Numerical Modelling of the Response of Tidal Resonance to a Tidal Barrage

L. Finlay, S.J. Couch, D.M. Ingram

Work stream 1: Numerical and physical convergence

Introduction

The Severn Estuary / Bristol Channel (figure 1) has been proposed as a suitable tidal energy barrage location due to it having the worlds second largest tidal range [1]. Existing barrages currently operating globally include La Rance estuary in France (figure 2) and Annapolis Royal in Canada.

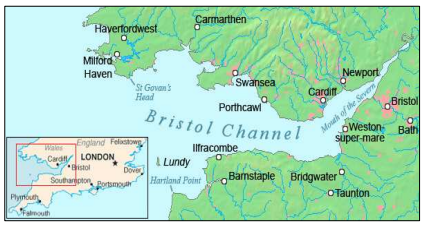

Figure 1: Bristol Channel, south-west Great Britain.

Figure 2: La Rance tidal barrage, north-west France.

The Severn Barrage project has been proposed and rejected several times over a number of years with official government studies being commissioned over the last few decades. Although tidal barrages are a secure and predictable source of energy, they are currently a highly controversial option. The high capital cost, lengthy construction times and environmental implications ensure that public, scientific and political opinions are divided [2].

Project Aims

Important PhD aims include to:

- Establish the effect on tidal resonance of various barrage positions,
- Determine what the implications may be of altered tidal hydrodynamics on barrage design and development,
- Examine the impact of altered tidal hydrodynamics on water quality, sedimentology, ecosystem dynamics, and potential for flood protection.

Tidal Resonance

Resonance occurs when the time taken for a large wave to travel from the mouth of the bay to the opposite end of the estuary, is then reflected and travels back to the mouth of the bay and coincidentally matches the time from one high tide to the next.

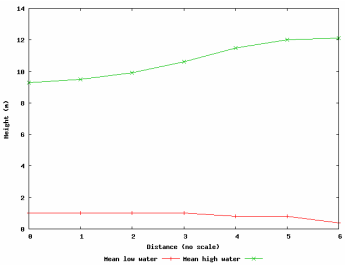

Figure 3. Tidal elevations at 7 locations along the Bristol Channel.

Hydrodynamic Modelling

The 2-dimensional 'Tidal Flow Development' (TFD) numerical model solves the conservative form of the shallow water equation and was used to analyse several simple grid systems of simulated estuaries with a variety of boundary and bathymetric conditions. A simple grid system was used whereby simulated estuary domains were created ranging from a simple box channel with a north and south boundary and uniform flat bed to simulated Severn estuary with topography shape and bathymetric values.

Preliminary Results

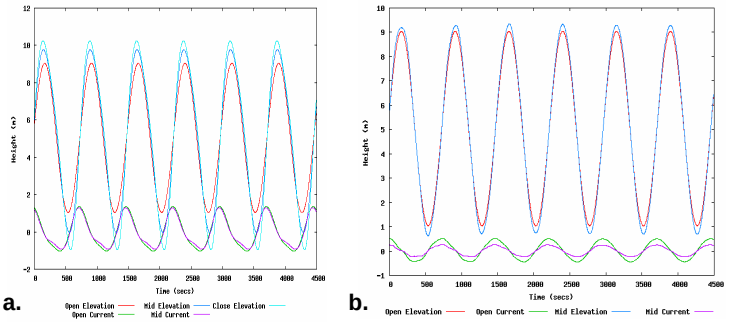

Figure 4: Mid channel surface elevation and depth averaged current velocity (streamwise component) for Grid 3 (a) and Grid 6 (b) on a simulated spring tide.

Grid 3 (without barrage) shows a system that is resonating with an increase in tidal elevation up to 1m on the flood tide and 2m on the ebb tide, velocity has a lag of up to a quarter wave length behind elevation. Grid 6 (with barrage) remains resonant but is reduced by approx 1m and velocity overall decreases, potentially due to the presence of the barrage.

Conclusion

- The model has demonstrated the progression of tidal amplitude, phase and velocity and has realistically simulated tidal hydrodynamics of the area.
- The inclusion of a solid barrier or barrage into the Severn Estuary will act to reduce tidal resonance.

The simple TFD model used within this research is employed as a forerunner to a build up of comparisons using TELEMAC .

References

1. R. Kirby & T.L. Shaw. 2005. Severn Barrage, UK – environmental appraisal. *Environmental Sustainability* (Proceedings of the Inst. of Civil Engineers)158. 31-39,
2. T.J.Hammons.1993.Tidal Power. Proceedings of the IEEE.81,419-433.

laura.finlay@ed.ac.uk
Institute for Energy Systems
The University of Edinburgh
Kings Buildings
Edinburgh EH9 3JL

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