

Report No. HEL098002 v1.1

**Dispersion Modelling of potential impact to
Salinity Levels in Renmore Lough
Galway Harbour Extension Project**

**Prepared for
Galway Harbour Authority**

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Dispersion Modelling of potential impact to Salinity Levels in Renmore Lough Galway Harbour Extension Project

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Prepared by:	Anthony Cawley BE, MEngSc, CEng MIEI
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1 Introduction

This assessment considers the potential impact of the Harbour Extension on Salinities within Renmore Lough. Salinity is primarily supplied to Renmore Lough from Lough Atalia. A localised TELEMAC hydrodynamic model was developed to model the hydrodynamics of Renmore Lough and the salinity dispersion.

2 Description

Renmore Lough is a small tidal Lough located to the south of the Railway line and measures 0.88 ha in area with retaining banks at 2.3 to 2.6m. The inflow to Renmore Lough is via a narrow long channel running northeast under the Railway track to Lough Atalia. The ground level to the south separating Galway Bay from Renmore Lough is typically at 3m OD. The Lough is founded on metamorphic rock of igneous origin and drains down to the invert crest level of its inflow/outflow channel with Lough Atalia (1.77m O.D). The Lough is permanently wet but is shallow with water depths varying from 0.3 to 0.8m at low water (low water is typically 1.77m O.D.). A small local freshwater contribution enters the Lough from runoff from the Railway embankment, from Mellows Drive and the Playing Pitches and Par 3 to the east and also direct rainfall from immediate surroundings lands to the west and the lough surface itself.

The Saline inflow only occurs for a relatively short period of time when tide levels in Lough Atalia exceed c. 1.75m O.D. and consequently only occurs on spring tides with the inflow period generally less than 2hours. Salinity measurements within the Lough generally reflect a wide range of salinities depending on spring tide salinities in Lough Atalia which in turn are influenced by the magnitude of the Freshwater flow in the River Corrib. The average salinity in Renmore Lough will be slightly higher than Lough Atalia as the salt contribution only occurs during spring tides which generally have a higher salt content than neap tides in Lough Atalia. The salinity range in Lough Atalia is from c. 30 to nil ppt, whereas in Renmore Lough due to the tidal restriction this salinity range is less from c 23 to 2ppt.



Photo 1 Railway Culvert downstream Face in Lough Atalia at Low-Water



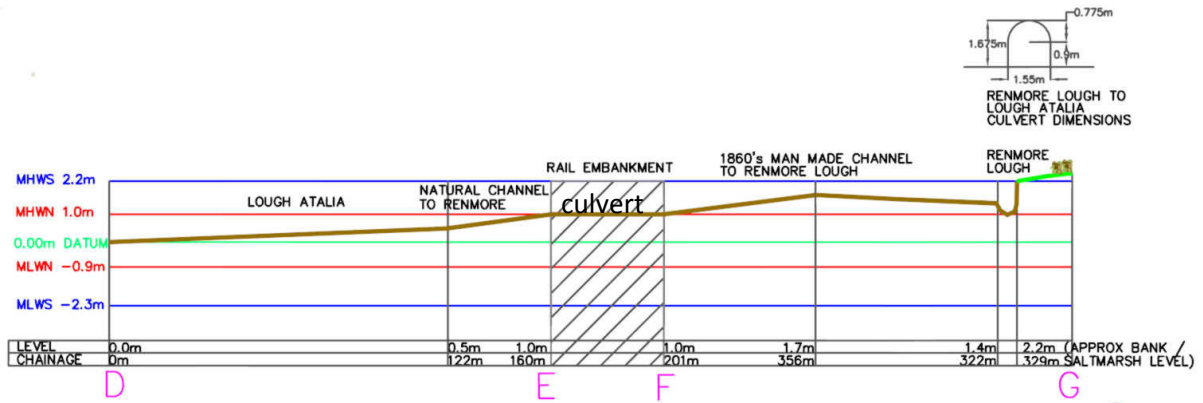
Photo 2 Railway Culvert downstream Face in Lough Atalia at Highwater



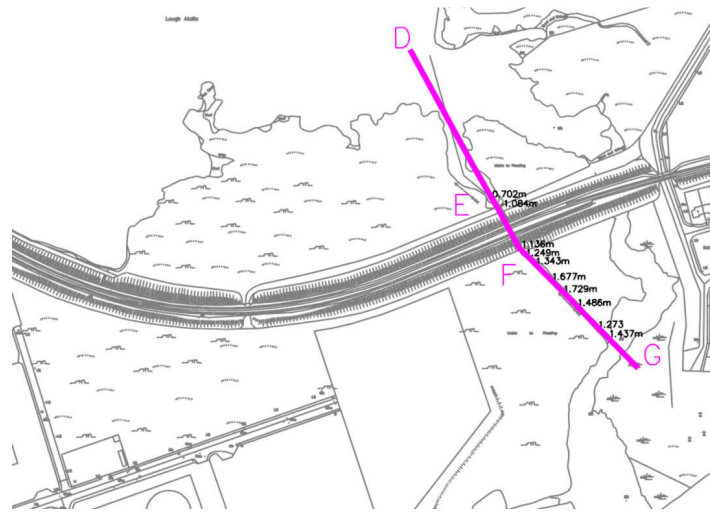
Photo 3 View of Renmore Lough and tidal channel near highwater



Photo 4 View of Renmore Lough tidal channel at Low Water



Bed Profile of Tidal Channel and culvert dimensions



Channel bed crest level c. 1.73m O.D.

Figure 1 Renmore Lough Inflow Channel characteristics



Figure 2 Aerial Map of Renmore Lagoon with contours

A topographical survey of the Lough and its tidal channel and railway culvert connecting it to Lough Atalia was carried out by Tobin Consulting engineers. This survey revealed that the Lough is reasonably constrained within its banks at 0.88ha in area and that the tidal channel has a masonry arch culvert 41m long and 1.55m wide by 1.67m high.

3 Hydrodynamic Modelling

A local model of high grid refinement was developed to model the hydrodynamics of Renmore Lough. Given that the culvert Arch ope was only 1.55m wide and the channel typically 2 to 2.5m wide, very narrow finite element grid was required to model the channel, refer to Figures 4 and 5. This local model was driven by tide levels and salinity in Lough Atalia at its tidal boundary, refer to Figure 5. The tidal and salinity boundary information was obtained from the Large Scale model of Lough Atalia and the Proposed Harbour Area, refer to Figure 3.

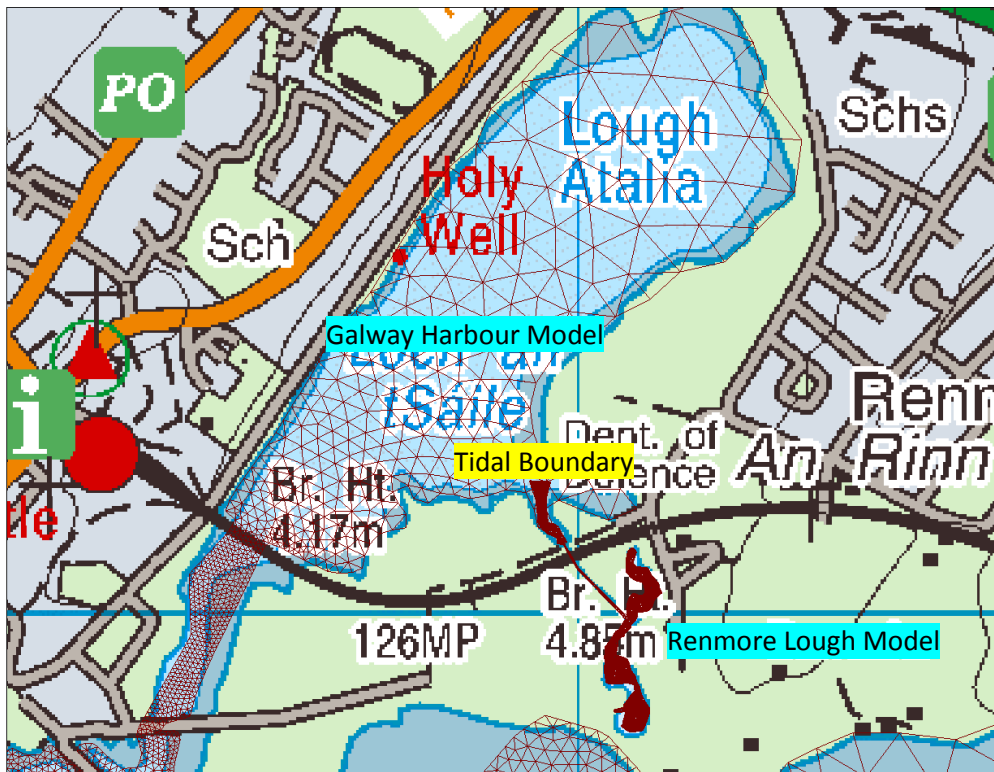


Figure 3 Local Hydrodynamic model Domain for Renmore Lough



Figure 4 Grid Refinement required to model inflow channel to Renmore Lough

Hydrodynamic and salinity simulations modelling spring-neap tides with the same range of Corrib Flows as carried out for the Lough Atalia Salinity Dispersion Study (HEL May2013) were performed for the Renmore Lough Model. The Renmore Lough model was driven by inputting the results from the Lough Atalia model along the northern Tidal boundary (refer to figure 3), specifying tidal elevation and salinity concentration at each time step over the 16day simulation period. Pre and Post harbour development simulations were carried out for the following Corrib flow conditions:

1. 99-percentile River Corrib Low flow of 9.1cumec
2. 90-percentile River Corrib flow of 28.5cumec
3. 50-percentile River Corrib flow of 82cumec
4. 10-percentile River Corrib flow of 200cumec
5. 1-percentile River Corrib flow of 272cumec

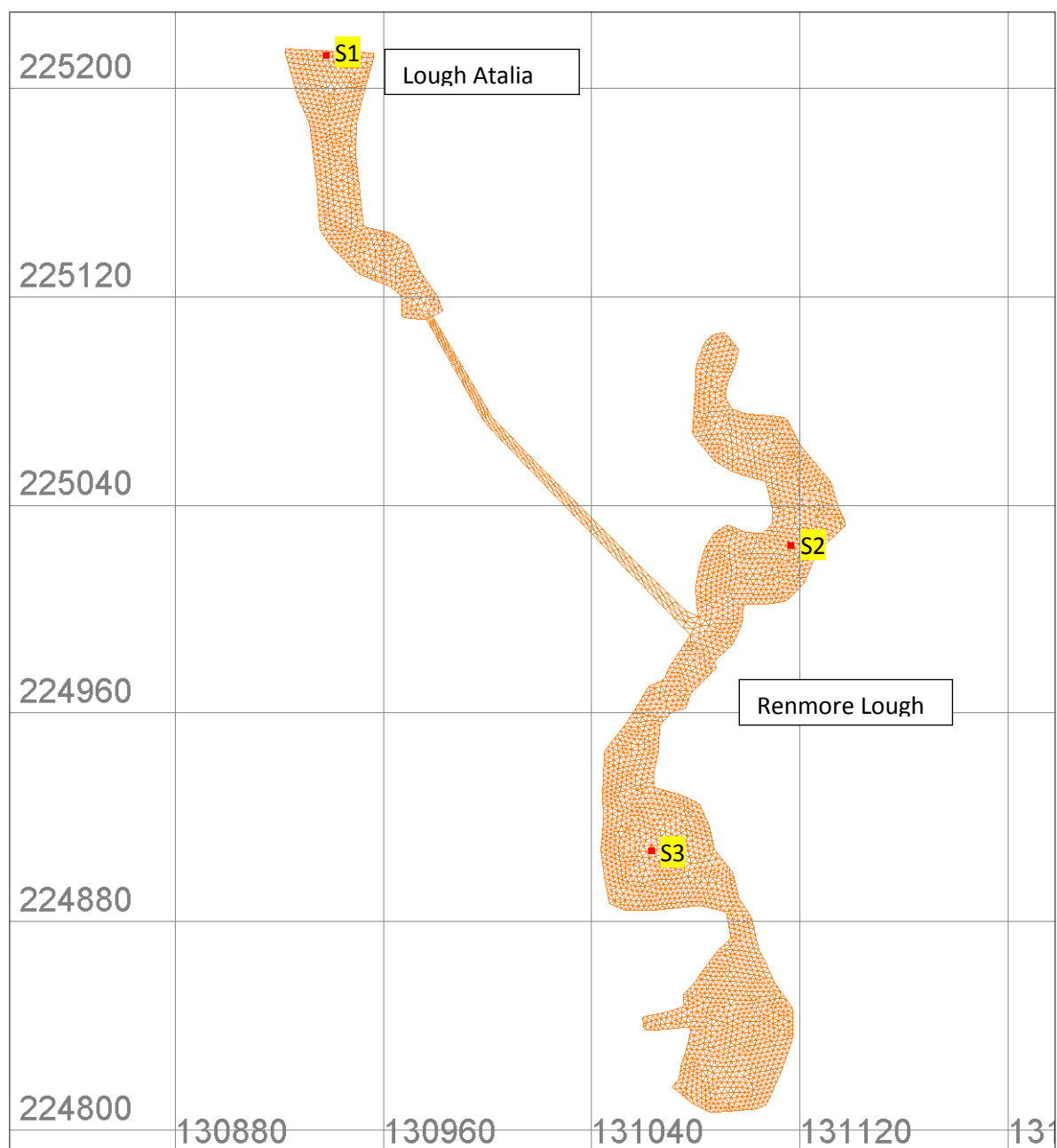
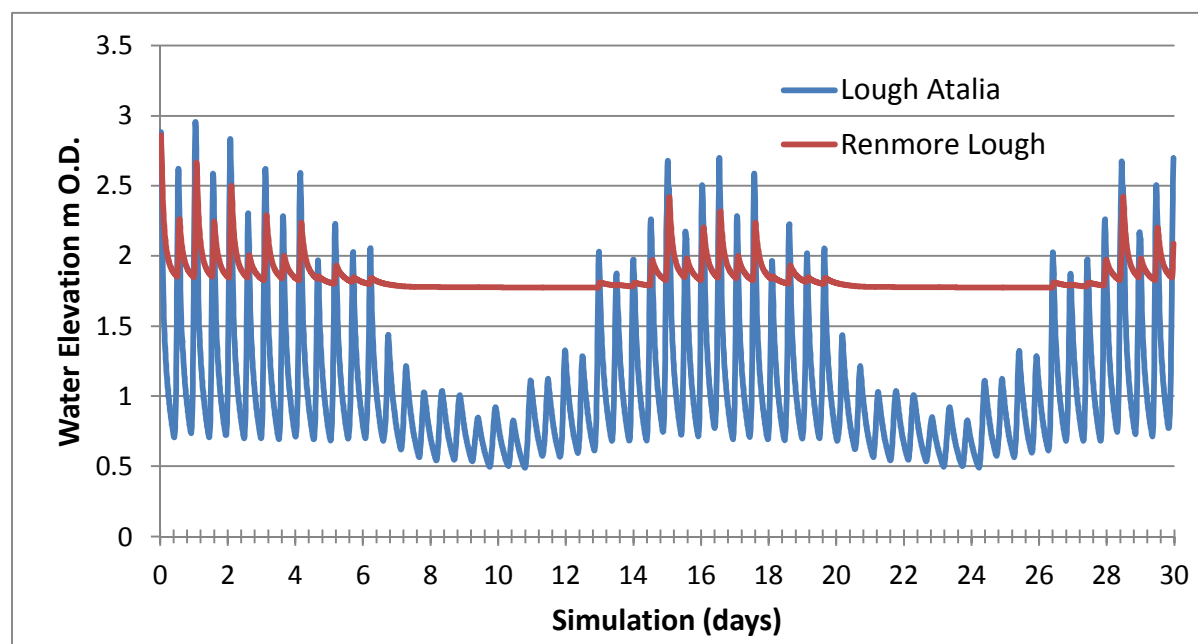


Figure 5 Reference sites for Salinity Time series**Figure 6** Predicted Tide elevation in Lough Atalia (S1) and Renmore Lough (S2) (note due to invert levels in connecting channel the inflow period restricted to spring tides (no inflow can occur during neap tides)).

4 Renmore Lough Salinity Simulation Results

As demonstrated in Figure 6 for a typical spring-neap tidal period the tidal (saline) inflow to Renmore Lough is restricted to a very short period of 1 to 2 hours on spring tides with little or no inflow occurring during mean and neap tides. The source of salinity for Renmore Lough is the spring tide salinity levels in Lough Atalia from the Lough Atalia waters in the vicinity of the Railway culvert entrance. These waters are relatively shallow and generally well mixed (unstratified). Renmore Lough is approximately 0.88ha in area and on a typical spring tide the Lough rises by 0.35m in a 1 hour 45min inflow period (average inflow in that period 0.5cumec). This represents an inflow volume of approximately 40% of the total highwater Lough volume. The Lough water level recedes over the outflow period back to a low water level of 1.8m OD and falling to a minimum level of 1.75m OD during neap tides. It is clear from the dynamics of the Lough that changes to the Salinity in Lough Atalia will have a similar effect within Renmore Lough.

Time series plots for the five spring-neap tide and percentile Corrib Flow simulations are presented in Figures 7 to 11 for the existing and proposed harbour development at the three reference sites shown in Figure 5 earlier. Tables of computed mean, maximum and minimum salinities for these hydrodynamic runs with and without the proposed Harbour development are presented in Tables 1 to 5. Table 6 presents an overall summary of predicted salinities in Renmore Lough for the five simulation runs.

The simulations show for the existing situation that salinities in Renmore Lough vary from 25.51 to 3.34 ppt and that for the proposed harbour extension development case this will slightly reduce to 25.03 to 2.19ppt. More extreme Corrib low and flood flow conditions than have been modelled in the five flow cases will result in higher and lower salinities occurring within Renmore Lough for both existing and proposed cases, refer to Figure 12.

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 (refer to Table 6) with the largest reduction shown to be 1.58ppt. 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 will not be altered by the development and thus the inflow rates to Renmore Lough will remain unchanged.

Figure 13 demonstrates the variation in median salinity with River Corrib Flow in Lough atalia and Renmore Lough. This figure demonstrates that Renmore Lough will on average be more saline than Lough Atalia with the exception being during River Corrib Low flow periods.

Salinity Units ppt (or kg/m³)and psu

Please note that the salinity measurement data referred to in this report are in the units of psu, whereas the hydrodynamic salinity model TELEMAC-3D refers to salinities in grams of salt per kilogram of solution (g/l or parts per thousand (ppt)). The modern oceanographic definition of salinity is the Practical Salinity Scale of 1978 (PSS-78). The numeric unit from PSS-78 is psu (practical salinity unit) and is distinct from the previous physical quantity ppt (kg salt per kg water in parts per thousand). Salinity values in ppt and psu are nearly equivalent by design, and for the purposes of this assessment can be treated as equivalent.

Table 1 Summary of Salinity Results for Neap to Spring Simulation period subject to 99percentile Corrib low Flow

Reference site	Existing			Proposed			Difference		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Median Salinity	26.89	21.78	21.39	26.32	21.40	21.02	-0.58	-0.38	-0.37
Maximum Salinity	28.65	25.70	25.58	28.19	25.19	25.07	-0.45	-0.51	-0.50
Minimum Salinity	25.00	20.78	20.58	24.42	20.43	20.23	-0.58	-0.35	-0.35

Salinities in ppt

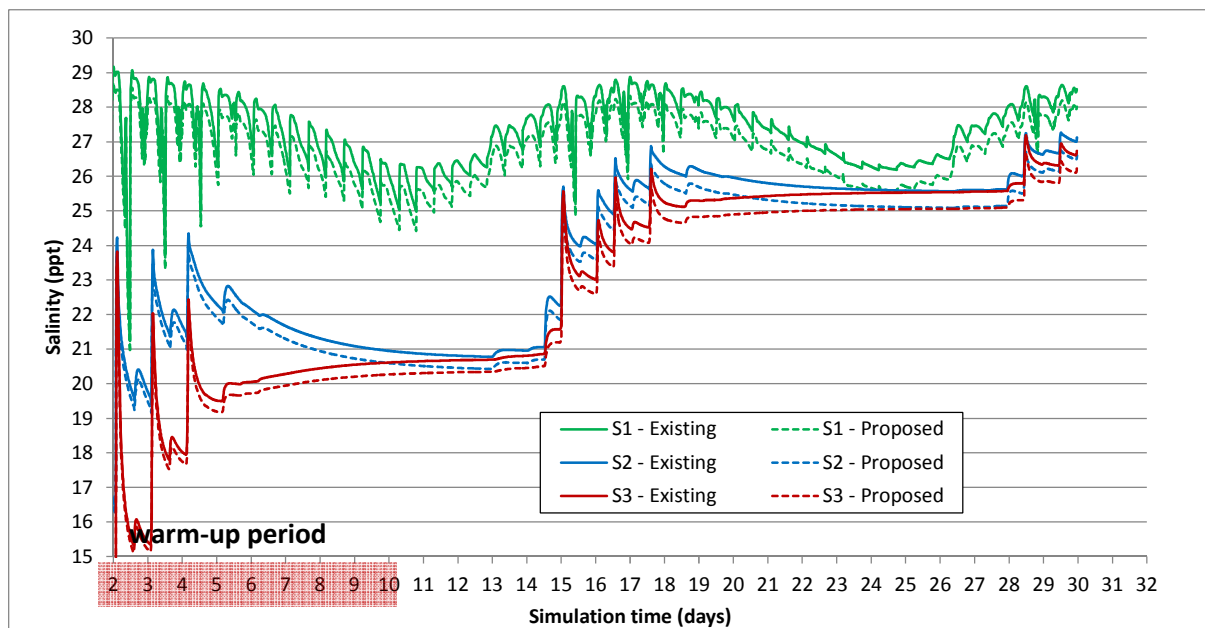


Figure 7 Time series of computed salinities at reference sites – existing and proposed for 99-percentile Corrib Low flow condition

Table 2 Summary of Salinity Results for Neap to Spring Simulation period subject to 90percentile Corrib Flow

Reference site	Existing			Proposed			Difference		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Median Salinity	20.93	20.65	20.50	19.76	19.60	19.46	-1.16	-1.05	-1.04
Maximum Salinity	23.63	21.57	21.18	22.42	20.45	20.10	-1.21	-1.12	-1.08
Minimum Salinity	18.37	17.46	17.40	17.12	16.66	16.60	-1.25	-0.81	-0.80

Salinities in ppt

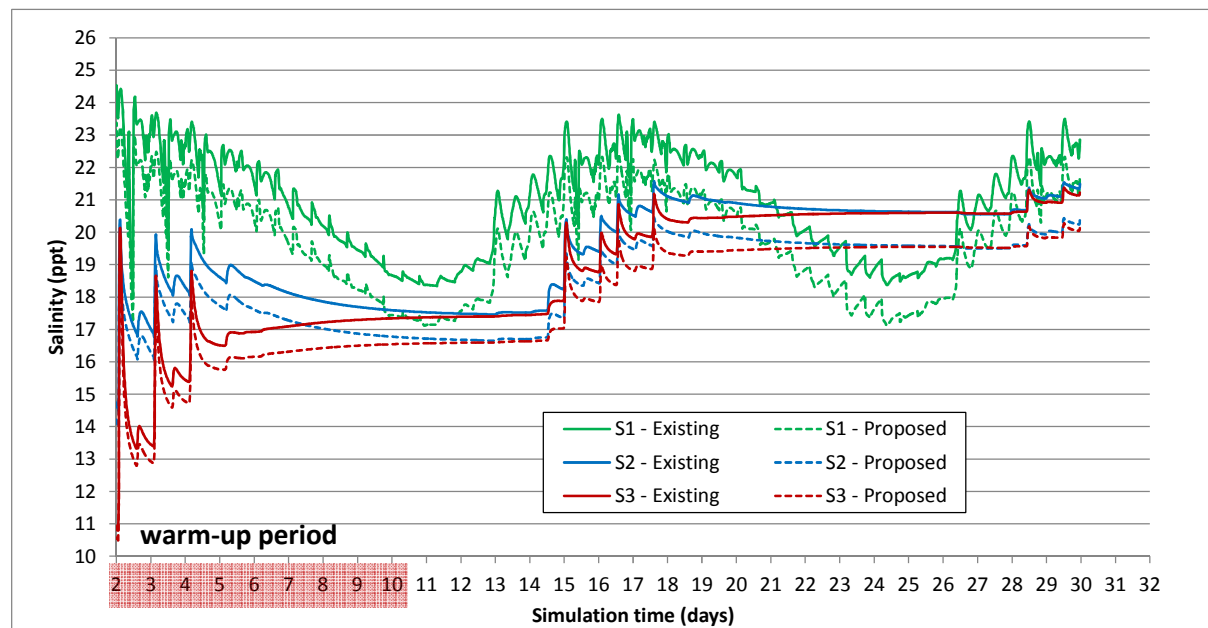


Figure 8 Time series of computed salinities at reference sites – existing and proposed for 90-percentile Corrib flow condition

Table 3 Summary of Salinity Results for Neap to Spring Simulation period subject to 50 percentile Median Corrib Flow

Reference site	Existing			Proposed			Difference		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Median Salinity	12.10	13.17	13.08	10.57	11.77	11.71	-1.53	-1.40	-1.37
Maximum Salinity	12.23	13.39	13.32	10.69	11.95	11.89	-1.54	-1.44	-1.43
Minimum Salinity	16.22	13.87	13.75	14.64	12.34	12.27	-1.58	-1.53	-1.49

Salinities in ppt

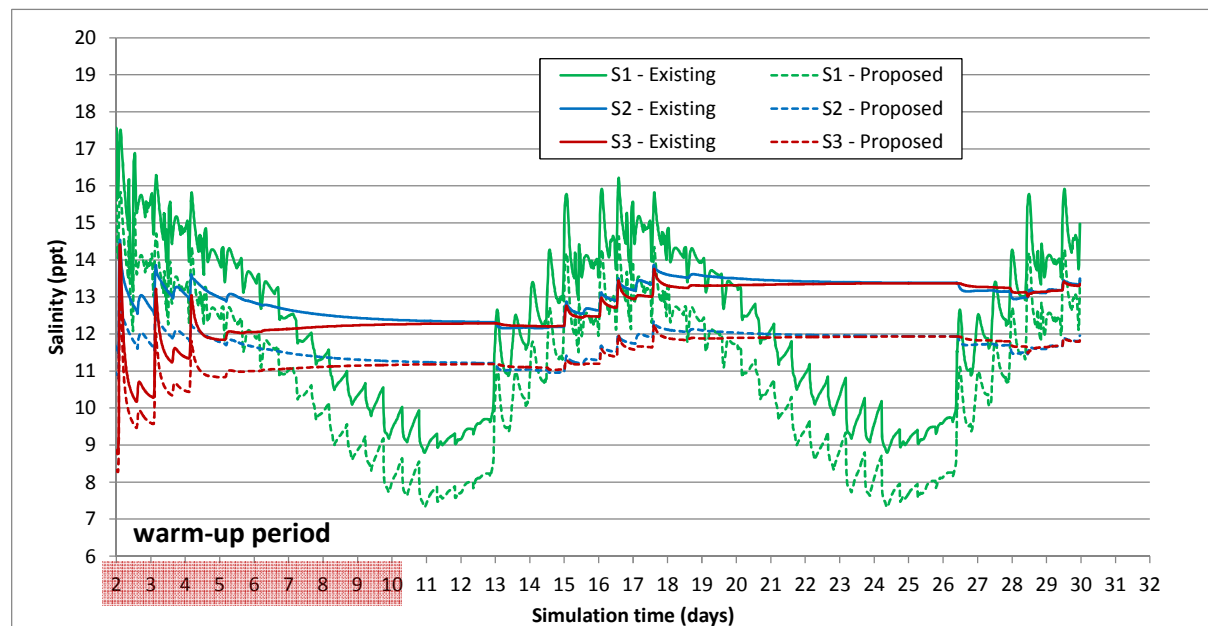


Figure 9 Time series of computed salinities at reference sites – existing and proposed for 50-percentile (median) Corrib flow condition

Table 4 Summary of Salinity Results for Neap to Spring Simulation period subject to 10 percentile Corrib Flow of 200cumec

Reference site	Existing			Proposed			Difference		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Median Salinity	4.17	5.45	5.47	2.86	4.17	4.20	-1.31	-1.28	-1.26
Maximum Salinity	6.58	6.21	6.24	5.03	5.22	5.26	-1.55	-0.99	-0.98
Minimum Salinity	2.51	4.95	4.92	1.31	3.68	3.66	-1.20	-1.26	-1.27

Salinities in ppt

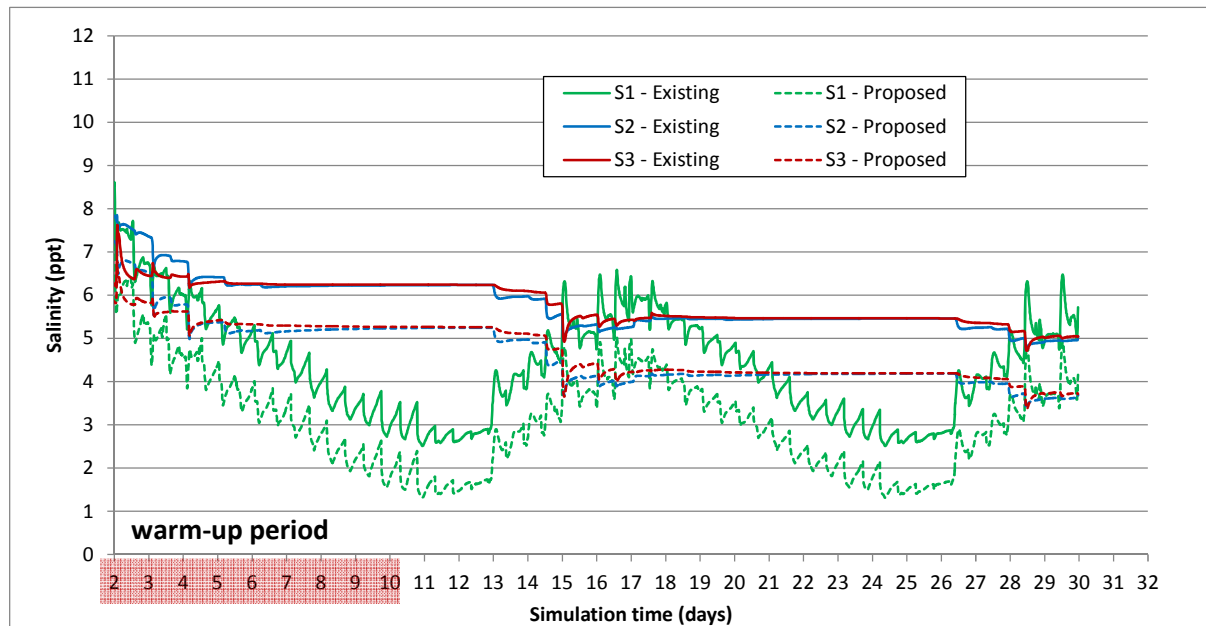


Figure 10 Time series of computed salinities at reference sites – existing and proposed for 10-percentile Corrib flow condition

Table 5 Summary of Salinity Results for Spring-neap Simulation period subject to 1 percentile Corrib Flood Flow

Reference site	Existing			Proposed			Difference		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Median Salinity	1.97	3.31	3.37	0.87	2.15	2.22	-1.10	-1.16	-1.14
Maximum Salinity	3.93	4.74	4.80	2.52	3.91	3.98	-1.42	-0.82	-0.82
Minimum Salinity	0.75	2.86	2.83	0.15	1.74	1.72	-0.60	-1.12	-1.11

Salinities in ppt

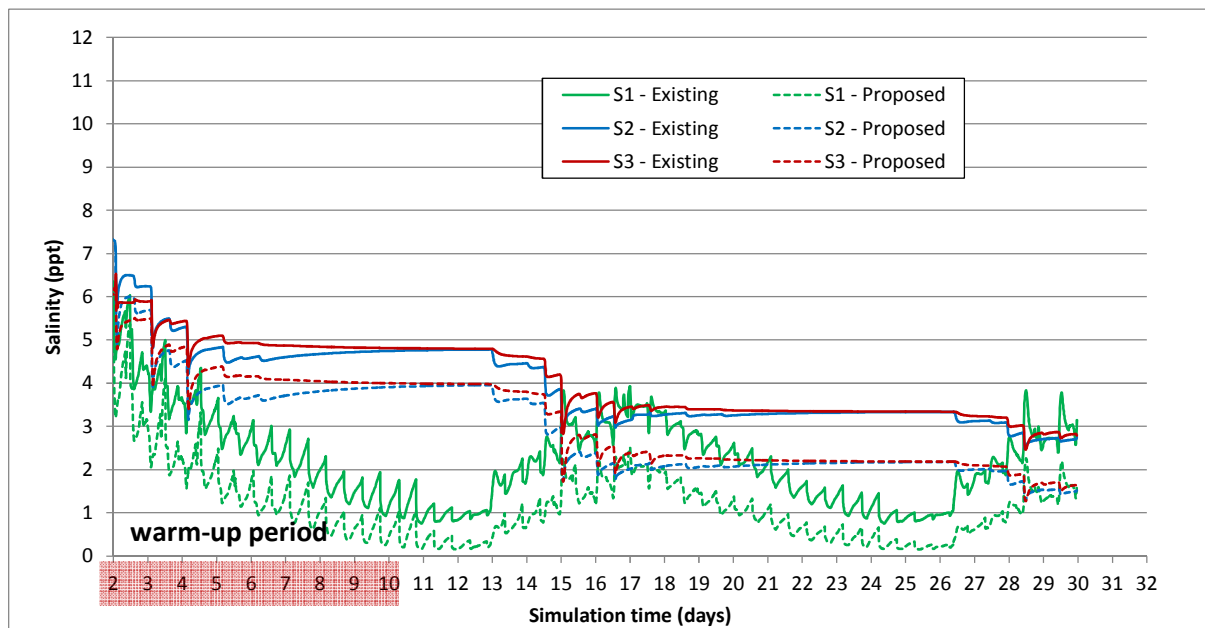


Figure 11 Time series of computed salinities at reference sites – existing and proposed for 1-percentile Corrib Flood flow condition

Table 6 Summary of Renmore Lough Salinity Results neap –spring period

		Existing median Salinity (ppt)	Proposed median Salinity (ppt)	Change in median Salinity (ppt)
Hydro 1 Neap-Spring with 99% low flow (9.1m ³ /s)	5.5%	25.51	25.03	-0.48
Hydro 2 Neap-Spring with 90% flow (28.5m ³ /s)	24.5%	20.57	19.53	-1.04
Hydro 3 Neap-Spring with 50% flow (82m ³ /s)	40%	13.35	11.92	-1.43
Hydro 4 Neap-Spring with 10% flow (200m ³ /s)	24.5%	5.46	4.19	-1.27
Hydro 5 Neap-Spring with 1% flood flow (272m ³ /s)	5.5%	3.34	2.19	-1.15
Overall Median	100%	13.30	12.08	-1.22

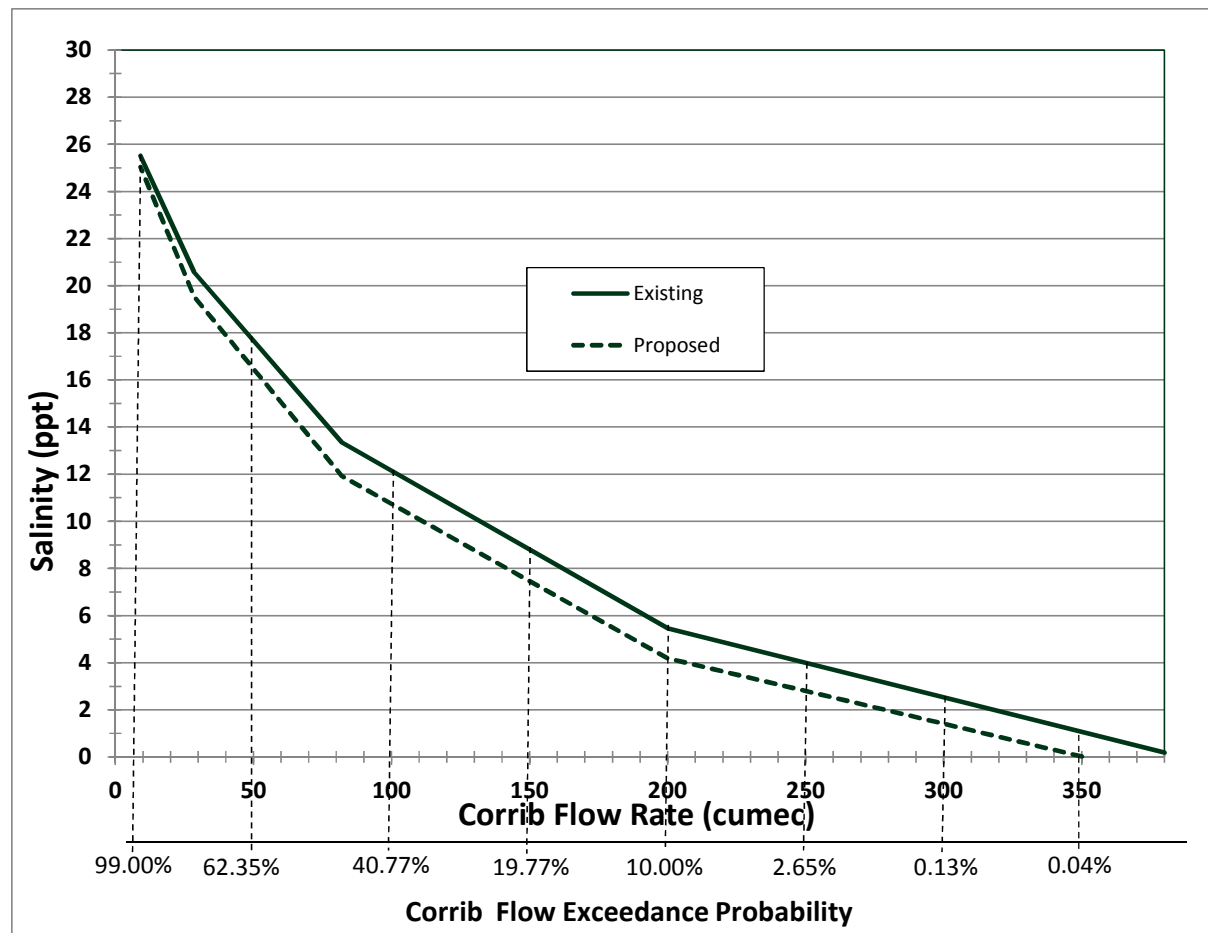


Figure 12 Predicted Median Salinity in Renmore Lagoon V's Corrib Freshwater Flow

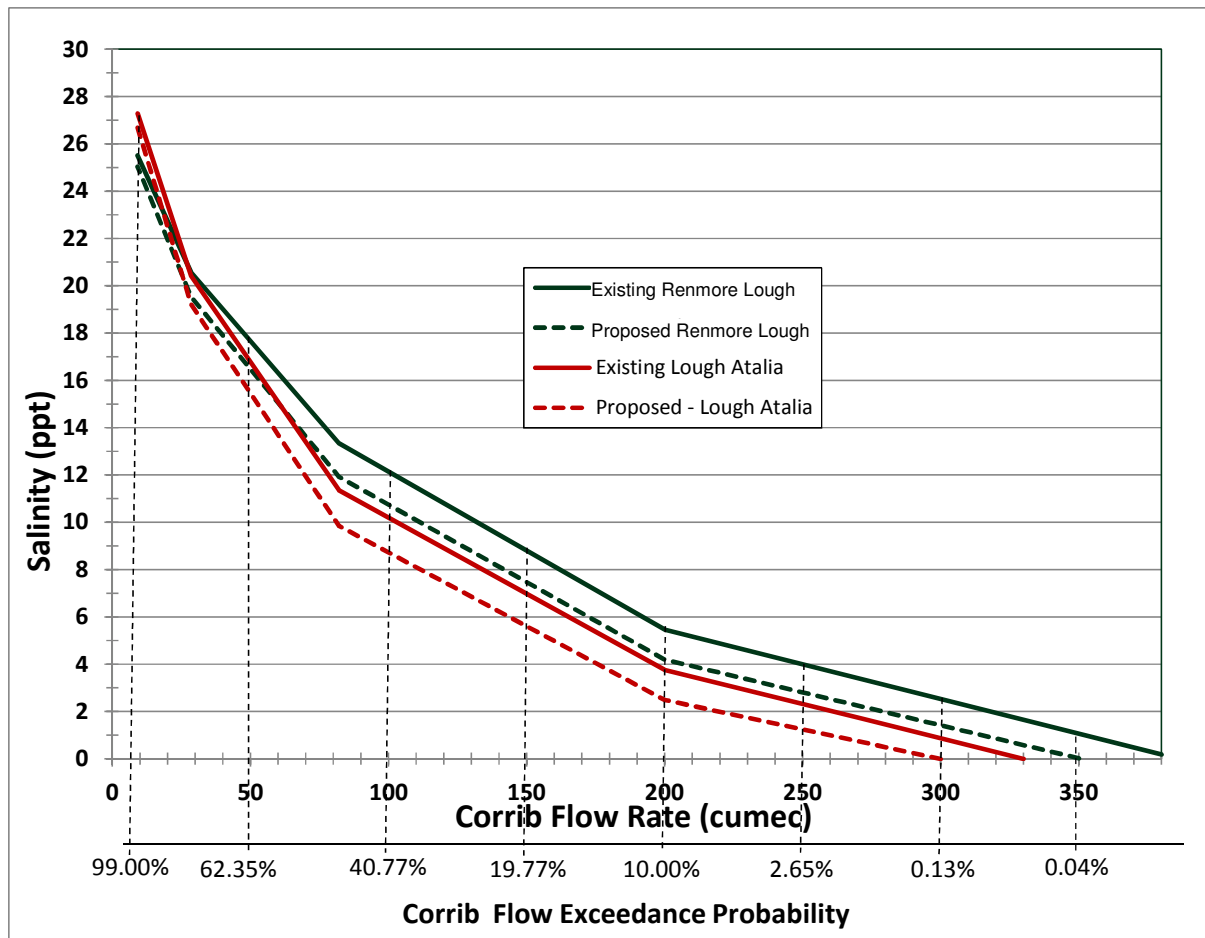


Figure 13 Predicted Median Salinity in Renmore Lough and Lough Atalia V's Corrib Freshwater Flow