Dunkellin River and Aggard Stream Flood Relief Scheme (Reg. No.PL07.JA 0035)

Technical Report Prepared For

Bord Pléanala

Technical Report Prepared By

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CONTENTS

1.0 INTRODUCTION

Galway Co. Co. is applying for planning permission to undertake flood alleviation on the Dunkellin River and Aggard Stream. This report presents my independent review of the hydrogeological and hydrological aspects of the proposed flood alleviation scheme in the context of relevant legislation.

The proposed scheme has been considered in this report under the following headings:

- Assessment of the impact of the proposed flood alleviation plan on water level and water quality at Rahasane Turlough (cSAC and SPA),
- Understanding of the baseline hydrogeology and hydrogeological connectivity,
- Assessment of the impact of the proposed flood alleviation scheme on karst features and conduits,
- Consideration of proposed mitigation measure at the unnamed karst feature (Killeely Beg)
- Review of the proposed monitoring programme for Rahasane Turlough (Post Works).
- Review of the salinity assessment undertaken by the applicant in Dunbulcaun and Dunkellin Bay
- Review of the impact of the proposed flood alleviation scheme on water quality in Dunbulcaun Bay
- Review of proposed schedule of environmental commitments

1.1 METHODOLOGY

I reviewed the following documents to prepare my report.

Dunkellin River and Aggard Stream Flood Relief scheme EIS Folder 1

Dunkellin River and Aggard Stream Flood Relief scheme EIS Folder 2

Dunkellin River and Aggard Stream Flood Relief scheme – Natura Impact Statement.

Dunkellin River and Aggard Stream Flood Relief Scheme – Further Information

Dunkellin River and Aggard Stream Flood Relief Scheme – Responses to Bord Pleanála

In addition, I considered submissions and representations made at the Public Hearing (October 2th, 28th and November 3rd). These representations are tabulated below:

Submitted By	Presenter	Topic
Galway Co Co		Letter from Transport Infrastructure Ireland
Galway Co Co	Sean Langan	Need for the Scheme
Galway Co Co	Lauren Williams	Aquatic Ecology
Galway Co Co	Roger Goodwillie	Ecology / Turloughs
Galway Co Co	Paula Kearney	Terrestrial Ecology
Galway Co Co	Paula Kearny	A – EIS and NIS Addendum

		B – EIS, NIS and Response to ABP - Errata
Galway Co Co		NUIG – Expert Opinion report on the results of the environmental modelling for the Dunkellin Flood Alleviation Scheme
Galway Co Co	Michael McDonnell	Engineering
Galway Co Co	Dr. Naomi Shannon	Environmental Salinity Modelling
Galway Co Co	Paula Kearney	Environmental Impact Assessment and Environmental Aspects
Galway Co Co	Gerry Baker	
Galway Co Co	Tim Joyce OPW	
Galway Co Co	James Massey	Marine Ecology
Galway Co Co		Letter from Mr. Fahy on behalf of Tom and Mary Forde
Galway Co Co		Letter from Tom and Mary Forde withdrawing objection
Galway Co Co	Michael McDonnell	Oral presentation in relation to certain matters raised at the oral hearing
Galway Co Co	Dr. Shannon	Response to the Clarinbridge Oyster Cooperative/Michael Kelly Shellfish Further Information Submission
Galway Co Co	Paula Kearney	Response to the Dept. of Arts, Heritage and the Gaeltacht
Clarinbridge Oyster Co-Op Society Ltd. And Michael Kelly Shellfish	Diarmuid Kelly James Allison Dr. Marcel Curé Dr. Oliver Tully	Submission
Galway Co Co	Michael Donnell	Rating Curve for November 2009 Event
Galway Co Co	Dr. Naomi Shannon	Response to submission of Clarinbridge Oyster Co-Op Society Ltd. And Michael Kelly Shellfish (19)
Galway Co Co		Seasonal Composition of Meroplankton in the Dunkellin Estuary, Galway Bay, P. Byrne
Galway Co Co		Schedule of Environmental Commitments
Galway Co Co	Michael McDonnell	Graphs in response to Clarinbridge Oyster Co-Op Society Ltd. And Michael Kelly Shellfish

2.0 ASSESSMENT OF THE IMPACT OF THE PROPOSED FLOOD ALLEVIATION PLAN ON WATER LEVEL AND WATER QUALITY AT RAHASANE TURLOUGH (CSAC AND SPA).

2.1 BACKGROUND

The Rahasane Turlough cSAC (site code 000322) was the natural sink of the Dunkellin River prior to it being connected to Rinn Turlough by an artificial channel. The "overflow channel" is c.0.5 metres above the floor of the Rahasane Turlough. Active swallow holes are still present in the floor of the Turlough i.e. water discharges to ground through these swallow holes as well as through the artificial overflow channel. During flooding, storage in the underlying aquifer and the channel is at capacity and water overflows to fill an extensive depression which forms the Turlough and which has been known to fill to an area at high flood of c. 300ha.

Along with maintenance works e.g. removing terrestrial vegetation and trees, the proposed scheme requires deepening of the channel (maximum 1 metre) up-gradient of the Turlough (main channel and bypass channel at Craughwell village) and the installation of a two stage channel and embankment (to provide additional storage during flooding) downgradient of the Turlough commencing 1.75 m upgradient of Dunkellin bridge extending to Kilcolgan bridge. No works are to be undertaken in Rahasane Turlough or immediately downgradient of it. The bed level up-gradient of Rinn Bridge will continue to act as a hydraulic control for Rahasane Turlough. The two stage channel will not result in a change in the existing river bed level. It incorporates a wider channel width at a higher level to contain flood water which would previously have overflowed onto surrounding lands. A full description of the proposed alleviation works is provided in the EIS including cross sections with existing and post plan bed and bank levels ([1] Section 1). Having reviewed the relevant cross sections (existing and proposed), I am satisfied that the proposed works will not result in lowering of the existing water level at the Turlough.

The Turlough cSAC (site code 000322) is designated for the Annex I habitat "Turloughs". Rahasane is also a SPA (site code 004089) and supports extensive bird life including Annex I species, Greenland White fronted Goose. Turloughs are groundwater dependent terrestrial ecosystems (GWDTE) also included in the register of protected areas established by S.I. No. 722 of 2003. The receiving bay is part of the Galway Bay Complex cSAC (site code 000268) and inner Galway Bay SPA (Site Code 000268). Details of the habitat and species present are provided in the EIS and NIS [(2&3)].

2.2 REVIEW OF ALTERNATIVE SCHEMES CONSIDERED

A number of alternative scheme designs were considered by the applicant (EIS [(2)] section 7 and EIS [(1)] section 3.6). One of the main reasons for the choice of the proposed scheme is that it avoids any significant impact on existing water level at Rahasane Turlough. Alternative schemes were considered by the applicant, some of which may have resulted in lowering the considered "ecological critical level" of 16.5 metres OD at Rahasane Turlough e.g. the option of channel widening between the mouth of the Rahasane Turlough to Rinn Bridge. The applicant showed that the latter scheme would have provided flood relief to additional houses along the Turlough and adjacent road during extreme flood conditions e.g. a 1 in 122 year flood event (November 2009 event) but this alternative scheme design would have impacted on peak flood water levels in the Turlough e.g. above 15.7 m OD (EIS [(2)] Section 7 Figure 7.2). Apart from peak flood conditions, predicted water levels in the Turlough are similar for the proposed and this alternative scheme as the "do nothing" scenario. As such the scheme choice is constrained by the need to maintain and allow inundation to a 16.5 m O.D water level at the Turlough.

Roger Goodwillie, (applicants' ecologist) has identified that 16.5 metres O.D is the high water level at which flooding becomes visible in the vegetation and as such is a useful marker of the boundary of the Turlough. The applicant has taken the precautionary approach by choosing a design which has no impact on the flood water level in the Turlough. I agree that 16.5 m OD marks a high water level at the Turlough where vegetation is identified, however, my opinion is that there is not adequate scientific information presented to support this water level as the ecological critical water level required to maintain the favourable conservative status of the Turlough. A slight lowering in the flood water level in extreme flood events will not impact on its use as a habitat for birds (which require seasonal flooding) or impact on the annex II aquatic species which primarily need maintenance of channel flow (EIS [2], section 11.3.6). The Fairy Shrimp, an indicator species identified by the applicant for baseline monitoring requires *maintenance of the overflow to the Rinn Basin and this is the ecological critical level for this species*, i.e. a low water level (14.7 m O.D) which is unaffected by other flood alleviation options considered. The mosses which indicate the high water level boundary are not in themselves specifically protected under the Habitats Directive. However, on questioning at the Hearing on this point, Mr. Goodwillie advised that "lowering of the high water level could result in the habitat moving down and any change in the area of the habitat could result in an impact on habitat protection".

In conclusion, I agree that based on the available data, the applicant was correct in taking the precautionary approach in choosing the proposed flood alleviation scheme. Extensive and long term monitoring work over many years would be required to have confidence in a lower critical water level which would confidently maintain favourable conservation status of the Turlough habitat and provide additional flood alleviation to property owners. It is proposed to undertake both habitat and aquatic monitoring pre and post construction as part of the proposed works. I would recommend that this data is made available publically to facilitate further research on determining critical water levels at this and other Turlough systems. This type of study will facilitate improved flood alleviation projects in the future.

2.3 ASSESSMENT OF THE IMPACT OF THE PROPOSED SCHEME ON FLOOD WATER LEVEL AT RAHASANE TURLOUGH.

The NIS [2&3] prepared by the applicant stated the requirement to maintain the *ecological critical water level of 16.5 m OD* as a major factor required to maintain favourable conservative status. The applicant undertook a detailed flood model (HEC-RAS) to predict the discharge flow pattern pre and post plan at the Turlough during normal conditions and for extreme conditions e.g. November 2009 flood event (122 year return period (EIS [1] , Table 2-1 OPW flood return data).

HEC-RAS is a widely used model used for assessment of channel flow. I have reviewed the model inputs and assumptions (EIS [1], Section 2) and am satisfied that the applicants' model provides a sound basis for predictive analysis of channel flow and velocity. The model was built using river profile survey data at selected cross sections and was calibrated against existing long-term flow data collated from four OPW and EPA hydrometric stations as well as local anecdotal data (EIS [1] , Figure 2-4 presents the gauge locations) located along the river channel. Having reviewed the comparison of predicted data against river gauge data, presented by the applicant (EIS [1], section 4 and associated cross sections), I am satisfied that the model is capable of determining a scientifically sound discharge and flow velocity prediction. Strong correlation by the applicants model with historic flow gauge data and local knowledge at Craughwell to Rahasane Turlough was also confirmed by Mr. Tim Joyce (OPW Local Engineer) during the Hearing[4]. In undertaking the design of flood protection measures, climate change has been adequately considered on future flow scenarios within the model predictions. The approach taken follows the OPW 2009 guidance "Assessment of potential future scenarios for flood risk management" (EIS [1], Section 2.3).

The actual and modelled flood levels for Rahasane pre and post proposed flood alleviation works were presented in the EIS and no significant difference in predicted Turlough water level was noted at mean annual flow, 5 percentile flow, 50 percentile flow and 95 percentile flow (EIS [(1)], Figure 4.7 and Figure 4-6). In summary, I am satisfied that the data shows that the proposed flood alleviation works upgradient and downgradient of the Turlough will have no notable change in water level at Rahasane Turlough.

2.4 ASSESSMENT OF THE IMPACT OF THE PROPOSED SCHEME ON SEDIMENT RUN-OFF INTO RAHASANE TURLOUGH.

Increase in flow velocity can increase channel scouring and sediment transfer. The HEC-RAS model predicts a very slight increase in channel velocity (EIS [(1)], Table 4-2)) from the pre to the proposed scheme work up-gradient and downgradient of the Turlough.

The existing channel up-gradient of the Turlough at Craughwell will be deepened during the proposed works, which will require in-channel works and these in-channel works have the potential to increase the sediment load to Rahasane primarily during construction. The applicant has highlighted this risk and presented a programme of mitigation measures to minimise this potential risk, (refer to section 8 below).

However as a Turlough naturally periodically experiences changes in water level and flow, flushing of sediment into the Turlough frequently occurs and as such is a natural and frequent occurrence. On being questioned on this point at the Hearing, Mr Goodwillie, ecologist for the applicant, confirmed that “communities in Turloughs are not highly impacted by silt”.

In conclusion, it is my professional opinion that the proposed plan will not have a high risk of impact on water quality in the Turlough post-construction. The highest risk exists during construction and strict adherence to the construction management plan should minimise this risk during construction. Variation in sediment content in the inflow to this habitat is a natural occurrence during flooding and as such minor changes will not alter the natural characteristics of the habitat.

3.0 ASSESSMENT OF IMPACT OF THE PROPOSED FLOOD ALLEVIATION SCHEME ON KARST FEATURES AND CONDUITS

The proposed development is located in an area underlain by a *Regionally Important* karstified aquifer (Rkc). As such a detailed consideration of impact of the proposed works on underground karst conduits and epikarst (shallow karstification) is required. Additional site specific geological information was provided in item 2 of the Response to An Bord Pléanala [(5)]. This included a geophysics survey (seismic, conductivity and EM61 resistivity) (Appendix D [(5)]) on areas identified as having potential for karst, review of borehole data [(6)] supported by a karst walkover survey undertaken by the project hydrogeologist. I have reviewed the field data collected (geophysics, boreholes and surface mapping) and interpretation by the project hydrogeologist presented in the EIS and at the Hearing and am satisfied that a detailed survey has been undertaken to allow adequate mitigation be undertaken during construction works.

The field mapping of karst features which has been undertaken will allow mitigation around karst features e.g. reduce the likelihood of blocking of springs and sinkholes due to sediment laden run-off during soil spreading or collapse due to compaction. The applicant has provided clear mapping showing karst features with appropriate exclusion zones for spoil deposition – buffer zones of 5 metres around these features. (Figure 2.1 – Fig 2.6[(5)]).
Further site assessment (section 2.3[(5)]) confirm that the potential site compounds are not within or adjacent to karst features.

In relation to protection of near surface karst, the applicant stated within the Response to An Bord Pléanala that "appropriate geotechnical design to minimise the percolation of sediment through the karst rock and into fissures will be undertaken". It is stated that his will be "defined at detailed design stage". As the proposed schedule of environmental commitments (7) state that an ecologist will supervise the contractor works, I am satisfied that this will facilitate identification of any currently unidentified karst and incorporation of necessary mitigation around karst features.

Excavation works could result in interference in the natural hydrogeological regime by either blocking an existing spring/swallowhole or resulting in creating a new upwelling. The only required excavation of river bed level for the scheme is along a 950 metres stretch around Craughwell village. Excavation is generally increasing the depth by 0.6 metres with localised areas of 1m depth. A review of borehole records (6) and geophysics profiles along this stretch of the proposed development shows that the proposed excavation will be entirely in silt. In general the depth to bedrock is > 6 metres in this area, and there is no obvious evidence of significant karstification. This was confirmed in questioning of the project hydrogeologist Dr Baker at the Hearing. I am satisfied that the risk of impact during excavation within the stream channel on the natural karst hydrogeological regime is low.

3.1 CONSIDERATION OF PROPOSED MITIGATION AT THE UNNAMED KARST FEATURE (KILLEELY BEG)

The impact of the proposed plan on the unnamed karst feature at Killeely Beg is identified further in the Response to An Bord Pléanala (section 2.4) provided by the applicant. Adjacent to this location the river flow is proposed to be controlled by a flood embankment which is part of the two stage flood alleviation channel works. This is required to protect the houses and farm buildings at Killeely which are regularly flooded. However, during questioning, Mr Baker (project hydrogeologist) advised that seasonal flooding due to overflow of this sinkhole/spring would continue to occur when the storage in the karst aquifer is full the overflow and without mitigation could result in flooding of the housing/farm buildings albeit at a slower rate than would have occurred due to overland flow from the river. Mr. McDonnell (Project Engineer), confirmed that a two stage channel is proposed at Killeely Beg as a flood defence measure. This will significantly reduce the risk of flooding to the houses and farm building present. To minimise the risk from ponded groundwater being impeded by the flood embankment, an open toe drain/swale will be incorporated at the base of the embankment to convey run-off downstream to the main channel (oral hearing submission, drawing no 6408-2260). In addition he confirmed that emergency flood defences could be erected if required and pumping put in place if necessary.

Having reviewed the proposed flood alleviation measures proposed at Killeely Beg, it can be seen that there will be significant improved flood protection for the cluster of residents in this area.

4.0 UNDERSTANDING OF THE BASELINE HYDROGEOLOGY AND HYDROGEOLOGICAL CONNECTIVITY

Although it was stated within the EIS (Section 9.5.2) that "*there has been limited monitoring of the groundwater levels and Turlough levels at Rahasane Turlough. As such the hydrogeological conditions controlling the water level fluctuations are poorly understood*", clarification was provided on the understanding of the Turlough hydrogeology within the Brief of Evidence presented by the project hydrogeologist (8). I am satisfied that the hydrogeological conditions are adequately understood by the applicant to allow assessment of the proposed plan based on the following:

- A conceptual understanding of the hydrogeology and hydrology is based upon previous studies undertaken which identified significant karst conduits in the area

(EIS [2] Figure 9.5 Karst Features and Tracer lines) and specifically reviewed both the natural regime at the Turlough controlled by swallow holes and springs connecting to this karst system and the effect of the artificial channel which controls drainage during lower flow conditions. The Turlough is known to connect directly with downgradient karst systems.

- The project hydrogeologist outlined at the hearing that the long term flow monitoring records at monitoring stations both up-gradient and downgradient of the Turlough (Gauges No 29010, 29007, 29002) allow the functioning of the Turlough during both flood and non-flood conditions to be assessed. This data has been modelled using a well calibrated HEC-RAS model and is presented in the EIS. Modelling has been undertaken both with the proposed scheme and without the scheme and results confirm no perceptible impact on the hydrogeological regime.

5.0 REVIEW OF PROPOSED MONITORING PROGRAMME POST PROPOSED FLOOD ALLEVIATION SCHEME AT RAHASANE TURLOUGH

A programme of baseline hydrological, hydrogeological and ecological monitoring was presented by the applicant [5]. As there is no long-term baseline record available for ecology or hydrogeology in the area, it is my opinion that the most effective way of determining that the impact of the scheme is as predicted will be comparison of future water level data with historical water level data. The applicant has proposed doing this through ongoing monitoring of the flow gauge water levels up-gradient and down-gradient of the Turlough during flood events. It is recommended that this data is collected, assessed and made publically available. This data set will also provide a basis for NPWS in the development of the management plan for the cSAC.

Monitoring of three groundwater wells was proposed as part of operational phase monitoring within the EIS, however no long-term record for these boreholes is available. At the Hearing, the project hydrogeologist recommended that ongoing monitoring of the flow gauge water levels would provide the necessary data to confirm any impact on groundwater contribution due to the proposed scheme on the Turlough regime. As stated above, I agree with this recommendation in regard to assessing that the outcome is as predicted. Consideration for collection of representative groundwater data should be considered by NPWS and the EPA in terms of ongoing assessment of the habitat requirements of the SAC. As changes in karst flow can occur due to natural collapse of conduits or infilling of swallow holes, I would also recommend that the applicant include field assessment of swallow holes during the operational monitoring programme so that the impact of any natural changes in the groundwater regime can be considered in the hydrological assessment.

Significant ecological monitoring (botanical and aquatic) is proposed by the applicant. Although recording of chosen habitat transects and survey of chosen aquatic species will again be undertaken prior to construction there is no long-term record against which a comparison can be undertaken. This makes confident assessment of the cause of any impact identified difficult as changes in ecology are often due to many broader habitat issue e.g. over grazing, competition etc. However, collection of this data is useful as part of development of a management plan for the cSAC.

In conclusion, to confirm that the outcome is as predicted at the Turlough i.e. no impact, monitoring of water level at existing river gauges and analysis with climate data is the primary consideration. It is recommended that a monitoring report covering a period of c. 5 years post construction should be prepared for Galway Co. Co and included on the planning file for access by the public

6.0 REVIEW OF THE SALINITY ASSESSMENT UNDERTAKEN BY THE APPLICANT IN DUNBULCAUN AND DUNKELLIN BAY

Experts from both the applicant and third party agreed that prolonged low salinity conditions can impact on the life cycle of shellfish. It is known that under periods of low salinity, the shellfish tend to close their shells, resulting in reduced feeding and ultimately if such low salinity conditions are prolonged mortality can occur. Questioning at the Hearing to both Dr Shannon and Dr Massey (applicants salinity modeler and marine ecologist) confirmed that there is no exact data available on the level of salinity and duration of a low salinity event which could cause a direct level of reduction in feeding or ultimately shell fish mortality. However, Dr Massey advised the Bord that a risk exists where the salinity level is low (less than 12 PSU) and continues for an extended period of > 5 days.

Natural periods of low salinity (<12 PSU) are already known to persist over several tidal cycles within Dunbulcaun bay and inner Dunkellin bay. Where low salinity conditions occur along with extreme floods (i.e. a large contribution of freshwater as in the 2009 flood event), impacts on the shell fish lifecycle are known to naturally occur. However, currently there is no definitive information available on the degree of impact on the shell fish industry due to such flood events.

In reviewing the salinity assessment presented by the applicant, the question to be addressed is whether the proposed flood alleviation plan could result in a significant reduction in natural salinity conditions. To address this, the November 2009 flood event has been considered by the applicant as it presents a significant scenario in terms of freshwater contribution to the bay. The applicant has undertaken a comparative salinity model in the bay based on a maximum increased discharge of 1% freshwater flow over the period of the November 2009 flood event and has concluded that the maximum increase in existing salinity levels in the bay is <1 PSU and as such does not add any significant risk event in a significant flood event. A third party (Clarinbridge Oyster Co-op and Michael Kelly Shellfish) disagreed with the adequacy of the salinity model presented by the applicant in determining the impact of the proposed works on the salinity contribution in the bay during an extreme flood event such as the November 2009 event.

My review of the information provided and presented from both parties and my conclusions having reviewed this information is provided below, firstly in relation to the assessment of discharge from the river and then in terms of the suitability of the salinity model assessment.

6.1 REVIEW OF THE ASSESSMENT OF IMPACT OF PROPOSED FLOOD ALLEVIATION WORKS ON DISCHARGE OF FRESHWATER TO GALWAY BAY.

The applicants use of a comparative salinity model is based on the modeller's (Dr Shannon) understanding of the discharge flow from the river post the proposed plan being <1% above "do nothing" scenario for a 122 year flood (November 2009 flood event). In her written response to the third party at the Hearing, Dr Shannon stated "It is understood that the mixing of stratified freshwater flows is complex and indeed if changes in flow of the magnitude indicated are anticipated the modelling undertaken would have used a different approach akin to that suggested. However, less than a one percentage change would not change the flow and particularly mixing mechanisms" (ref: RPS responses to Numerics Warehouse Ltd Nov 3rd 2015). As such confidence in the applicant's assessed discharge flow post proposed flood alleviation works is required to support the interpretation on salinity provided by Dr Shannon, i.e. the HEC-RAS model.

The applicant undertook a detailed flood model (HEC-RAS) to determine the discharge flow pattern during normal operation and at extreme conditions e.g. November 2009 flood event

(122 year flood). HEC-RAS is a widely used model used for assessment of channel flow. I have reviewed the model information and am satisfied that the applicants' model provides a good basis for predictive analysis of channel flow and velocity (see section 2.3 above).
Based on the HEC-RAS modelling undertaken, I am satisfied with the following predictions of impact post plan:

During a flood event similar to the November 2009 event (122 year flood):

- the peak discharge rate of flow into Galway Bay will increase due to the proposed scheme by no more than 1 %,
- the time to peak of the flood event will be slightly reduced from 95 to 93 hours.
- the total volume of fresh water discharging is predicted to remain the same (as the "do nothing" scenario).

During "normal" flow conditions:

- the post flood alleviation works water surface profile associated with mean annual flow is in most cases contained within the main channel downstream of Rinn Bridge i.e. the discharge rate will remain as in the "do nothing" scenario.
- examination of the channel velocities for the "do nothing" scenario and the proposed scheme scenario show that the expected change in flow velocity is minimal.

It is noted that the third party (Clarinbridge Oyster Co-op and Michael Kelly Shellfish, modelling advisor Dr Marcel Cúre) agreed with many of the HEC-RAS model predictions for the 2009 flood event including the following:

- that a peak discharge rate of flow into Galway Bay will increase due to the proposed scheme by no more than 1 %
- the time to peak of the flood event will be slightly reduced from 95 to 93 hours.
- the total volume of water discharging over the total event is predicted to remain the same.

However, Dr Cúre advised the Hearing that the increase in freshwater discharge prior to the flood peak due to the proposed plan had not been adequately considered within the salinity model. In his review of the HEC-RAS model rating curve (discharge rate vs time) for the pre works ("do nothing scenario") and post plan he advised the Hearing that the increase in discharge rate leading up to the peak (Nov 11th to Nov 26th 2009) is significantly greater for the post-plan than the pre-plan scenario while after the peak of the flood the reverse is true, i.e. the total volume of discharge (cubic metres/time) is still in the order of 1 % greater than the "do nothing scenario". The argument presented by Dr Cúre for consideration was that the impact of this early increase in discharge of fresh water during a significant flood event could extend a period of low salinity, if low salinity conditions already existed in the bay and this potential impact on the shellfish receptor has not been assessed by the applicant.

As Dr Cúre did not have direct access to the HEC-RAS model, he has derived his assessment of the discharge data from superimposing the pre and post plan flood rating curves presented by the applicant in the EIS. Based on his considered data assessment he advised that this could result in a cumulative volume change before the peak flood level between pre and post plan of 1.21 million cubic metres (over a period of 14 days of the November 2009 flood). Based on an rough estimated area of the bay of 1 x1 km, Dr Cúre stated that "this would be equivalent to a depth of 1.2 metres of freshwater over the bay equivalent to doubling of the freshwater layer in the bay in the period rising to the peak" during a similar event to that which occurred in 2009, i.e. "equating in a volume difference up to 10% of the pre-works situation" ([9] Submission by Dr Cúre at the Hearing on 3rd November 2015).

In order to confirm the change pre and post works in the 122 year flood (November 2009) event, the applicant was requested by the Bord to present the actual and predicted

discharge data prior to the peak as derived from the HEC-RAS model. The modelled discharge rating curve for the flood period was presented at the Hearing by Mr. McDonnell (applicant's engineer) and a calculation of the difference in discharge for the pre and post works for the period up to the peak flow provided to the Bord. A rating curve for the period 17th November to 26th November (a period of 8.6 days) pre and post proposed works was presented in relation to the assessed flow into the bay through Kilcolgan Bridge and Rack stream. The modelled data does confirm Dr Cúres' assessment that there is a predicted increase in freshwater discharge pre peak for the post plan works. However, the modelled difference in discharge differs from the comparison of curves estimation presented by Dr Cúre. The difference in discharge flow (delta Q) presented by the applicant (Graph showing flow vs time) shows a peak of c. 4 m^3/sec compared with the estimation by Dr Cúre of c. 7.5 m^3/sec for the November 20th date. In my opinion the HEC-RAS model prediction will be more accurate as it is a numerical value predicted by the model as opposed to an approximated value.

The modelled difference in discharge pre and post proposed works during the 8.6 day period leading to peak flow in 2009 was assessed by Mr. McDonnell using the HEC-RAS model to be a difference of 50, 062 m^3 (pre works discharge: 36,0004,356 m3 , post works 36,059,418 m^3) i.e. < 1% of a difference (0.15 of 1%). Based on my review of the validity of the HEC-RAS model (section 2.3 above), I am satisfied that this is an accurate prediction for the period measured. However, it was noted during the hearing that the rating curve presented by the applicant was for a shorter period (6 days less) than that used in Dr Cúre's calculation and therefore the difference in cumulative flow was not directly comparable to the third parties calculation. A direct comparison over the same number of days (from November 17th 2009 to November 26th 2009) would lead to a more accurate calculation of the difference pre and post plan for an extreme event and could be requested by the Bord if required. However, it is my considered opinion that further assessment is not warranted as the applicants calculated discharge included the period during which the peak difference (greatest discharge of freshwater) between the pre and post works occurred (8 days prior to the peak). I conclude that post plan, the cumulative discharge of freshwater during the pre peak period for an extreme 122 flood event (November 2009 flood event) is adequately assessed as <1% as predicted using the HEC-RAS model.

In conclusion, during a similar 122 year type flood event, once the proposed flood alleviation plan has been completed, I agree that there will be an increase in freshwater discharge pre-peak compared to the do-nothing scenario. However, over the full flood event, the freshwater discharge is predicted to be a <1% increase on the "do nothing scenario". The impact of this additional early contribution of freshwater would only have significance if the 122 year flood event coincides with low salinity conditions already being present in the bay and particular tidal and possibly wind conditions resulting in a long duration of low salinity i.e. a combination of these factors all occurring at the same time would be required to prolong the period of low salinity present.

Unfortunately all experts advised that is no adequate local record available of salinity data in the bay and no record of the actual impact of salinity on the shell fish lifecycle to allow actual quantification of the economic risk to this industry.

Based on my review of the HEC-RAS model predictions provided in the EIS and the additional information on increase in freshwater discharge pre peak during an 122 year flood event my opinion is that the change in pattern of freshwater discharge due to the proposed flood alleviation works is not significant in terms of change to the salinity in the bay. This is based on the following:

- post plan there will be no measureable change in discharge of freshwater to the bay,
- during extreme flood conditions freshwater will arrive into the bay slightly earlier than in the pre plan scenario. However, the overall discharge volume will be unchanged,

- the likelihood of a 1 in 122 year type flood event occurring combined with existing low salinity and tidal and wind conditions required to prolong low salinity in the bay does occur but is relatively rare. Post plan if this combined event did occur it could result in a slightly longer period of low salinity earlier in the flood than currently occurs. However, there is no confirmed evidence that this would have a significant impact on the overall shell fish lifecycle in the bay.

Dr Tully also referred in his written submission to the role of Native Oyster in the marine communities in relation to the stabilising of sediments which may reduce shoreline erosion. It is acknowledged that an Increase in flow velocity can increase channel scouring and sediment transfer. However, the HEC-RAS model predicts a very slight increase in channel velocity (EIS [(1)], Table 4-2)), as such I am satisfied that the proposed scheme would not have any significant effect on destabilisation of sediments and shoreline erosion.

6.2 ASSESSMENT OF THE SUITABILITY OF THE APPLICANTS' SALINITY MODEL FOR DETERMINING IMPACT ON THE SAC AND SHELL FISH HABITATS

6.2.1 BACKGROUND

To assess the likely impact of the proposed plan on the receiving bay, the applicant commissioned a comparative 3D salinity model based on an increased freshwater discharge rate of 1% during a 2009 flood event (i.e. based on the HEC-RAS model prediction discussed above). This modelling was undertaken on behalf of the applicant by Dr Shannon (RPS). A 3-dimensional MIKE3 HD with a flexible mesh was used to model the 2009 flood event pre and post proposed flood alleviation works. The water levels at the entrance to Galway Bay were derived from the RPS Storm Surge Forecast model which has been calibrated at a number of locations. Bathymetry data was derived from Lidar and recent survey data sourced from INFOMAR. The ambient tidal and flow conditions during the 2009 flood event were then modelled for spring and neap tides over the period of 18 October to 30 November 2009. Freshwater discharges to the bay was sourced from assessment of catchment characteristics and OPW flow data. The model did not consider the impact of onshore winds. The only parameter varied between the two modelled scenarios (pre and post development) was the discharge rate from the Dunkellin River in order to assess the impact of the proposed scheme on salinity levels. As such this was a comparative study and was not calibrated against measured data in the study area.

The applicant's model considered the November 2009 flood event which occurred during low water concurrent with a neap low tide. This event was modelled as it resulted in vulnerable conditions for shell fish as the subsequent flood tide prevented the significant volume of fresh water discharge during the flood event from leaving Dunbulcaun bay. As such the oyster beds were exposed at that time to prolonged low salinity conditions.

The output of the applicants comparative model was a maximum increase in modelled background salinity over the flood event of <1 PSU (0.15 PSU at peak) during a 122 year flood event within Dunbulcaun bay. As the increase above background even in the "extreme" scenario considered was concluded by the applicant as minor a more detailed predictive model calibrated with field measurement was not considered necessary as such a small increase above existing conditions was considered by the applicants ecological and shellfish experts (Dr Paula Kearney and Dr James Massey) not likely to have any deleterious effect on the SAC or Shell fish habitats.

Dr Cúre (on behalf of Clarinbridge Oyster Co-op and Michael Kelly Shellfish was of the view that a comparative model is not suitable as it cannot predict the actual change in salinity during a flood event at the oyster beds and as a change in salinity and duration of same is critical to their lifecycle this is necessary ([9]). He also disagreed with the methodology of mixing (vertical and horizontal) used in the model to determine dilution and the lack of

consideration of known environmental conditions e.g. onshore wind direction holding up freshwater in the estuary and therefore lengthening the duration of a low salinity event.

6.2.2 ASSESSMENT & CONCLUSIONS

MIKE3 HD which was used by the applicant is a reputable model and is suitable for salinity predictions. The boundary water levels at the entrance to Galway Bay and the Bathymetry data used are from reputable sources. The effectiveness of the model in determining general changes in salinity within the bay is dependent on a reasonable interpretation of the topography, hydrology, tidal, mixing and other environmental conditions present in the bay. In the absence of comparison against any known local salinity dataset, confirmation of the conclusions of the model are dependent on confidence in the mixing and environmental conditions used in the model rather than direct comparison with measured data. In my opinion this lack of any documented record of baseline salinity conditions on which to directly compare model predictions lead to a gap in confidence in the model prediction. As a comparative dataset is not available (evidence provided at the Hearing by Dr Shannon and Dr Massey) for comparison, assurance on the model prediction is only provided by the opinion report of a reputable scientist (Dr Rachel Cave) who has some local knowledge of the hydrological regime in the bay. Dr Rachel Cave (NUI Galway) is recognised by both parties as a scientist with local knowledge of hydrology and salinity conditions within Galway bay. In an opinion provided by Dr Cave to the applicant she confirmed that “The modelling work carried out by RPS is in agreement with the known circulation and salinity conditions in Galway Bay” (Dr R Cave February 27th 2012) and “under the same flood conditions as experienced in 2009, the flood alleviation scheme will not worsen conditions for shellfish in the bay”. (Ref dated February 27th 2012 and September 24th 2014).

The Bord could request the collection of a representative dataset of salinity and hydrology over time and the preparation of a calibrated model. However, this is likely to require a minimum period of two years to collect a reasonable dataset and a revised model to provide improved confidence. In reply to a question from the Bord at the Hearing, Mr. McDonnell (Applicants engineer) confirmed that if the scheme was split i.e. undertake flood alleviation works above Rahasane Turlough and no works downgradient of the Turlough that the impact on the bay would be as in a “do nothing” scenario. Thus splitting of the project could facilitate collection of data in the bay to allow calibration of a salinity model.

In regard to the feasibility of collecting adequate data to allow development of a predictive model, Dr Shannon advised the Hearing that there would be inherent difficulties in providing a sufficiently detailed predictive model. She stated that It would be difficult to collect adequate data as it should include both normal and peak flood measurements at many points in the bay and that the uncertainties within any such predictive model due to the need to model flows and stratification over the duration of an event over the bay area. Her view was that the applicants’ team had considered the use of such a model and concluded that it was disproportionate to the scale of the scheme and not necessary considering the small increase in discharge over a flood event. It is my opinion that representative data could be collected within a 2 year timeframe to provide improved confidence in the model outputs.

It is my opinion that a comparative model cannot predict every local variation as this is likely to be impacted by local topography, currents and wind impacts. The use by the applicant of a comparative model is unlikely to affect the assessment of the impact on the habitat requirements of the SAC as the qualifying interests of the communities in the SAC are not highly impacted by short term salinity variation. This would also have no impact on the status of the waterbody under the requirements of the Water Framework Directive.

Based on my review of the comparative model used by the applicant to predict salinity, these are my conclusion:

-The absence of a model calibrated against real data reduces confidence in the predictions of salinity particularly at a local scale during extreme flood events,
-The comparative model is adequate for assessment of the impact on the qualifying interests of the SAC as these are less sensitive to variations in salinity,
-Only in an extreme flood event is there a measureable difference in the freshwater discharge between the pre to post plan. Under normal conditions, there is no measureable difference in discharge between the pre and post plan and as such the risk of impact by an incremental addition of freshwater over the shell fish lifecycle is low. In addition, vulnerable conditions only exist during the extreme flood event when it coincides with low salinity already present in the bay and tidal and onshore wind conditions retaining low salinity conditions in the bay.
-Even with a calibrated model the impact of this event on the shell fish lifecycle cannot be fully determined as there is no empirical data to allow accurate comparison on low salinity conditions on shell fish life cycle.

In view of the low likelihood of the necessary combination of meteorological conditions occurring which could result in even a slight lengthening of the duration of low salinity in the bay due to the scheme, I conclude based on the data available that this is a low risk of the additional freshwater discharge during a storm event having a significantly negative impact on the salinity in the bay. There is inadequate data available to identify what level of impact on the shellfish population might occur during a 2009 type flood event.

6.3 REVIEW OF IMPACT OF THE PROPOSED FLOOD ALLEVIATION SCHEME ON WATER QUALITY IN DUNBULCAUN BAY

The applicants NIS stated that the conveyance of freshwater slightly more quickly in a flood event will not result in the transport of significant additional quantities of suspended sediment, salinity change and nutrients to the Dunkellin Estuary and therefore is unlikely to impact on the “intertidal sandy mud community complex community” and “intertidal sand community complex”. Based on my review of the HEC-RAS model prediction of velocity in the river channel post plan ([1] Section 4.3 Impact on Flow Velocity) and the discussion at the hearing, I am satisfied that although slightly more sediment may reach the bay in an extreme flood, this will not have a significant impact on the receiving habitat. The habitat already receives significant sediment influx in flood conditions.

The third party (Clarinbridge Oyster Co-op and Michael Kelly Shellfish), were concerned that the increase in velocity during flooding post plan in a 1 in 122 flood event could result in increase in sediment loading and reduced retention time resulting in a corresponding increase in bacterial loading to the bay. It was noted by the applicant that bacterial and nutrient loading is already causing a significant risk to the shell fish industry in the bay.

Although, post development there is evidence of increase in freshwater flow pre flood peak (described above) which may result in increase in erosion during a November 2009 flood event, this would only occur for a very short period, and until the two stage steam comes into operation. As such, it is my opinion that increase in sediment loading over this short period in a flood event is unlikely to be measureable against the natural high sediment loading which would occur in any case in a flood. In addition, containment in the proposed two stage river system will reduce flooding over land and reduce the corresponding land associate erosion which would normally occur.

Known significant bacterial sources which currently impact on water quality in the bay include run-off from agricultural land, septic tanks and a significant point source i.e. overflow from WWTP at Loughrea. The proposed flood alleviation plan will not impact on conveyance of bacterial loading from the Loughrea WWTP. Overland flow downgradient of Rahasane Turlough will be reduced which may have some minor improvement in water quality at peak

flow. However, in my view there will be no measureable change in bacterial loading or overall water quality in the bay as a result of this proposed scheme.

In conclusion, it is my opinion that the proposed plan will not have a high risk of impact on water quality in the bay post construction. The highest risk to water quality in the bed is agricultural run-off, septic tanks and in particular overflow from WWTPs. At the Hearing, the applicant's ecologist Dr Massey stated that upgrading of the WWTP is in Irish Waters' program of works. This upgrade should have a significant improvement in the water quality in the inner bay area.

7.0 REVIEW OF PROPOSED SCHEDULE OF ENVIRONMENTAL COMMITMENTS

The applicants EIS and NIS states that potential exists for construction phase impacts but these can be readily mitigated. The risk of increased runoff during construction is present due to the requirement for instream excavation work, excavation of two stage channel works, spreading of excavated material and construction of bankside embankments. These proposed works have a high potential to impact on water quality in the river and habitat requirements in the Dunkellin River, Rahasane Turlough SAC and Dunbaulcan Bay, if adequate mitigation is not undertaken. In particular, managing of the construction works to comply with fishery and ecological timeframes and the unpredictable nature of the weather increases the risk of a sediment laden discharge occurring. I am satisfied that the draft CEMP (Appendix C EIS [(2)]) and schedule of environmental commitments [(7)] provided by the applicant at the Hearing presents a comprehensive methodology for reducing the risk of impact from sediment runoff into the channel.

As the construction management plan is draft and will be undertaken by the contractor, the commitment by the applicant[(8)] to have an environmental officer (EO) engaged by Galway Co. Co. for the full duration of the works, auditing the contractors work provides further confidence of good environmental management being undertaken during construction. The schedule of environmental commitments states *"The Local Authority will ensure that the EO is delegated sufficient powers under the construction contract so that he/she will be able to instruct the contractor to stop works and to direct the carrying out of emergency mitigation/cleanup operations*".

Additional commitments in relation to monitoring discharge water into the bay from the Dunkellin River were proposed by the applicant at the Hearing in reply to a request for same by the Clarinbridge Oyster Co-op and Michael Kelly Shellfish, I would support the collection of this data, pre and post construction.

REFERENCES

1 Dunkellin River and Aggard Stream Flood Relief Scheme, EIS, Folder II
2 Dunkellin River and Aggard Stream Flood Relief Scheme, EIS, Folder I
3 Dunkellin River and Aggard Stream Flood Relief Scheme, NIS
4 Tim Joyce, OPW, Oral Hearing Engineering Brief of Evidence
5 Dunkellin River and Aggard Stream Flood Relief Scheme – Response to Bord Pleanála
6 Dunkellin River and Aggard Stream Flood Relief Scheme, Response to Bord Pleanála, Appendix C
7 Dunkellin River and Aggard Stream Flood Relief Scheme, Schedule of Environmental Commitments
8 Gerry Baker Soils, Geology & Hydrogeology BOE section 3 Errata to the EIS.
9 Submission by Dr Cúre at the Hearing on 3rd November 2015
10 Dr R Cave, Expert Opinion dated February 27th 2012 and September 24th 2014.