9.8 Hydraulic Cross Sections

Appendix 9.8 Hydraulic Cross Section Data

Tables A9.8.1 and A9.8.2 refer to cross sectional velocity data for the Bunree, Moy, Quignamanger and Tullyegan. As a salmonid spawning/nursery river within the River Moy SAC, the Brusna (Glenree) River required greater scrutiny: **Tables A9.8.3 to A9.8.6** set out average cross section water velocities and Froude number comparing baseline and post-scheme under 50%AEP and 1%AEP for the Brusna (Glenree) reach affected by set-back walls and embankment.

Table A9.8.1 Pre- and Post-Scheme cross section velocity 50%AEP

Watercourse	Cross Section	Location	Baseline - 50% AEP Velocity (m/s)	Post Scheme - 50% AEP Velocity (m/s)	Difference
Bunree	34BNRE379	U/S (Moyvale Park)	0.456	1.404	0.948
	34BNRE357	D/S (Moyvale Park)	0.249	0.618	0.369
Moy	34MOYR00436	Ridge Pool (c.171m U/S Upper Bridge)	1.053	1.051	-0.002
	34MOYR00428	Ridge Pool (c.90m U/S Upper Bridge)	1.528	1.523	-0.005
	34MOYR00420	Ridge Pool (c.11m U/S Upper Bridge)	1.331	1.328	-0.003
Quignamanger	34QUIG00007	U/S (@ Cregg Rd culvert exit)	1.568	1.481	-0.087
	34QUIG00006I	D/S (@ Quay Rd culvert entry	0.375	0.842	0.467
Tullyegan	34TULN00063	U/S (near railway)	1.369	1.413	0.044
	34TULN00052	D/S (near N26)	0.724	1.018	0.294

Table A9.8.1 Pre- and Post-Scheme cross section velocity 1%AEP

Watercourse	Cross Section	Location	Baseline - 1% AEP Velocity (m/s)	Post Scheme - 1% AEP Velocity (m/s)	Difference
Bunree	34BNRE379	U/S (Moyvale Park)	0.486	3.099	2.613
	34BNRE357	D/S (Moyvale Park)	0.292	1.05	0.758
Moy	34MOYR00436	Ridge Pool (c.171m U/S Upper Bridge)	1.332	1.328	-0.004
	34MOYR00428	Ridge Pool (c.90m U/S Upper Bridge)	1.976	1.999	0.023
	34MOYR00420	Ridge Pool (c.11m U/S Upper Bridge)	1.715	1.705	-0.010
Quignamanger	34QUIG00007	U/S (@ Cregg Rd culvert exit)	1.599	2.029	0.43
	34QUIG00006I	D/S (@ Quay Rd culvert entry	0.379	1.121	0.742
Tullyegan	34TULN00063	U/S (near railway)	1.772	1.816	0.044
	34TULN00052	D/S (near N26)	0.98	1.217	0.237

Figure A9.8.1 Bunree Cross Sections – currently culverted near Moyvale Park but will be reinstated as open channel in the modelled reach under the proposed scheme.

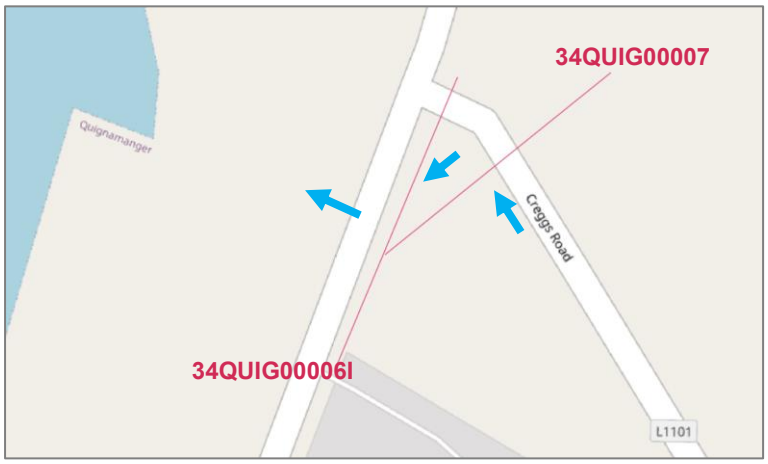

Figure A9.8.2 Quignamanger Cross Sections

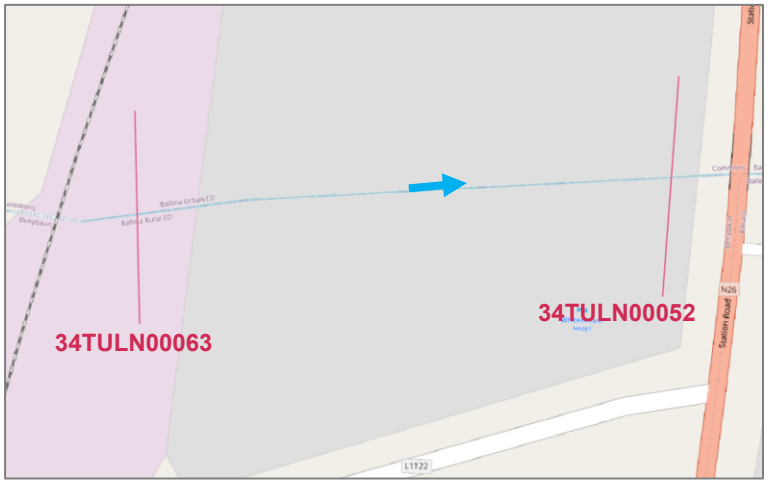

Figure A9.8.3 Tullyegan Cross Sections – Upstream and downstream within proposed reach of flood walls / embankment

Figure A9.8.4 River Moy Cross Sections – Ridge Pool Ballina

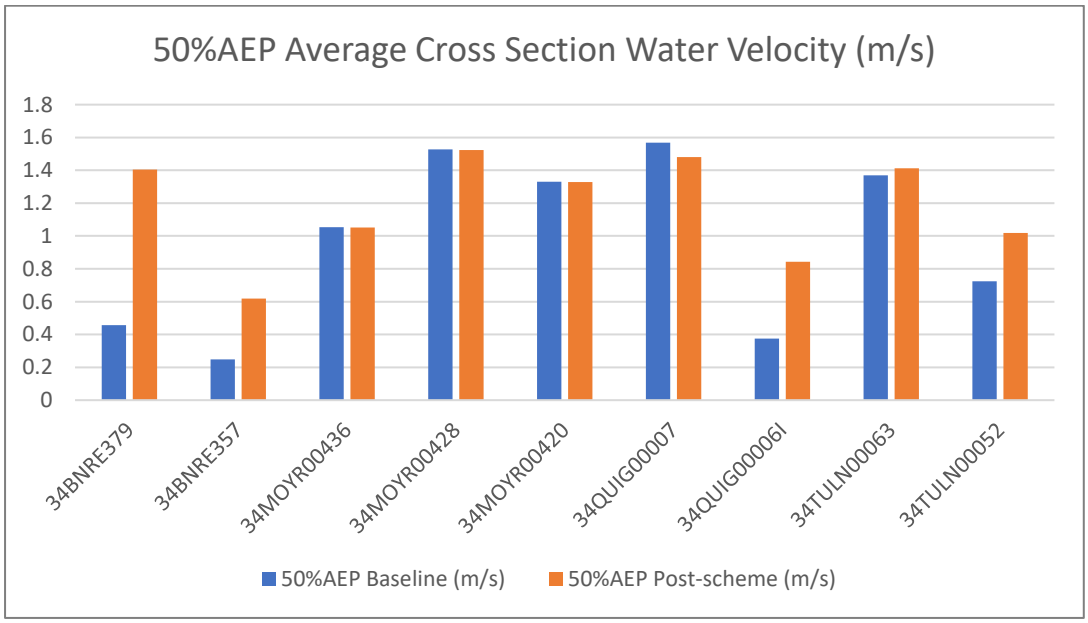

Figure A9.8.5 Pre- and Post-Scheme cross section velocity 50%AEP

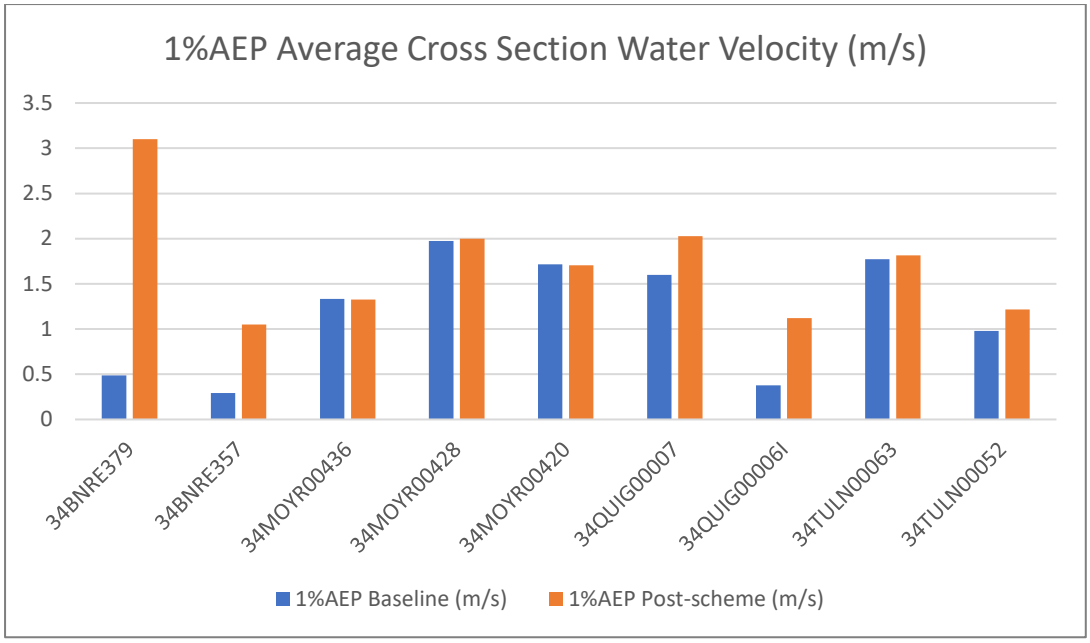

Figure A9.8.6 Pre- and Post-Scheme cross section velocity 1%AEP

Detailed Examination of Brusna (Glenree) River Hydraulic Data

Figure A9.8.7 Brusna (Glenree) Cross Sections – upstream / downstream Shanaghy Heights Bridge

Table A9.8.3 Brusna (Glenree) Pre- and Post-Scheme cross section velocity 50%AEP

Watercourse	Cross Section	Location	Baseline 50% AEP Velocity (m/s)	Post Scheme 50% AEP Velocity (m/s)	Difference
Brusna (Glenree)	34BRUS00159	260m DS Shanaghy Heights Bridge	1.846	1.846	0
	34BRUS00173	~	1.866	1.865	-0.001
	34BRUS00183	Just DS Shanaghy Heights Bridge	1.443	1.447	0.004
	34BRUS00186	Just US Shanaghy Heights Bridge	1.853	1.922	0.069
	34BRUS00206	~	1.863	1.883	0.02
	34BRUS00220	~	1.8	1.818	0.018
	34BRUS00228!	~	1.947	1.958	0.011
	34BRUS00231!	~	1.717	1.749	0.032
	34BRUS00240	545m US Shanaghy Heights Bridge	2.25	2.271	0.021

Table A9.8.4 Brusna (Glenree) Pre- and Post-Scheme cross section velocity 1%AEP

Watercourse	Cross Section	Location	Baseline 1% AEP Velocity (m/s)	Post Scheme 1% AEP Velocity (m/s)	Difference
Brusna (Glenree)	34BRUS00159	260m DS Shanaghy Heights Bridge	2.11	2.143	0.033
	34BRUS00173	~	2.298	2.324	0.026
	34BRUS00183	Just DS Shanaghy Heights Bridge	1.829	2.045	0.216
	34BRUS00186	Just US Shanaghy Heights Bridge	1.866	1.927	0.061
	34BRUS00206	~	1.909	1.932	0.023
	34BRUS00220	~	1.938	1.965	0.027
	34BRUS00228!	~	2.139	2.085	-0.054
	34BRUS00231!	~	2.015	1.972	-0.043
	34BRUS00240	545m US Shanaghy Heights Bridge	2.454	2.426	-0.028

Table A9.8.5 Brusna (Glenree) Pre- and Post-Scheme cross section Froude No. 50%AEP

Watercourse	Cross Section	Location	Baseline 50% AEP Froude no.	Post Scheme 50% AEP Froude no.	Difference
Brusna (Glenree)	34BRUS00159	260m DS Shanaghy Heights Bridge	0.676	0.675	-0.001
	34BRUS00173	~	0.537	0.537	0
	34BRUS00183	Just DS Shanaghy Heights Bridge	0.364	0.365	0.001
	34BRUS00186	Just US Shanaghy Heights Bridge	0.54	0.564	0.024
	34BRUS00206	~	0.533	0.538	0.005
	34BRUS00220	~	0.514	0.518	0.004
	34BRUS00228!	~	0.615	0.616	0.001
	34BRUS00231!	~	0.492	0.505	0.013
	34BRUS00240	545m US Shanaghy Heights Bridge	0.727	0.734	0.007

Table A9.8.6 Brusna (Glenree) Pre- and Post-Scheme cross section Froude No. 1%AEP

Watercourse	Cross Section	Location	Baseline 1% AEP Froude no.	Post Scheme 1% AEP Froude no.	Difference
Brusna (Glenree)	34BRUS00159	260m DS Shanaghy Heights Bridge	0.677	0.677	0
	34BRUS00173	~	0.672	0.678	0.006
	34BRUS00183	Just DS Shanaghy Heights Bridge	0.429	0.468	0.039
	34BRUS00186	Just US Shanaghy Heights Bridge	0.54	0.564	0.024
	34BRUS00206	~	0.548	0.555	0.007
	34BRUS00220	~	0.583	0.591	0.008
	34BRUS00228!	~	0.617	0.617	0
	34BRUS00231!	~	0.494	0.507	0.013
	34BRUS00240	545m US Shanaghy Heights Bridge	0.729	0.736	0.007

To assist in assessment of potential impacts on the hydraulic environment of the Brusna (Glenree) River, baseline and post-scheme values for two hydraulic parameters were examined: channel velocity (m/s) and froude number. Modelled hydraulic changes were examined for nine (9 no.) river cross-sections spanning 545m upstream to 260m downstream of Shanaghy Heights Bridge, numbered and mapped as shown in **Figure A9.8.7** above.

Froude number is a dimensionless descriptor of the flow environment of a river calculated as a function of depth and velocity. It is a useful signifier of hydraulic habitat in relation to salmonid spawning and nursery habitat, being more versatile than river velocity or depth alone (Moir *et al*, 2002). Whilst larger fish tend to spawn in deeper, faster waters than smaller fish; the froude number within their selected spawning habitats has been found to be very similar. As an expression of depth-velocity character, it is thus comparable between different sized rivers and different sized fish. The

relationship between mean depth / velocity and froude number for salmonids is set out in **Figure A9.8.8** (reproduced from Moir et al. 2002), using amalgamated data from the literature (as listed).

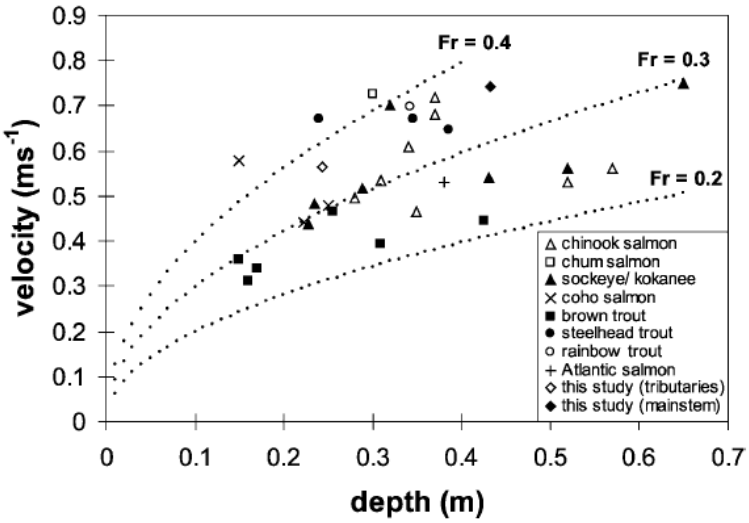

Fig. 8. Plot of mean depth and velocity-use data by spawning salmonids from the literature (Beland et al., 1982; Briggs, 1953; Burner, 1951; Delisle, 1962; Deverall et al., 1993; Grost et al., 1990; Hamilton and Remington, 1962; Hoopes, 1972; Kondolf, 1988; Mullner and Hubert, 1995; Orcutt et al., 1968; Parsons and Hubert, 1988; Sams and Pearson, 1963; Shirvell and Dungey, 1983; Smith, 1973; Swan, 1989; Witzel and MacCrimmon, 1982) and this study. Dashed curves represent Froude number equal to 0.2, 0.3 and 0.4.

Figure A9.8.8 Velocity, depth and froude number relationship (Moir et al. 2002)

Moir et al (2002) demonstrated that salmon in Scottish mainstem and tributary streams spawn in a wide variety of depths (0.12 to 0.66m) and velocities (0.22 to 1.29 m/s), but that the froude number was very consistent with the optimal range being 0.3 to 0.44 (mean 0.38). For trout (*Salmo trutta*) the reported Froude number range is 0.2 to 0.3 (Fig. 9-3).

Armstrong et al (2003) reviewed published literature regarding habitat utilisation by Atlantic salmon and brown trout. Salmon were reported spawning in areas at average water velocities of 0.40 to 0.54 m/s, with nursery waters averaging 0.10 to 0.40 m/s (mean column velocity). Trout spawning was reported in mean water velocities of 0.39 to 0.47 m/s with nursery habitat having mean column velocities of 0 to 0.5 m/s. Spawning and nursery habitats of both species tend not to exceed mean column velocity of circa 1.0 m/s.

The Brusna (Glenree) River currently overtops the bank at 50%AEP, mainly just downstream of Shanaghy Heights Bridge. This is the flood return period where changes over the baseline initiate under the scheme. Velocity and froude number were used to examine baseline and post-scheme changes for smaller, higher frequency (50%AEP) and larger, lower frequency (1%AEP) flood events as shown in **Figure A9.8.9**, below.

Baseline and predicted water velocities are high at 50%AEP and 1%AEP along the examined channel reach, generally in excess of 1.5m/s which is sub-optimal for both spawning and nursery habitat (at elevated flows), though noting that bed velocity will be lower than mean column velocity. Important to this assessment is that there is very little change in cross section water velocities between baseline and post-scheme scenarios.

Froude numbers are also elevated along the channel reach, remaining virtually unchanged under baseline and post-scheme scenarios for both 50%AEP and 1%AEP events. Yellow dashed lines on Fig. A9.8.9 show the optimal Froude number band for salmonid spawning habitat (salmon and trout). This demonstrates the reach is sub-optimal in terms of froude number for both baseline and post-scheme scenarios, including during smaller, higher frequency events (50%AEP) that would be more likely to occur during the winter spawning months. The data shows the effect of the Proposed Scheme on hydraulic conditions as relate to quality of salmonid habitats is Not Significant.

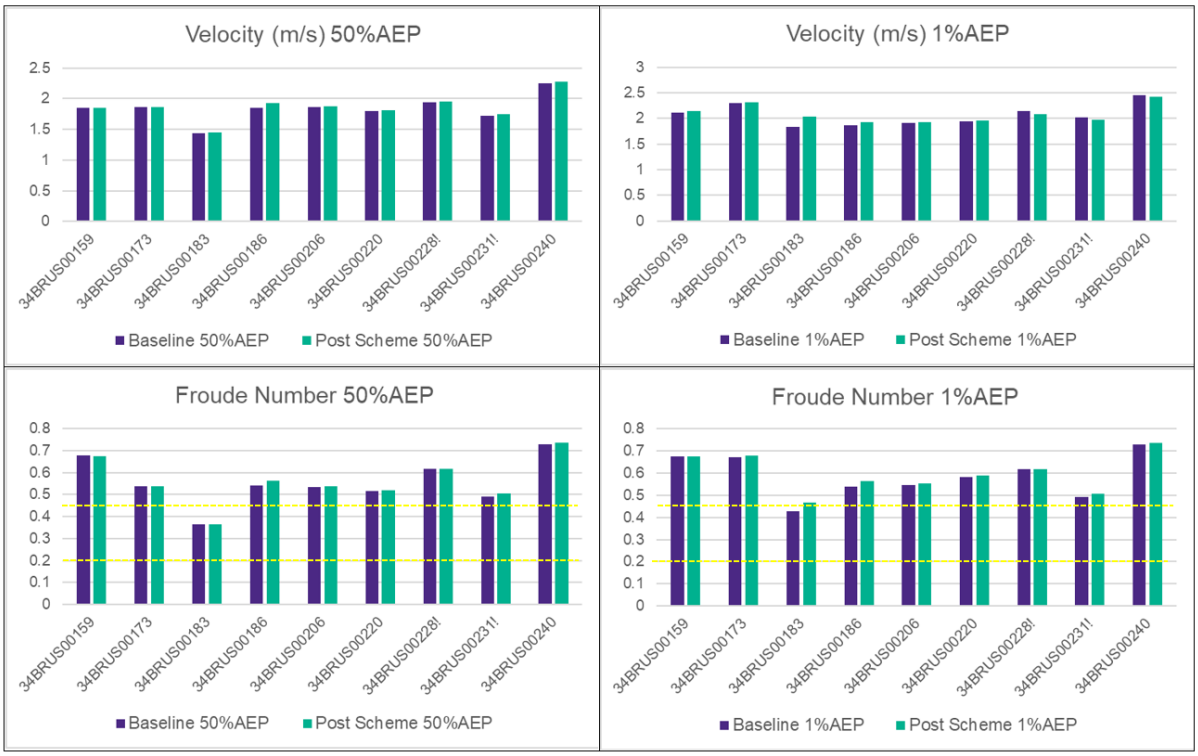

Figure A9.8.9 Brusna (Glenree) Cross Sections – channel velocity and Froude number comparisons

Examination of River Moy (Estuary) Downstream N59 Lower Bridge

The estuarine reach of the River Moy is examined below with reference to average cross section water velocity and depth pre- and post-scheme under 50%AEP and 1%AEP flood scenarios, as relates to potential hydromorphological changes specific to transitional water bodies. Figure A9.8.10 shows the cross-section locations. Tables A9.8.7 to A9.8.10 show modelled hydraulic data. Figure A9.8.11 graphs the pre- and post-scheme changes, showing virtually no changes in velocity and depth.

Table A9.8.7 Brusna (Glenree) Pre- and Post-Scheme cross section Froude No. 1%AEP

Cross Section	Location	Baseline - 50% AEP Velocity (m/s)	Post Scheme - 50% AEP Velocity (m/s)	Difference
34MOYR00385	15m d/s Lower Bridge	1.484	1.471	-0.013
34MOYR00376	100m d/s Lower Bridge	1.178	1.166	-0.012
34MOYR00367	200m d/s Lower Bridge	1.057	1.046	-0.011
34MOYR00356	300m d/s Lower Bridge	0.998	0.987	-0.011
34MOYR00347	400m d/s Lower Bridge	1.165	1.155	-0.01
34MOYR00336	500m d/s Lower Bridge	1.683	1.678	-0.005

Table A9.8.8 Brusna (Glenree) Pre- and Post-Scheme cross section Froude No. 1%AEP

Cross Section	Location	Baseline - 50% AEP Depth (m)	Post Scheme - 50% AEP Depth (m)	Difference
34MOYR00385	15m d/s Lower Bridge	3.679	3.675	-0.004
34MOYR00376	100m d/s Lower Bridge	4	3.995	-0.005
34MOYR00367	200m d/s Lower Bridge	4.057	4.052	-0.005
34MOYR00356	300m d/s Lower Bridge	4.543	4.536	-0.007

34MOYR00347	400m d/s Lower Bridge	4.442	4.436	-0.006
34MOYR00336	500m d/s Lower Bridge	3.325	3.32	-0.005

Table A9.8.9 Brusna (Glenree) Pre- and Post-Scheme cross section Froude No. 1%AEP

Cross Section	Location	Baseline - 1% AEP Velocity (m/s)	Post Scheme - 1% AEP Velocity (m/s)	Difference
34MOYR00385	15m d/s Lower Bridge	1.968	1.959	-0.009
34MOYR00376	100m d/s Lower Bridge	1.595	1.589	-0.006
34MOYR00367	200m d/s Lower Bridge	1.438	1.441	0.003
34MOYR00356	300m d/s Lower Bridge	1.387	1.39	0.003
34MOYR00347	400m d/s Lower Bridge	1.533	1.531	-0.002
34MOYR00336	500m d/s Lower Bridge	2.161	2.155	-0.006

Table A9.8.10 Brusna (Glenree) Pre- and Post-Scheme cross section Froude No. 1%AEP

Cross Section	Location	Baseline - 1% AEP Depth (m)	Post Scheme - 1% AEP Depth (m)	Difference
34MOYR00385	15m d/s Lower Bridge	4.107	4.115	0.008
34MOYR00376	100m d/s Lower Bridge	4.42	4.425	0.005
34MOYR00367	200m d/s Lower Bridge	4.466	4.464	-0.002
34MOYR00356	300m d/s Lower Bridge	4.931	4.923	-0.008
34MOYR00347	400m d/s Lower Bridge	4.798	4.794	-0.004
34MOYR00336	500m d/s Lower Bridge	3.595	3.597	0.002

Figure A9.8.10 River Moy (Estuary) Cross Sections – downstream N59 Lower Bridge

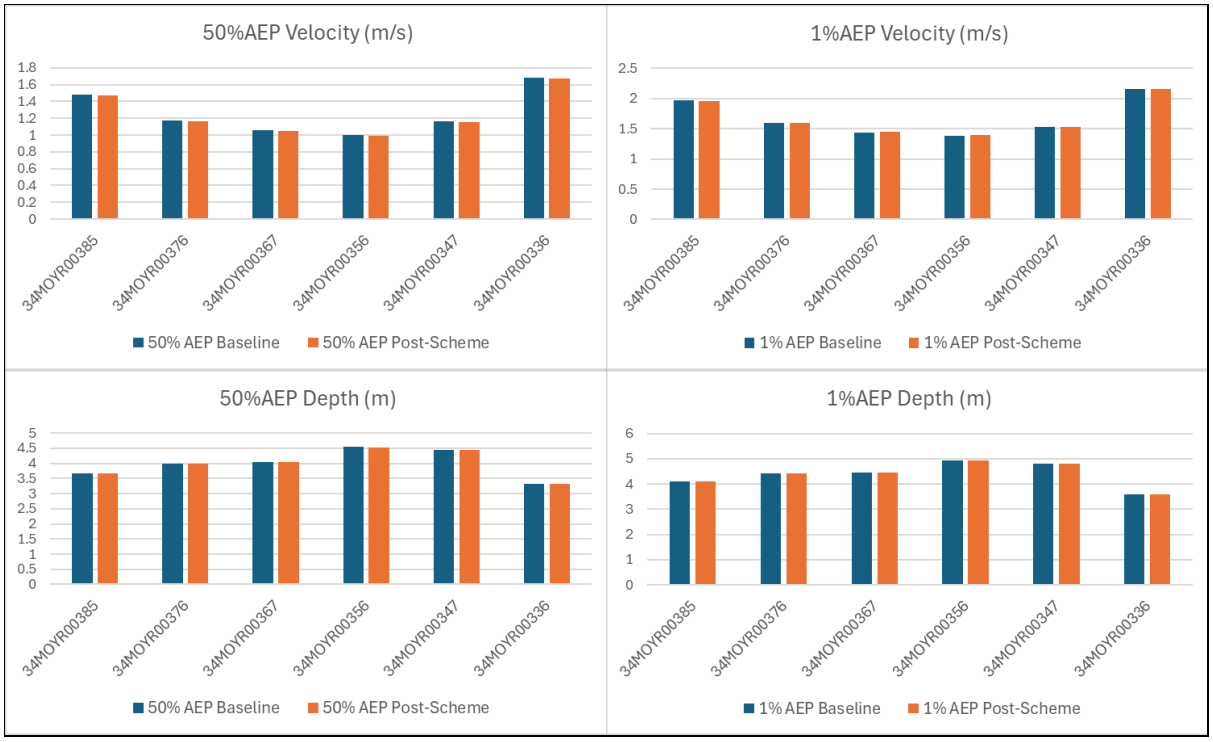

Figure A9.8.10 River Moy (Estuary) Hydraulic Comparison – downstream N59 Lower Bridge