HR Wallingford
Working with water

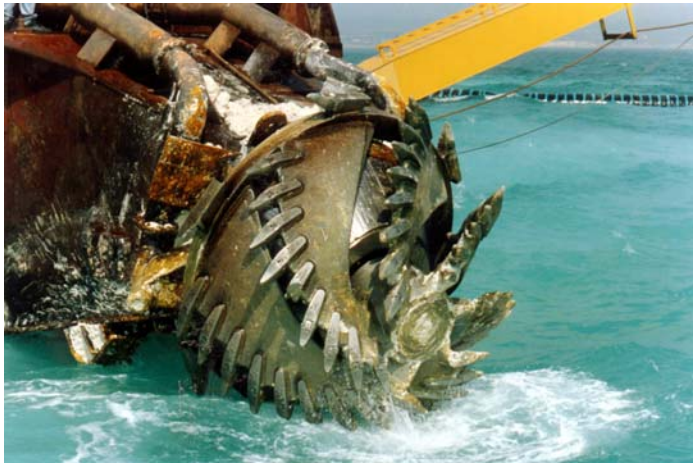
Sediment plumes arising from dredging and reclamation activities
- The application of expert assessment and modelling

Michael Costaras
Jeremy Spearman
Mike Dearnaley

Issues involved – creation of plumes

Dredging and reclamation plumes can be caused by:

- THSD: (when dredging) overflow, draghead and propeller disturbance, bottom dumping, screening for aggregate (when pumping ashore) pipe leakage, unconfined reclamation run-off
- CSD: dispersion of disturbed sediment not sucked into pipe, pipe leakage, unconfined reclamation run-off (when pumping to barges) overflow



Issues involved – creation of plumes

Dredging and reclamation plumes can be caused by:

- GRAB (CLAM) & BACKHOE: disturbance by the downward pressure wave, spillage during ascent and above water, effects of debris preventing closure
- RECLAMATION: unconfined run-off, run-off through water boxes, erosion of bunds by currents and waves

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Issues involved – potential adverse effects

Dredging and reclamation plumes (can) result in:

- Increases in turbidity
  - affects photosynthesis of phytoplankton and vegetation
  - can affect migratory patterns of fish
  - can impede forage opportunities for fish/birds and mammals
- Deposition of sediment
  - burial/change in substrate type (affects beaches & fauna/flora)
  - can affect maintenance dredging of other nearby locations
  - deposition can occur both locally and at some distance from the point of release
  - for large projects can cause changes in nearby morphology (intertidal areas)
- Changes in water quality
  - contamination by pollutants
  - increase in suspended sediment concentration (particularly for intakes)
- Large-scale changes in the overall sediment budget

Issues involved – the Developer

Involving the consultant at an early stage will flag up potential problems early on and smooth the process of design/evaluation

Failure to involve the consultant at an early stage may result in:

- Project delay through re-design at a late stage
- Restrictions on production
- Overly onerous monitoring
- Bad publicity through adverse impacts on sensitive sites

If you invest in studies up front it is likely that you will save hassle/money overall

Issues involved – the consultant

A helpful consultant should:

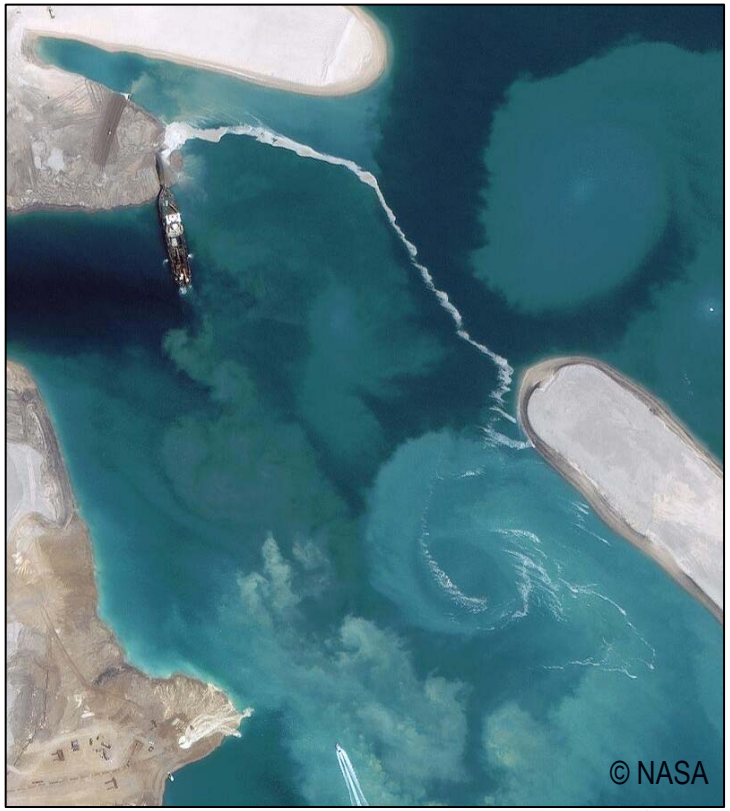
- Be included at early stage
- Understand the existing conditions
- Flag up the potential for adverse impacts of dredging/reclamation before the design and/or construction methodology becomes entrenched
- Flag up the need for specific measurements if they will reduce uncertainty (and therefore the need for onerous monitoring later)
- Be able to suggest options for mitigating any envisaged impacts
- Be able to use the most efficient methods (balancing the need for simplicity with the need to provide rigorous and convincing output) to address the studies. This will include expert judgement and/or state-of-the-art computational models.
- Be able to design an appropriate monitoring programme.
- Be able to communicate this information to interested parties.

Issues involved – the consultant

The consultant should be included during the scoping of the project as well as the subsequent evaluation of impacts.

The consultant needs to be part of the initial evaluation of the environment in which the development will take place and be part of the "concept development within the total environment"

Nick Bray



Scoping

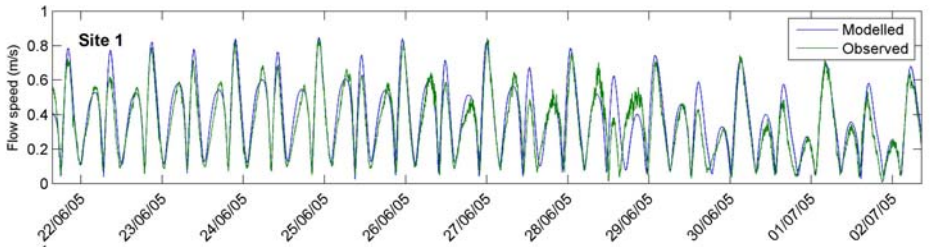
- What are the important features of the operation?
- What issues are there ?
- What are the relevant questions?
- How can the available tools be used to answer the relevant questions?
- Can this be done in a manner which is communicable and convincing to all the interested parties?

Issues involved – effects needing evaluation

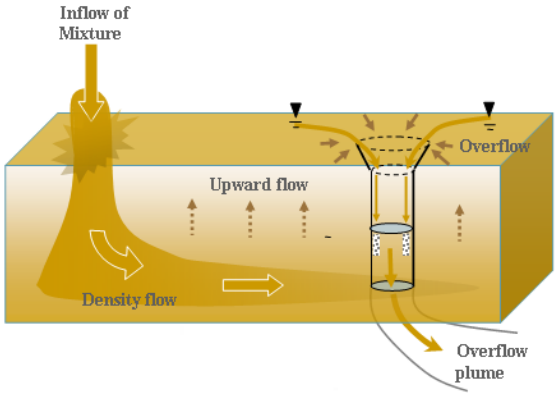
- Short term increase in suspended sediment concentrations and deposition of fine sediment
  - Effects that can be discerned using plume dispersion models
  - Specific to the dredging scenario represented
- Effects that may occur over the longer term
  - Wave resuspension (followed by advection and re-settlement) of fine material previously deposited over long periods of dredging under calmer conditions
  - Gradual increases in turbidity that may occur over long periods of dredging but are not discernible from short term modelling
  - Dispersion of sandy material released/disturbed by dredging project
- Effects resulting from the entire project
  - It is often possible to make a reasonable estimate of the total loss of sediment that will be released and where this is likely to end up

Tools required (1)

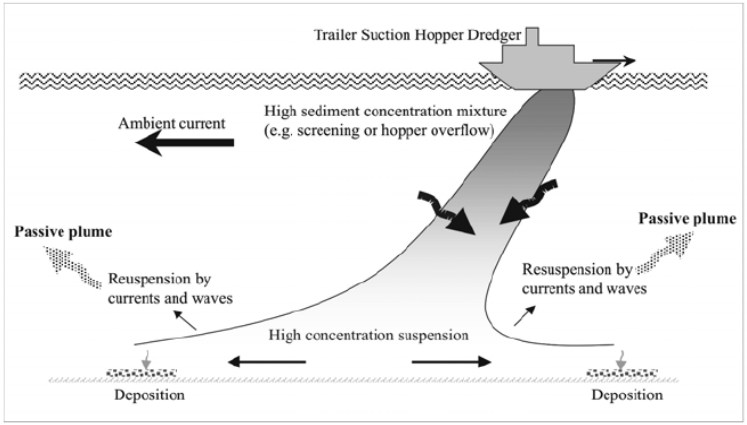
- A good flow model



- Production model
  - calculates magnitude and PSD of released sediment from the hopper



- Near field mixing model
  - dynamic plume
  - Collapse onto bed
  - May also include other release mechanisms such as propeller turbulence, draghead disturbance, sediment released to surface, etc



Tools required (2)

- Fine sediment dispersion model
  - Such models are common but not all are suitable for simulation for long periods of time (years) or if the concentrations within the released/natural sediment concentrations are very high .
- Sand dispersion model
  - For dredging operations which disturb large amounts of sand the subsequent dispersion of this sand is not well described by the normal dispersion model
  - Specifically the effects of wave stirring, burial, and changes to the threshold of mobility resulting from the ambient surficial sediment need to be included.
  - Can affect sand/gravel winning operations, especially where dredging targets coarser fractions

"Belt and Braces" *vs* "Issue-focussed"

"Belt and braces"

- Attempts to model everything, for all conditions
- Unwieldy with respect to changes in design/construction methodology which arise during the project (all the runs have to be repeated)
- Can be inefficient
- Superficially reassuring but doesn't necessarily answer the right questions
- Can overlook important uncertainties (the effort is spent on endless model runs)
  - Flow model/data uncertainties (3D effects, seasonal changes in wind and fluvial flow, wave driven currents, etc)
  - Dredging methodology
  - Estimates of sediment release/disturbance
  - Sediment transport processes (flocculation, turbulent damping, mixed sediment interactions, etc)
  - Other processes not represented (vessel resuspension, stochastic storm events, surges, biology, etc)

"Belt and Braces" *vs* "Issue-focussed"

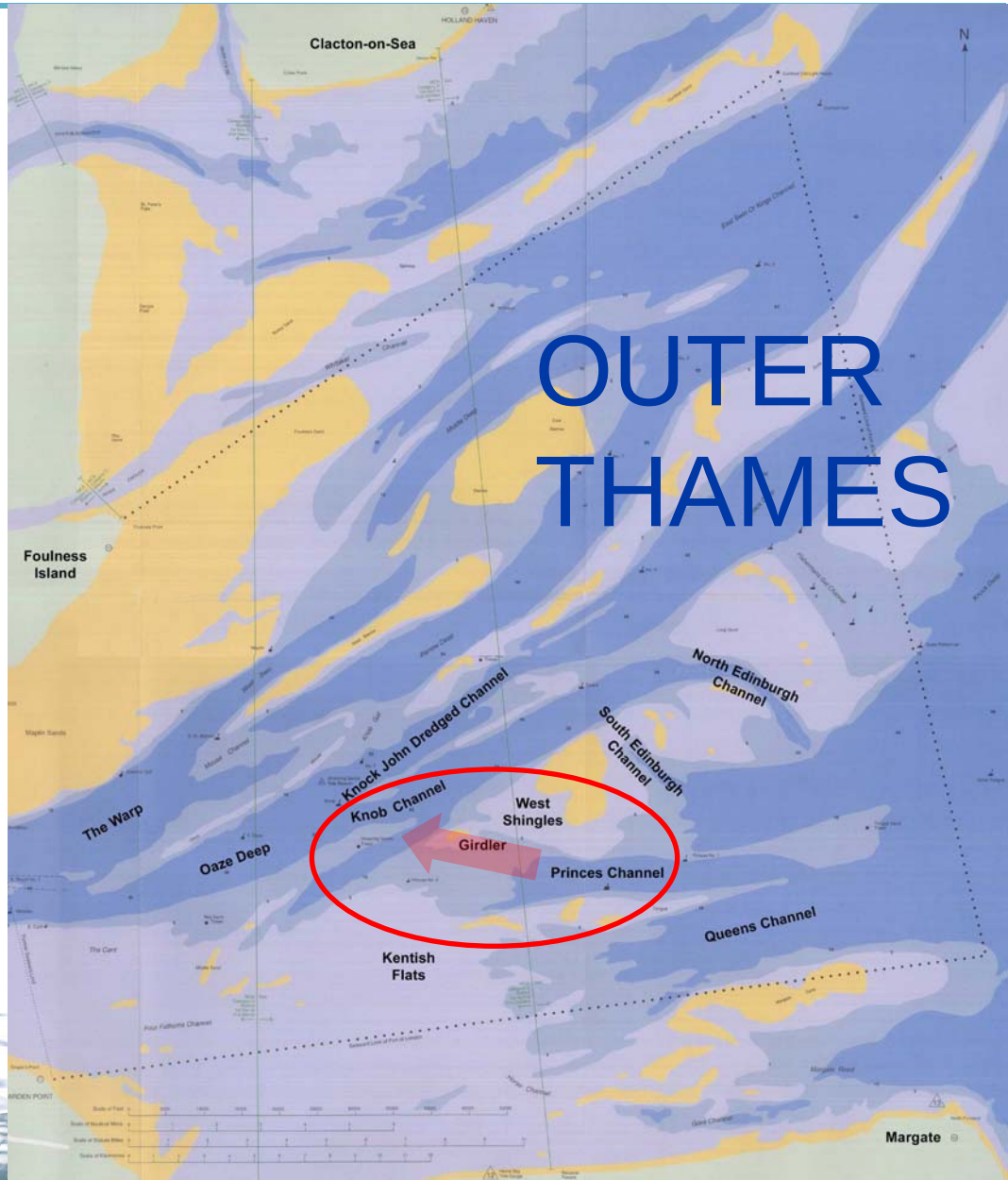
"Issue-focussed"

- Concentrates on framing the issues into questions which can be answered given the information and tools available
- Looks to encapsulate the uncertainties rather than model endlessly
- Concentrates on a smaller amount of more meaningful simulations: a tiered approach to studies
- Looks to answer the concerns of the developer & regulator/end users
- Does not entirely rule out the belt and braces approach but uses it only if absolutely necessary

Case study: studies reducing extent of monitoring

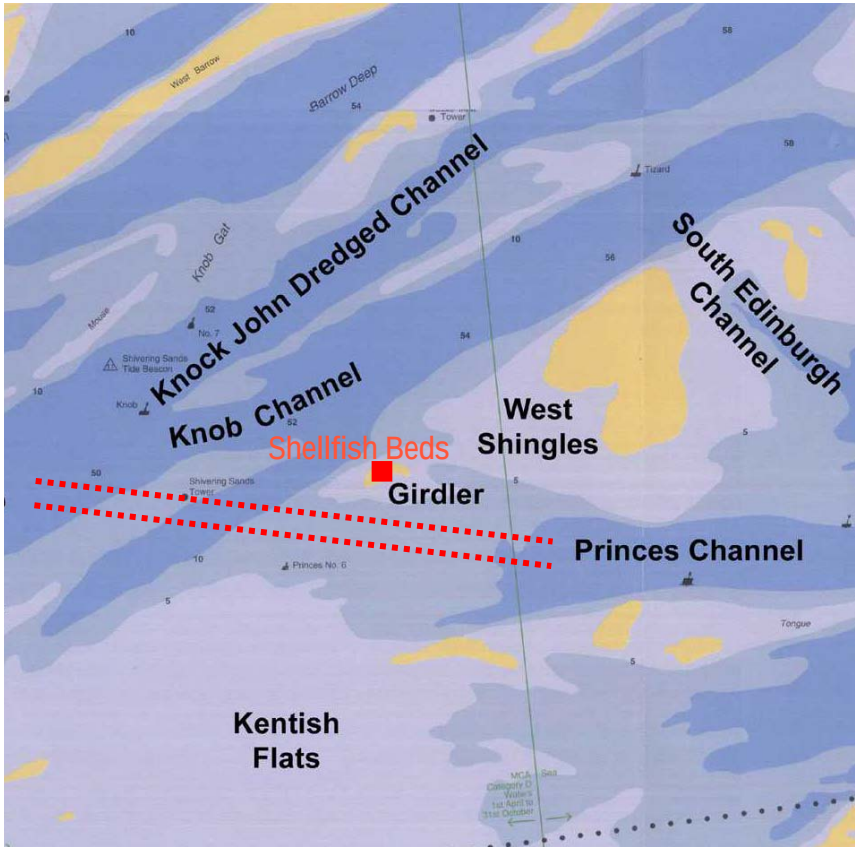
Princess Channel

- Scheme to provide alternative E-W access to Thames Estuary, UK
- ~3Mm^3 fine silty to coarse sand
- Various studies undertaken to evaluate potential impacts of the proposed channel: flows, waves, morphology, etc
- Site within designated Shellfish Waters
- Dispersion studies required to evaluate potential effects of plume on local shellfish beds



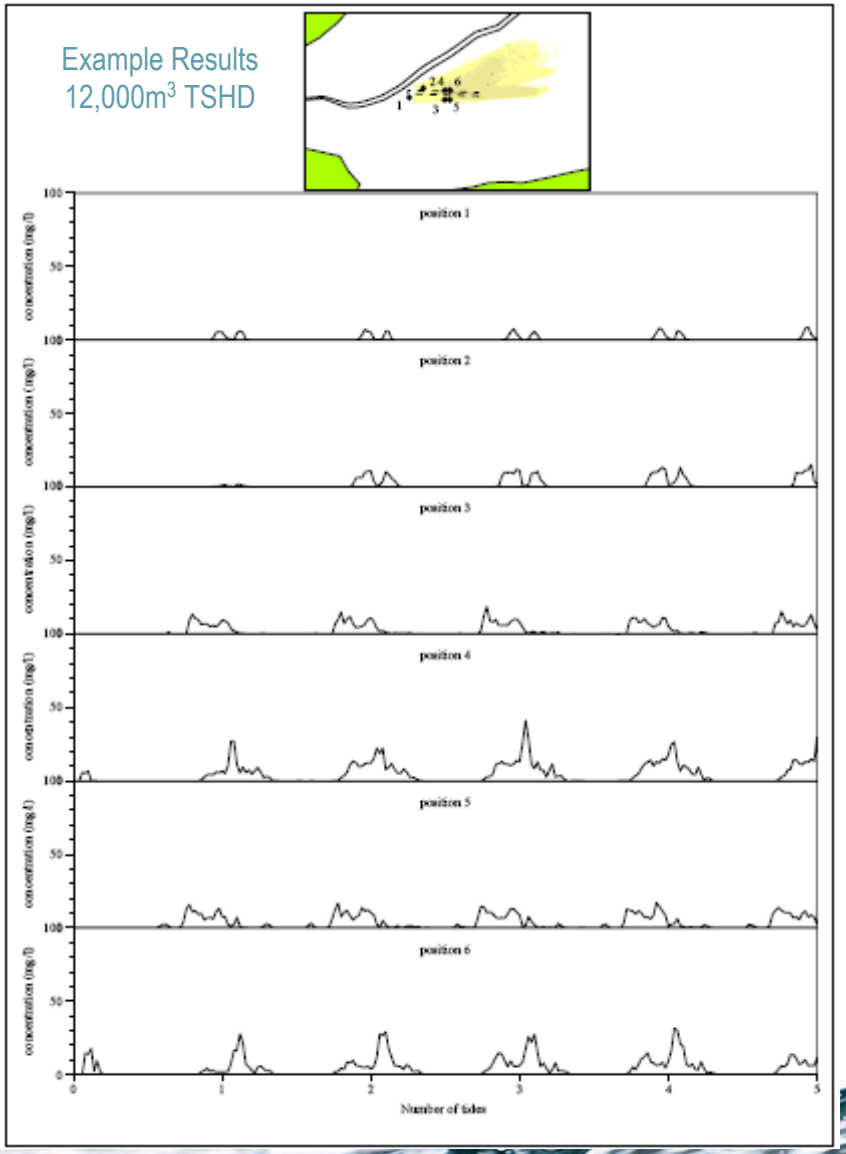
Case study: studies reducing extent of monitoring

- Shellfish beds some 2km to north of channel
- Plume studies undertaken to evaluate whether shellfish beds could be impacted
- Various timings and plant sizes were considered
- Results showed shellfish beds should not be subject to either high suspended solid levels or deposition.



Case study: studies reducing extent of monitoring

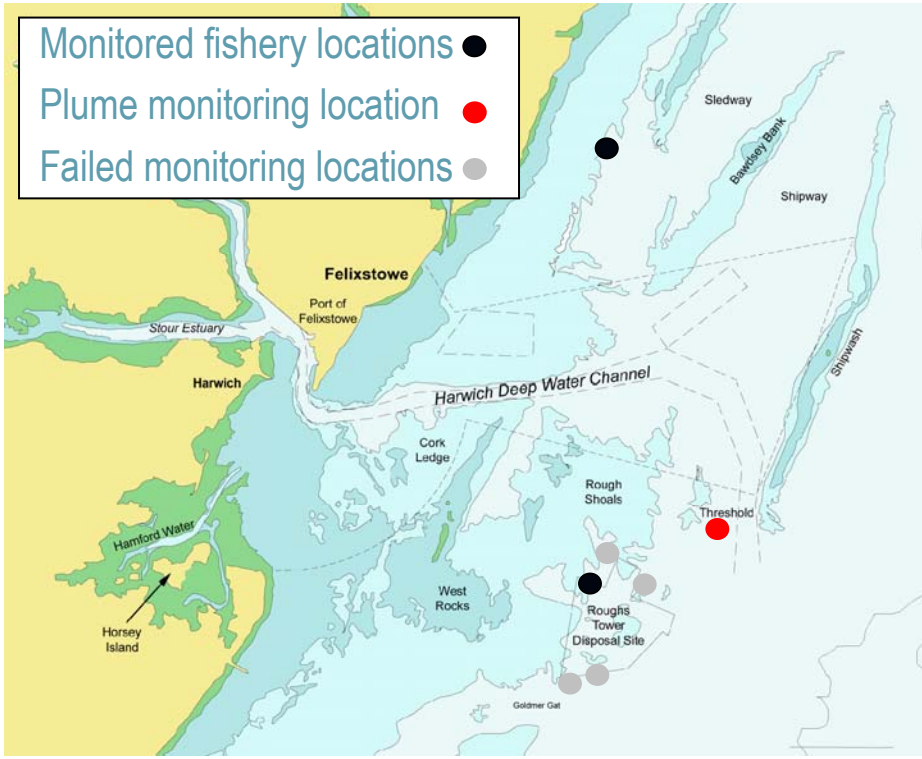
- Results of plume studies showed shellfish beds should not be affected
- As a result monitoring was scaled down – ie merely to validate this finding
- Monitoring instruments (OBS & ABS) were placed on frames (for a total period of 1 month) at four stations considered representative of either sensitive areas or the predicted direction of the plume.
- The monitors did not pick up the sediment plume (corroborating the modelling)
- As a check the plume from the dredger was tracked using a survey vessel deploying ADCP. Water samples were also taken.
- The survey indicated that, while there was an increase in turbidity of the water in the vicinity of the dredger, this did not translate into a sediment plume (the so called dynamic plume effect).
- Further dredging utilised OBS monitoring at only one location.



Case study: using models to inform monitoring

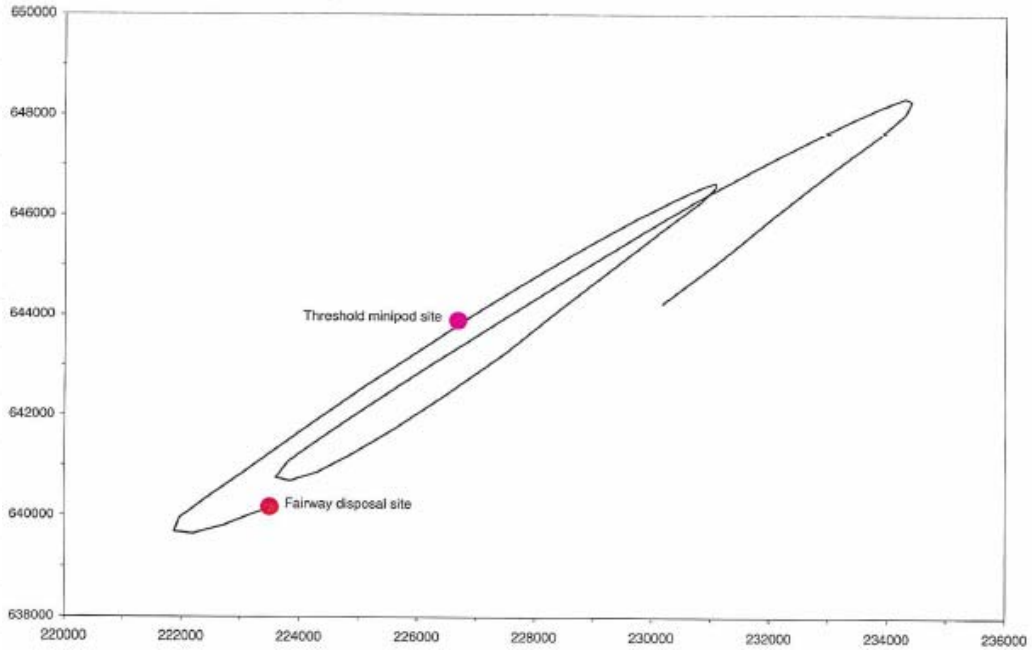
Roughs Tower Disposal

- Old capital and maintenance disposal site for Port of Felixstowe, UK
- During studies for the 1998-2000 channel deepening there was concern about the fate of plumes arising from disposal of capital dredge material (since placement rates would be higher than during maintenance operations)
- Sea bed frames deployed at various locations – plume not found
- Plume modelling then used to identify monitoring position at Threshold



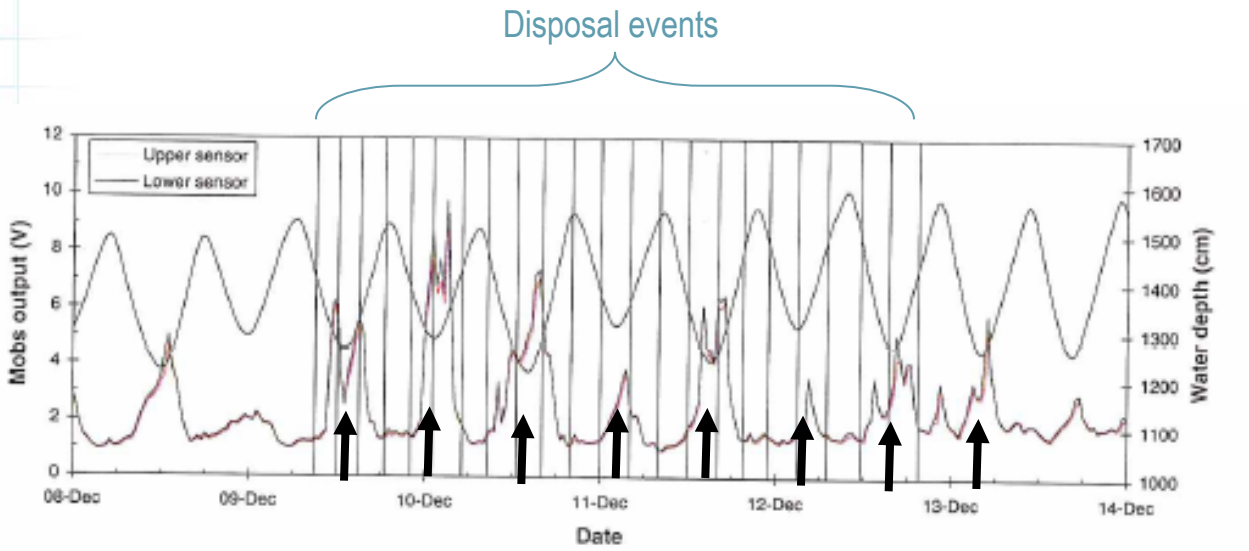
Case study: using models to inform monitoring

Field measurements from monitor show that plume went right through the monitoring location



Case study: using models to inform monitoring

- Increase in turbidity detected on late ebb and early flood tide
- No increase detected at HW – plume not passing back over monitor



Conclusions

- Plumes arising from dredging and reclamation can cause a variety of effects
- If included early on in the project the experienced consultant can:
  - help start the project along the right path
  - avoid pitfalls
  - devise studies that will answer the right questions efficiently
- Two simple examples have been shown to illustrate how the use of plume modelling can streamline and improve evaluation of impacts