Galway Harbour Company

Galway Harbour Extension

Response to An Bord Pleanála
EIS Addendum Sept. 2024
Chapter 8 Water

An Bord Pleanála (Ref: 61.PA 0033)

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8. Water

8.1. Introduction

The original Environmental Impact Statement (“EIS”) (Jan 2014) and subsequent EIS Addendum/Errata to Chapters documents (Oct 2014) summarised the water environment and potential impacts of the proposed development on Inner Galway Bay including the transitional waters of the Corrib and lagoonal waters of Lough Atalia including Renmore Lough and the coastal waters of Galway Bay.

This 2024 Addendum aims to identify any updates on the current water quality status and coastal processes of the Inner Galway Bay area and any updates in current guidance and legislation in reference to water since the original EIS was released. This Chapter is provided by Mr. Athony Cawley.

Anthony Cawley qualified with an honours degree in Civil Engineering from NUI Galway in 1987 and a post graduate master’s degree in Engineering Hydrology from NUI Galway in 1990. He is a Chartered Civil Engineer with Specialist education and 33 years professional consulting experience in the water engineering field in a wide variety of activities relating to hydrology, hydrogeology and flooding, and hydrodynamic and hydraulic assessment of fluvial and tidal processes. Mr Cawley was a lecturer in hydrology and hydraulics at the Hydrology and Civil Engineering Department at NUI Galway and is currently Lectures in Engineering Hydrology at the University of Limerick (2011 to 2023).

Mr. Cawley has carried out well over 250 flood risk assessment studies on rivers, estuaries and coastal areas throughout Ireland. These studies ranged from scoping type assessments to detailed flood risk assessments involving hydrometric measurements river channel survey, hydraulic modelling and flood inundation mapping. Involved in flood relief and flood management studies for OPW and local Authorities having provided hydrology and hydraulic modelling inputs to various flood relief schemes including Lucan, Ennis, Mullingar, Claregalway, Arklow, Cavan Town, Carrick-on-Shannon, Ballinasloe, Galway City and the Gort Lowlands.

Mr. Cawley is an expert hydraulic and coastal processes modeller and analyst with considerable experience in application of 1D, 2D and 3D models to rivers, estuaries and coastal waters. Detailed estuarine and coastal modelling experience using Telemac Software system with recent projects that include the Shannon Estuary hydrodynamic model and tidal harmonic analysis of tide elevations and velocities for oil spill tracking, the sediment transport, wave climate and hydrodynamic assessment of the proposed New Port for Galway and the flood impact and scour assessment of Arklow Bridge, Waterford pedestrian Bridge, Narrow Water Bridge Carrlingford Lough and the Kish Bank Offshore Wind Farm and numerous sewage outfall and aquaculture studies in Irish coastal waters.

8.2. Comprehensive review of the previous EIS chapter

The original EIS Chapter 8 (Jan 2014) and Addendum/Errata Chapter 8 (Oct. 2014) outlines the following:

- Bathymetry
- Water Quality
- Hydrodynamics,
- Wave climate,
- Flood Risk
- Sediment Transport,
- Salinity
- Outfall Dispersion Simulations
- Impacts and mitigation

Mitigation measures between the original EIS and 2014 Addendum/Errata included:

- Implementation of best practice and Environmental Management Practice. Use of well managed bunds will prevent grey water entering the sea.
- Bilge water is collected from the vessels and disposed of by licenced operators.
- Accidental Release of hydrocarbons into the marine waters during construction phase will be prevented by retaining all construction site runoff on site within settlement areas prior to discharge.
- Construction site sewage with be either discharged to the public sewer or taken off site licenced waste operator for suitable treatment and disposal.
- The use of bunds will prevent leakages into the sea from construction vessels and onshore plant.
- In light of the model sediment transport simulations, dredging will be controlled to ensure that no waters carrying a silt load above ambient will enter Lough Atalia. Mitigation to protect Lough Atalia will involve confining construction dredging activities to the outgoing ebbing flow for the proposed navigation channel section to the Docks and Marina on the west side of the harbour.
- Hydrocarbon spills and other accidental release of fluids/solids during loading/offloading of vessels will be mitigated through an oil spill contingency plan (OIL/HNS spill contingency plan).
- Disposal of ballast waters is regulated by the International Maritime Organization under the International Convention for the control and management of ships' ballast water and sediments 2004 (BWM Convention). Vessels that make transitional passages may not dispose of ballast waters inside the EEZ (Exclusive Economic Zone) without first being treated.
- Moveable breakwater barriers may be used to address the impact of South Easterly waves on the fishing pier.

8.3. Chapter Format

The purpose of this Chapter is to bring the EIS Chapter 8 – Water and associated appendices and errata's documents up to date from its original publication in January 2014. The original EIS findings in relation to the water will be summarised and this section will outline any updates in data, including any constructed developments since January 2014 that form part of the new baseline environment, any additional surveys and analyses, relevant policies, legislation and guidelines used in the updated assessment. Cumulative impacts will include a review and assessment all relevant projects either mooted, in planning, in construction or approved but not commenced. All completed projects since January 2014 relevant to the study area will be included for in the updated baseline-built environment. The assessment of the validity of earlier conclusions or any necessary amendments to same and final conclusions will be presented.

8.4. Review of any material changes to Chapter 8 "Water" in Original EIS

There are no material changes to the proposed New Harbour development in regard to its design, its layout, plan and sectional drawings, its proposed finish levels, proposed materials, its proposed construction phases and construction methodologies and no material changes to its operational requirements or to any proposed mitigation measures.

8.5. Summary of previous conclusions of chapter 8 in the original EIS

The original EIS Chapter 8 identified that the construction of the proposed new development will have impacts on the physical and chemical characteristics of the aquatic environment in the vicinity of the mouth of the Corrib and these have been demonstrated by the output of the mathematical modelling studies. These effects relate to both the construction phase and the operational phase and described the following hydrological impacts:

- During construction, the most significant impact will arise due to sediment being brought into the water column by dredging activities but the modelling results show that the area of significant impact is close to where the dredger is operating and that the levels of suspended sediments outside this zone are significantly lower than the maximum measured disturbed background levels. The impact of the deposition of these sediments on benthic fauna has been discussed in Chapter 7.

- Once construction is completed, impacts include permanent changes to current direction and velocity, temporally short but permanent changes in sediment distribution in the area to the east of Mutton Island and permanent changes in salinity values and wave climate characteristics. Due to the physical and chemical nature of some of these impacts, it is not possible to mitigate for them. The scale of change indicated by the modelling studies are local and of a minor scale not to significantly affect the functioning of the ecosystem.

- Simulation of the fine sediment from the River Corrib showed the proposed development pushing the river plume and thus suspended sediment southwards out to sea past Mutton Island on the ebbing tide and away from the Renmore area only returning in a much more dilute plume on the flooding tide. The simulation results indicate a reduction generally of between 40 and 60% in fine sediment load east of the proposed development.

- The principal hydrodynamic impact is the deflection of the Corrib outflow more westwards giving it a more southerly heading towards Mutton Island resulting in a concentration of flow along the proposed dredged channel past the marina breakwater and southwards. The simulation indicates slightly higher velocities and more persistent flow in the new channel over the tidal cycle than that predicted for the existing dredge channel (without the development). One other principal impact on the flow regime is an increase in tidal velocity past the head of the southern breakwater protecting the commercial Harbour area with velocities increasing from 0.1 – 0.15 m/s to 0.2 - 0.25 m/s.

- The hydrodynamic simulations for various freshwater inflows from the Corrib and tides show the deflection of the Corrib freshwater plume westward due to the harbour extension site with freshwater only arriving into Ballyloughane / Renmore Bay area on the subsequent flooding tide. With the proposed development, the Corrib plume is directed more southwards with reduced opportunity for the freshwater plume to directly disperse into the Ballyloughane / Renmore Bay area on the returning tide. The modelling demonstrates significant increases in salinity to the east of development with greatest changes occurring to the northeast of proposed harbour extension due to the deflection by the proposed harbour structure of the Corrib Freshwater Plume. Less significant changes in salinities levels (reduction in salinity) are predicted to take place to the west of the structure and very minor changes predicted for Lough Atalia or the waters beyond Mutton Island. In the approaches to Galway Docks, south of Nimmo's Pier reduction in average salinity concentrations of 1.5 to 2ppt (parts per thousand) are predicted.

- Lough Atalia is classified as lagoonal and is designated a priority habitat, dredging will cease before the tide could move the silt plume into the Lough Atalia Channel. In light of the model simulations, dredging will be controlled to ensure that no waters carrying a silt load above ambient will enter Lough Atalia. Hydrodynamic analysis has shown that the available inflow period to Lough Atalia is limited to approximately 2 to 2.5 hours per tidal cycle with the principal tidal inflow occurring on spring tides and very limited inflow occurring on neap tides due to the presence of a raised shelf on the inflow channel.

- Mitigation to protect Lough Atalia will involve confining dredging activities to the outgoing ebbing flow for the proposed navigation channel section to the Docks and Marina on the west side of the harbour. No mitigation measures will be required for the main commercial harbour approach channel, turning circle and berths as the suspended sediment disperses quickly due to the large depths

- The impact of the Harbour Extension Development on salinity concentrations within Lough Atalia is to reduce salinities by on average by 1.29ppt over the complete range of flow and tide conditions. Given the large range of salinity within the Lough from c. 30ppt to nil ppt, this reduction of 1.29ppt in salinity, which is only 10% of the mean salinity, is not considered significant. The model analysis also demonstrates that the range of salinities (maximum to minimum) within Lough Atalia will not alter as a result of the harbour extension, only the frequency of occurrence will change.

- Periodic large and extreme flood flows in the Corrib will reduce salinities to practically nil in Lough Atalia for both the existing and proposed cases, principally during neap tides but also on spring tides for a less frequent more extreme flood flow. Over the full tidal range the probability of nil Salinity in a given year occurring within Lough Atalia will increase from 0.08% to 0.21% (7 to 18hours in an average year).

- The overall impact on salinity within Renmore Lough by the proposed Harbour extension will be to decrease the median salinity within the Lough by 1.22ppt. The overall water balance and inflows to and from Renmore Lough will not be affected by the proposed development as the tidal elevations in Lough Atalia which connects Renmore Lough will not be altered by the development and thus the inflow/outflow rates to Renmore Lough will remain unchanged.

- The proposed development site is located within the High Flood Risk Zone (*i.e.* Zone A of the Planning Guidelines). Flood Zone A is the high flood risk zone and represents lands that are below the 100year fluvial Flood level or the 200-year tidal or combined (tidal and fluvial) flood level. From the Flood risk assessment the critical condition for the harbour is the 200-year tidal storm surge event. The proposed development being a Commercial Harbour and Marina with associated dockside activities is classified as a water compatible development and recognised as appropriate development for Flood Zone A in the Flood Risk Management Planning Guidelines (Nov 2009) and therefore under these guidelines is justifiable from a flood risk management perspective provided suitable flood risk mitigation is provided.

- The quay height and operational ground level along the Quay are set at 4.7 m O.D. Malin which is above the design flood level of 4.646 m O.D. (assume 4.65m OD) and therefore considered safe from inundation from storm surge tides. The minimum finish floor level for all buildings on the port site is to be 5.5 m O.D. which is well above the design flood level providing a freeboard of 850 mm and thus not considered at risk of flooding from tidal/combined fluvial flood inundation.

- The breakwater protection varies in height depending on the location and exposure to wave climate with southerly breakwater having a crest elevation of 9.1 to 10.1 m O.D. which provides 4.465 to 5.465 m above the design tide level of 4.635 m O.D. for wave climate and wave run-up effects. This level of protection will minimise the risk of overtopping of the breakwater structure by extreme waves. The westerly breakwater located in the more sheltered waters has a top elevation 6.65 to 6.95 m O.D. which based on wave climate analysis will protect this area from overtopping by the waves predicted for these locations.

- The wave climate simulations show that the proposed harbour development impacts the local wave climate environment through a combination sheltering via dissipation and reflection off its breakwaters and diffraction and refraction of the wave field around the development and over the dredged channels. The development generally shelters the eastern section of the adjacent Renmore / Ballyloughane shoreline against storms from the south to southwest sector. It protects the Galway Docks entrance and much of the Southpark shoreline against storms from the south to the east.

- The simulations show under south and south westerly storms increased wave activity along the south face of Nimmo's Pier and the entrance to Galway Docks and the Corrib channel. These are not the most significant waves which presently occur at this location and theses waves are directed across the Corrib channel as opposed running up along it.

- The wave simulations show that this increased wave activity at Nimmo's pier entrance does not appreciably impact wave heights within the inner Claddagh Basin area and such impacts are less than those which presently arise from the southeast direction which will now be blocked by the proposed development.

- The proposed harbour extension development has been shown not to impact on flood risk for the adjoining areas. It has no perceptible impact on peak combined tide levels within the Claddagh Basin, Spanish Arch and Galway Docks area upstream of Nimmo's Pier. The development does not adversely impact on wave climate in respect to flooding and flood risk with the harbour development generally sheltering the shoreline areas at South Park, the existing docks and the Renmore/Ballyloughane shoreline against local and offshore generated waves.

- No changes are predicted for flooding episodes in Galway due to the construction of the proposed development. The Flood Risk Assessment shows that the proposed development is appropriate development for Flood Zone A, being a harbour development, and that it will not increase flood risk to adjacent lands and developments from extreme sea level, wave climate and river flood flow events.

- The outfall dispersion results show for the existing Mutton Island outfall some variation in the plume characteristics to the east of Mutton Island as a result of the proposed Harbour Development. These changes in plume shape and extent are brought about by local changes in the velocity pattern as a result of the physical harbour extension structure. The overall impact is considered to be local and minor and importantly the simulations show no impact along the Salthill/Silverstrand, South Park and Renmore shoreline areas or upstream at the existing Galway Harbour where amenity and bathing standards are important. The simulations show practically imperceptible impact to the westerly excursion of the tracer plume from the outfall site and no perceptible impact to water quality at the more remote bathing waters of Silver Strand, Barna and Furbo. The simulations also show no impact to the designated shellfishery waters located in the south inner Galway Bay area.

- The proposed Galway East outfall location at E131892, N222010 will not be impacted by the proposed new harbour development with the predicted tracer plume shape, extent and concentration almost identical between the with and without development cases.

8.6. Additional Surveys, data or policy developments of relevance

8.6.1. Updated Built Environment

The construction projects completed in the period from publication of the original EIS in January 2014 to end August 2024 were reviewed as part of the updated baseline environment in respect to their significance on the water environment. No significant changes to the shoreline boundary was identified that would materially impact the hydrodynamic, wave climate and flooding assessments. Such completed projects included the additional 50m cantilevered walkway on the south elevation of the Wolfe Tone Bridge over the Corrib at the Claddagh Basin, the recently completed pedestrian and cycle bridge south of the Salmon Weir Bridge, near the Cathedral, the replacement of the old timber lock gate section and replacement by a fixed weir on the Eglinton Canal, rock armouring and shore protection to the Blackrock area of Salthill and to a section of the Southpark shoreline area near the Mutton Island causeway access, improvements to the Southpark walkway, completion of the large Mixed Use Development including 4 no. Office Blocks on the Former Irish Shell/Topaz Oil Storage Facility (1972 to 2009) on the Dock Road / Queen Street or the new Irish Water Terryland Intake Facility from the River Corrib located on the east river bank a short distance downstream of the Quincentennial Bridge. This new intake replaces the existing Jordan Island Intake which has an abstraction order for 45,000m^3 per day. The capacity of the new intake is 70,000m^3 per day gravity flow to the Terryland water treatment plant.

The Dunkellin and Aggard Stream Flood Relief Scheme was completed in 2019; this scheme has improved the conveyance of floodwaters in the Kilcolgan River to the sea giving rise, potentially to increased surges of freshwater into the estuary giving resulting in changes to the salinity of the receiving Estuary. The Harbour development on the north shoreline of inner Galway Bay is sufficiently remote as not to influence or be influenced by any local hydrodynamics and salinity changes in Kilcolgan and the Clarin Estuaries as a result of the flood relief scheme. The impact assessment for this scheme identified only localised salinity impacts.

Completion of schools, hotels and large residential developments within the Galway City and environs and in the towns of Oranmore, Claregalway and Bearna and further afield at Clarinbridge, Athenry, Kilcolgan, Kinvarra and Spiddal since publication of the EIS in January 2014 have not materially changed the baseline environment for the coastal process modelling and assessment of the hydrological regime within inner Galway Bay, including the Claddagh Basin, Corrib Estuary, Galway Docks and Harbour, Southpark, Salthill, Whitestrand Beach, Lough Atalia including Renmore Lough, Deadman's and Ballyloughnane Beaches, Renmore shoreline and the outer Galway Bay area. This increased urban development will have increased the hydraulic and pollutant load on the Mutton Island Treatment Plant and such development will also have generated greater impervious area for surface water runoff to be generated. All such developments are required through planning to implement SUDs (Sustainable Urban Drainage systems) solutions to the management of their storm water runoff so as to limit it to greenfield runoff rates and minimise surface drainage pollution entering either watercourses or the public storm network. The Waste Water Treatment Plant ("WWTP") and outfall discharge at Mutton Island and the WWTP at Claregalway, Kinvarra and Athenry are managed by Irish Water and are governed by discharge licences requiring effluent standards to meet the water regulations and water framework directive. The Mutton Island WWTP and outfall located close to the development is governed by such regulations and it provides full secondary and tertiary treatments in order to maintain the high and good status of the Coastal waters in outer and inner Galway Bay and protect the bathing waters and Shellfish Waters within the Bay. The latest quality status of these waters which includes moderate status for the transitional waters in the Corrib estuary and good status for the River Corrib through Galway City have been included for in the updated baseline conditions and updated impact assessment.

There has been no significant changes to the shoreline sections of the Galway Docks area, outer Galway harbour area, Lough Atalia, and the Ballyloughane / Renmore shoreline that would alter the coastal processes, hydrodynamics and wave climate within the Development Study area or result in altering the model set-up or potential changes to the model results and findings.

8.6.2. Bathymetry

The seabed levels in the vicinity of the proposed New Harbour site including the existing navigation channel are reasonably stable having limited sources of silt and sediment for deposition there. As part of Galway Harbour seabed navigation channel monitoring, regular bathymetric surveys of the Galway Docks basin Area and the navigation approach channel are conducted on a 6-month basis for the Harbour Authority. These surveys have been reviewed. The most recent survey conducted by Hydro Survey in March 2024 and showed little change in bed levels occurring (refer to Appendix 8.1 and Appendix 8.2 of this Chapter for bathymetric survey drawing) over the original bathymetry used in the hydrodynamic modelling assessments.

The overall tendency over the years is for very slight accretion within the artificially deepened navigation channel (dredged to 3.45m below chart datum). The last maintenance dredging of the deepened navigation channel was carried out in September 2001 and no maintenance dredging campaign has been required since. This indicates that the seabed levels at the proposed development site are stable and not subject to any significant changes in level either from deposition or erosion. Within the Corrib channel section and the entrance to Lough Atalia the velocities maintain a stable rocky bed with no deposition. Therefore the seabed description in the hydrodynamic and wave climate models developed for the 2014 EIS remain valid for the project and this update.

8.6.3. Water Quality

Updates regarding water quality baseline data were identified in this review. The EPA map viewer (https://gis.epa.ie/EPAMaps/SewageTreatment) was accessed on the 12th of July 2024. The following data was recorded:

The Coastal Waterbody Status of Inner Galway Bay North 2013-2018 was measured as 'Good'. The Mutton Island Treatment Plant Sewage Treatment >500pe (a sewage treatment plant that treat sewage waste produced by more than 500 people) had a 'Pass' described under the 'Directive Compliance' category.
Bathing Water Quality was measured at Ballyloughane Beach in 2023 and was noted as having 'Excellent Water Quality', while Grattan Road Beach achieved 'Good Water Quality' status in 2023.

The Annual Environmental Report (Irish Water, 2022) for the Galway City Wastewater Treatment Plant ("WWTP"), located at Mutton Island, was consulted as part of this assessment. The report found that the Galway City WWTP was compliant with the Emission Limit Values set in the Wastewater Discharge License. Additionally, it noted the discharge from the wastewater treatment plant does not have an observable impact on water quality and the discharge from the WWTP does not have an observable negative impact on the Water Framework Directive status. No report for 2023 or 2024 was available at the time of composing this Addendum/Errata.

8.6.4. River Flows

The River Corrib flows used in the original modelling were based on available gauged flows for the Corrib at the OPW gauging station at Wolfe Tone Bridge (30061). In the original 2014

EIS Study the following River Corrib flow rates were estimated from the available gauge record at Wolfe Tone Gauge and used in the hydrodynamic simulations.

- 95-percentile Corrib Flow estimated at 26.4 m^3/s
- Median River Flow estimated at 82 m^3/s
- 100year Corrib Flow estimated at 458 m^3/s

The flow duration date for the River Corrib used in the 2014 EIS is as follows:

- 99-percentile River Corrib low flow of 9.1 m^3/s
- 95-percentile River Corrib low flow of 26.4 m^3/s
- 90-percentile River Corrib flow of 28.5 m^3/s
- 50-percentile River Corrib flow of 82 m^3/s
- 10-percentile River Corrib flow of 200 m^3/s
- 5-percentile River Corrib flow of 240 m^3/s
- 1-percentile River Corrib flood flow of 272 m^3/s

A significant review of the rating relationship for the Wolfe Tone hydrometric gauge has been recently carried out by the Office of Public Work ("OPW") hydrometric section with the new rating relationship applied to the most recent record from 2009 to 2024. As a result there are material changes to the estimated river flows, both in normal and flood conditions. The following are the updated fluvial flow statistics for the River Corrib at Wolfe Tone Bridge extracted from the OPW Hydro Website (https://waterlevel.ie/hydro-data/).

Table 8.1: River Corrib Flow Duration Curve (2009 to 2024)

Flows equalled or exceeded for the given percentage of time (m^3/s) (Data derived for the period 2009 to 2024)								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
327.5	251.6	210.0	157.0	90.5	44.1	28.6	23.7	13.6

The estimated return period flows for the River Corrib is presented below in Table 8.2. These return period flood estimates are based on fitting an Extreme Value Type 1 distribution to the published annual maximum flood flow series for the hydrometric years 2009 to 2023 (https://waterlevel.ie/hydro-data/).

Table 8.2: River Corrib Return Period Flood Flow Estimates (2009 to 2024)

River Corrib Return Period Flows								
T (years)	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**1000**
QT (m^3/s)	284.3	325.4	357.8	389.0	429.3	459.5	489.6	559.3

- 95-percentile Corrib Flow estimated at 23.7 m^3/s
- Median River Flow estimated at 90.5 m^3/s
- 100year Corrib Flow estimated at 459.5m^3/s

These revised flow estimates for the River Corrib are not significantly different than the previous flow estimates used in the 2014 EIS and therefore the modelling and findings relying on these the previous flow inputs in the EIS remain valid.

8.6.5. Astronomical Tide levels

The astronomical tides in respect to neap and spring tide high and low water levels, the tidal cycles and tidal curve profile have not changed significantly in the intervening period and the spring and neap tide profiles used in the 2014 EIS remain valid.

Table 8.3: Tidal elevation at Galway Port Gauge chart datum and OSGM15 Malin datum

	Tide level Chart Datum	Tide level m OD Malin OSGM15
Highest Astronomical Tide (HAT)	+5.840	+2.895
Mean Highwater Springs (MHWS)	+5.087	+2.142
Mean Highwater Neaps (MHWN)	+3.987	+1.042
Mean Sea level (MSL)	+2.987	+0.042
Mean Low Water Neaps (MHLN)	+1.987	-0.958
Mean Low Water Springs (MLWS)	+0.910	-2.035
Lowest Astronomical Tide (LAT)	-0.022	-2.967

8.6.6. Tidal Flood Levels

In the intervening period an additional 13years of gauged tidal flood data has become available for the gauges at Wolfe-Tone Bridge (30061) and at Oranmore gauge (29015), refer to Table 8.4 and Table 8.5. Additional tidal flood data from the Marine Institute is available for the Galway Port Gauge, refer to Table 8.6. This additional data increases the robustness and accuracy of the extreme water level predictions for updating the flood risk and impact assessment.

Table 8.4: The OPW Annual Maximum Tidal Flood level series for Oranmore gauge (29015)

OPW Annual Maximum Tidal Flood Levels (Oranmore Gauge (29015))				
Year	m OD Malin	Stage (m)	Date	Comment
1982	2.87	1.790	08.09.1983	Levels are tidal peaks
1983	2.94	1.860	19.02.1984	Levels are tidal peaks

OPW Annual Maximum Tidal Flood Levels (Oranmore Gauge (29015))				
Year	m OD Malin	Stage (m)	Date	Comment
1984	3.1	2.020	23.11.1984	Levels are tidal peaks
1985	2.88	1.800	28.03.1986	Levels are tidal peaks
1986	2.98	1.900	03.12.1986	Levels are tidal peaks
1987	3.08	2.000	27.09.1988	Levels are tidal peaks
1988	3.15	2.070	09.03.1989	Levels are tidal peaks
1989	3.11	2.030	26.02.1990	Levels are tidal peaks
1990	3.46	2.380	05.01.1991	Levels are tidal peaks
1991	2.99	1.910	29.08.1992	Levels are tidal peaks
1992	3.13	2.050	12.01.1993	Levels are tidal peaks
1993	3.22	2.140	12.01.1994	Levels are tidal peaks
1994	3.55	2.470	17.01.1995	Levels are tidal peaks
1995	3	1.920	28.09.1996	Levels are tidal peaks
1996	3.54	2.460	10.02.1997	Levels are tidal peaks
1997	3.05	1.970	30.03.1998	Levels are tidal peaks
1998	3.16	2.080	02.01.1999	Levels are tidal peaks
1999	2.95	1.870	26.12.1999	Levels are tidal peaks
2000	3.05	1.970	09.03.2001	Levels are tidal peaks
2001	3.32	2.240	02.02.2002	Levels are tidal peaks
2002	2.84	1.760	08.10.2002	Levels are tidal peaks
2003	2.94	1.860	19.03.2004	Levels are tidal peaks
2004	3.34	2.260	08.01.2005	Levels are tidal peaks
2005	3.06	1.980	29.03.2006	Levels are tidal peaks
2006	3.06	1.980	20.02.2007	Levels are tidal peaks
2007	2.89	1.810	27.10.2007	Levels are tidal peaks
2008	2.85	1.770	22.08.2009	Levels are tidal peaks
2009	3	1.920	02.03.2010	Levels are tidal peaks
2010	3	1.920	08.10.2010	Levels are tidal peaks
2011	2.9	1.820	26.10.2011	Levels are tidal peaks
2012	3.084	2.004	14.12.2012	Levels are tidal peaks
2013	3.663	2.583	01.02.2014	Levels are tidal peaks
2014	3.095	2.015	03.08.2015	Levels are tidal peaks
2015	3.107	2.027	08.02.2016	Levels are tidal peaks
2016	2.948	1.868	16.10.2016	Levels are tidal peaks
2017	3.795	2.715	02.01.2018	Levels are tidal peaks
2018	3.257	2.177	12.10.2018	Levels are tidal peaks
2019	3.3	2.220	09.02.2020	Levels are tidal peaks
2020	3.199	2.119	14.11.2020	Levels are tidal peaks
2021	3.232	2.152	07.12.2021	Levels are tidal peaks
2022	3.193	2.113	23.03.2023	Levels are tidal peaks
2023	3.854	2.774	13.11.2023	Levels are tidal peaks

Table 8.5: The OPW Annual Maximum Tidal Flood level series for Wolfe Tone Gauge (30061)

OPW Annual Maximum Flow Levels (Wolfe Tone Gauge (30061))			
Year	m OD Malin	Stage (m)	Date
1992	3.214	3.04	11.01.1993
1993	3.174	3.00	12.01.1994
1994	3.434	3.26	17.01.1995
1995	2.974	3.80	25.10.1995
1996	3.574	4.40	10.02.1997
1997	3.024	3.85	16.10.1997
1998	3.084	3.91	02.01.1999
1999	3.254	4.08	25.12.1999
2000	3.014	3.84	12.12.2000
2001	3.514	4.34	01.02.2002
2002	2.934	3.76	08.10.2002
2003	2.817	3.643	02.08.2004
2004	3.124	3.95	08.01.2005
2005	3.134	3.960	30.03.2006
2006	3.174	4.000	20.02.2007
2007	2.874	3.700	27.10.2007
2008	2.889	3.712	22.08.2009
2009	3.06	3.883	02.03.2010
2010	3.021	3.844	08.10.2010
2011	2.893	3.716	29.10.2011
2012	3.127	3.950	14.12.2012
2013	3.629	4.452	01.02.2014
2014	3.093	3.916	03.08.2015
2015	3.087	3.910	28.10.2015
2016	2.974	3.797	16.10.2016
2017	3.854	4.677	02.01.2018
2018	3.3	4.123	12.10.2018
2019	3.257	4.080	18.12.2019
2020	3.131	3.954	16.12.2020
2021	3.223	4.046	07.12.2021
2022	3.176	3.999	23.03.2023
2023	3.828	4.046	13.11.2023

Table 8.6: The Marine Institute Annual Maximum Tidal Flood Level Series for Galway Port Gauge (30062)

OPW Annual Maximum Flow Levels (Galway Port Gauge (30062)		
Year	**m OD Malin**	**Date**
2007	2.99	10/03/2008
2008	2.94	22/08/2009
2009	3.1	02/03/2010
2010	3.01	08/10/2010
2011	2.97	29/10/2012
2012	3.17	14/12/2012
2013	3.59	01/02/2014
2014	3.02	03/08/2015
2015	3.02	28/10/2015
2016	2.99	16/10/2016
2017	3.772	02/01/2018
2018	3.204	12/10/2018
2019	3.178	18/12/2019
2020	3.091	15/11/2020
2021	3.176	07/12/2021
2022	3.119	23/03/2023
2023	3.78	13/11/2023

8.6.6.1. Updated Flood Frequency Analysis for Extreme Tidal Flooding

The Oranmore gauge site provides 42 years of annual maximum tide flood level data (1982 to 2023), the Wolfe Tone gauge (30061) in Galway City provides 32 years and the Galway Port gauge (30062) provides 17 years of annual maxima tidal flood data. The record lengths available at these gauges are relatively short when predicting extreme tides of 200 year return period magnitudes and, therefore, caution needs to be exercised in their interpretation and use, particularly with the non-stationarity of the flood series due to climate change. The Galway Port gauge record period is considered too short for accurate estimation of large return period events.

Given the relatively short record lengths available at these gauges the at-site frequency analysis uses a more robust 2-parameter EV1 distribution rather than a larger 3 parameter distribution in estimating the design return period flood levels, refer to Figure 8-1 to Figure 8-3. The three-parameter distributions includes a shape parameter based on skewness which potentially fits better the sample data but introduces significant sample bias and consequently may not perform well for the larger return periods. The 3- parameter distributions have a much higher statistical error associated with then over the 2-parameter distributions as a consequence of this bias.

The Wolfe Tone Bridge gauge (30061) AM record is slightly influenced by River Corrib flows and as such, is considered to represent a combined fluvial and tidal flood level series and therefore to overestimate the return period tidal flood level at the proposed new harbour site.

The River Corrib influence on tidal flood levels at Wolfe Tone gauge site is relatively small due to the large flow depth available at highwater but sufficient to result in potentially a 15cm increase in the true tidal flood level at 200year return period event, particularly upstream of the bridge due to bridge afflux.

The Oranmore gauge is the most dependable of the three gauges based on its longer unbroken record period of 42years. There is a reasonable agreement between Oranmore and Galway Port tidal flood level estimates with Galway Port gauge having a higher statistical error due to the shorter sample period of 17 AM years.

The EV1 analysis suggests that the tide event of the 1st Feb 2014 at Oranmore gauge of 3.603m OD Malin was equivalent to a 27year return period event and that the more recent and historical maximum recorded Storm Eleanor tidal flooding event that occurred on the 2nd of Jan 2018 of 3.735mOD was equivalent to a 57year return period event. The predicted 200year return period tide level is 4.044 with a statistical error of 0.15m and the 1000year is 4.350m OD with a statistical error of 0.191m.

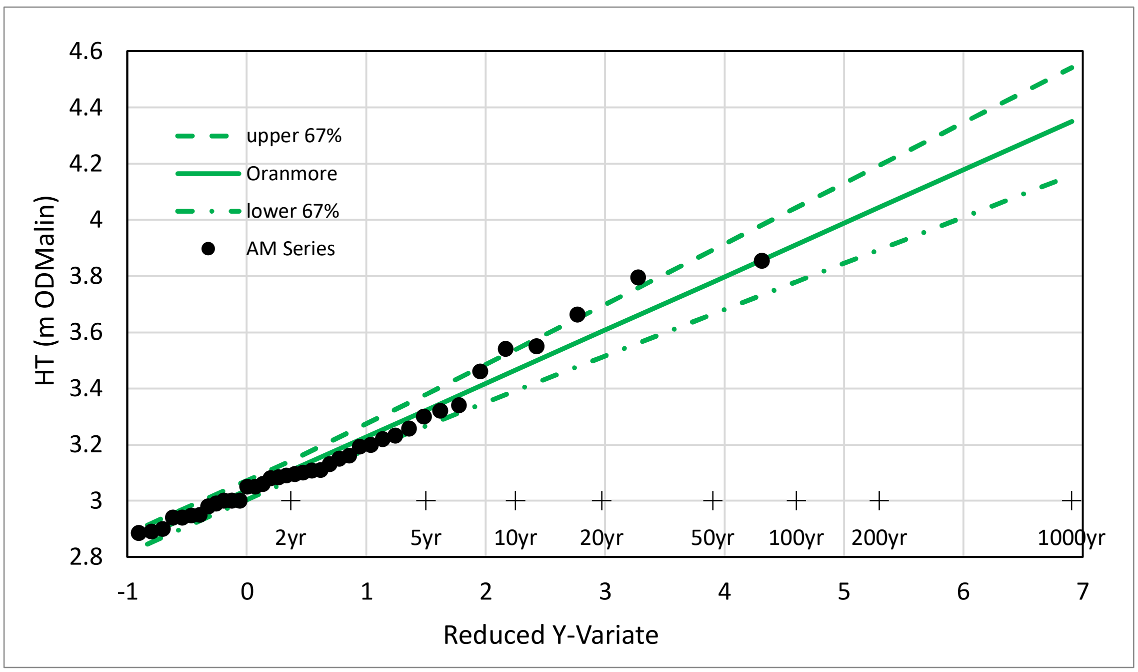

Figure 8-1: Tidal Flooding H – T with 67-percentile upper and lower confidence Intervals based on EV1 analysis of the Oranmore Gauge

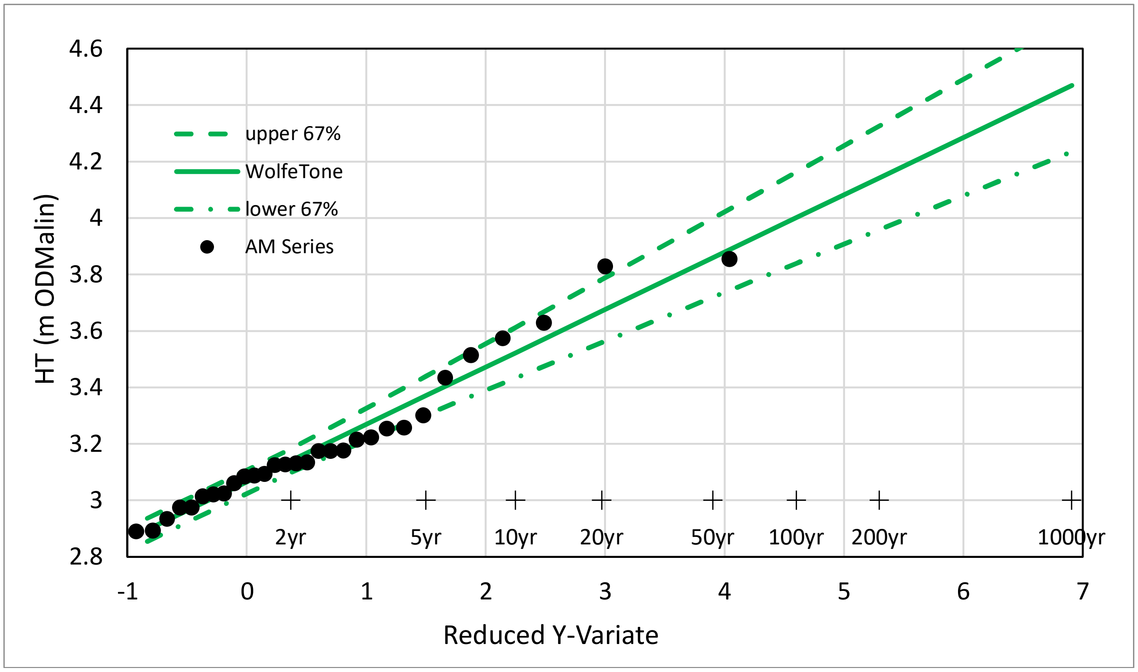

Figure 8-2: Tidal Flooding H – T with 67-percentile upper and lower confidence Intervals based on EV1 analysis of the Wolfe Tone Gauge

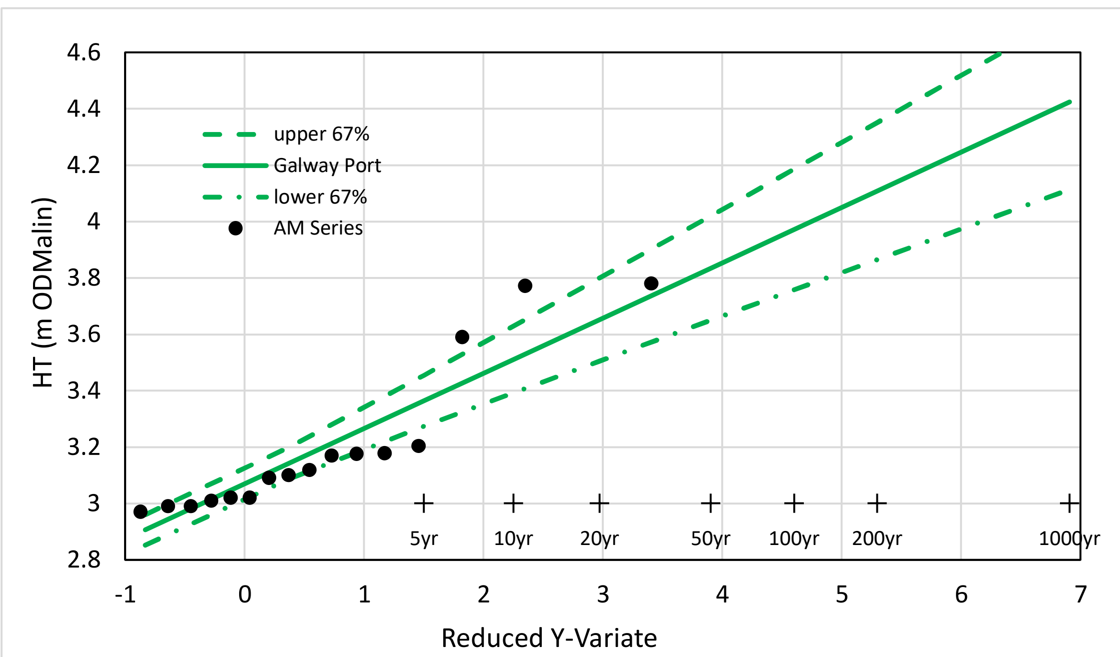

Figure 8-3: Tidal Flooding H – T with 67-percentile upper and lower confidence Intervals based on EV1 analysis of the Galway Docks Gauge

Table 8.7: Return Period Tide level estimates from At Site Frequency Analysis using EV1 distribution.

Return Period	Wolfe Tone Gauge 30061		Galway Port Gauge 30062		Oranmore Gauge 29015	
T years	H_T mOD	S.E.(HT) mOD	H_T mOD	S.E.(HT) mOD	H_T mOD	S.E.(HT) mOD
1	2.896	0.041	2.907	0.054	2.880	0.033
2	3.140	0.042	3.142	0.056	3.108	0.035
5	3.371	0.068	3.364	0.090	3.323	0.056
10	3.523	0.090	3.511	0.118	3.466	0.073
20	3.670	0.111	3.652	0.147	3.602	0.091
50	3.859	0.140	3.835	0.185	3.779	0.114
100	4.001	0.162	3.972	0.214	3.912	0.132
200	4.142	0.184	4.108	0.243	4.044	0.150
1000	4.470	0.235	4.424	0.310	4.350	0.191

H_T is Return Period tidal Flood Level, and S.E. is Statistical Standard Error

8.6.6.2. Estimates from the Irish Coastal Wind and Wave Study 2018

The Irish Coastal Wind and Wave Study ("ICWWS" - 2018) was published in November 2020 (RPS, 2020) and represents an update to the previous Irish Coastal Protection Strategic Study (ICPSS 2012) for which published flood maps are available nationally. This update extends the sample period from 2012 to the end of 2018 for analysis and modelling of coastal storm events and includes improved relationship between mean sea level (MSL) and Malin Head OGSM15 datum. It also includes Wave climate analysis and joint probability analysis.

The predicted return period tidal flood levels from the ICWWS 2018 are presented below in Table 8.8 relative to OSGM15 Malin datum for the relevant nodes W5 and W6. Node W5 represents the Oranmore Bay Area and W6 represents Galway Harbour area (refer to Figure 8-4). These predicted flood levels include a constant allowance over the return periods for local wind wave and seiching effects of 0.15m for the inner Galway Bay area and reducing to 0.05m at Cashla and Greatman's Bay. These allowances are similar to the original Irish Coastal Protection Strategy Study ("ICPSS") (2012) study allowances.

The ICWWS is an update to the 2012 ICPSS study that includes additional storm events for the years 2013 to 2018. This updated period include the large tidal flood events that were recorded in 2014 and 2018. The most significant factor influencing differences between the ICWWS and the ICPSS was not from the additional tidal events included, but from the conversion used to relate mean sea level predicted by the Irish coastal waters hydrodynamic model to Malin Head OGSM15 datum. The difference in the conversions between the ICPSS(2012) and the ICWWS(2018) is 0.25m and 0.18m for Mean Sea Level ("MSL") to Malin Head OGSM15 for Galway Harbour and Cashla Bay areas respectively with the previous ICPSS predictions lower than the current ICWWS predictions at the relevant nodes W5 and W6.

Table 8.8: Computed return period tidal flood levels at relevant nodal points to Oranmore (W5) and Galway Port (W6), ICWWS 2018 study (RPS, 2020).

Return Period T years	W5 HT m OD Malin	W5 S.E. m	W6 HT m OD Malin	W6 S.E. m
2	3.31	0.021	3.29	0.021
5	3.46	0.031	3.44	0.031
10	3.57	0.039	3.55	0.038
20	3.68	0.047	3.66	0.046
50	3.82	0.057	3.80	0.057
100	3.92	0.065	3.90	0.065
200	4.03	0.073	4.01	0.075
1000	4.28	0.092	4.26	0.091

H_T is the Return Period flood level and S.E. is the statistical standard error .

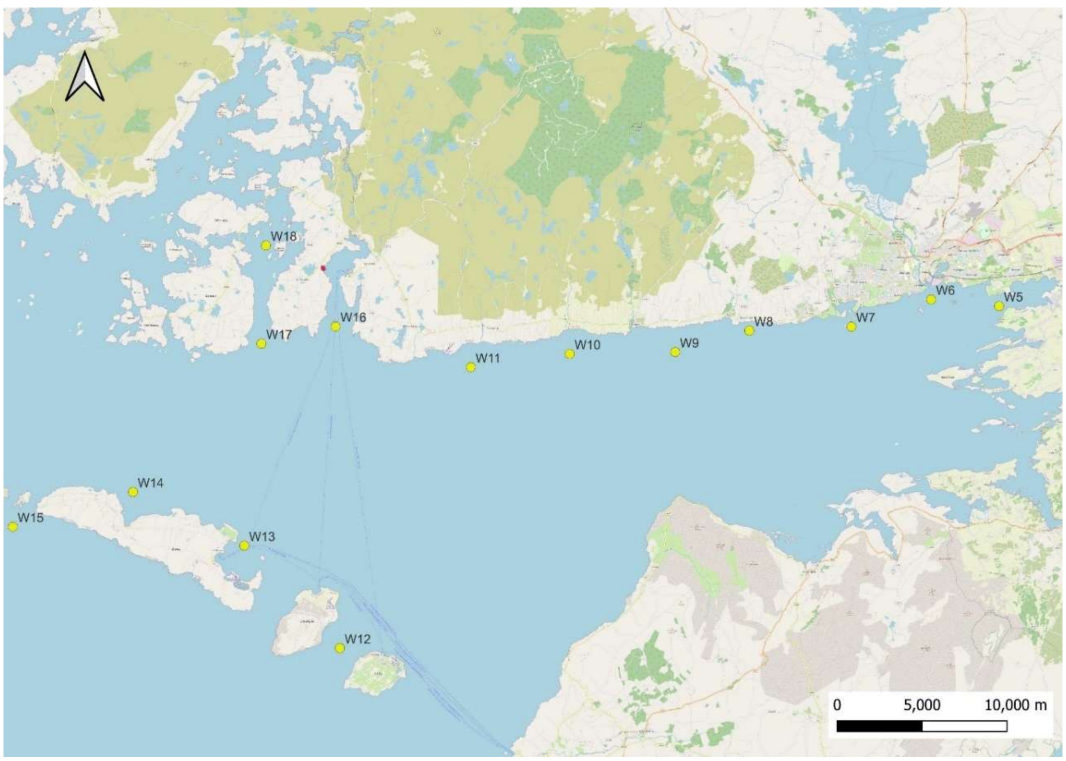

Figure 8-4: Location of the ICWWS Estimation Poits for return period tidal Flood Levels

8.6.6.3. Recommended Design Flood Tide Level

There is good agreement between the ICWWS(2018) tidal flood predictions and the at-site gauged AM series analysis (Oranmore gauge 29015). The slightly higher estimates from the gauged frequency analysis will be used for the purposes of defining the present day 200year and the 1000year tidal flood Level of 4.044m OD Malin and 4.350m OD Malin (OSGM15) at the proposed Harbour site, with associated statistical standard error of 0.150m and 0.191m.

Table 8-9 Comparison between ICWWS2018 and at-Site Coastal Flood Level Estimates

Return Period T years	Inner Galway Bay North Node W6 ICWWS 2018 m OD Malin	Statistical Analysis Oranmore gauge m OD Malin
2	3.29	3.11
5	3.44	3.32
10	3.55	3.47
20	3.66	3.60
50	3.80	3.78
100	3.90	3.91
200	4.01	4.04
1000	4.26	4.35

8.6.7. Wave Climate Analysis

Wind speed and direction is the primary driver in the wave climate analysis. The original wave climate study in the 2014 EIS used historical wind data from the Belmullet Station, and the Linacre (1992) EV1 analysis to generate 50year return period maximum wind speeds for the various wind direction sectors. In the original Study a wind speed magnitude of 30m/s used in the wave analysis for all direction sectors.

8.6.7.1. Extreme Winds

As part of this update the most recent 22-year wind record of hourly wind speeds from the nearest coastal Met station to Galway at The exposed Mace Head was examined and an EV1 frequency distribution fitted to 22 years of annual maximum hourly wind speeds extracted from the hourly record (September 2003 to July 2024). The return period estimates of hourly maximum wind speeds for the various wind direction sectors are presented in Table 8-10.

Table 8-10 Wind Direction Frequency At Mace Head (2003 to 2024)

Wind Direction	Frequency of time
Northeast	3.17%
East	12.34%
Southeast	9.34%
South	13.50%
Southwest	16.73%
West	23.00%
Northwest	12.38%
North	6.96%
Calm (no direction)	2.67%

Table 8-11 Return Period hourly maximum Wind Speed Magnitude for Mace Head Co. Galway

Return Period T years	EV1 Yvariate	East Ws (m/s)	Southeast Ws (m/s)	South Ws (m/s)	Southwest Ws (m/s)	West Ws (m/s)	Northwest Ws (m/s)
2	0.367	15.2	16).9	20.6	22.9	24.1	20.3
5	1.500	16.5	18.4	22.4	25.5	26.6	22.7
10	2.250	17.4	19.5	23.6	27.3	28.2	24.3
20	2.970	18.3	20.4	24.8	28.9	29.7	25.8
50	3.902	19.4	21.7	26.3	31.1	31.8	27.8
100	4.600	20.3	22.7	27.4	32.7	33.3	29.3

This analysis confirms that the use of 30m/s wind speed magnitude to represent the 50year return period Wind Speed in the original EIS is reasonable and valid.

8.6.7.2. Joint Probability Analysis

The recently published ICWW 2018 study by RPS (Nov 2020) included joint probability wave and tide analysis for the Salthill and Galway City area in order to produce the critical combination of wave state and high-water levels for overtopping of coastal defences and shoreline areas. The joint probability produced the following corelation coefficients between tide levels and wave heights for the following directions.

Table 8-12 Derived Correlation between Offshore Wave Heights and tidal water levels on the West Coast (RPS, 2020)

Direction	Correlation Coefficient
Southeast	<0.1
South	0.25
Southwest	0.45
West	0.60
Northwest	0.33

The marginal return periods of extreme water level and wave height that combine to produce the 200year joint probability return period for Galway for the most correlated West Sector are below in Table 8-13. The other wave directions are less correlated and require lower marginal return periods with east and southeast local wind wave directions showing almost no correlation with extreme water levels and acting independent.

Table 8-13 Margin Return Periods of Extreme Water Level and Significant Wave height from the West Sector to produce the 200year Joint Exceedance Return Period

Marginal Return Period of extreme Sea Level (years)	Marginal Return Period of Significant Wave height from West (years)
0.2	200.0
0.5	161.7
1	80.8
2	40.4
5	16.2
10	8.1
20	4.0
50	1.6
100	0.8
200	0.4

In the 2014 EIS study a conservative precautionary approach was chosen, where a 50year magnitude wave climate was combined with the 200year extreme water level to assess flooding and hydrodynamic impact on the local wave climate. In reality, based on the ICWWS findings, a combined 200year event is potentially the 200year extreme water level with a 0.4year wave climate or 50year wave climate with a 1.62year extreme water level. Such events are significantly less than what was analysed in the original EIS 2014.

The wave climate modelling and findings presented in the 2014 EIS remain valid in respect to flood risk and flood impact as they represent conservative estimates of the combined probability and the precautionary approach to assessing potential wave climate impacts.

8.6.8. Climate Change Allowances and adaptation

There is a high degree of uncertainty in relation to the potential effects of climate change and particularly in respect to fluvial flooding, and therefore a precautionary approach is required. Examples of precautionary approach for future planning of urbanised areas include:

- Recognising that significant changes in the flood levels and flood extent may result from an increase in rainfall and accordingly adopting a cautious approach to zoning lands in these potential transitional areas.
- Ensuring that the finish levels of structures are sufficient to cope with the effects of climate change over the lifetime of the development.
- Ensuring that structures to protect against flooding (e.g., defence walls / embankments) are capable of adaptation to the effects of climate change when there is more certainty about the effects (e.g., foundations of flood defence designed to allow future raising of flood wall to combat climate change).

8.6.8.1. Climate Change Allowance for Fluvial and Pluvial Flooding

There is a high degree of uncertainty in relation to the potential effects of climate change on fluvial flooding, and therefore a precautionary approach is required. Examples of precautionary approach for future planning of urbanised areas include:

- Recognising that significant changes in the flood levels and flood extent may result from an increase in rainfall and accordingly adopting a cautious approach to zoning lands in these potential transitional areas.
- Ensuring that the finish levels of structures are sufficient to cope with the effects of climate change over the lifetime of the development.
- Ensuring that structures to protect against flooding (e.g., defence walls / embankments) are capable of adaptation to the effects of climate change when there is more certainty about the effects (e.g., foundations of flood defence designed to allow future raising of flood wall to combat climate change).

The Intergovernmental Panel on Climate Change ("IPCC") Global climate models (Echam 5 (EC5), Hadley Centre High Sensitivity (HAH) and Hadley Centre Low Sensitivity (HAL) and their downscaled simulations for Ireland show significant projected decreases in mean annual, spring and summer precipitation amounts by mid-century. The projected decreases are largest for summer, with reductions ranging from 0% to 13% and from 3% to 20% for the medium-to-low and high emission scenarios, respectively. The frequencies of heavy precipitation events show notable increases of approximately 20% during the winter and autumn months.

The IPCC Global climate models (Echam 5 (EC5), Hadley Centre High Sensitivity (HAH) and Hadley Centre Low Sensitivity (HAL) and their downscaled simulations for Ireland show significant projected decreases in mean annual, spring and summer precipitation amounts by mid-century. The projected decreases are largest for summer, with reductions ranging from 0% to 13% and from 3% to 20% for the medium-to-low and high emission scenarios, respectively.

The frequencies of heavy precipitation events show notable increases of approximately 20% during the winter and autumn months. In light of much uncertainty in respect to climate change effects on catchment hydrology it is considered prudent to retain the present OPW recommendations for flood relief schemes of a potential 20% increase in flood flows at the mid range future scenario (MRFS) and 30% increase in flood flows at the high emission future scenario (HEFS).

8.6.8.2. Climate Change Allowance for Coastal Flooding

Scientists predict that global sea level rise will have two main causes. Firstly, as the oceans heat up the ocean water will expand. At present this thermal expansion accounts for about half of the observed increase in sea level. However, as ocean temperatures increase the thermal expansion contribution will have the greatest contribution on sea level rise. The second cause is the melting of land ice from glaciers and ice caps. The rate of melt and the volumes of water locked within these sources are uncertain and this is a cause for concern.

In recent decades, ice shelves have broken off huge ice sheets in Antarctica and Greenland. The ways in which they are melting is only now beginning to be understood fully enough to allow estimates of how fast this melt is occurring and how much this will affect sea levels. If they melt as fast as is now thought to be possible, sea levels could rise dramatically over the next century, flooding many of the world's major cities and much of the world's most productive farmland. Consequently, guidance on sea level rise allowances for flood risk management is continually changing as more scientific research is published with allowances likely to increase as opposed to decrease in future years.

The biggest threat to coastal flood risk areas is from sea level rise. Global mean sea levels are predicted to increase from a combination of thermal expansion of the water column and melt from the glaciers and reduction of liquid water storage on land. The Intergovernmental Panel on Climate Change Third Assessment Report (IPCC TAR) that preceded the published IPCC Fourth and fifth Assessment Reports (2007, 2014) has been used as the basis of future sea level projections for Ireland. A best estimate increase of 480 mm to year 2100 has been suggested by Sweeney et al (2003) and used in the Greater Dublin Strategic Drainage Study (GDSDS 2005). This value was not directly challenged in the 2007 IPCC report, with a range of 0.2 - 0.51 m given for the prudent Medium-High A2 emission scenario.

The IPCC fifth Assessment Report (2014) has investigated the current and future trends in global mean sea level rise ("GMSLR") and have concluded with a high level of confidence under various emission scenarios considered (four modelled RCPS (Representative Concentration Pathways) that thermal expansion of the sea due to warming will increase Global mean sea level by between 0.15 to 0.3m by 2100. This report predicts at medium confidence the contribution of glacier mass loss to GMSLR for the four RCP scenarios. The global glacier volume is projected to decrease by 15% to 55% for RCP2.6, and by 35% to 85% for RCP8.5 and in between these rates for the other two RCP scenarios. RCP2.6 is representative for scenarios leading to very low greenhouse gas concentration level, it is a so called "peak" scenario with radiative forcing reaching a peak level of 3.1 W/m^2 mid-century and returning back to 2.6W/m^2 by 2100. RCP8.5 is characterised by increasing greenhouse gas emissions overtime leading to high greenhouse gas concentrations by 2100.

Estimates show that globally, average sea level has risen approximately 160 mm since 1902, at a rate of approximately 1.4 mm per year. Satellite observations indicate that the sea level around Ireland has risen by approximately 2-3 mm/year since the early 1990s.

The IPCC sixth Assessment Report ("AR6") Working Group II systematically assessed possible changes of global surface air temperature, precipitation, large-scale circulation and modes of variability, and changes in ocean and cryosphere, and further reasonably estimated the climate change beyond 2100. The assessments show that global mean surface air temperature would reach 1.5℃ or even beyond it. Mean-state and variability of precipitation would increase as well but would vary with season and region.

Projections of GMSLR by 2100 under the high RCP8.5 scenario are 0.53 to 0.98m with rises of 8 – 16mm per annum during 2081 to 2100 and under the low RCP2.6 scenario are a rise is 0.28 to 0.61mm per annum.

The IPCC concluded that it is very likely that sea level will rise in more than about 95% of the ocean area. About 70% of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change. GMSLR during 1901–2010 can be accounted for by ocean thermal expansion, ice loss by glaciers and ice sheets, and change in liquid water storage on land. It is very likely that the 21st-century mean rate of GMSLR under all RCPs will exceed that of 1971–2010, due to the same processes. It is virtually certain that global mean sea level rise will continue for many centuries beyond 2100, with the amount of rise dependent on future emissions.

The most recent UK Climate Change Projections (UKCP18) is at the 95%-percentile upper confidence interval that under the mid-range emission scenario (RCP4.5) a sea level rise of 0.64m is projected for Belfast and 0.83m for London by 2100. At the high-end emission scenario (RCP8.5) the sea level rise projection at the upper 95-percentile confidence interval is 0.94m and 1.15m for Belfast and London respectively.

8.6.8.3. Sea level rise adaptation for Ireland

The longest continuous tidal record for Ireland is available from the Dublin Port gauge which commenced gauging in 1923 with fully digitised records from 1938 onwards. From this record since the 1980s there has been significant variability in the monthly mean sea level record, with an upward trend evident over the last 25 years. The attribution of this recent increase is not certain but is suggestive of accelerated sea level rise from global warming. However, taken over the full time period, the sea level in Dublin has risen by 1.67 mm per year, consistent with global rates.

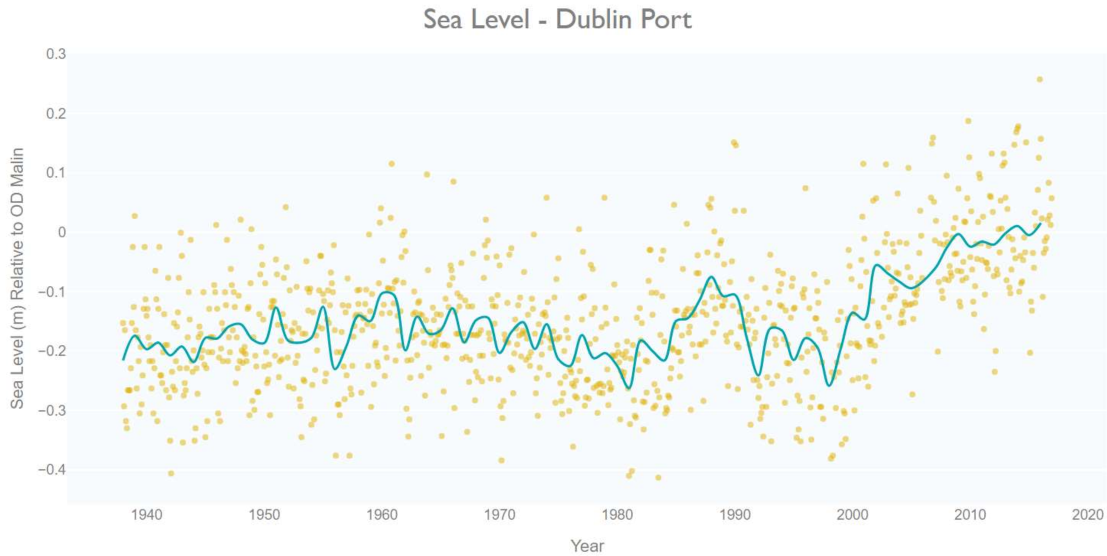

Figure 8-5 Monthly mean sea level Rise for the Dublin Port Gauge from 1938 to 2016 (copied from Climate Status Report Ireland (CSRI, 2020).

The Dublin port record based on the trend line suggests a potential increase in monthly mean sea level of 7mm per annum for the period 1984 to 2016.

The Office of Public Works (OPW) Flood Risk Management (FRM) climate change sectoral adaptation plan (OPW, September 2019) has recommended that a mid-range future scenario of a 500mm rise in sea levels is considered and a 1000mm increase in sea levels is considered for the high-end future scenario. These allowances would seem appropriate and consistent with the medium and higher end estimates from the regional climate change predictions when both sea level rise and an increase in storm surge are considered. This guidance from the OPW is being reviewed at present in light of more recent global trends and research findings and evidence of accelerated global warming of land and sea temperature.

8.6.8.4. Sea State changes

The global model suggest that a warming sea will increase the frequency and severity of Atlantic storms resulting in increased wave heights and wave lengths. The 2020 climate status report Ireland observed increasing wave heights over the last 70 years in the North Atlantic with typical winter season trends of increases up to 20 cm per decade, along with a northward displacement of storm tracks. Seasonal variations in wave heights have been observed at Marine Institute wave buoys deployed off the coast of Ireland, however no comprehensive analysis of wave parameters has been carried out on these data sets.

There is a high degree of uncertainty as to how much the wave climate will be altered but with increased energy and storm conditions it is accepted that wave climate will become more aggressive particularly extreme events and the frequency of storm wave events.

The current OPW flood Risk management guidance for flood risk management is for a MRFS of 0.5m sea level rise and 20% rainfall and fluvial flooding and with no specific guidance on wave climate allowances. The UK Environmental Agency recommend 5% allowance for extreme wave height allowances for the period 2000 to 2055 and 10% for the period 2055 to 2100.

8.6.9. Flood Risk Assessment

In the original 2014 EIS the flood risk conclusion was that the critical flood level for the harbour and surrounding areas is produced by a tidal storm surge event of 4.146 m O.D. Malin (200year tide with statistical error) plus a climate change allowance (sea level rise) of 0.5m giving a flood design level of 4.646 m.

The updated assessment of flood risk confirms that the critical flood level is the 200year tidal storm surge plus statistical error of 4.194m OD plus mid range climate change allowance (sea level rise) of 0.5m giving a flood design level of 4.694 m OD Malin (OGSM15). This design flood level is only 0.048m higher than the original design flood Level in the 2014 EIS. This increase from the updated analysis is insignificant and is well within the freeboard allowance provided for the Harbour Development which has the operational quay level set at 4.70m OD. The minimum finish floor level for all buildings on the development site is to be 5.5 m O.D., which is well above the design flood level providing a freeboard of 806 mm and thus not considered at risk of flooding.

The findings of the Flood Risk Zoning in the original EIS remain valid and are summarised here:

- The proposed development site is located within the High Flood Risk Zone (*i.e.* Zone A of the Planning Guidelines). Flood Zone A is the high flood risk zone and represents lands that are below the 100year fluvial Flood level or the 200-year tidal or combined (tidal and fluvial) flood level. From the Flood risk assessment the critical condition for the harbour is the 200-year tidal storm surge event. The proposed development being a Commercial Harbour and Marina with associated dockside activities is classified as a water compatible development and recognised as appropriate development for Flood Zone A in the Flood Risk Management Planning Guidelines (Nov 2009) and therefore under these guidelines is justifiable from a flood risk management perspective provided suitable flood risk mitigation is provided.

- The proposed port development has been shown not to impact on flood risk for the adjoining areas. It has no perceptible impact on peak combined tide levels within the Claddagh Basin, Spanish Arch, Long Walk and Galway Docks area upstream of Nimmo's Pier.

- The development does not adversely impact on wave climate in respect to flooding and flood risk with the harbour development generally sheltering the shoreline areas at

South Park, the existing docks and the Renmore shoreline area against local and offshore generated waves.

8.6.10. Climate Change adaptation

The inclusion of climate change allowances and to precautionary approach taken to hydrological uncertainty in respect to the flood impact and risk assessment in the design of the breakwaters, setting of finish levels and the development layout provides for a sustainable development well into the future. This inclusion of appropriate climate change allowances upfront avoids significant climate change adaptation measures being required in the future to protect against flood risk. This development satisfies the Irish National Flood Risk Management Planning Guidelines (2009) in respect to selection of design flood events and the precautionary principle in respect to climate change and hydrological uncertainty.

8.7. Cumulative Impacts

8.7.1. Residential, commercial and institutional developments

A review of all proposed future projects currently approved, in construction or in planning was carried out within the Inner Galway Bay environs and any potential future projects within the catchment that could give rise to significant in combination impacts with the Harbour Extension Development in respect to having a potential to cause significant hydrological regime change and water quality and morphological impacts.

A review of the projects either approved and not commenced, under construction or in planning identified a substantial number of large residential developments, Student accommodation developments, and a number of Hotel developments with extensions or new constructions. None of these development will impact on the hydrological and coastal processes regime of the Corrib estuary or the transitional and coastal waters of Inner Galway Bay including the existing Galway Harbour area and the priority lagoonal habitats of Lough Atalia and Renmore Lough.

The cumulative increase in housing and development in the Galway City and Environ's of Oranmore and Bearna is serviced by the Irish Water sewer network and treated in the Mutton Island WWTP and marine outfall. The proposed waste generated by the New Harbour extension development will discharge to the foul network and treated at Mutton Island and discharged into Galway Bay c. 300m south of Mutton Island similar to all proposed developments. Storm water from the harbour development will be directly discharged to the sea via its own storm pipe network and storm outfalls and therefore combined impact with other developments on the capacity of the public storm water network will not arise and the development will not discharge into the combined sewer to mutton island. The majority of development of Greenfield sites are required through planning to implement SUDs approach to managing their storm water so as to limit the flood runoff and potential for pollution.

Future developments may give rise to capacity issues for the WWTP and thus the water quality in the receiving marine waters and adjacent bathing areas. The mutton Island WWTP and outfall is managed by Irish Water and is subject to a discharge licence from the EPA where it is required to meet the Water Framework Directive (WFD) objectives of good status coastal and transitional waterbody and satisfy shellfish standards at the designated shellfish areas in the inner the Bay area, Bathing water standards at the nearby bathing areas and meet the surface water regulation standards. To meet the growing population of Galway City and environs into the future long-term planning of a new WWTP and outfall is in the pipeline and capacity issues if arising in the future will be required to be resolved through increased capacity and standard of treatment.

A review of the MARA foreshore licence applications and also the EPA IPC and Discharge Licences was conducted and the assessment found that there would be no potential cumulative impacts with any of these projects.

8.7.2. Specific Projects

8.7.2.1. Crown Square Mixed Development.

This project is located on the former Crown equipment factory site and is currently under construction for a Hotel and Neighbourhood Centre with 288 apartments (ref GCC 18/363. Also on the site is proposed 345 build to rent apartments (ABP 310348). This development is within the Lough Atalia topographical catchment, located c. 900m upgradient. The Foul sewage discharges to the Public foul sewers on the Monivea Road and the Storm Water is attenuated and discharged to the Public Storm water sewers located on the Monivea and Tuam Roads. On-site attenuation is provided in the form of large concrete tanks and the storm outflow to the public sewer is controlled by hydro-breaks limiting flow to an agreed greenfield runoff rate. The storm water is passed through an interceptor before discharging to the public sewer. The new harbour development in combination with the Crown Square development will not have any cumulative impact on hydrology, water quality or Coastal processes.

8.7.2.2. Redevelopment of lands at Ceannt Train Station for Mixed Development.

This project is located on the Corás Iompair Éireann lands (3.3ha) and 0.16ha in the ownership of Galway City Council at the rear of Ceannt Train Station. This site is close to Lough Atalia and the Galway Docks. The proposed development which has been granted planning permission by An Bord Pleanála in 2023 involves demolition, adaptive reuse and new build to provide for mixed-use scheme. The proposed development comprises a mixed-use regeneration development arranged over 10 blocks including 6 residential towers above four of the blocks (376 apartments) and multi storey carpark in block 4). The proposed development will discharge to the public storm sewer on the junction of Queen St. and Bóthar na Long. The foul will discharge to the public foul sewer on Bóthar na Long. The storm water is designed to meet the SUDs requirements in respect to runoff rates. Part of the site is identified to be in

Flood Zone B associated with tidal flooding. The flood mitigation measures proposed are designed to ensure that the finish floor levels on these lands are sufficiently raised above the future 200year flood level. The flood assessment submitted identified that no adverse impact on flooding elsewhere would occur as a result of the development.

The New Harbour Development does not impact flood levels for this site and therefore there will be no cumulative impact on flooding between the developments. The implementation of SUDs limits surface runoff contributions to the public storm flow from the Ceannt Development and the harbour development discharges storm water to sea and therefore no cumulative impact will occur between the developments. Both development discharge to the public Foul network which is combined and treated at Mutton Island WWTP that is subject to a discharge licence by the EPA to protect water quality in the receiving coastal and transitional waters of Inner Galway Bay.

8.7.2.3. Galway Inner Harbour Regeneration Project

The 'Inner Harbour Regeneration Project' relates to the potential development of 17 acres of land situated at the Inner Harbour Lands surrounding the existing gated Galway Docks and to the East towards Lough Atalia Bridge and Lough Atalia Channel. A vision document has been prepared in relation to this project and was released to the public in May 2021. The vision is underpinned by a planning framework. The Inner Harbour Regeneration Site is referenced in Section 10.6 of the Galway City Development Plan 2023 - 2029 and a Masterplan is pending for the entire site. The Land Development Agency ("LDA") and Galway Harbour Company are also working on a more detailed Masterplan for an initial phase of the overall site.

Such development is likely to contribute to increased sewage load on the foul sewer network and potentially on the Storm Water Network. Some of these lands are located in Flood Zones A and B and will require flood mitigation. The proposed new harbour development has through the coastal processes and flood modelling been shown not to adversely impact the existing inner harbour area including the gated Galway Docks in respect to flood risk and morphology. It is unlikely that any significant cumulative impact will occur between both projects.

8.7.2.4. Galway Flood Relief Scheme – Coirib Go Cósta

This project is still at feasibility and design stage and a proposed scheme has not been fully developed. It is understood that the likely solution to coastal flooding will be shoreline defences in the form of walls, rock armouring, embankments and possibly demountable defences. The proposed New Harbour will not obstruct any potential defence locations, nor will it compromise the potential flood risk or required defence heights in such areas which included the Galway Docks, Claddagh Basin, Southpark, and Salthill promenade. The New Harbour development meets the flood risk management standards and will not represent a development requiring protection from the Flood relief scheme.

8.7.2.5. Gort Lowlands Flood relief scheme

This scheme is at feasibility and design stage and potentially will involve turlough overflows that eventually will discharge into Kinvarra Bay near Dunguaire Castle. Such a scheme will through the conveyance of floodwaters into inner Kinvarra Bay will potentially increase surges of freshwater into the Bay giving rise to potential changes in the salinity. The Harbour development on the north shoreline of inner Galway Bay is sufficiently remote as not to influence or be influenced by the hydrodynamics in Kinvarra Bay.

8.7.2.6. The Galway City Ring Road Project

The Galway City Ring Road Project extends from Doughiska on the M6 near the Coolagh Roundabout on the east side of Galway City to R336 west of Bearna. The project will involve a full span Bridge crossing of the Corrib near Dangan and culvert crossings of a number of smaller tributaries including the Knocknacarra and Bearna Streams and the Trusky Stream. This project is over 4km upstream of the Galway Harbour and the only potential hydrological impacts on the Harbour potential combined impacts will be associated with water quality during construction and operational road drainage discharges. Due to the sensitivity of the River Corrib Receptor as an SAC, the downstream Galway Bay SAC and the Galway City Terryland water supply abstraction, stringent controls are proposed in relation to control and treatment of construction site runoff and water quality treatment and attenuation of the road runoff passing it through hydrocarbon interceptor and a retention pond / wetland for settlement and filtering prior to either on-site infiltration, generally on the east side of the Corrib or outfalling to watercourses and the public storm sewer on the western side of the Corrib. Taking into account the mixing and hydrodynamics of the marine waters at the harbour site and the inner Galway Bay area no significant cumulative hydrological impact will occur either during construction or operation of these projects.

8.7.2.7. Galway Racecourse Development

As part of the N6 Ring Road Project temporary stables to be located within the inside track area at Ballybrit and permanent stables to be constructed on the northside of the Track adjacent to the existing stables along with new parade ring and new borehole source of water. In terms of hydrology the temporary stables will attenuate and dispose of storm drainage on-site and will connect to the public foul sewer and the permanent replacement stables will, similar to the existing situation will connect to the public foul and storm sewers. After the N6 ring road is constructed, the temporary stables will be decommissioned and the area will be retained as a racecourse carpark with the storm management facilities in terms of Attenuation and wetland pond and hydrocarbon interceptors. There is no direct surface water connection between the racecourse and the marine waters at the proposed Harbour site except via the public sewers with the foul and combined sewer being treated at the Mutton Island WWTP. Drainage waters at the racecourse drain through the limestone tills to the underlying regionally important karst aquifer which drains eventually to the coastal and transitional waters of Inner Galway Bay. Any constructional impacts will be contained on site and both operationally and during construction there will be no potential for any combined impact on the downstream Marine Waters of inner Galway Bay.

8.7.2.8. The Mweeloon and Twain Habitat protection and restoration Projects

This project which is a habitat compensatory project for the Galway Harbour Project in respect to restoration of stony bank and intertidal habitats lost as a result of the proposed new Harbour encroachment into Galway Bay is designed to naturally enhance and retain these habitats at the proposed sites through the purchase of the lands and the implementation of Habitat Management Plans in respect to managing grazing to curtail overgrazing / poaching, ceasing use of fertilizers and herbicides, controlling anthelmintic use, limiting tractor access, ceasing all construction / reclamation works, control of litter and the ceasing of some aquaculture and the control of a marine invasive species known as *Didemnum vexillum*. There will be no changes to the natural coastal processes on these lands and within the coastal waters and consequently there will be no cumulative hydrological impacts with the Harbour Development on the inner Galway Bay coastal and transitional Waters.

8.7.2.9. East Galway Bay WWTP and new marine outfall

A proposed East Galway Wastewater treatment plant and outfall to inner Galway Bay was assessed in the original EIS and the assessment concluded that the proposed Harbour development would not impact on the mixing characteristics of the potential new outfall in inner Galway Bay. This new sewage outfall project is not in the current planned Irish Water projects and would appear to be a more long-term strategic project for when Mutton Island treatment plant and outfall have reached their capacity.

8.7.2.10. Sceirde Rocks Offshore Wind Farm Project

Currently a Mara foreshore licence for a large area of Galway Bay for site investigation in respect to an export cable corridor for a proposed Offshore Wind Farm Development. The nearest corridor to the harbour development makes landfall at Tawin Island, Maree Oranmore. The impact of the Harbour Development on the marine environmental in respect to coastal processes and water quality has been shown to be very localised to marine waters in the vicinity of the development, and consequently, will not combine with either the offshore wind farm or the proposed pipeline export corridor to result in any significant cumulative impact on Galway Bay.

8.7.2.11. Rossaveal Harbour and Marina Developments

The Rossaveal Harbour and marina development which is under construction is located in Cashla Bay and sufficiently remote from inner Galway Bay as not to result in any potential for cumulative impact either on coastal processes or water quality with the Galway Harbour Development.

8.7.3. Cumulative Impact Conclusion

In conclusion there are no projects either planned and approved, in construction or in planning that would in-combination with other projects and the new Galway Harbour development give rise to any significant hydrological impact on the water environment, including hydrodynamics and wave climate, flood risk and flood impact and sediment transport, salinity and water quality.

The most significant development identified that could have any potential for significant in-combination effects is the Galway Flood Relief scheme, but such a scheme has not been advanced sufficiently to model the likely combined impacts. The hydrological assessment has shown that the proposed harbour development does not impact the existing coastal and fluvial flood risk at the Galway City or elsewhere and therefore any future impact that might occur would be associated with the Flood Relief scheme itself.

8.8. Conclusions

The conclusions previously described in the original January 2014 EIS and the Addendum and Errata Chapters to the EIS published in October 2014 and summarised above in Sub-Section 8.5 remain valid and appropriate to inform the Impact Assessment.

Following an updated desk study assessment on water quality within the proposed development area and the surrounding Inner Galway Bay, it is confirmed that the conclusions in relation to water quality remain valid as no significant changes to the baseline have occurred since the original EIS and associated documentation was submitted.

The conclusions previously described in the EIS remain valid and appropriate to inform the Impact Assessment on the same. Water quality in the Galway Harbour Area is of "Good to Excellent" bathing quality, with the Galway City WWTP operating within its limits and meeting its Water Framework Directive status. Previously identified mitigation measures should remain in place to ensure this water quality status is maintained.

The various hydrodynamic, transport dispersion, sediment transport and wave climate models, model simulation analyses and findings and conclusions reached in the EIS remain valid. The update assessments examined changes to bathymetry, River Corrib flows, fluvial flood extremes, meteorological conditions, tidal conditions including astronomical and extreme and extreme wave climate conditions using the most up to date gauged records available and where applicable. The changes in the model parameters, bathymetry and boundary conditions (Corrib inflow and open sea tidal and the surface wind shear conditions) were found not to be significantly different to those considered in the 2014 EIS. It is concluded with confidence that the original results, the findings and conclusions as contained in the EIS and in the Addenda/Errata to Chapter 8 of the EIS (October 2014) remain valid.

The ICWWS 2018 joint probability analysis of extreme tidal levels and significant wave heights show that approach used in the EIS of a 200year extreme tidal storm surge event with a 1 in 50year wave climate is conservative and will safely over predict potential over topping conditions for the proposed new harbour in respect to the Quays, marina and Breakwater protection. It is considered that this is appropriate given the uncertainty around the potential effects of climate change on wave climate (potential 10% increase in extreme wave heights). The findings from the ICWWS joint probability analysis for the most critical offshore wave direction (highest correlation coefficient of 0.6 for westerly storm event) for a 200year combined design event is either a 200year extreme tide level with a 0.4year significant wave height or 1.6year extreme tide level with a 50year significant wave height.

The results from the wave climate modelling and the conclusions reached in the EIS remain valid in regard to predicted wave heights and the overall sheltering effects of the New Harbour on the eastern and western sides, slight increase in wave height at Nimmo's Pier and no impact on wave agitation within the Claddagh basin area, Southpark, Long Walk and the Docks area.

The findings for the impact of the development on the treated effluent dispersion from the Mutton Island sewage outfall and the proposed future sewage outfall in the EIS remain valid and the conclusion is that the proposed harbour development will not impact negatively on the water quality status, bathing water quality status and shellfish waters within and outside of Inner Galway Bay.

The conclusion in regard to salinity impacts in the EIS remain valid in regard to decreases on the western side of the development and increases on the eastern side due to the deflection of the Corrib freshwater plume further west. The impact of reduced salinity within Lough Atalia and Renmore Lough presented in the EIS remain valid both in terms of magnitude and effect.

Similarly for construction and operation phases in respect to sediment transport, deposition and suspended solids, the EIS findings and modelling results remains valid and does not represent a significant impact on seabed and on the water column.

The conclusion from the updated Flood Risk Assessment is that the proposed harbour development is appropriate development for Flood Zone A being a harbour extension and that it will not increase flood risk to adjacent lands and developments from sea levels, wave climate and river flows. The inclusion of climate change allowances and the precautionary approach taken to hydrological uncertainty in respect to the flood impact and risk assessment in the design of the breakwaters, setting of finish levels and the development layout provides for a sustainable harbour development for Galway City well into the future. The proposed harbour development meets in full the requirements of the Flood Risk Management Planning guidelines (2009).

There are no cumulative impacts on the water environment of significance that would arise between the proposed Harbour Extension Development in combination with other proposed development projects either approved, in construction or in planning.

8.9. References

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