Dunkellin River and Aggard Stream Flood Relief Scheme

Response to Numerics Warehouse Report

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TABLE OF CONTENTS

INTRODUCTION

RPS was commissioned by Galway County Council in 2011 to prepare an Environmental Impact Statement (EIS) for the Dunkellin River and Aggard Stream Flood Relief Scheme, hereafter called the "scheme", in south County Galway. The Dunkellin River and the Aggard Stream form part of the Dunkellin Drainage District which was constructed in or around 1857 and Galway County Council has a statutory maintenance responsibility for these works.

The scheme was submitted to An Bord Pleanála (ABP) in October 2014 for planning approval in line with Section 175 of the Planning and Development Act 2000, as amended. In February 2015, the Board, in accordance with Section 175(5)(a) of the Planning and Development Act, 2000, as amended, requested further information in relation to the proposed development.

Item 7 of the Board's letter stated that, "*The applicant is invited to respond in detail to the written submissions made by parties including local residents, prescribed bodies and others.*"

The purpose of this document is to provide a response to the issues raised by Numerics Warehouse in their report on behalf of Clarinbridge Oyster Co-op and Michael Kelly Shellfish Ltd.

1 ITEM 1 - ANALYSIS OF THE RPS SALINITY MODEL MIKE 3 MODEL SETUP

1.1 Whereas the model domain seems to be sufficiently large, we do not know what horizontal model resolution has been used in the MIKE 3 model. We would expect the horizontal resolution to be less than 100 m. Without this level of resolution, the model will not be able to resolve estuarine circulation in the inner bay, especially in narrow channels which might have significant lateral circulation. A model with poor horizontal resolution will not resolve the reduction in salinity properly, since there will be artificial horizontal dispersion and salinity fronts will not be resolved adequately.

The modelling was undertaken on a flexible mesh with varied mesh size across the domain to reflect changes in bathymetry flow and stratification. In the most critical areas and those of most interest, i.e. Mweenish Strait, Rincara Bay, Point & Spit, the cell size was typically less than 25m.

1.2 The authors have not detailed the vertical discretisation in their model. We would expect there to be at least 20 vertical levels in the model setup. Vertical salt, temperature and momentum mixing processes requires a sufficient number of vertical levels, since the freshwater layer will at times be thin and would be artificially mixed out of the model with poor resolution, thereby under predicting the reduction in salinity and the stress on oysters. In addition a model with an insufficient number of vertical levels would not simulate the effect of the sea bed shear stress properly.

Model testing was undertaken with various numbers of layers ranging from 3-7, the use of a 'sigma' layer type meant the layers were varied proportionally to water depth and did not become excluded from the model which would over-estimate mixing. The proportional thickness of the layers was also tested to include detail at the surface and bed. For this comparative study this was considered sufficient.

1.3 Has the model been established with any grid scale reduction? If so then we do expect the model to not predict salinity reduction well. We would like the model to have no grid scale diffusion (I.e. harmonic or bi-harmonic diffusion). This would give us the sharpest gradients and thereby generate a conservative estimate that we need to model salinity reduction. If there is any prescribed grid scale horizontal diffusion, then this will lead to artificial mixing too (unless mixing is constrained to be along pcynoclines).

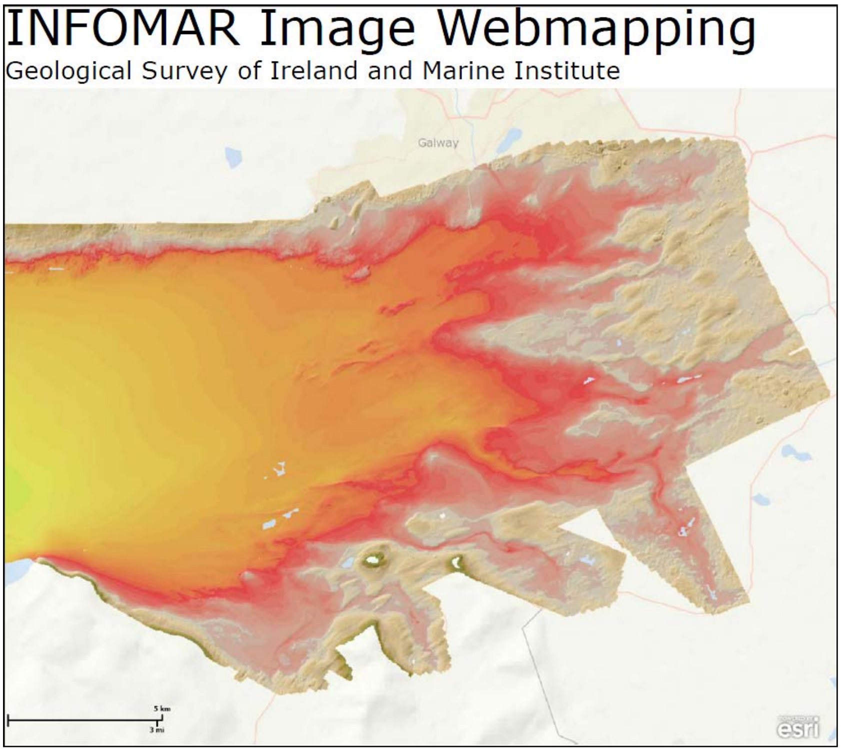
Horizontal diffusion was defined by a scaled eddy viscosity formulation. The eddy viscosity was implemented using the Smagorinsky formulation which expresses sub-grid scale transports by an effective eddy viscosity related to a characteristic length scale.

1.4 What vertical mixing scheme has been used in the model setup? This is a question of considerable importance since different schemes will generate different answers to the sea bed salinity levels. Have the authors simply used Mellor-Yamada 2.5 or something more sophisticated?

Vertical diffusion was defined by a scaled eddy viscosity formulation; the eddy viscosity was implemented using the log law formulation.

1.5 An accurate bathymetry is critical for the proper maintenance of the model. The authors state that they have used INFOMAR data to establish their model bathymetry. Can they be more precise please? – since INFOMAR multibeam swath bathymetry does not in general extend into waters shallower than 20 m depth and so could not be used for most of the area of interest – the Dunkellin estuary. Did the authors use LIDAR data instead? If so can they please show the coverage of the area of this data. It seems likely to us that the authors have used data much older than INFOMAR data for this modelling problem, with all attendant problems in accuracy this would entail. Some of this data may be more than 100 years old (hand held line measurements) and the contemporary estuarine shape will likely to be very different.

From EIS **Appendix E** - Environmental Modelling Report: "*The source of the bathymetric data was the latest survey and Lidar data provided by INFOMAR which extended across the entire domain*." Figure 2.1 of aforementioned Report shows the extent of the bathymetry. This data was the most up-to-date information at time of writing. The data coverage available from INFOMAR for the Galway Bay area is shown below.



1.6 The whole of Galway Bay is affected by the Shannon river plume. This can be clearly seen in the operational modelling simulations produced daily by the Marine Institute. Have the authors properly included the intrusion of freshwater from the Shannon in their model boundaries? In fact have the authors included any temperature and salinity variation at boundaries of the model, or have they simply used an elevation change?

As previously stated the modelling was undertaken as a comparative study. The effect of the Shannon river plume would be implicit both with and without the scheme in place, similarly the effect of any further temperature or salinity variations introduced at the boundaries would be negated when the alteration are calculated. Therefore elevation boundaries were used with specified salinity.

1.7 The authors have not included a wetting-drying scheme in their model. Since the tidal elevation changes periodically [to] expose and cover large areas of seabed in the shallow Dunkellin estuary, the whole circulation is dependent on this. For instance, at low water spring tide the channel becomes very narrow and the salinity will drop considerably. In the model solution shown in the [EIS] report a mean tide level is maintained irrespective of the tide state. This means that the model has been set with a minimum depth that must be deeper than 5 m. What is the minimum depth that has been used in the model? Without a wetting –drying algorithm, we would not expect the model to give realistic simulations.

Wetting and drying was implemented within the model as wetting depth of 0.1m was used with a corresponding drying depth of 0.05m

1.8 What initial conditions were used for the model? Did the author use a realistic temperature salinity distribution and if so, what data did they use for this?

The salinity and temperature used within the model domain and at boundaries and inflows was taken from data available from the Irish Spatial Data Exchange hosted by Marine Institute. The model was then run for a sufficient period for the gradients to stabilise, i.e. become cyclic in nature.

1.9 How long was the model spun up before the model was used to generate the data presented in the [EIA] report? We would expect the spin up period to be at least 1 month.

The warm up period was 6 weeks, see previous response.

1.10 How many tidal constituents were included at the model boundaries? We consider that at least 8 constituent should be included.

The boundary levels were taken from the RPS Irish model which was developed for the Irish Coastal Protection Strategy which used a suite of 18 harmonics, specifically calibrated for the coast of Ireland to generate tidal levels.

1.11 How did the authors force the surface of the model? Did they use wind stress, heat fluxes and precipitation from a weather model? If so which one? How often did they update the forcing? (3 or 6 hours?). If the author did not use any surface forcing for the 2009 simulation, then we would not expect the results to be in [any] way accurate.

As previously stated, this was a comparative study in which the model underwent tidal forcing without the application of meteorological data.

1.12 We do not consider the salinity model presented in the EIS to be well founded, or the range of conditions to be wide enough. As a consequence, we are not able to endorse the conclusion of the modelling study. We consider that the modelling study should be conducted again following a proper measurement campaign. The authors must properly describe the model set up and be able to demonstrate that the model can perform well.

As outlined in the Environmental Modelling Report, **Appendix E** of the EIS: The 2009 event is adequate as the ‘worst case scenario’ for the model because - as well as the extra volumes of water - the peak discharge rate was observed during low water and when a flooding tide was acting to reduce this significant volume of fresh water from leaving the Bay. These factors meant that the shellfish community were at their most vulnerable. Works undertaken in 1992 were significant and as stated any of these effects would have been felt during the 2009 event. The proposed works are much smaller in scale and are, for the most part, maintenance related and will have a much smaller impact. The modelling compares the impact of the new proposals. Should the modelling have indicated a greater impact then a much more wide-ranging study would have been undertaken requiring the establishment the full baseline conditions. The validity of this modelling approach was agreed under auditing by NUI Galway.

With respect to the model set-up detailed information is provided in the Modelling Report (see Appendix E Environmental Modelling Report of the EIS) with additional information being furnished within this response document.

2 ITEM 2 – SALINITY MODEL VALIDATION

2.1 The biggest omission from the salinity model as reported is the lack of any model validation against measured temperature and salinity data.

A model such as this MUST be validated. Without proving that the model is able to reproduce well a few weeks of measured data, it is of little worth…It is absolutely critical that the authors can demonstrate that the model can stand up well against measurement. We recommend that at least two calibrate (with certificate to prove the measurement accuracy) self-recording Temperature-Salinity recorders are deployed for a minimum of 1 month (two spring-neap cycles) in the Dunkellin estuary to be used for model validation. The [EIS] report should show a comparison of model results against the data and then some regression statistics shown to quantify the models accuracy.

Without proper model validation we do not know the errors in the model simulation and the model results must be disregarded out of hand.

The purpose of the salinity modelling study was to determine the change in flow and salinity as a result of the scheme rather than to carry out a study into the stratified flow within Galway Bay. The model used was sufficiently detailed to recreate tidal and stratified conditions such as those found within the Bay and to distinguish the changes due to the revised inflow at Kilcolgan. Having compared the 'before' and 'after' scenarios and seen that the changes in the magnitude of peak discharge flow rate and the local salinity regime during the 2009 flood event (i.e. the worst case scenario) were indeed minor then no further modelling was required or undertaken. Should the modelling have indicated a greater impact then a much more wide-ranging study would have been undertaken requiring the establishment the full baseline conditions. The validity of this modelling approach was agreed under auditing by NUI Galway.

3 ITEM 3 – SALINITY MODEL LOCATION

3.1 ***Figure 3.5 of RPS Salinity model is reproduced here [see figure included in stakeholder submission i.e. Figure 3.5: Licensed aquaculture sites - red hatched areas].***

It [Figure 3.5] shows the location chosen for detailed analysis by the model as denoted by the red hatched areas. Only one location (and not a very representative one at that) was chosen for detailed presentation of a time series of salinity in the report – Lynch's Quay. The actual location of shell fisheries is quite different from this however. The figure below [see Figure included on page 8 of stakeholder submission] shows a more comprehensive and accurate map of the shell fisheries with licensed aquaculture sites. In particular the RPS salinity model does not represent the wild oyster farmed areas, or the areas around Mweenish island. A well founded hydrodynamic model, will show considerable variation in seabed salinity between these varied sites and it is our opinion that the EIS should show this.

The numerical modelling report (included in the application), which examined the extent and magnitude of the potential change in salinity due to the proposed works, shows the variation in seabed and within the water column salinity (in excess of 10 PSU) across the entire bay. By presenting modelling results for the entire bay allowed change in salinity to be identified for all relevant features including sensitive receptors and designated protected and licenced areas, despite these features not be explicated indicated on the model output.

During the most critical phase of the modelled event (i.e. when the salinity is the lowest) the proposed scheme was shown to result in short-term change in salinity of less than 0.5PSU. The extraction location at Lynch's Quay was chosen as a typical and representative location to illustrate the temporal variation since the spatial variation had already been demonstrated.

The model demonstrated that changes as a result of the proposed scheme were minor even under extreme events. As a result the model provided sufficient information in order for the impact assessment of the proposal to be conducted and no further modelling was required or undertaken. The validity of this modelling approach was agreed under auditing by NUI Galway.

4 ITEM 4 – FLOOD MODEL

4.1 The authors have modelled the 2009 flooding episode. Whilst this is likely a good choice to choose to model, it probably does not represent the most onerous conditions at the oyster beds would be subject to due to the increased levels of riverine discharge. The changes to the waterways will result in a higher pulse of freshwater. This will affect the circulation of freshwater in the estuary and it is the job of the model to show how the circulation changes due to the new input and timing of this freshwater pulse. We would like to see the selection of periods to model from when there is a strong and sustained west or north west wind which would likely act to hold up freshwater in the estuary and thereby reduce the salinity levels over the oyster beds. Such conditions are not uncommon. The selection of the period to model could be taken from the last 30 years when there was a combination of significant rainfall and wind from different direction, speed and stage of spring-neap cycle. It is the duty of the modellers to show that the proposed drainage works do not significantly affect the oyster beds under a range of conditions. We consider the modelling of only one period to model (2009) as presented to be severely limiting to the possible conclusions of the [EIS] report.

As outlined in the Environmental Modelling Report, Appendix E of the EIS, the selection of the 2009 flood event was specifically made to take into consideration the impacts on shellfish stocks, impacts on flow and salinity which would have been most apparent during and immediately after this extreme flood event. The 2009 event is identified as the ‘worst case scenario’ for the model because - as well as the extra volumes of water - the peak discharge rate was observed during low water and when a flooding tide was acting to reduce this significant volume of fresh water from leaving the Bay. These factors meant that the shellfish community were at their most vulnerable.

The total volume of water conveyed to the Bay will not change over the duration of the flood event as the provision of the works, i.e. the works do not involve re-routing of any flow from other parts of the catchment. The hydrograph downstream of the works is presented in the EIS Appendix: Salinity Modelling Report and demonstrates that there is a small increase in peak discharge rate which is not persistent. The existing and proposed hydrographs have the same shape, indicating that timing rather than flow mechanisms are altered and therefore sediment transport regimes remain unaltered.

5 ITEM 5 – SEDIMENT FLUX

5.1 ***In section 11.4 of the EIS Release of sediment the report states that there is 'potential for the release of sediment during the construction phase' which 'can adversely affect marine invertebrates'.***

We already know from past construction work in the Dunkellin that released sediments damage the oyster beds in the estuary. Why has this not been addressed by the EIS?

Clearly no attempt has been made to quantify the suspension and transport of sediment along the Dunkellin and into the estuary. Once the clays and silts reach higher salinity water, they will flocculate (aggregate due to surface changes on clay particles) and then very quickly fall out of suspension. This is likely to occur in the region of the oyster beds in the estuary (i.e. where the freshwater first meets higher salinity water). The EIS does not mention the oyster beds or the possible impacts on them by deposition of riverine sediment fluxes.

5.2 ***In Section 11.6.1 Residual Impact the authors state that the impact will 'be slightly negative' during construction and 'long term neutral' thereafter. No attempt has been made to quantify the effect of suspended sediment, or even to justify how the increased flows that are expected during normal operation will not resuspend more sediment. How do they justify their assessment of 'long term neutral' when it comes to the transport of sediment into the estuary?***

5.3 ***It seem obvious to us that during construction there will be more suspended sediment transported into the estuary. It is the duty of the modellers to show how much extra sediment will be deposited on the oyster beds and the likely mortality that will result.***

5.4 ***The authors need to characterise the sediment in the river courses (i.e. the size fractions of each types of sediment, their proportion relative to each other and their depth of sediment at each point in the river course). They then then need to calculate the shear stresses required to either resuspend the sediment, or create a 'bed load' (i.e. roll along the river bed). In addition the quantity of loose material which will enter the river courses during construction will have to be estimated properly. The locations of these extra inputs should be estimate. Once these steps have been achieved, the transport of the sediment into the estuary can be modelled for peak river flow due to different rainfall scenarios (e.g. the 2009 event) for both the construction phase and on-going and during 2, 5, and 100 year return events.***

For the hydrodynamic model of the Inner Galway Bay, the sediment fluxes from the river models should be specified. Many modern numerical models include sediment transport modules. These should have been used in the context of the EIS. Such models will show where the sediments will be deposited and included all effect such as wind and tides.

As stated in Section 10.5 (Conclusions) of the NIS: "*The timing and sequencing of upstream flood relief scheme measures coupled with mitigation applied with respect to each measure will reduce the potential for silt generation at source and stem the potential for losses*. […]

Section 10.5 (Conclusions) of the NIS also states:

> "*The scheme model (see Appendix A*, Dunkellin River and Aggard Stream Flood Relief Scheme, Description of the Proposed Works) *predicts that there will be an increase in the peak discharge rate into Galway Bay by 1% and the time to peak flow (Tp) was also estimated to be reduced from 95 hours to 93 hours. The scheme conveys the freshwater discharge slightly more quickly but the total discharge is not increased over the course of the event. Any slight increase in peak discharge by 1% and reduction in time to peak flow is not likely to cause the transport of significant additional quantities of suspended sediment and nutrients to the Dunkellin Estuary.*
>
> *Any slight increase in peak discharge by 1% and reduction in time to peak flow is not likely to cause the transport of significant additional quantities of suspended sediment and nutrients to the Dunkellin Estuary."*

Table 9.2.1 of Section 9 (Mitigation Measures) of the NIS shows extensive mitigation measures for each flood alleviation area. Furthermore, as outlined in Section 9.2.2 (Mitigation Measures for the control of Waterborne Pollutants during Construction Activities) of the NIS*: "A detailed design and method statement should be drawn up by the contractor indicating what standard measures will be taken to avoid (i) sediment or soil loss and (ii) cement and hydrocarbon release, associated with all aspects of the construction phase.* Therefore, a detailed construction management plan (CMP) addressing details of construction methods and all recommendations for mitigation presented in the EIS and the NIS will be presented to statutory bodes for consideration prior to commencement of works.

5.5 After construction has finished the authors state (in 4.4 in the Appendix page 59 [of the EIS]) that the Time to Peak flow will be reduced from 95 to 93 hours and there would be a less that 1% increase in the rate for the equivalent 2009 flooding extent. They have not shown ant curves from their model for us to see how the volume flux changes with time for the 2009 event, or a comparison of the pre and post construction regimes. In particular we are interested to know the duration of this slightly increased rate. Is it much longer that for the pre-construction modelled event? It could be that a sustained high flux into the bay (albeit at a similar rate to before) will transport significantly more sediment and freshwater to the oyster beds. This, in our opinion should all be modelled properly.

The total volume of water conveyed to the Bay will not change over the duration of the flood event as the provision of the works, i.e. the works do not involve re-routing of any flow from other parts of the catchment. The hydrograph downstream of the works is presented in the EIS Appendix: Salinity Modelling Report and demonstrates that the there is a small increase in peak discharge rate which is not persistent. The existing and proposed hydrographs have the same shape, indicating that timing rather than flow mechanisms are altered and therefore sediment transport regimes remain unaltered.