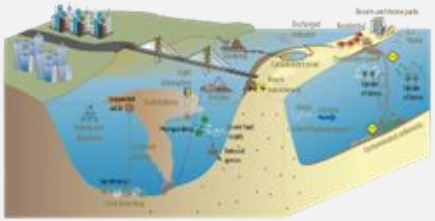
Water Quality Modelling
Case Study
Environmental Agency Abu Dhabi

Emma McCall

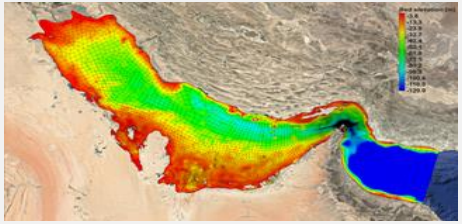
AWS July 2022

Presentation outline

EAD Capacity Building Program



Case Studies - Overview



Hydrodynamic and Water Quality Modeling

Focus Case Study
Key water quality parameters of:
Salinity concentrations
Dissolved oxygen
Total nitrogen

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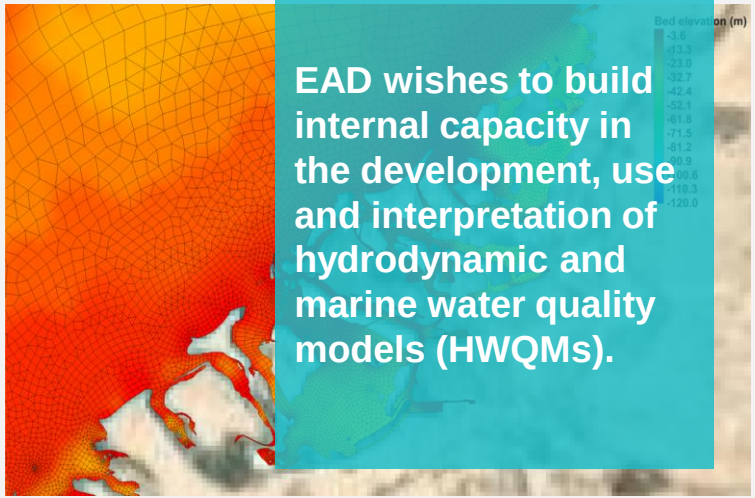
EAD Capacity Building Program

The Environment Agency - Abu Dhabi (EAD) works for the protection of the environment through the promotion of sustainable management practices.



EAD wishes to build internal capacity in the development, use and interpretation of hydrodynamic and marine water quality models (HWQMs).

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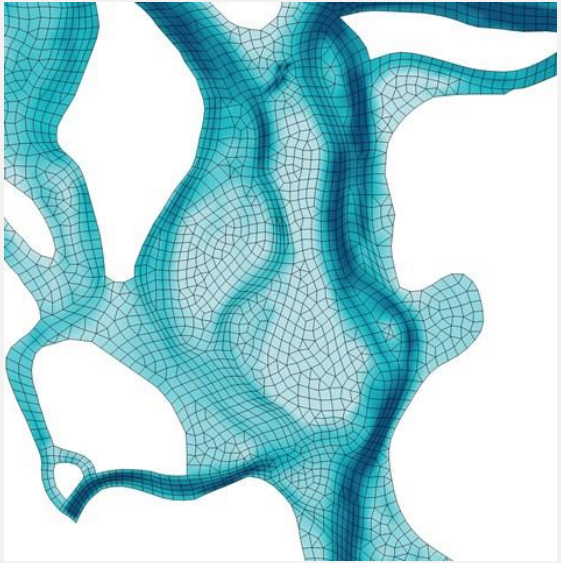
EAD Capacity Building Program

BMT was commissioned by the Environmental Agency Abu Dhabi (EAD) to conduct a two-year training program to build capacity in numerical modelling

- Understanding how models are built/developed
- The data campaign behind the modelling
- How the data is used to validate/calibrate models
- Types of numerical models
  - Hydrodynamic models and water quality models, 2D or 3D
- Appropriate use of models – fit for purpose



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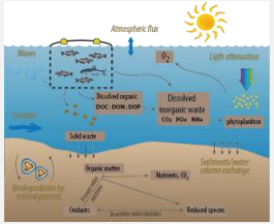
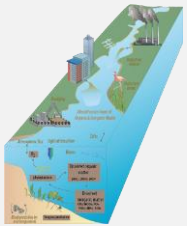
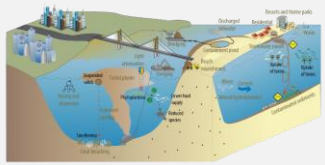
Case Study Overview



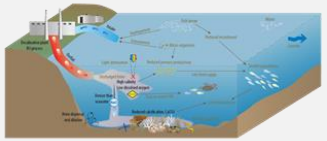
Case Study 1
Delma Island Aquaculture Carrying Capacity



Case Study 2
Mussafah Channel Water Quality

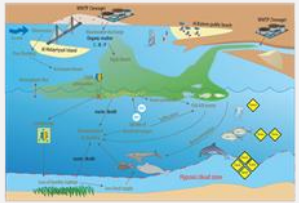


Case Study 3
Al Hidayriyat Island Development

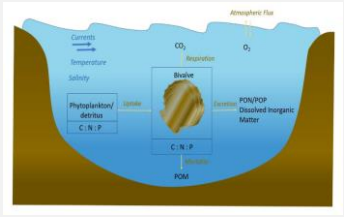


Case Study 4
Mirfa Desalination Plant – Brine Discharge

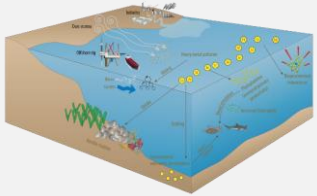
Case Study 5
Khalifa Port Region (Taweelah)



Case Study 6
Al Bateen public beach - Algal Bloom Impact Study



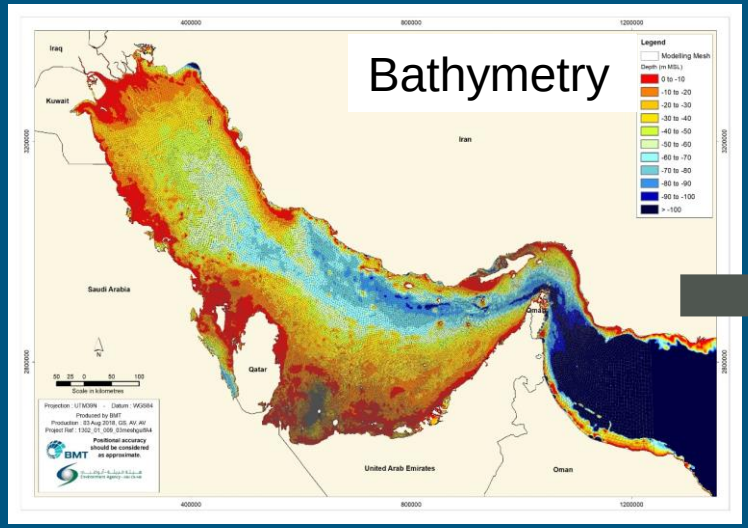
Case Study 7
Pearl Farm Site Selection

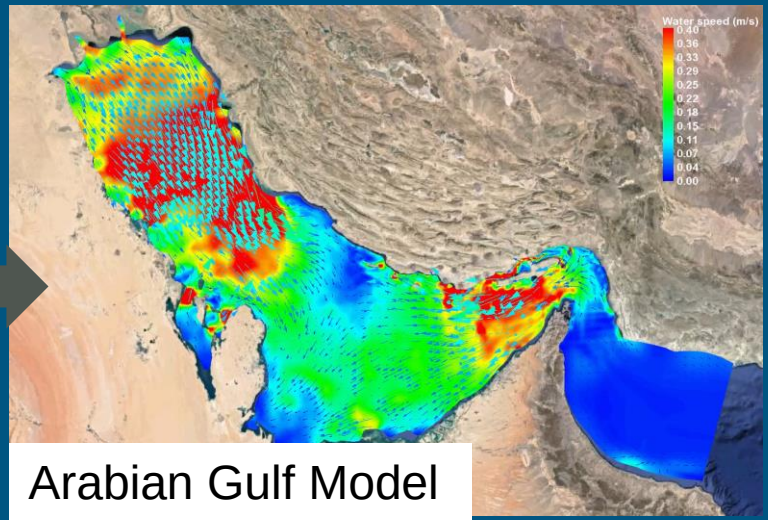


Case Study 8
Heavy Metal Contaminants in Abu Dhabi Coastal Waters

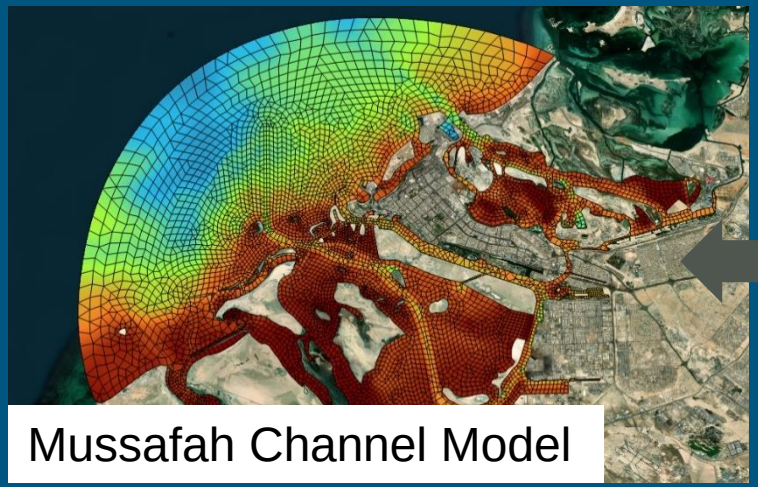
Case Study 9
Sea Level Rise Coastal Inundation Risk and Mitigation

Case Study Locations

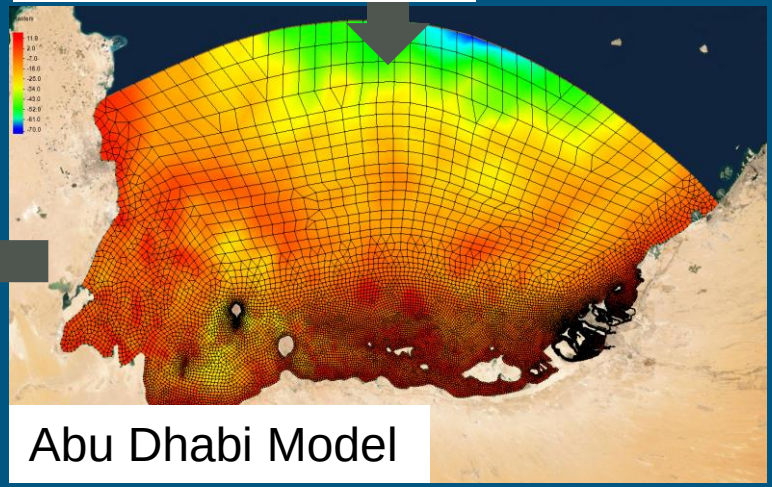




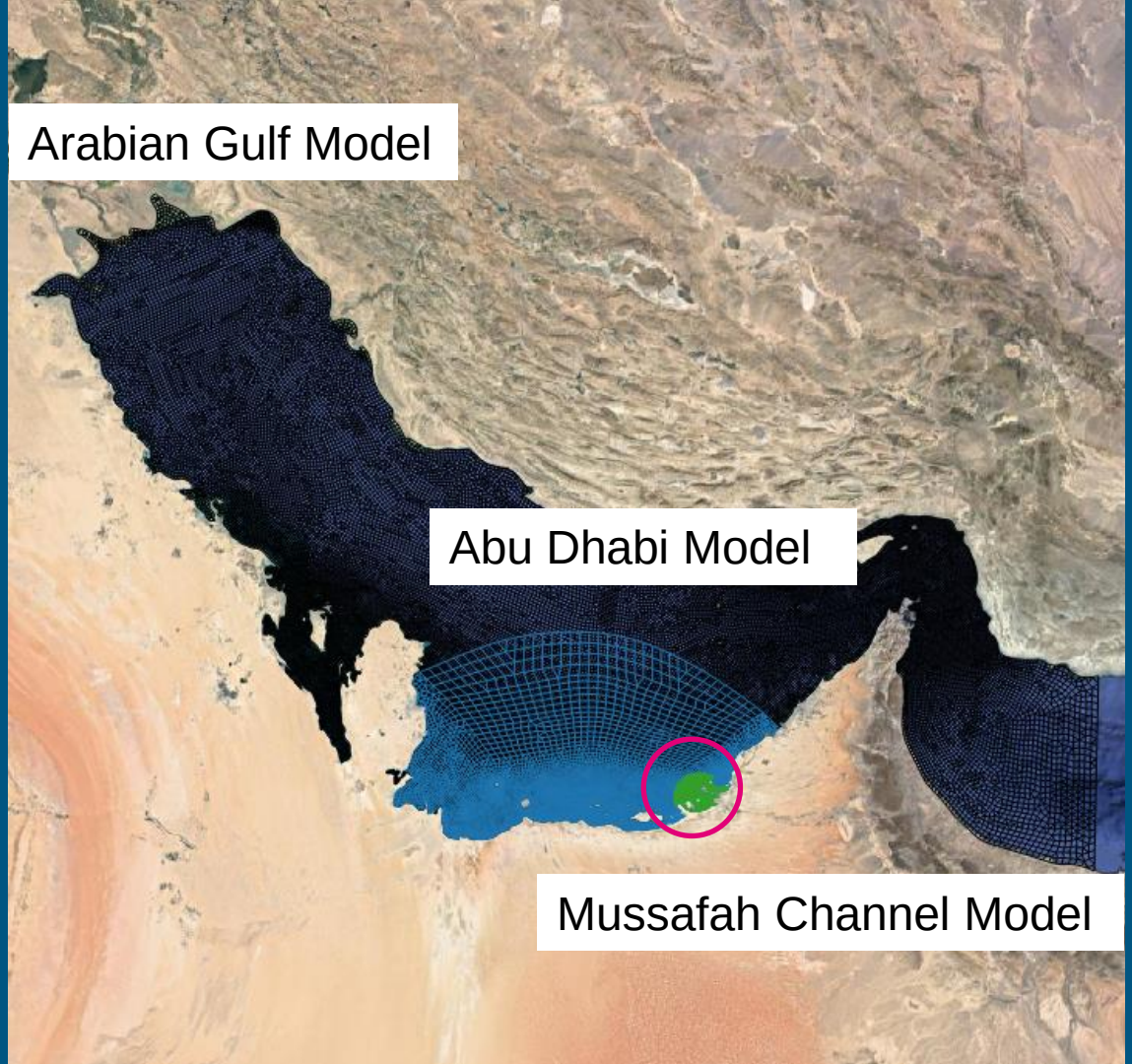
Arabian Gulf Model



Mussafah Channel Model



Abu Dhabi Model


Arabian Gulf Model
Abu Dhabi Model
Mussafah Channel Model

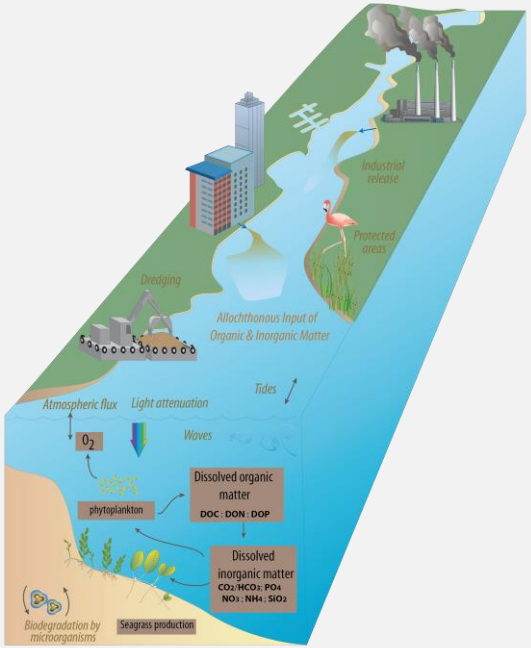
Focus Case Study
Mussafah Channel Water Quality

Purpose

Investigate the impact of changes in nutrient loads from Mussafah Channel on nearby marine ecosystems

Study objectives

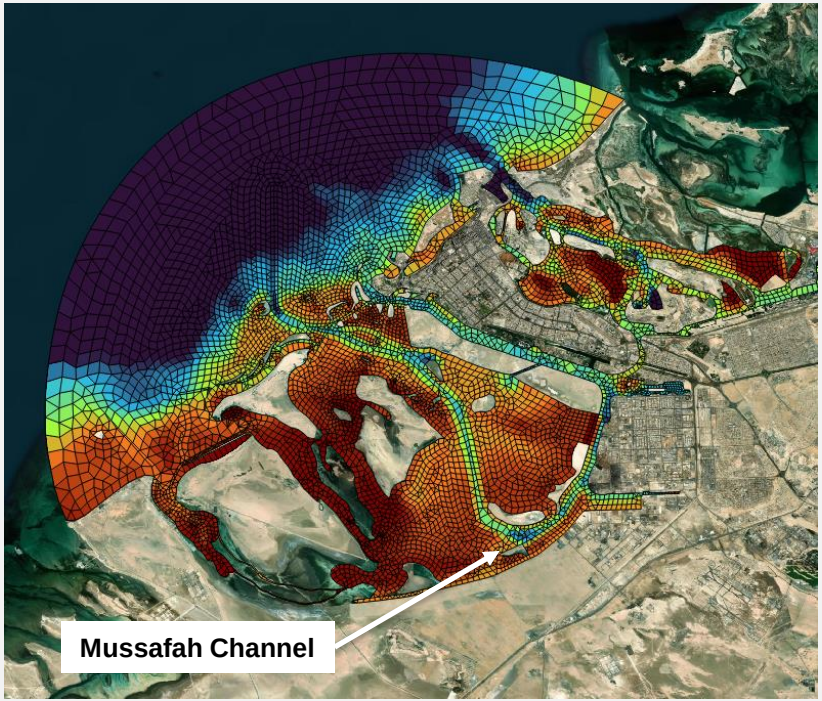
- Develop a hydrodynamic and water quality model of Mussafah Channel and surrounding area
- Model a base line scenario to represent current nutrient loading from industrial discharges into Mussafah channel
- Simulate two scenarios representative of:
  - Removal of the industrial discharges (full re-use of treated discharge)
  - Opening Mussafah Channel to the lagoon
- Predict relative impact of changes in nutrient loads to marine ecosystems



Focus Case Study
Mussafah Channel Water Quality

Abu Dhabi near shore waters

- Mussafah Channel – deep water channel providing access to Mussafah Industrial Area and ICAD I, II, III
- There are several industrial discharges into Mussafah Channel



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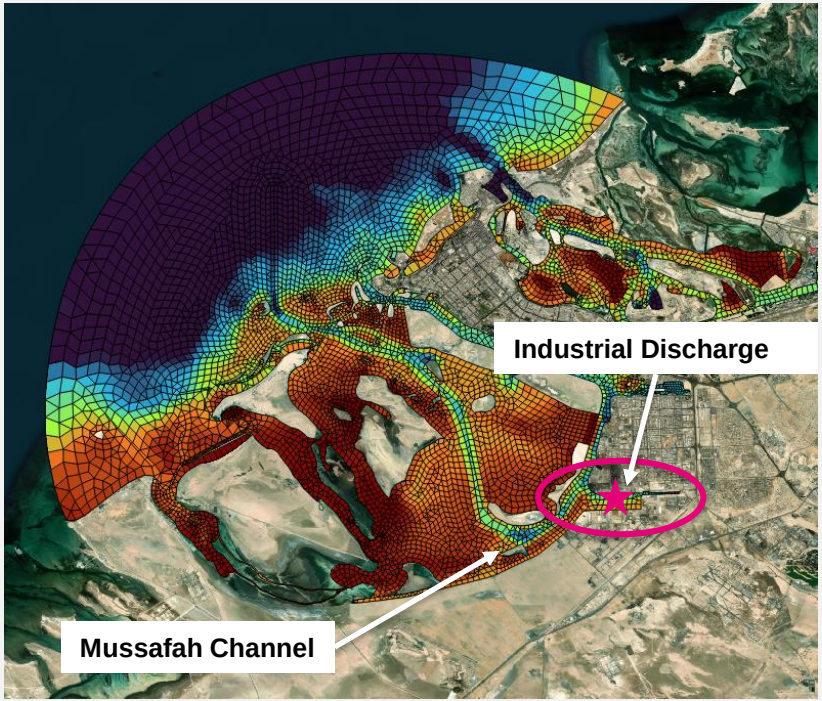
Focus Case Study
Mussafah Channel Water Quality

Abu Dhabi near shore waters

- Mussafah Channel – deep water channel providing access to Mussafah Industrial Area and ICAD I, II, III
- There are several industrial discharges into Mussafah Channel
- The Industrial Effluent Treatment Plant (IETP) services the Mussafah Industrial District and contributes to excess nutrient loads.



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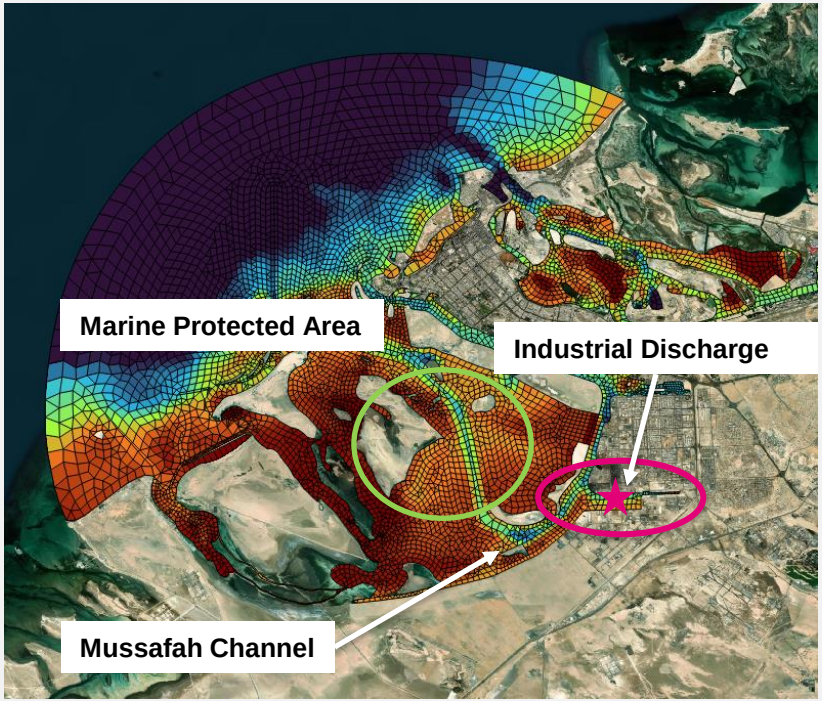
Focus Case Study
Mussafah Channel Water Quality

Abu Dhabi near shore waters

- Mussafah Channel – deep water channel providing access to Mussafah Industrial Area and ICAD I, II, III
- There are several industrial discharges into Mussafah Channel
- The Industrial Effluent Treatment Plant (IETP) services the Mussafah Industrial District and contributes to excess nutrient loads.
- Nearby marine protected area



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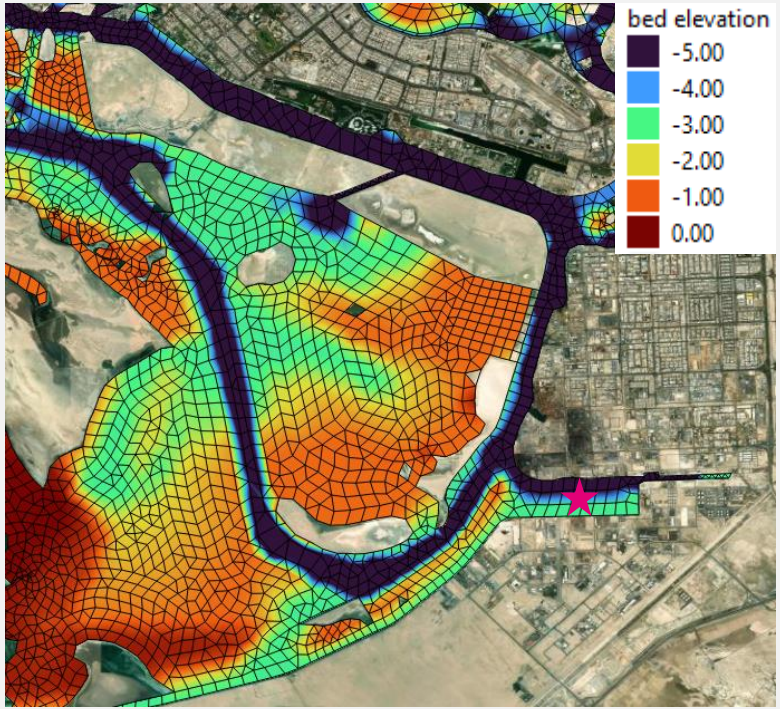
Focus Case Study
Mussafah Channel Water Quality

Scenario 1 - Remove discharge

- Removed the industrial discharge from Mussafah Channel – compete re-use of industrial discharges.

Impacts

- Removed the low salinity inflow (impacting salinity and stratification)
- Reduced the nutrients into surrounding environment
  - Total nitrogen reduced
- Dissolved oxygen decrease in the near field
  - Reduced mixing without discharge and removal of the higher DO in discharge water



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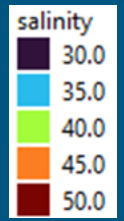
Map outputs – salinity (instantaneous)

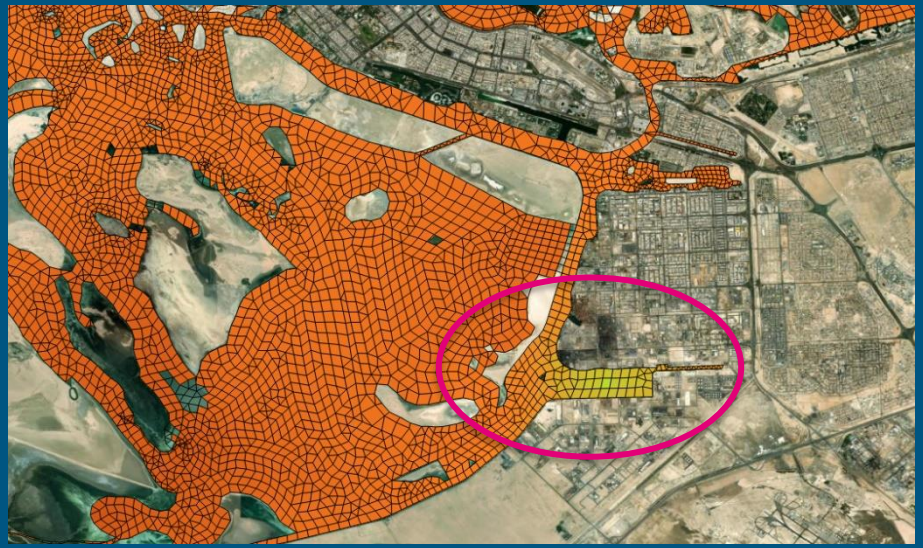
Baseline - With industrial discharge

Scenario - Without industrial discharge



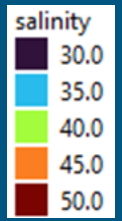
Salinity concentration (g/L) - near surface (0-2m from surface)

Map outputs – salinity (instantaneous)



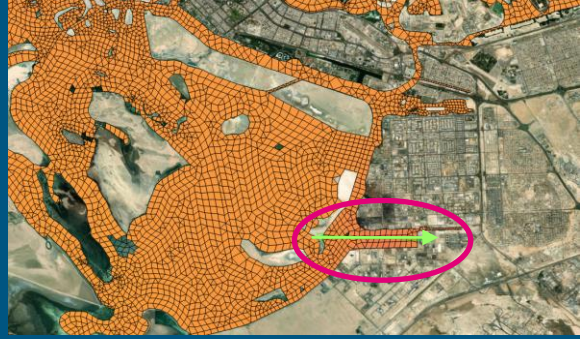
Baseline - With industrial discharge

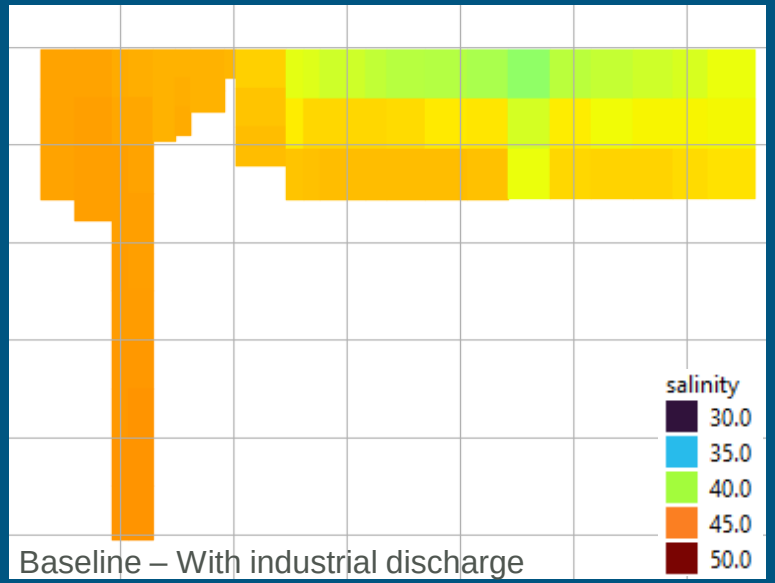
Scenario - Without industrial discharge

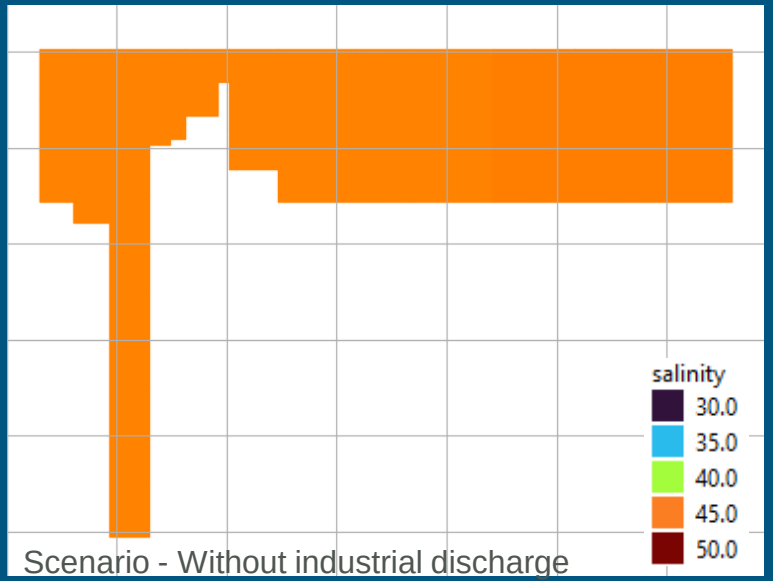


Salinity concentration (g/L) - near surface (0-2m from surface)

Curtain plots – salinity (instantaneous)





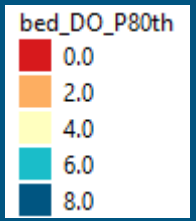


Salinity concentration (g/L)

Map percentile plots – dissolved oxygen (12 months)

Baseline - With industrial discharge

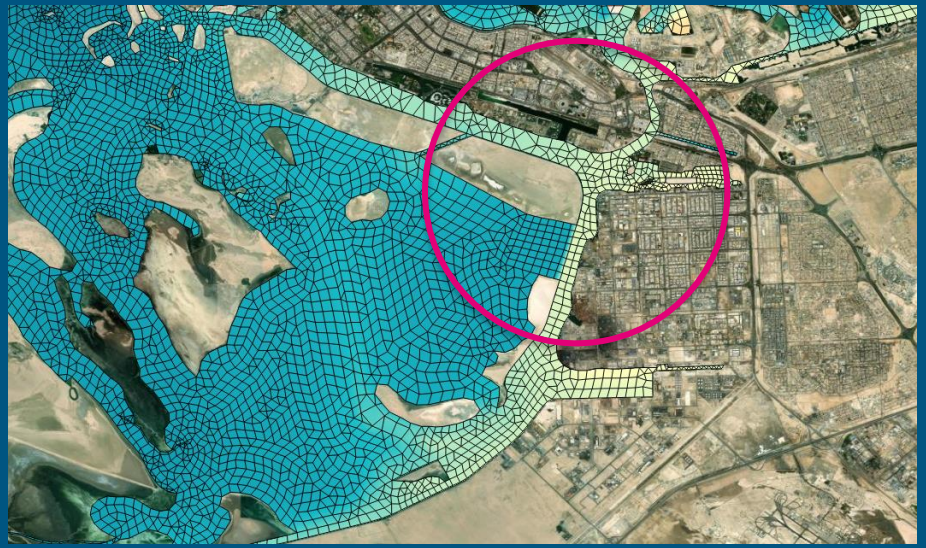
Scenario – Without industrial discharge



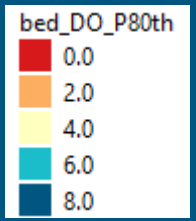
Dissolved oxygen (mg/L) - 80th percentile near bed (0-2m from bed)

Map percentile plots – dissolved oxygen (12 months)

Baseline - With industrial discharge



Scenario – Without industrial discharge



Dissolved oxygen (mg/L) - 80th percentile near bed (0-2m from bed)

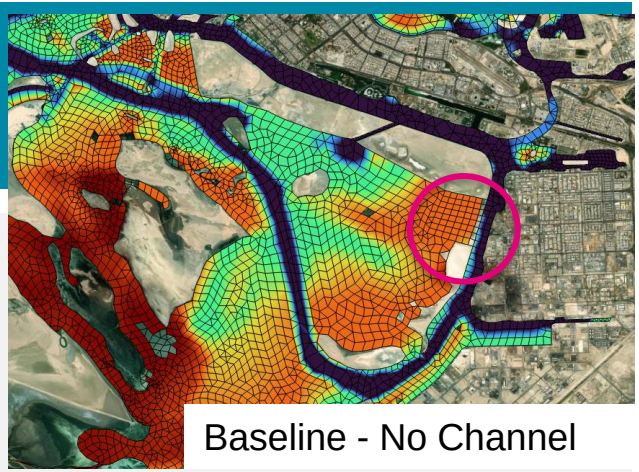
Focus Case Study
Mussafah Channel Water Quality

Scenario 2 - Additional channel to improve flushing

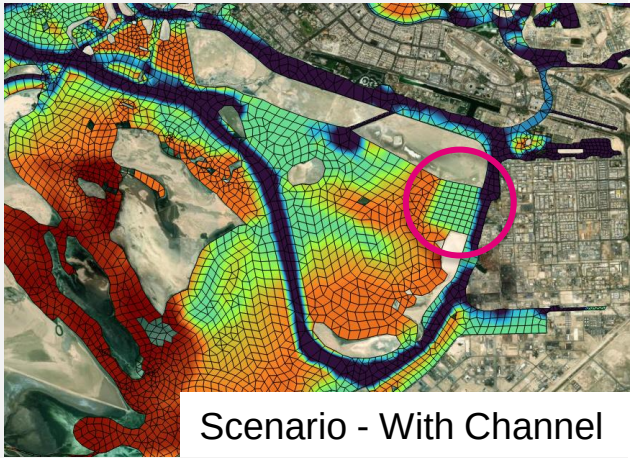
- Dredged channel to increase flushing of Mussafah Channel

Impacts

- Changes to mesh to simulation opening of channel
- Bathymetry estimated from satellite imagery
- Flow patterns and dispersal of nutrients changed



Baseline - No Channel

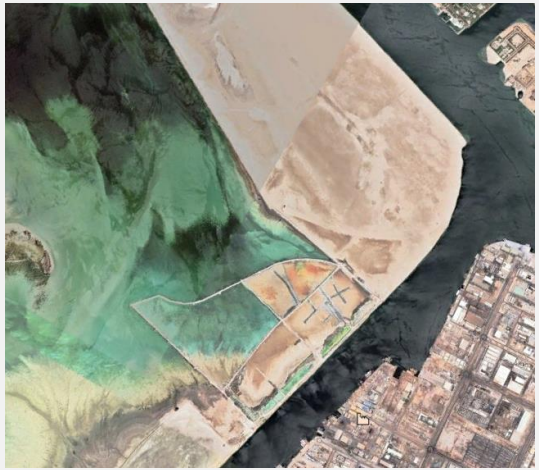


Scenario - With Channel

Focus Case Study
Mussafah Channel Water Quality

Scenario 2 - Additional channel to improve flushing

2015



2020

2021

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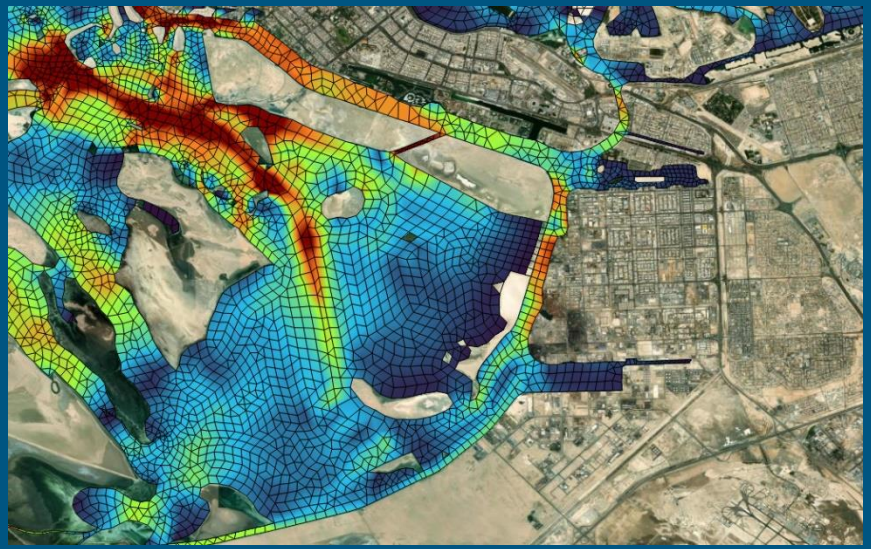
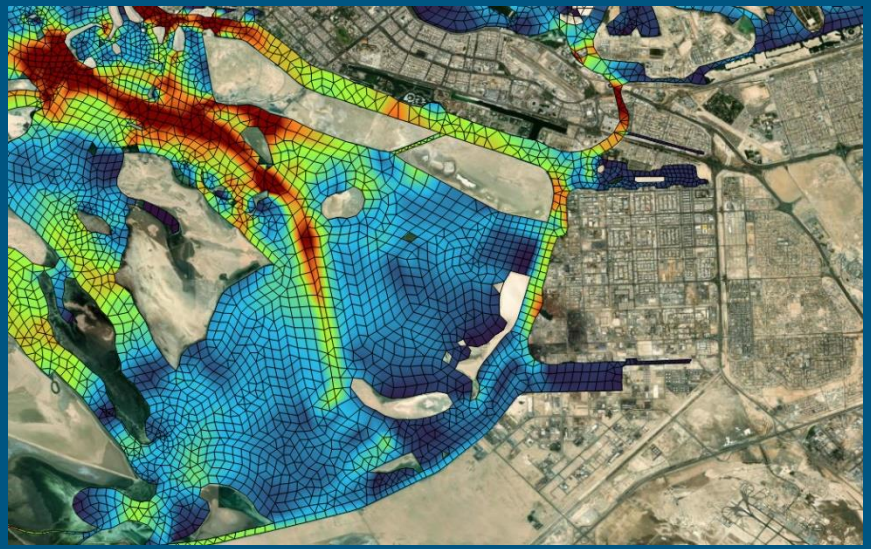
Map plots – velocity



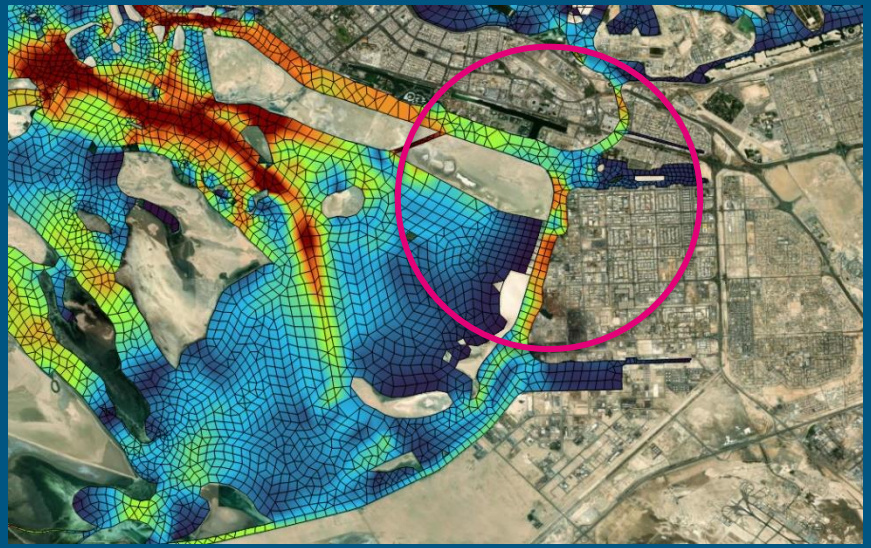
Baseline - Without channel



Scenario - With channel

Velocity (m/s) – near surface (0-2m from surface)

Map plots – velocity



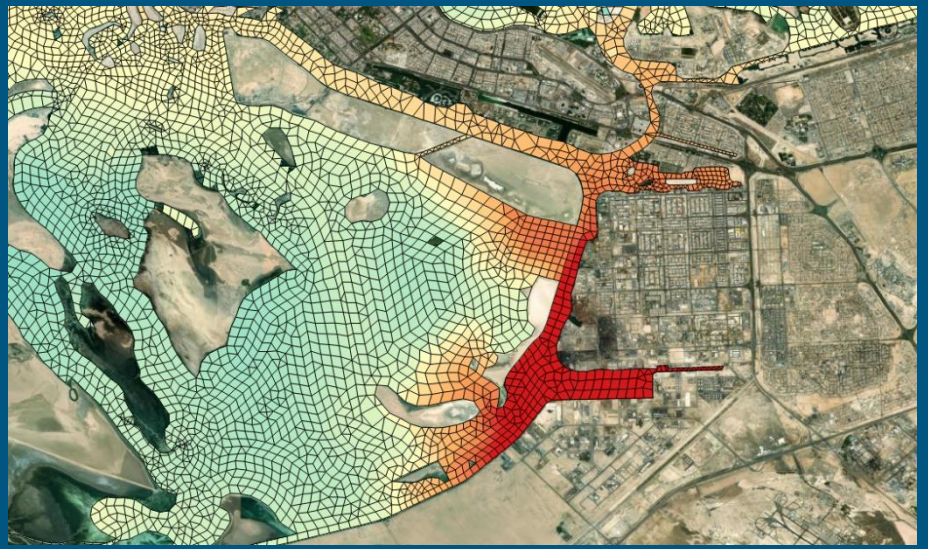
Baseline - Without channel

Scenario - With channel

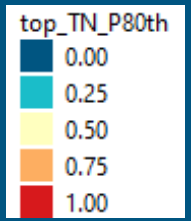
Velocity (m/s) – near surface (0-2m from surface)

Map percentile plots – total nitrogen (12 months)

Baseline - Without channel

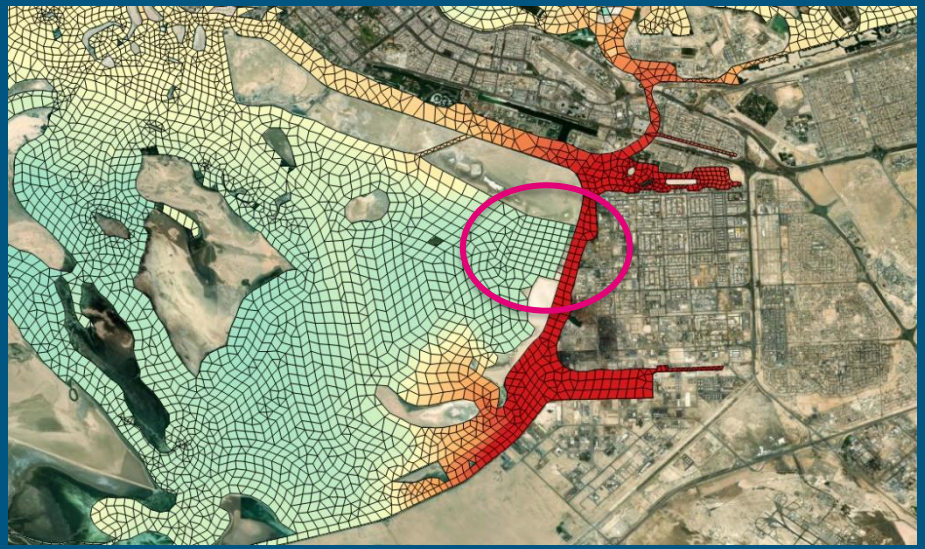


Scenario - With channel

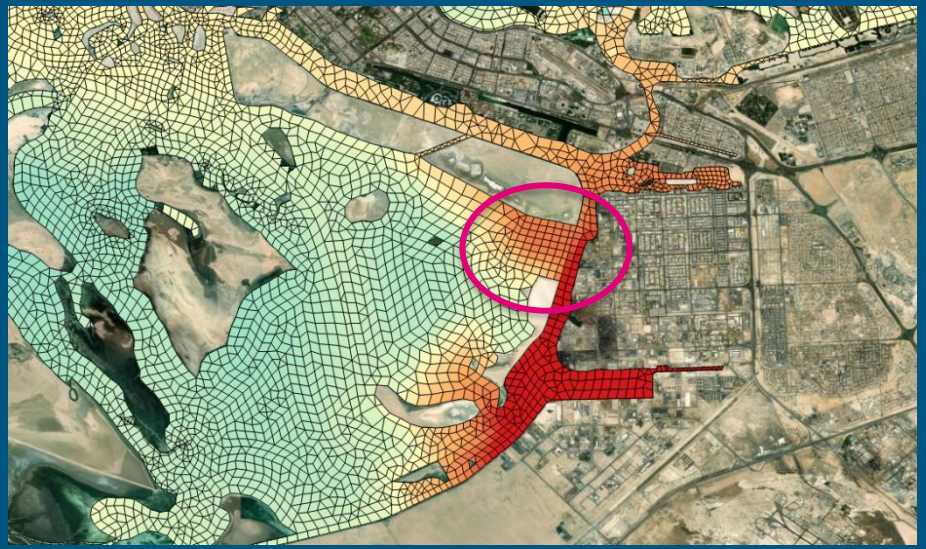


Total nitrogen (mg/L) - 80th percentile near bed (0-2m from bed)

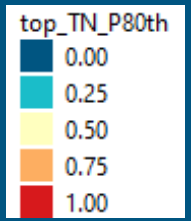
Map percentile plots – total nitrogen



Baseline - Without channel



Scenario - With channel



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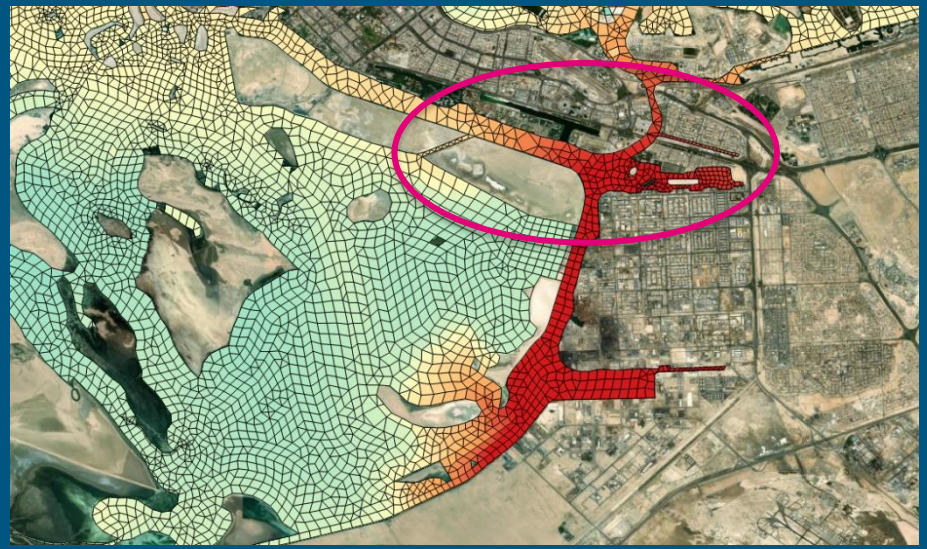
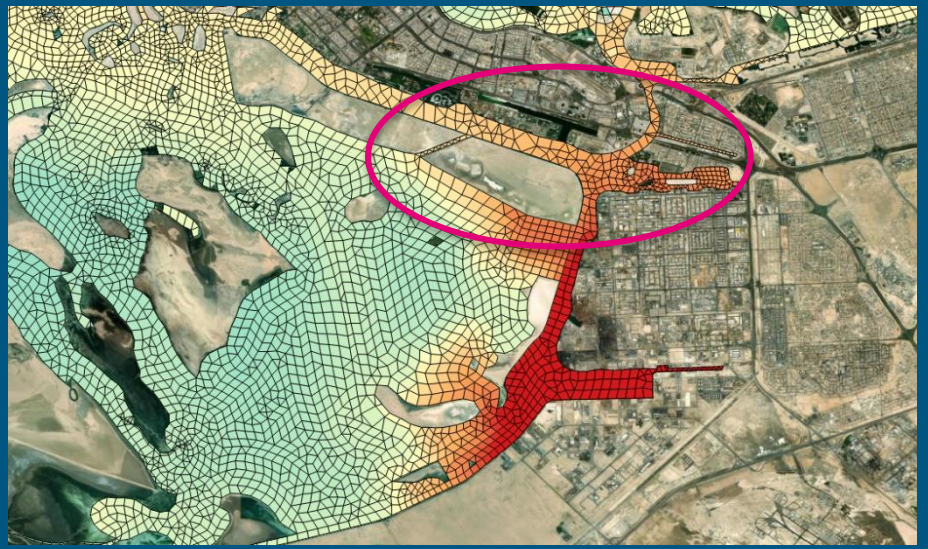
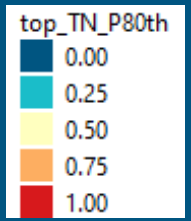


Without channel



With channel



Total nitrogen (mg/L) - 80th percentile near bed (0-2m from bed)

Summary

Numerical model can be used to:

- Inform sustainable management practices
- Highlight potential benefits and risks
- Make decisions that improve water quality outcomes

Next up:

- Using numerical models to assess implications of sediment transport