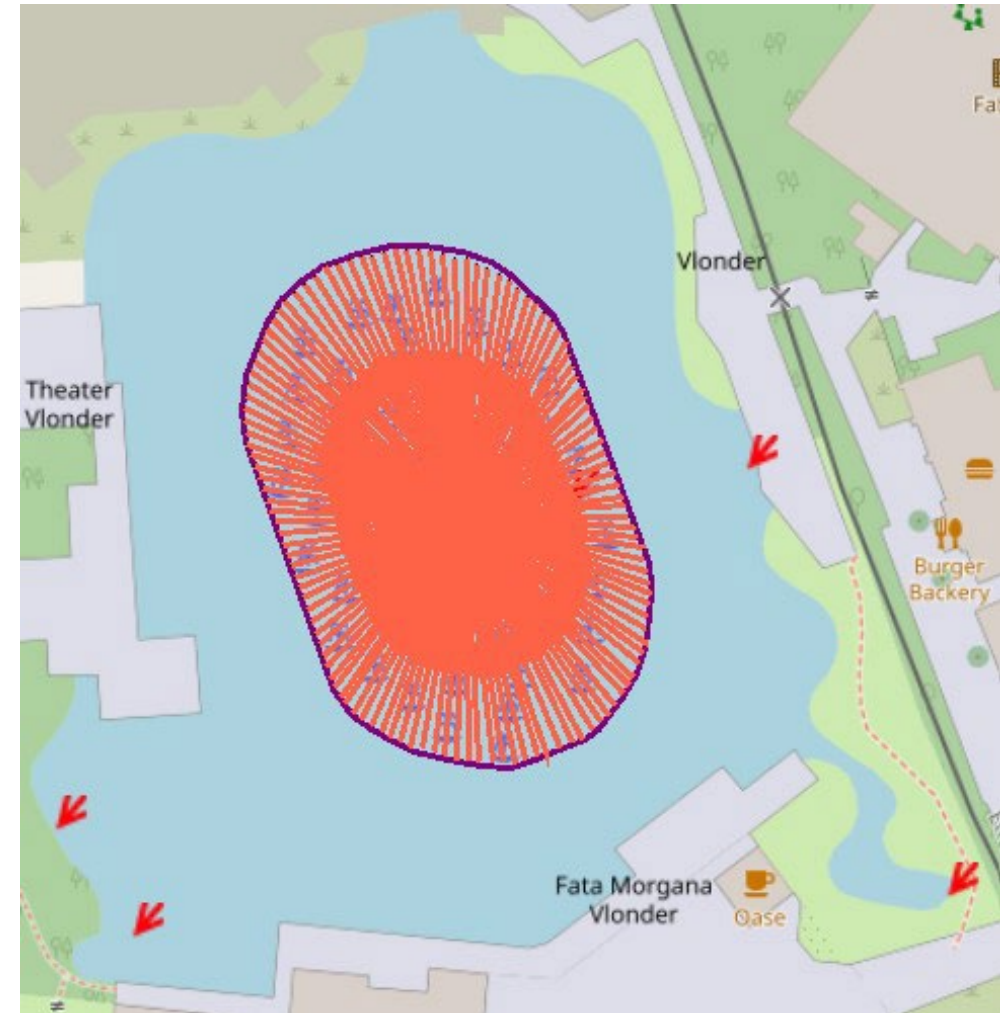


Purple:  
Model

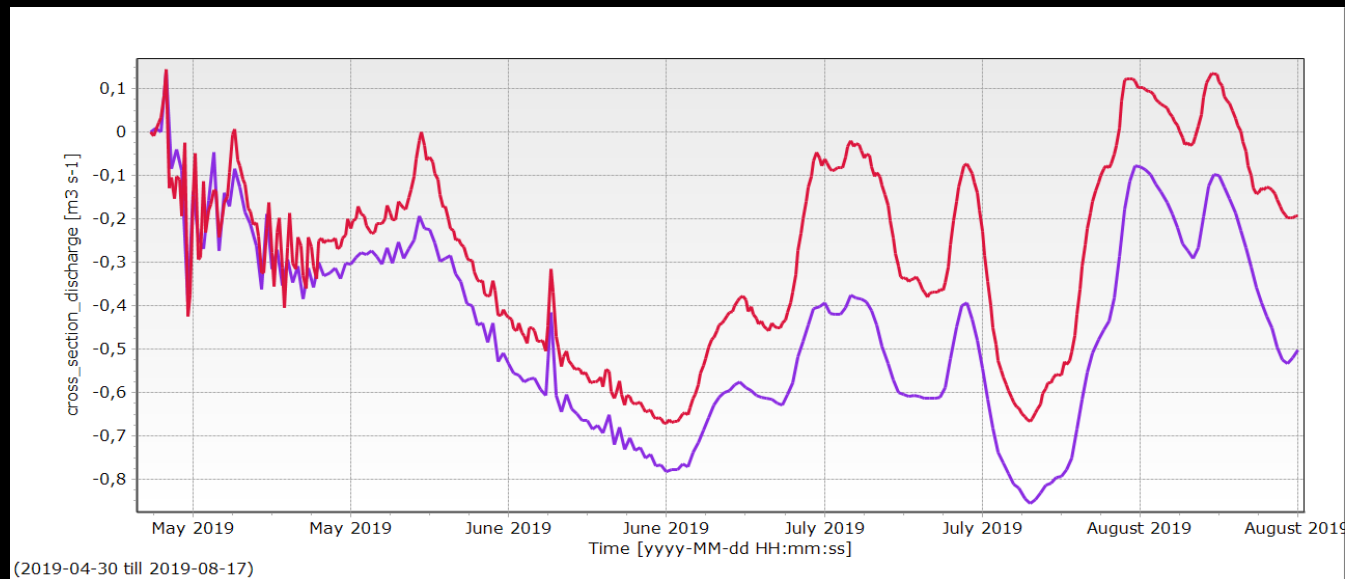
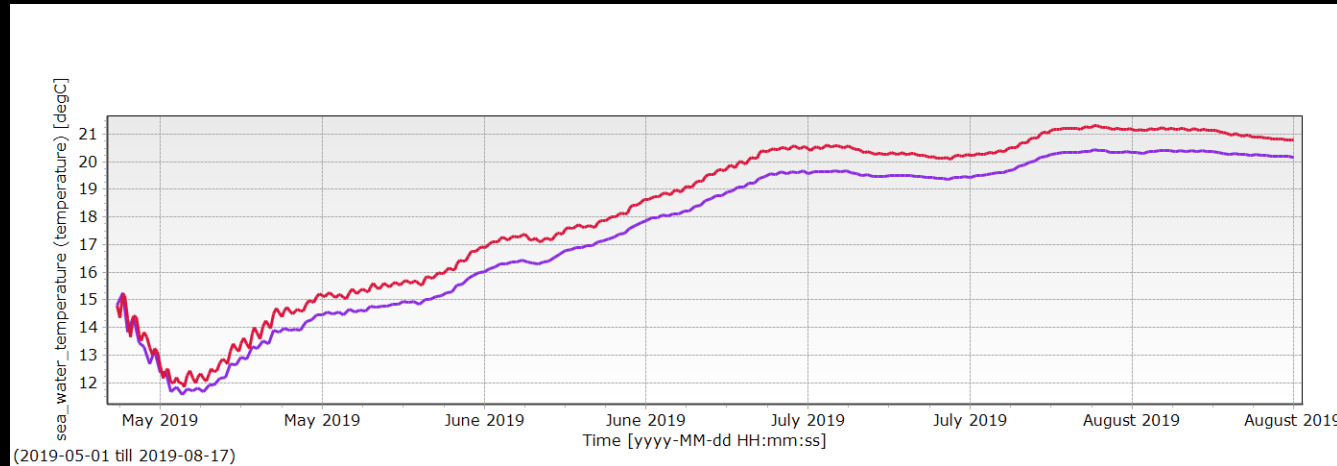
Black, green, blue, yellow, orange:  
Measurements

# New aquathermal extraction/injection prediction

- Extraction of 100 m<sup>3</sup>/h in centre
- Re-injection via multiple holes in ring pipeline along outside of inner pond
- Extraction temperature: .....
- Injection temperature: .....



# Predicted effect of heat extraction





# Conclusions

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- Delft3D model developed for Aquanura pond temperature distributions
- Model gives excellent agreement with existing situation
- Model adapted for future heat extraction
- Predictions show temperature drop in pond as expected
- Comparison with experiments expected starting summer 2023
- Temperature predictions can be used for water quality predictions