Applied Hydrodynamic Modelling – Part 1

Suspended Sediment Modelling at the Port of Gladstone

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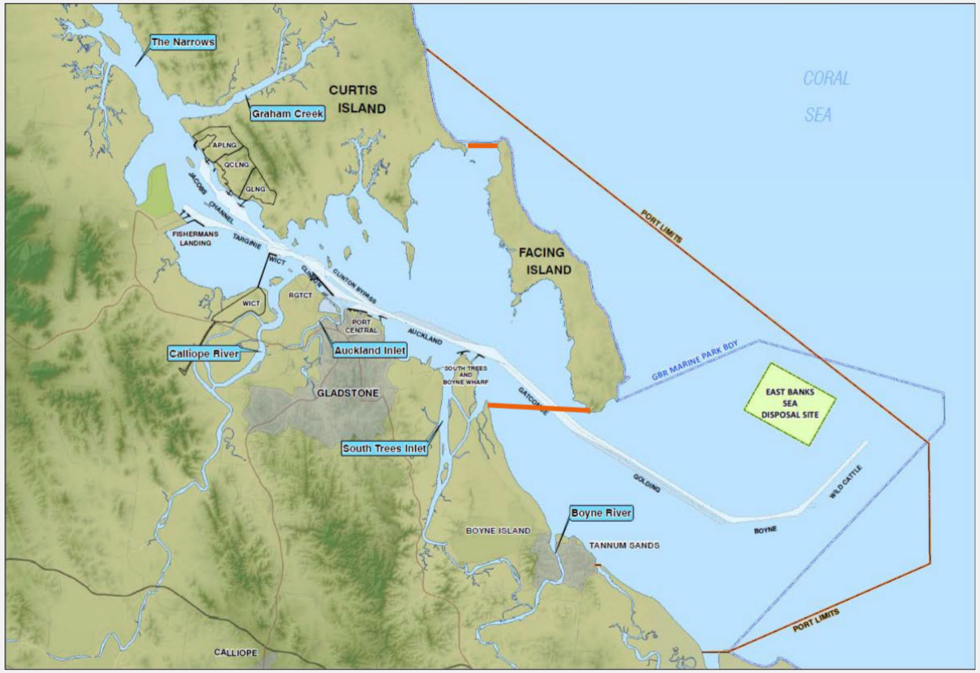
Suspended Sediment Modelling at the Port of Gladstone

The Port of Gladstone

- One of Australia’s finest natural harbours
- Queensland's largest multi-commodity port – 100 million tonnes per year
- Major cargoes include coal, bauxite, alumina, aluminium, cement and liquefied natural gas (LNG)
- Ongoing maintenance and capital dredging operations are conducted to maintain and expand the shipping channel infrastructure
- Commitment to minimising environmental harm



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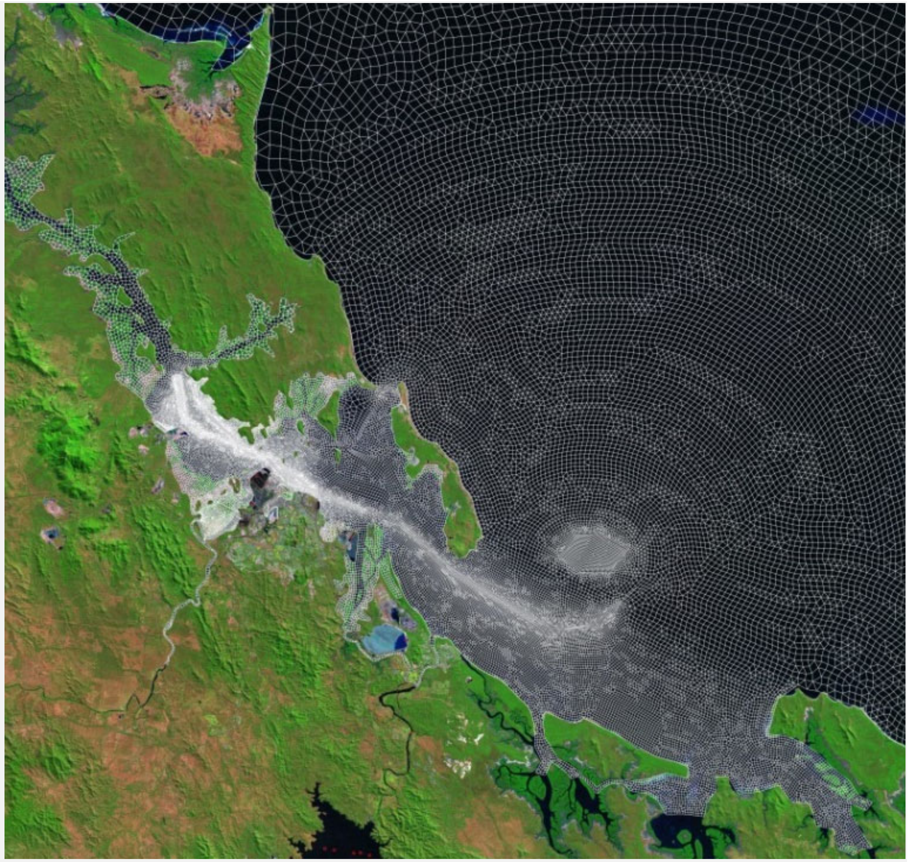
TUFLOW FV

- Finite Volume 2D/3D Hydrodynamics Solver
- Baroclinic terms included
- One-way / two-way coupling with SWAN waves
- Flexible mesh allows variable resolution
- Sediment transport module

Port of Gladstone Model

- Resolution 50-150m cells within the Port
- Regional-scale model
- Includes 3D hydrodynamics, freshwater inflows, wave coupling, wind/pressure/heat flux boundary conditions, ocean current forcing



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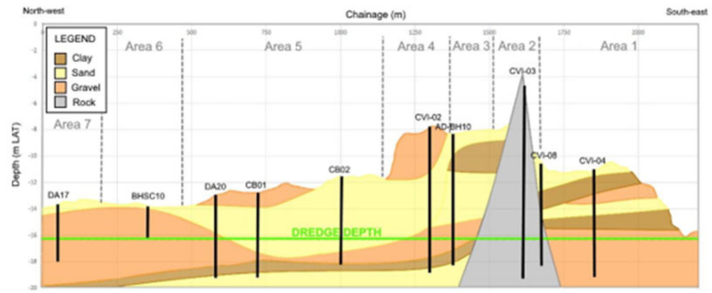
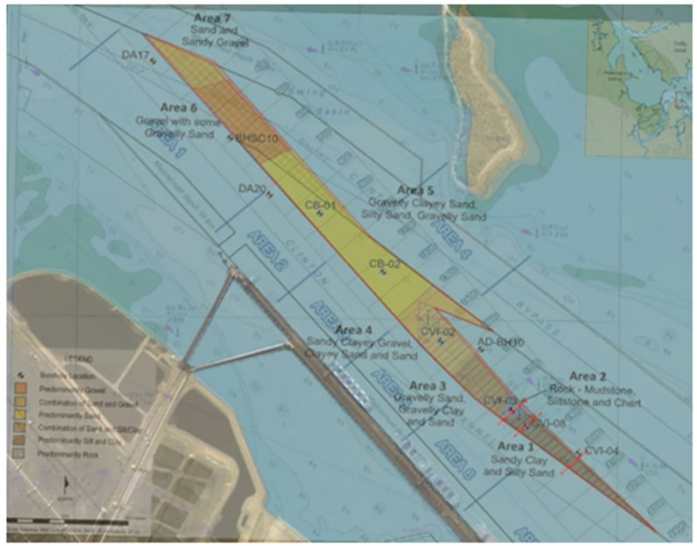
The Clinton Vessel Interaction Project

- 2020 Project to Widen Clinton Channel in the Port of Gladstone
- Approx. 800,000m^3 of material removed by large Backhoe Dredger
- Fine Sediment Management Plan required by the federal government environment department
- The plan involved measuring the total mass of sediment particles less than 15.6 micron released to the environment
- A monitoring plan was developed to measure dredging activity on three occasions working in different material





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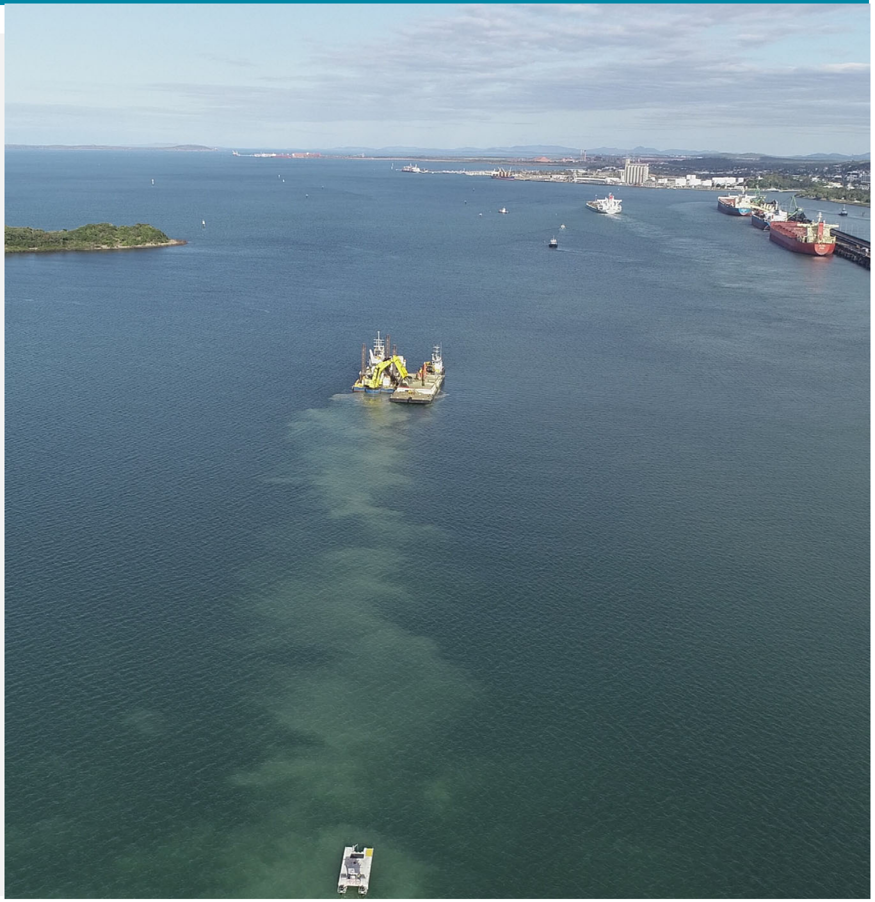
Field Work Components

- Boat-based transect measurements of suspended sediment concentration
- Vessel-mounted downward-facing ADCP recorded the acoustic backscatter intensity across transects
- Turbidity profiles, both within and outside the plume
- Water samples collected for laboratory analysis of TSS and PSD.
- In-situ particle size distribution measurements and volume concentration profiles using a LISST-100X
- Positional GPS instruments to record boat heading and position.

Three measurement campaigns
31 March, 1 April and 2 April 2020 - sandy material
14 July, 15 July and 16 July 2020 - harder material
11 August and 12 August 2020. - clayey material



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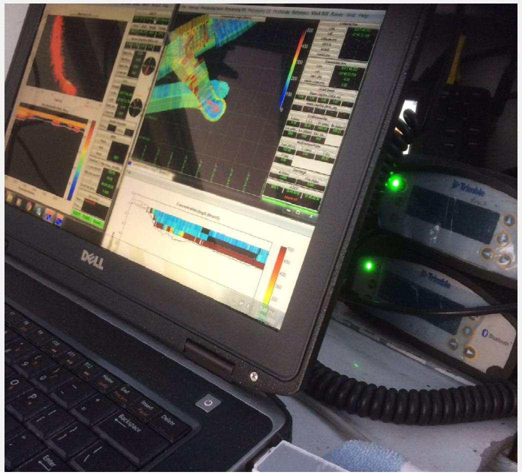

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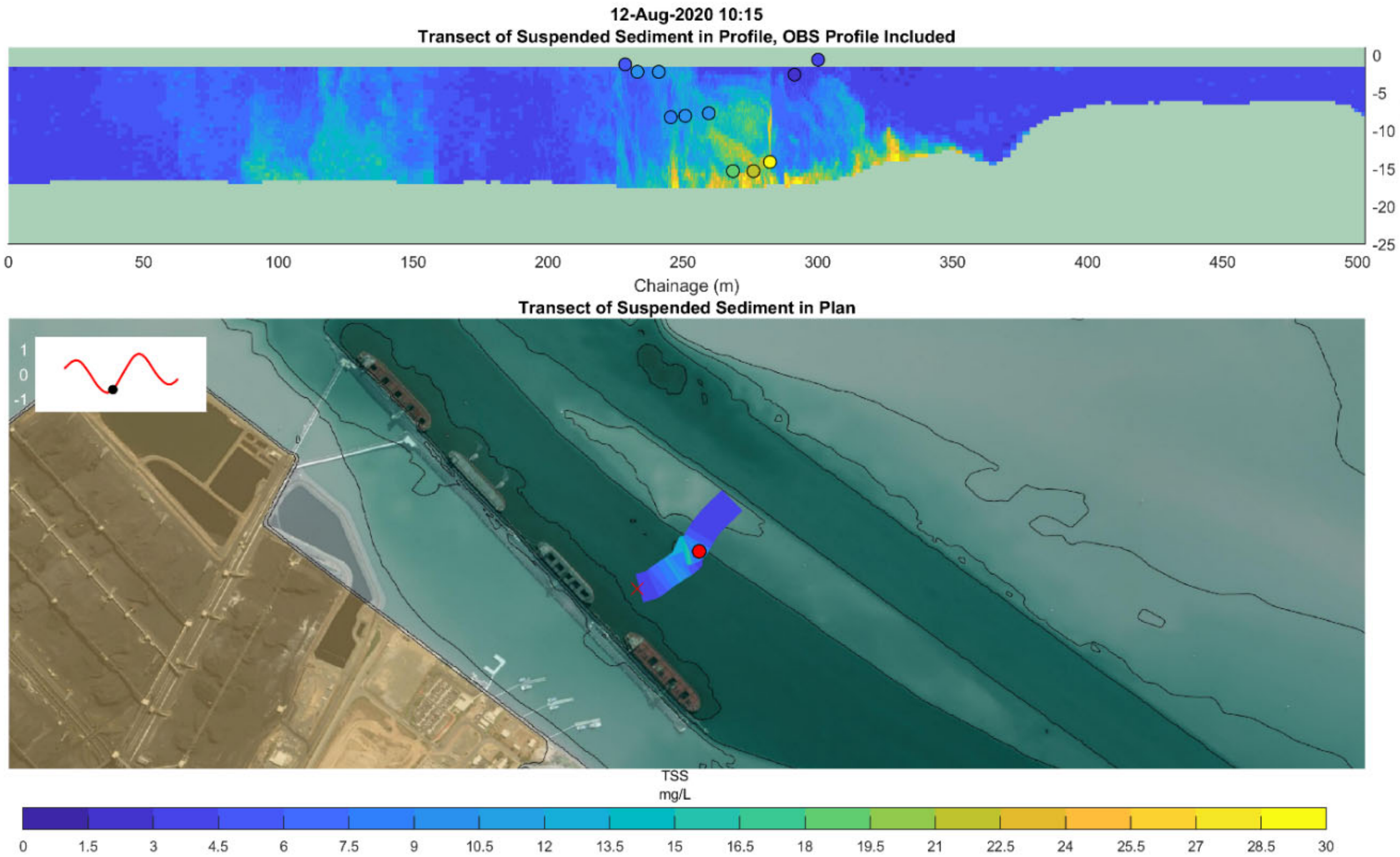

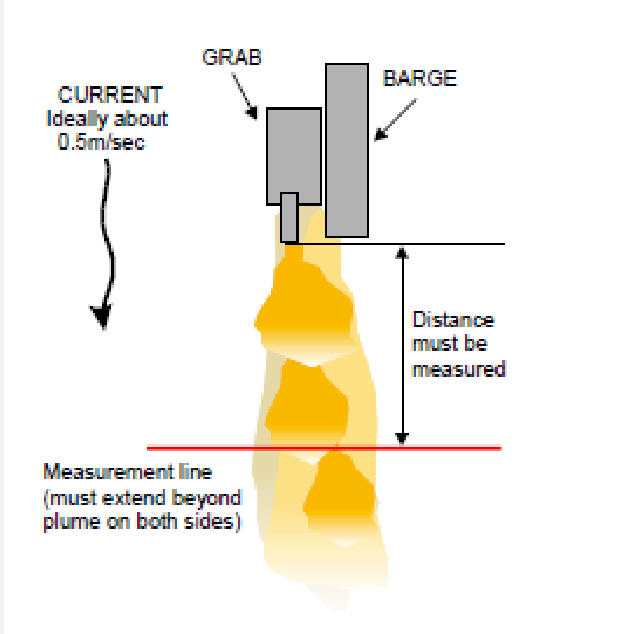

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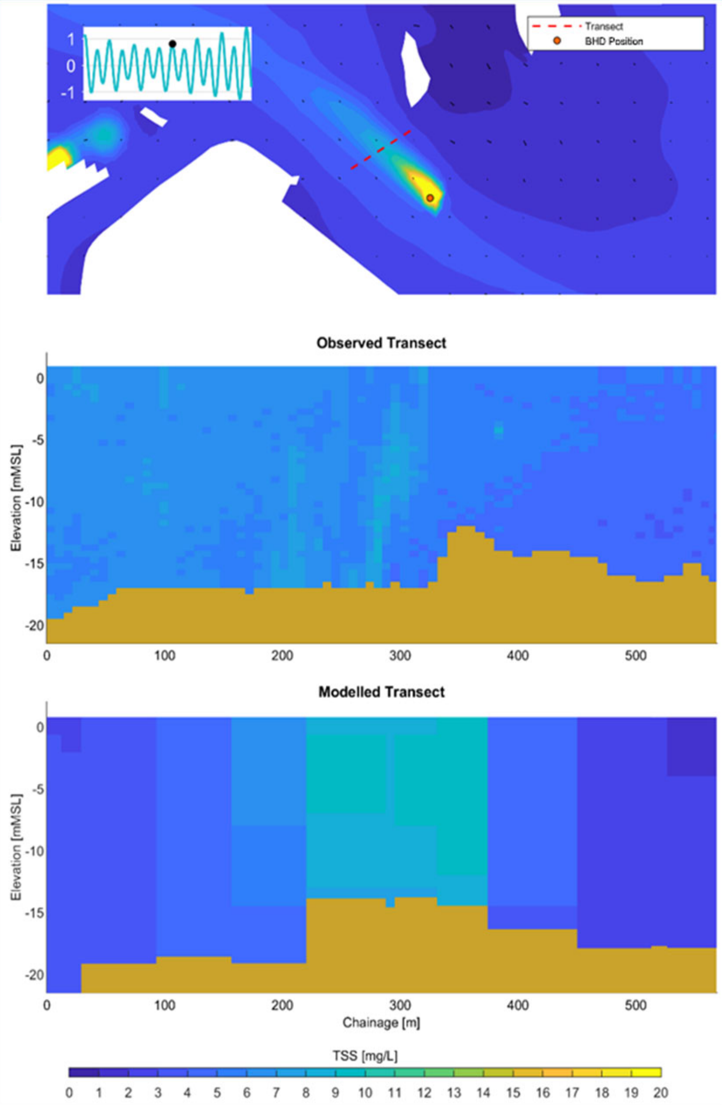
Numerical Modelling

- The validated TUFLOW FV model of the Port of Gladstone was used to undertake hindcast modelling of the dredging operation during the monitoring periods.
- The estimated dredging-related sediment flux from each ADCP transect measurement was compared to the modelled dredging-related sediment flux.
- The plume source rate for the dredge working in each material type in the model was then adjusted over a series of simulations in order to achieve the best overall agreement between the model and field measurements.



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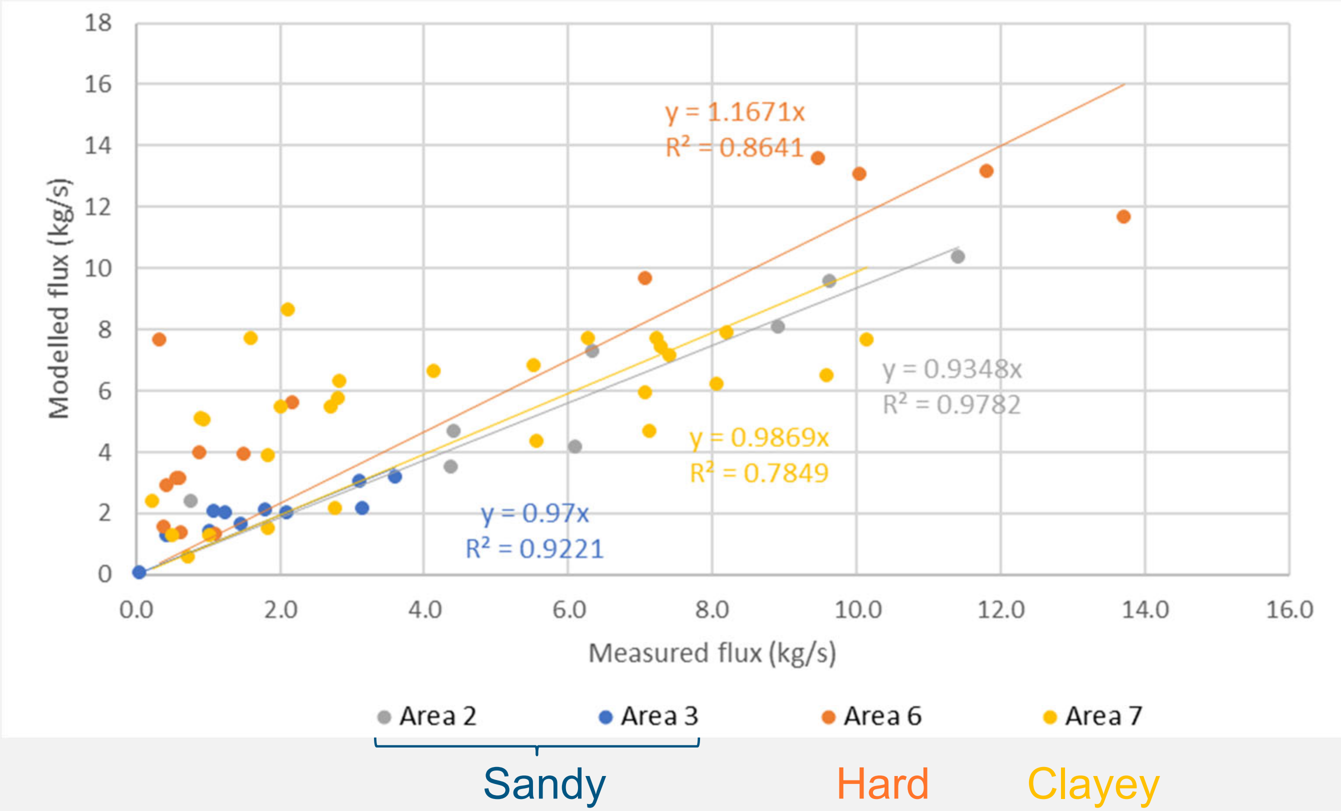
Transect Flux Comparisons

- Higher plume source rates were appropriate when dredging in hard/clay material compared with working in sand/gravel material.
- The slope of the best fit linear relationship between the modelled and measured fluxes is close to 1:1 for all four of the dredge work areas.



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Average rate of plume release per in-situ unit volume of each material type:

$$\frac{\text{kg plume / hour}}{\text{m}^3 \text{ / hour dredging}} = \text{kg/m}^3 \text{ plume}$$

Mass of fine particles released per in-situ unit volume of material:

$$\text{kg/m}^3 \text{ plume} \times \text{\% less than 15.6 micron} = \text{kg/m}^3 \text{ fines}$$

The total release quantity over the entire dredging campaign:

$$\text{kg/m}^3 \text{ fines} \times \text{volume of each material} = \text{total mass of fines}$$

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Why use a numerical model?

- The numerical modelling is very useful since it accounts for the plume advection, dispersion and settling that occurs between the point of discharge (the BHD bucket) and the measurement transect.
- It also accounts for temporal variability of plume generation since the dredging logs are used to estimate how the plume release rate varies with time.
- It provides an estimate for the proportion of the measured TSS that is likely to be ambient suspended sediment rather than dredging-related sediment.

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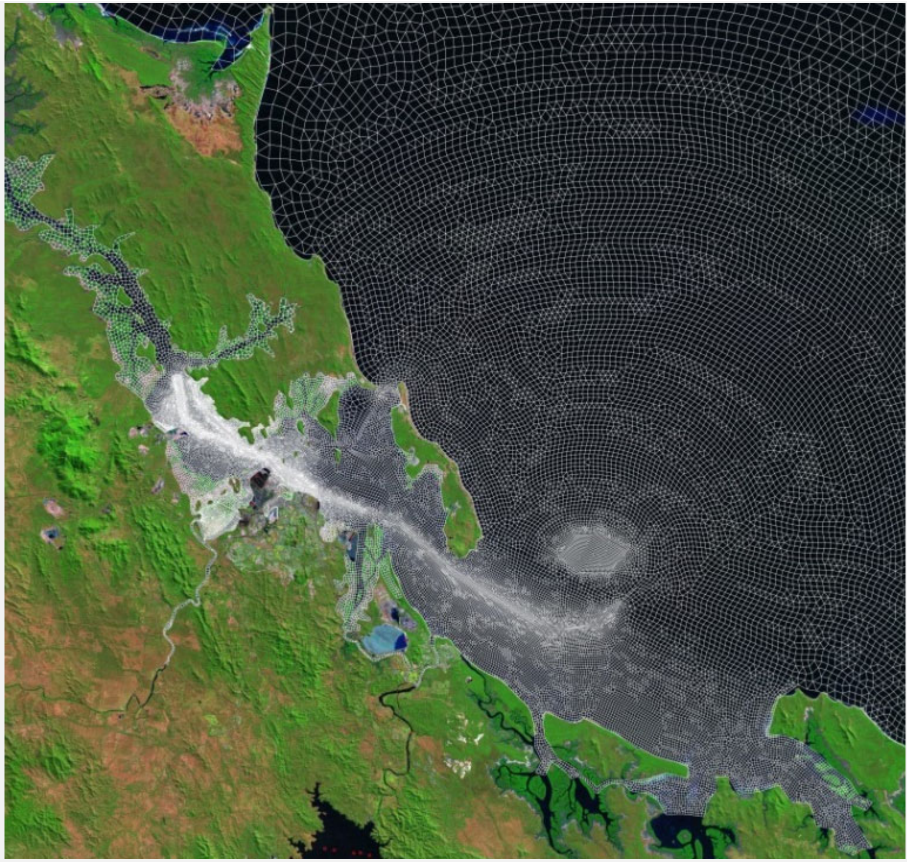
Conclusion

- Numerical modelling was a very useful component of the Fine Sediment Management Plan
- The client and the regulatory agency were pleased with the methodology and the outcome



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Thank You