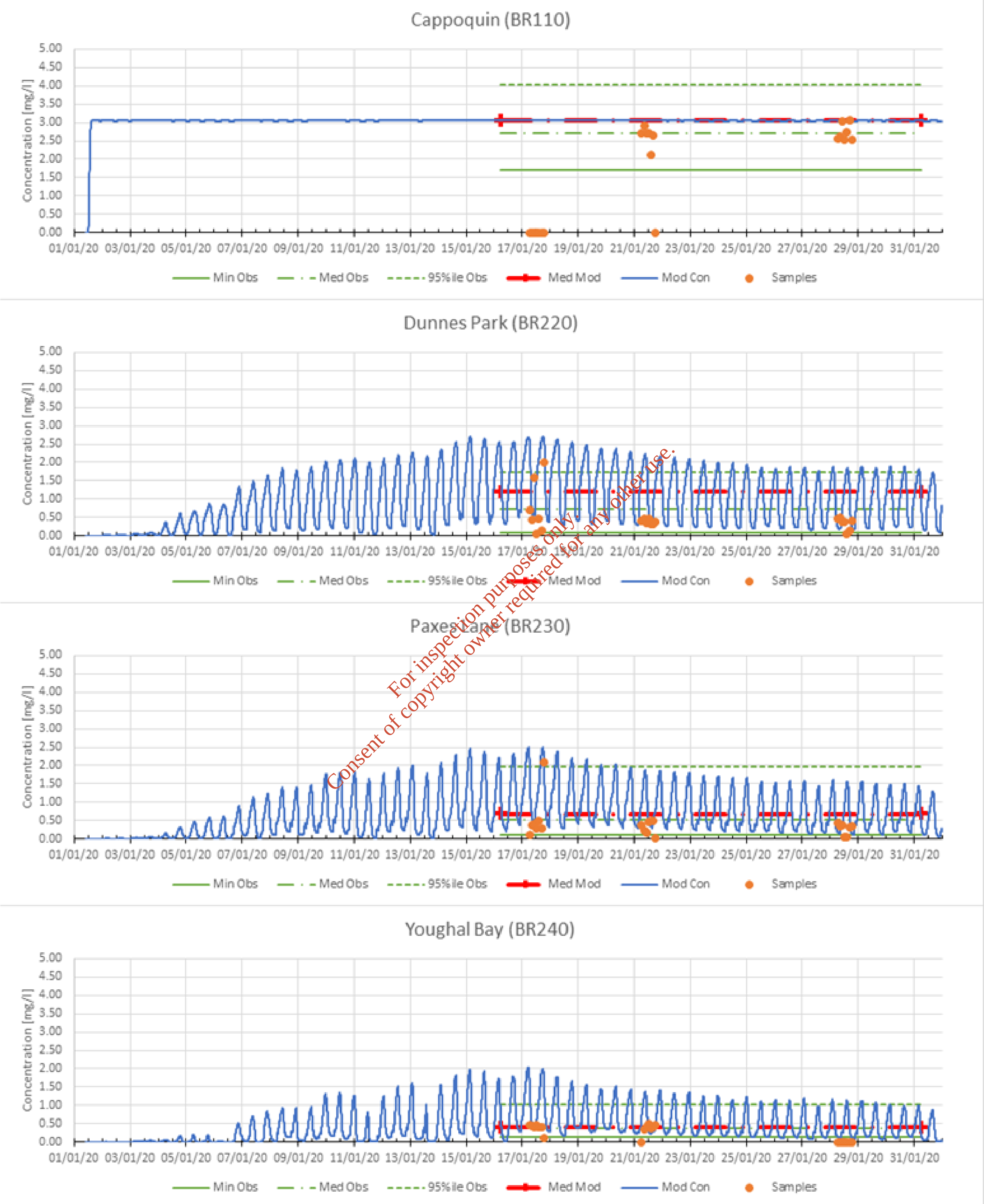
DIN [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	1.71	2.83	2.72	4.04	4.32	3.02	3.05	3.05	3.06	3.07	0.34	12%	-0.98	-24%
Dunnes Park (BR220)	0.08	0.79	0.72	1.72	1.84	0.15	1.17	1.20	2.39	2.70	0.48	66%	0.67	39%
Paxes Lane (BR230)	0.11	0.80	0.53	1.98	2.85	0.11	0.86	0.67	1.97	2.50	0.14	26%	-0.01	0%
Youghal Bay (BR240)	0.15	0.49	0.36	1.02	1.03	0.01	0.58	0.39	1.42	2.03	0.02	6%	0.40	39%

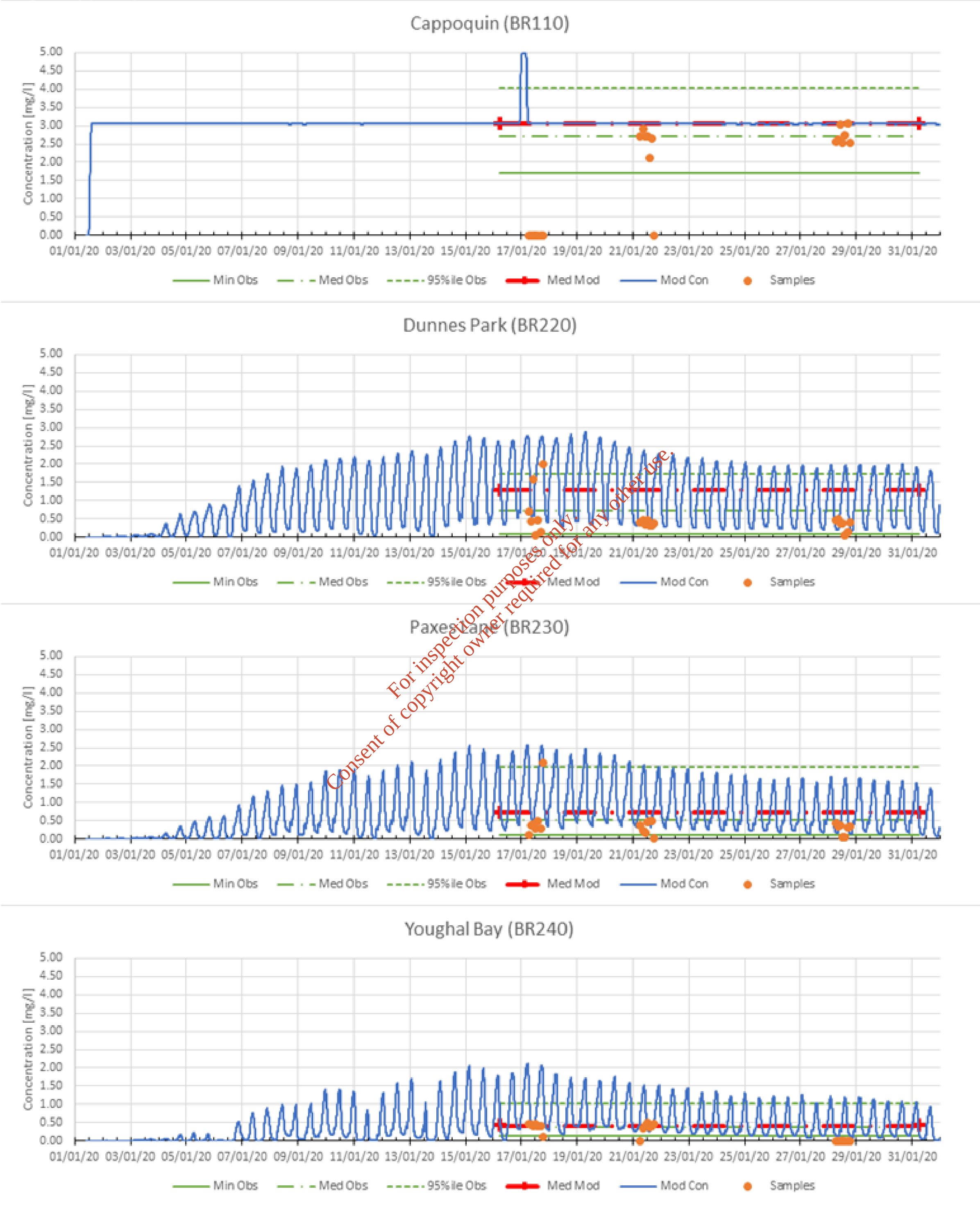


02.04.03_DIN_Revised Decay Rates (EC 48 hrs IE 96 hrs)

Figure 4-16. Summary statistics (mg/l) and plots for the initial model using median concentrations for DIN for a decreased T_{90} of 800 hours 04.03).

DIN [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	1.71	2.83	2.72	4.04	4.32	3.03	3.09	3.06	3.07	4.98	0.34	13%	-0.98	-24%
Dunnes Park (BR220)	0.08	0.79	0.72	1.72	1.84	0.16	1.25	1.28	2.58	2.88	0.56	77%	0.86	50%
Paxes Lane (BR230)	0.11	0.80	0.53	1.98	2.85	0.12	0.92	0.72	2.14	2.57	0.19	35%	0.16	8%
Youghal Bay (BR240)	0.15	0.49	0.36	1.02	1.03	0.02	0.62	0.41	1.57	2.10	0.05	14%	0.55	54%

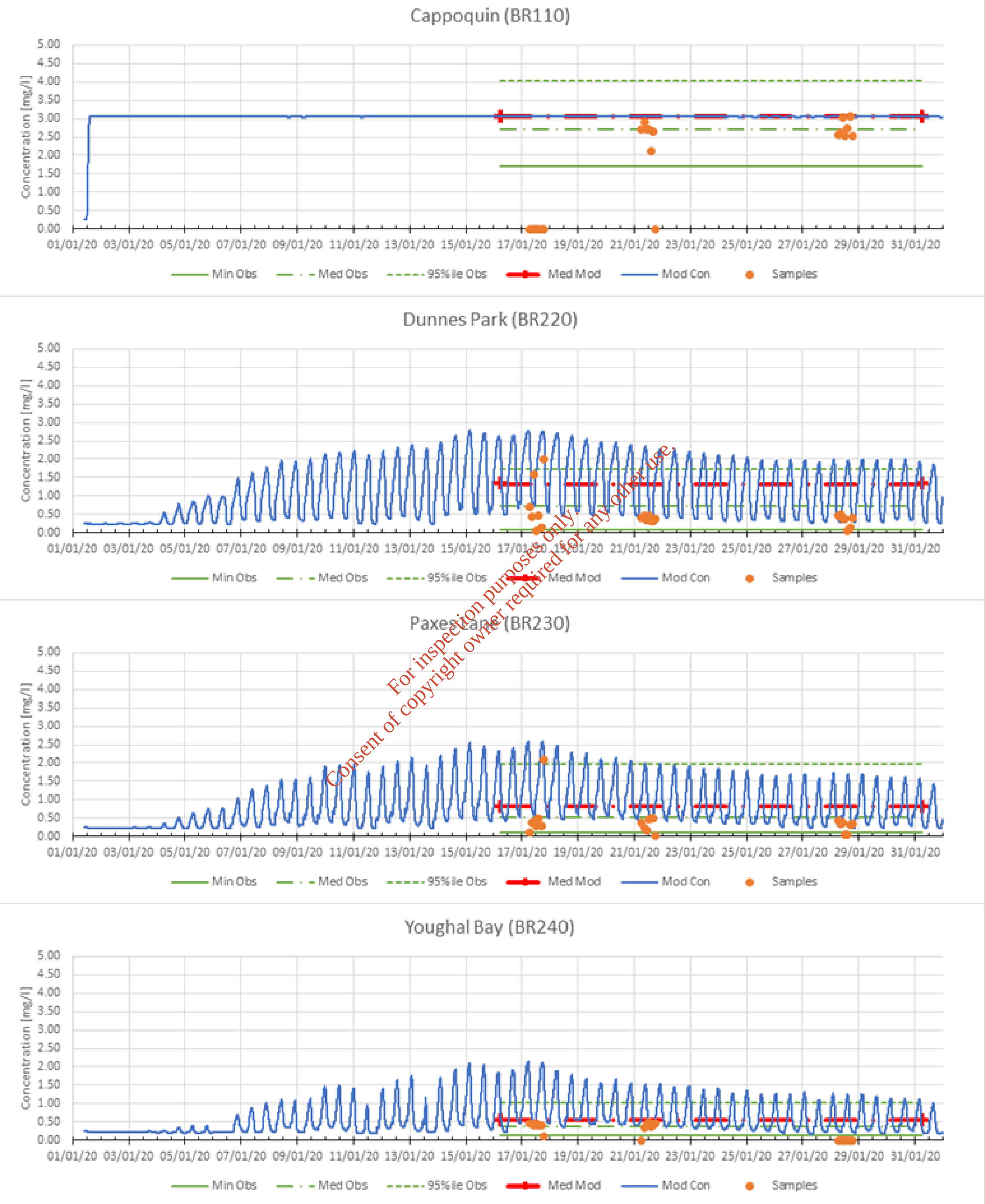


02.04.04_DIN_Pulse discharge in River Blackwater 2.YY.04

Figure 4-17. Summary statistics (mg/l) and plots for a 6-hour pulse of 5 mg/l to coincide with a high fluvial flow event at the start of Event B for DIN (run code 04.04).

DIN [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	1.71	2.83	2.72	4.04	4.32	3.03	3.06	3.06	3.07	3.07	0.34	13%	-0.98	-24%
Dunnes Park (BR220)	0.08	0.79	0.72	1.72	1.84	0.26	1.29	1.33	2.48	2.77	0.61	84%	0.76	44%
Paxes Lane (BR230)	0.11	0.80	0.53	1.98	2.85	0.23	0.99	0.81	2.07	2.58	0.27	51%	0.10	5%
Youghal Bay (BR240)	0.15	0.49	0.36	1.02	1.03	0.18	0.71	0.54	1.55	2.14	0.18	48%	0.53	52%



02.04.81_DIN_Surface Discharge Median values

Figure 4-18. Summary statistics (mg/l) and plots for the initial model (surface discharge) using median concentrations for DIN (run code 04.81).

4.8 Ammonia

A summary of the model runs simulating ammonia is provided in Table 4.6.

Table 4.6. Summary of the simulations for calibration of ammonia against the EPA monitoring data and Irish Water survey data.

Run Code	Description	Initial Conditions [mg/l]	Open Sea Boundary [mg/l]	T_{90} [hours]
06.00	Youghal WwTP only	0.000	0.000	275
06.01	Median concentrations for all rivers and WwTP's with actual flows.	0.010	0.016	275
06.02	As 06.01 with increased T_{90}	0.010	0.016	480
06.03	As 06.01 with decreased T_{90}	0.010	0.016	720
06.04	As 06.01 with a pulse discharge (River Blackwater) of 0.5 mg/l for 6 hours during a high flow fluvial event.	0.010	0.016	275
06.11	As 06.01 with changed initial and open sea boundary values	0.040	0.046	275
06.21	As 06.01 with changed initial and open sea boundary values	0.000	0.046	275
06.80	As 06.00 but with Youghal WwTP discharge in surface layer of water column	0.000	0.000	275
06.81	As 06.01 but with Youghal WwTP discharge in surface layer of water column	0.010	0.016	275

The maximum surface concentration of ammonia for the discharge from Youghal WwTP is shown in Figure 4-19 for the discharge in the bottom layer and Figure 4-20 for the discharge in the surface layer. This shows that the surface concentration of ammonia is below 0.002 mg/l within the lower estuary for both simulations. These plots provide a reference for the relative importance of other sources and the background concentration for the purposes of calibration.

The EPA monitoring data suggests that the 95%ile of surface concentration of ammonia is less than 0.12 mg/l at Cappoquin, with a maximum value of 0.22 mg/l on 19th January 2009. The monitoring data from January 2020 measured concentrations in a similar range. For the lower estuary the EPA monitoring data estimates a 95%ile less than 0.08 mg/l whilst the Irish Water survey recorded values between 0.2 and 0.5 mg/l for extended periods of time. These values were queried with the laboratory that undertook the tests and no irregularities were identified. It is unclear whether the high concentrations are linked to the decreasing river flows after the relatively large-scale events earlier in the month.

A mass balance using the river and WwTP flow rates and median concentrations for the 15 days of Event B yields an average (median) concentration of 0.028 mg/l. This is close to the median value for the EPA data for Dunnes Park (0.030 mg/l) and Youghal Bay (0.026 mg/l) and similar to the value for Paxes Lane (0.040 mg/l). Youghal WwTP contributes 0.1% of the total load.

The results of the water quality model using actual flows and median concentrations for all river and WwTP's are shown in Figure 4-21. The resulting statistics are all lower than the EPA data. Sensitivity tests to the decay rates do show some improvement; however, the absolute values for the median and 95%ile of the surface concentrations are not as high as the EPA monitoring data. Increasing the initial conditions to 0.04 mg/l and open sea boundary to 0.046 mg/l increases the median and 95%ile at each of the lower estuary monitoring points; however the increase is not significant (Figure 4-22). This suggests that the concentration is controlled by other sources rather than the values in the open sea.

Using an initial condition of 0 mg/l results in similar values for the median and 95%ile, less than 0.005 mg/l difference.

A pulse discharge of 0.5 mg/l for 6 hours results in a significant increase in the surface concentrations in the lower estuary. It is therefore considered that the concentration of ammonia must change, most likely with river flows, such that there are periods when the concentrations are significantly higher. However, there is insufficient data to demonstrate the relationship between river flow rates and concentration or whether or not the concentration is very high at the start of a fluvial event with a decreasing concentration as the event continues.

The maximum surface concentration from the Youghal WwTP only simulation suggests that the maximum surface concentration is less than 0.002 mg/l in the lower estuary (approximately 0.25% of the 95%ile for the EPA data). This is significantly smaller than the change in concentration from a single pulse event or the observed values. The implication is that the Youghal WwTP is contributing relatively small quantities of ammonia and the WwTP is having minimal effect on the concentrations within the estuary. Given the relatively low inputs from the WwTP, compared to the background concentration, it is recommended that no further effort on calibration is undertaken.

The model can reproduce the changes in concentration of ammonia in the estuary due to the WwTP; however, the absolute concentration is highly dependent on the other sources. The model has demonstrated that the warm-up period is of sufficient duration to achieve a "steady state" solution irrespective of the initial conditions. The model should be used to evaluate the dispersion of ammonia from the existing and proposed outfalls with due regard to the uncertainty in the other sources entering the receiving waters.

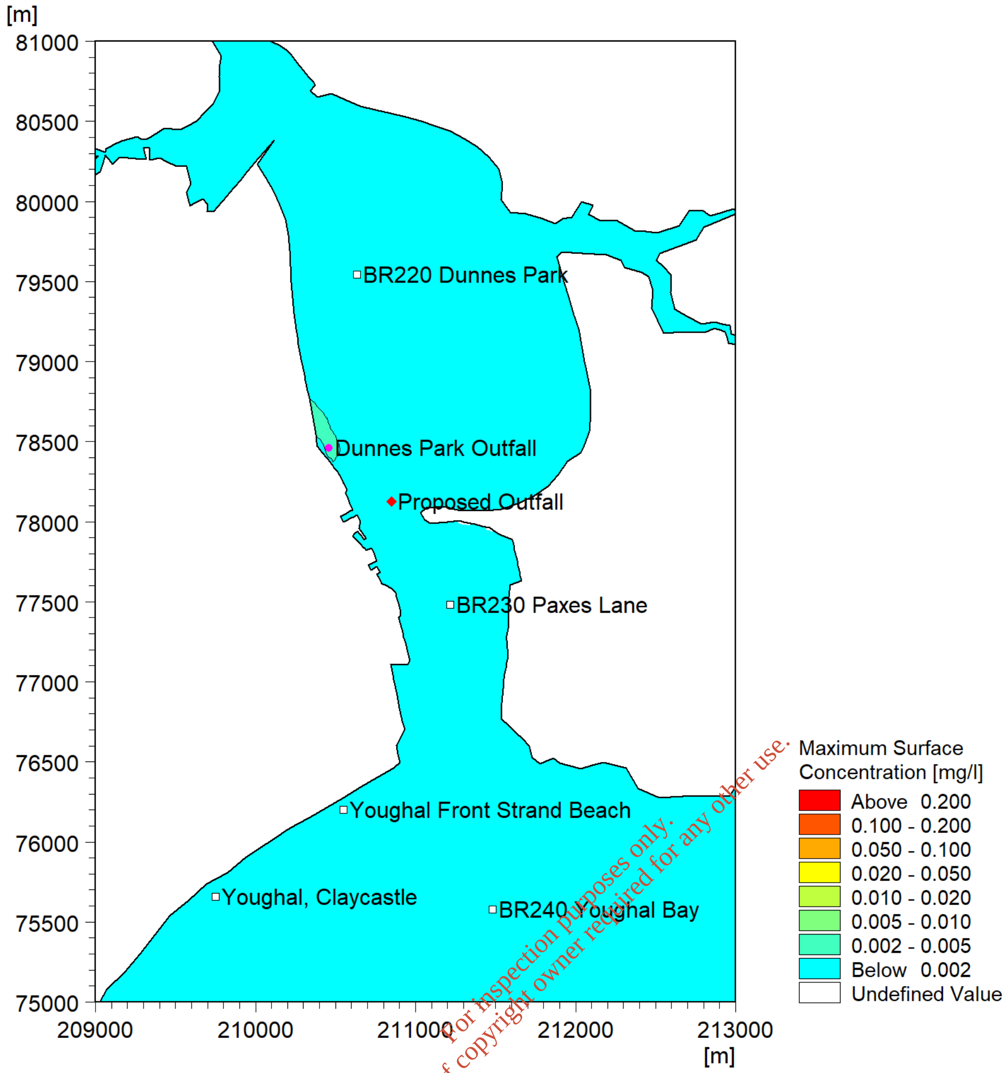


Figure 4-19. Maximum surface concentration of ammonia (mg/l) for the discharge from Youghal WwTP through Dunnes Park Outfall over the 15 days of Event B run code 06.00).

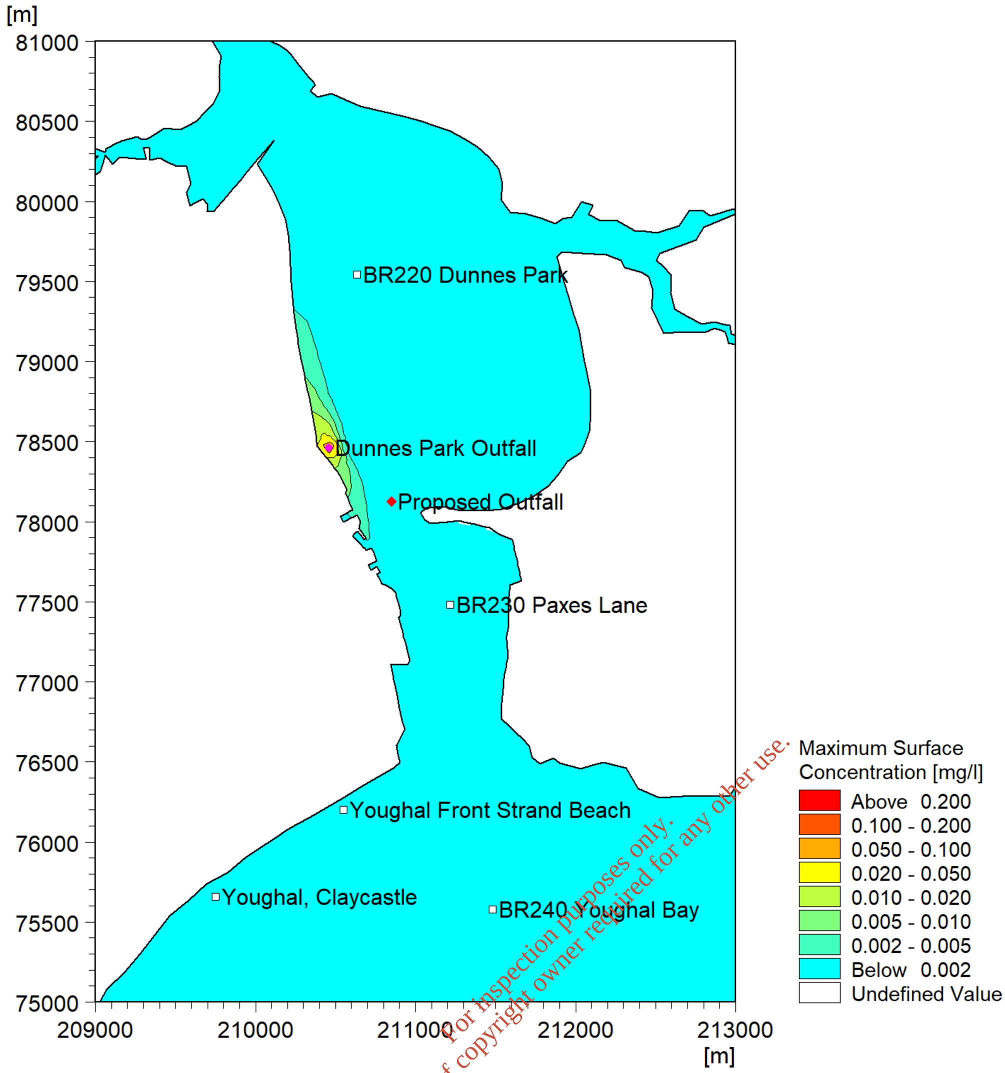
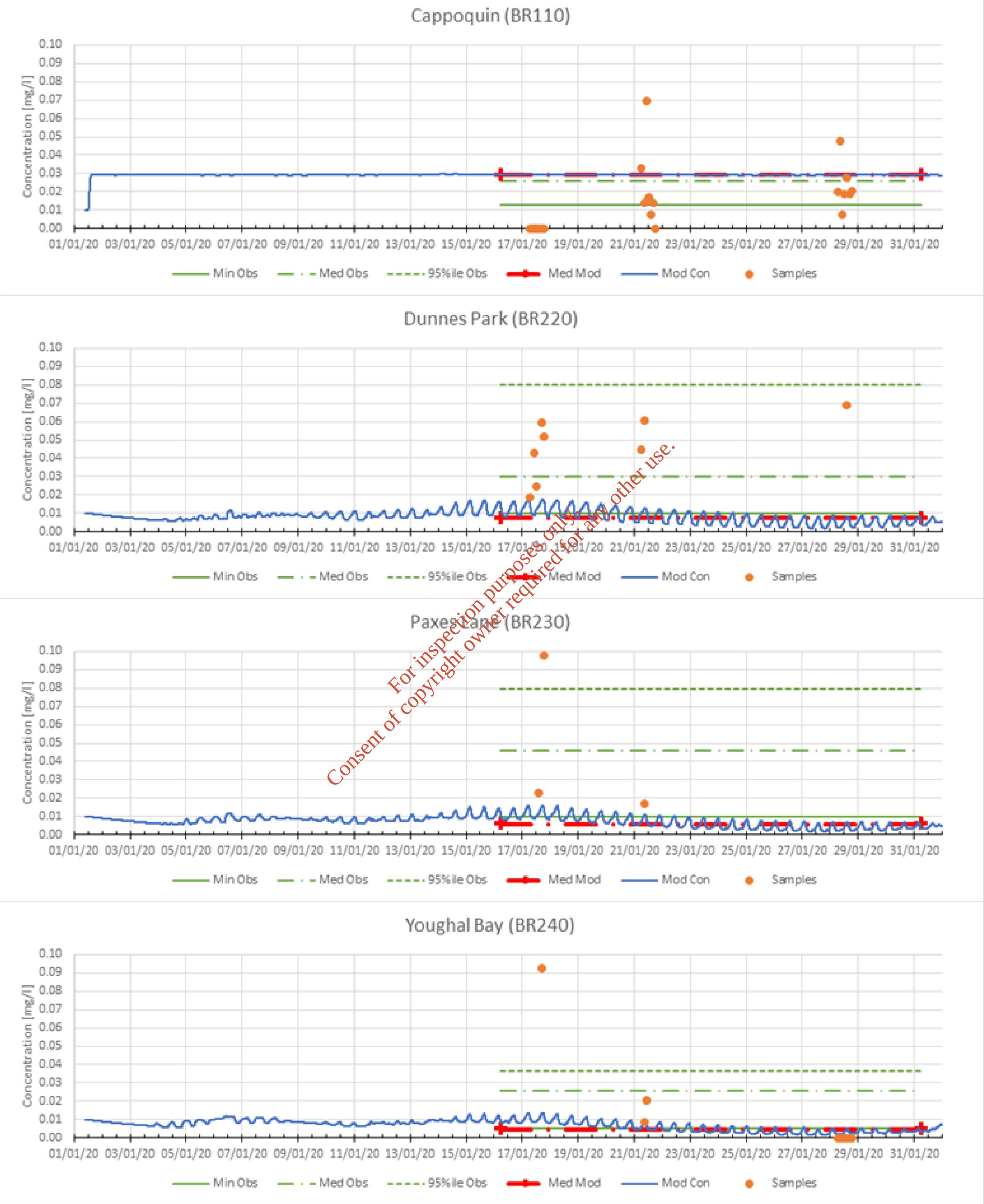


Figure 4-20. Maximum surface concentration of ammonia (mg/l) for the discharge from Youghal WwTP through Dunnes Park Outfall (surface layer) over the 15 days of Event B (run code 06.80).

Ammonia [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	0.013	0.042	0.026	0.119	0.223	0.029	0.029	0.029	0.030	0.030	0.003	13%	-0.090	-75%
Dunnes Park (BR220)	0.010	0.037	0.030	0.080	0.081	0.002	0.008	0.007	0.015	0.017	-0.023	-76%	-0.065	-81%
Paxes Lane (BR230)	0.010	0.045	0.046	0.079	0.080	0.002	0.006	0.006	0.013	0.016	-0.040	-87%	-0.066	-84%
Youghal Bay (BR240)	0.005	0.025	0.026	0.037	0.040	0.001	0.005	0.005	0.011	0.014	-0.021	-82%	-0.025	-70%

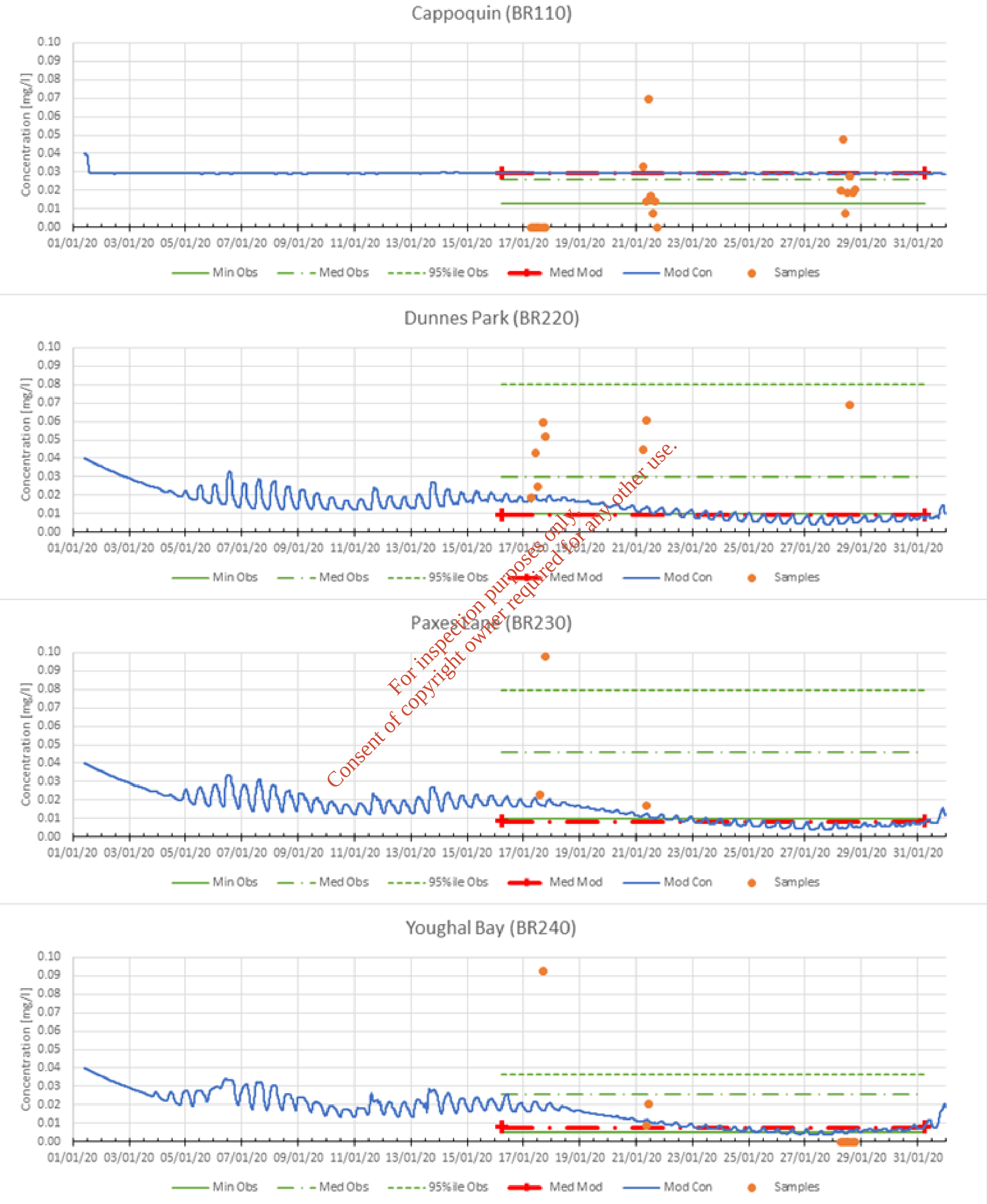


02.06.01_Amm_Base case of estimated values

Figure 4-21. Summary statistics (mg/l) and plots for the initial model using median concentrations for ammonia (run code 06.01).

Ammonia [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	0.013	0.042	0.026	0.119	0.223	0.029	0.029	0.029	0.030	0.030	0.003	13%	-0.090	-75%
Dunnes Park (BR220)	0.010	0.037	0.030	0.080	0.081	0.004	0.011	0.009	0.018	0.021	-0.021	-70%	-0.062	-77%
Paxes Lane (BR230)	0.010	0.045	0.046	0.079	0.080	0.004	0.010	0.008	0.019	0.022	-0.038	-82%	-0.061	-76%
Youghal Bay (BR240)	0.005	0.025	0.026	0.037	0.040	0.004	0.010	0.008	0.020	0.026	-0.018	-70%	-0.016	-45%

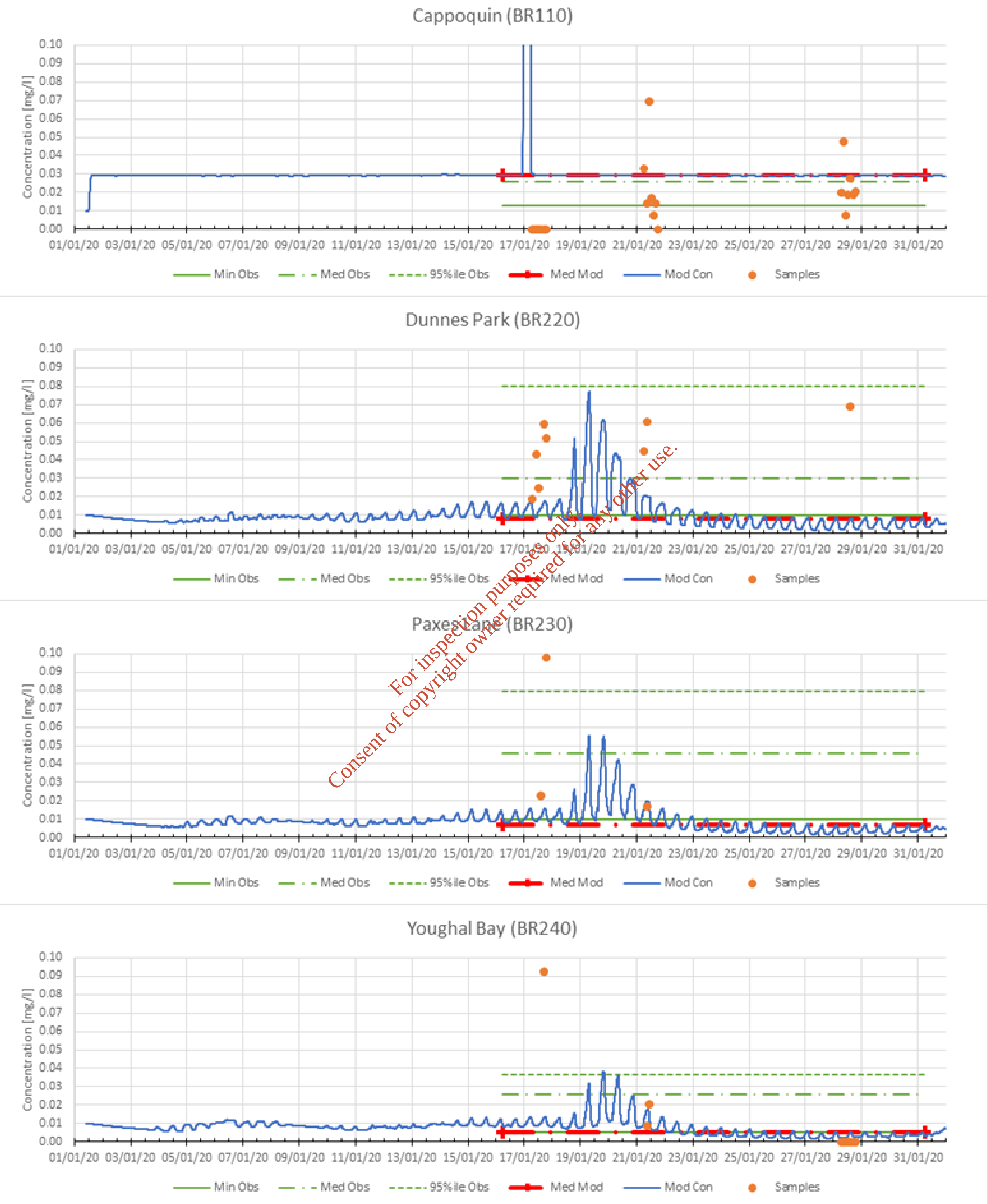


02.06.11_Amm_Modified Base Case- 2.YY.11

Figure 4-22. Summary statistics (mg/l) and plots for the model using median concentrations for ammonia and increased initial (0.04 mg/l) and boundary conditions (0.046 mg) (run code 06.11).

Ammonia [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	0.013	0.042	0.026	0.119	0.223	0.029	0.036	0.029	0.030	0.494	0.003	13%	-0.090	-75%
Dunnes Park (BR220)	0.010	0.037	0.030	0.080	0.081	0.002	0.011	0.008	0.041	0.077	-0.022	-73%	-0.039	-49%
Paxes Lane (BR230)	0.010	0.045	0.046	0.079	0.080	0.002	0.009	0.007	0.027	0.056	-0.039	-86%	-0.052	-65%
Youghal Bay (BR240)	0.005	0.025	0.026	0.037	0.040	0.001	0.007	0.005	0.019	0.038	-0.021	-81%	-0.017	-47%

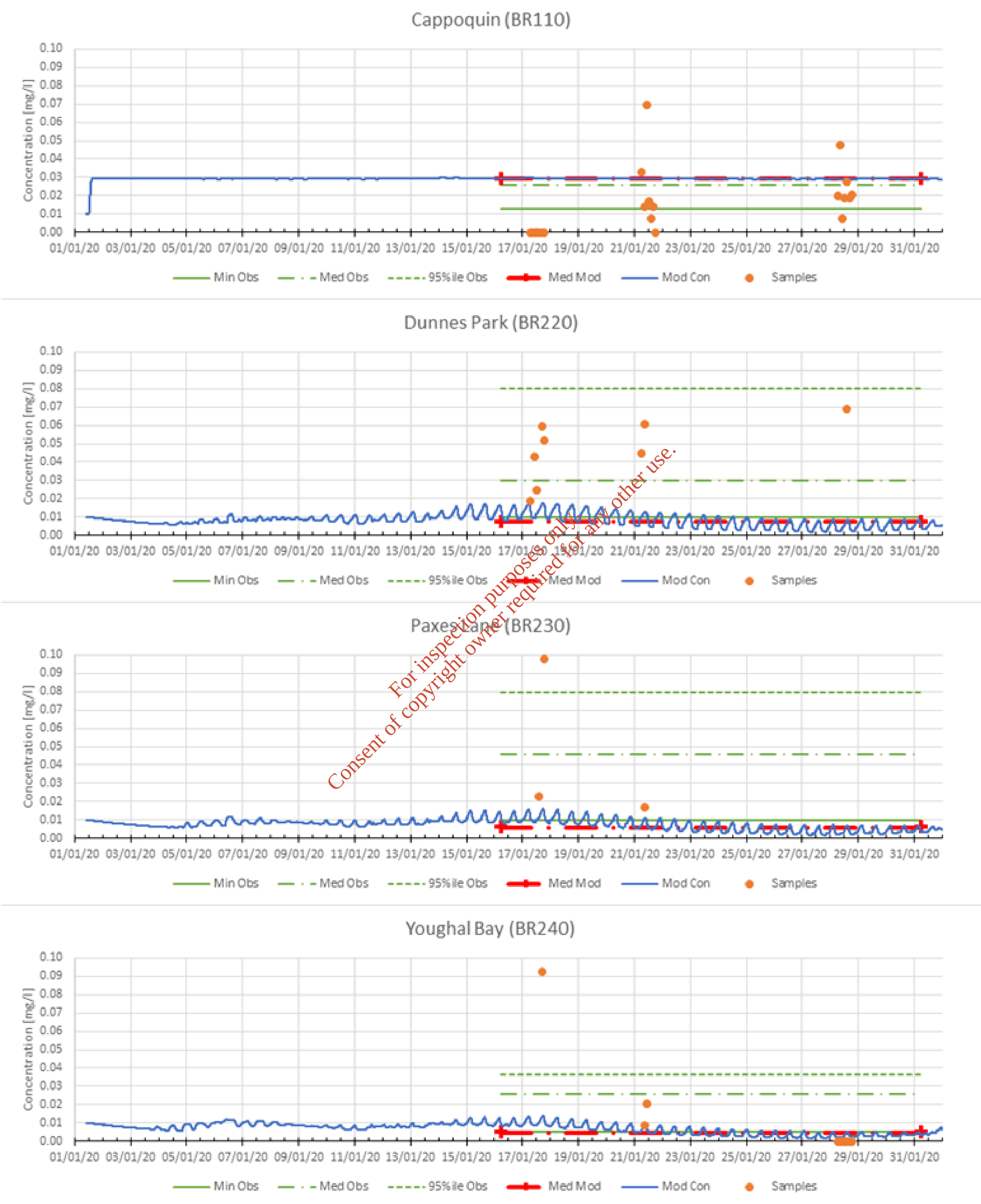


02.06.04_Amm_Pulse discharge in River Blackwater 2.YY.04

Figure 4-23. Summary statistics (mg/l) and plots for a 6-hour pulse of 0.5 mg/l to coincide with a high fluvial flow event at the start of Event B for ammonia. Note: Pulse discharge is 0.5 mg/l and all axes are scaled to allow other values to be readable (run code 06.04).

Ammonia [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	0.013	0.042	0.026	0.119	0.223	0.029	0.029	0.029	0.030	0.030	0.003	13%	-0.090	-75%
Dunnes Park (BR220)	0.010	0.037	0.030	0.080	0.081	0.002	0.008	0.007	0.015	0.017	-0.023	-75%	-0.065	-81%
Paxes Lane (BR230)	0.010	0.045	0.046	0.079	0.080	0.002	0.006	0.006	0.013	0.016	-0.040	-87%	-0.066	-83%
Youghal Bay (BR240)	0.005	0.025	0.026	0.037	0.040	0.001	0.005	0.005	0.011	0.014	-0.021	-82%	-0.025	-70%



02.06.81_Amm_Surface Discharge Median values

Figure 4-24. Summary statistics (mg/l) and plots for the model (surface discharge) using median concentrations for ammonia (run code 06.81).

4.9 Unionised ammonia

Unionised ammonia has been calculated from models of ammonia using the equation shown below (Appendix 7 of EPA, 2012).

$$UnIonised\ Ammonia(mg/l\ NH_3) = \frac{Total\ Ammonia(mg/lN) \times \frac{17}{14}}{1+10^{\left[0.09018+\frac{2729.92}{273.15+Temp°C}-pH\right]}}$$

In practical terms the function estimates unionised ammonia as being approximately 0.2% to 3.2% of the ammonia concentration for the range of pH and temperatures that can be expected in the estuary (7 to 8 for pH and 5 to 15°C for temperature). The factor for the median pH and temperature would be approximately 1% for the winter and 1.5% for the summer. For the purposes of information, a factor of 2% has been assumed for both summer and winter.

Unionised ammonia is directly proportional to the concentration of ammonia. This means that the same limitations exist for unionised ammonia as for ammonia: the contribution from the Youghal WwTP is relatively low compared to other sources and therefore the model can be used to investigate the concentration of unionised ammonia from the WwTP with due consideration of the relative loads from other sources.

4.10 MRP

A summary of the model runs simulating MRP is provided in Table 4.7.

Table 4.7. Summary of the simulations for calibration of MRP against the EPA monitoring data and Irish Water survey data.

Run Code	Description	Initial Conditions [mg/l]	Open Sea Boundary [mg/l]	T_{90} [hours]
05.00	Youghal WwTP only	0.00	0.00	1600
05.01	Median concentrations for all rivers and WwTP's with actual flows.	0.024	0.024	1600
05.04	As 05.11 with a pulse discharge (River Blackwater) of 5 mg/l for 6 hours during a high flow fluvial event.	0.020	0.020	1600
05.11	As 05.01 with changed initial and open sea boundary values	0.00	0.00	950
05.21	As 05.01 with changed initial and open sea boundary values	1.00	0.00	950
05.80	As 05.00 but with Youghal WwTP discharge in surface layer of water column	0.00	0.00	1600
05.81	As 05.01 but with Youghal WwTP discharge in surface layer of water column	0.024	0.024	1600

The maximum surface concentration of MRP for the discharge from Youghal WwTP is shown in Figure 4-25 for the discharge in the bottom layer and Figure 4-26 for the discharge in the surface layer. This shows that the surface concentration of MRP is below 0.002 mg/l within the lower estuary for the discharge to the bed and less than 0.1 mg/l close to the outfall for the discharge in the surface layer. These plots provide a reference for the relative importance of other sources and the background concentration for the purposes of calibration.

The results of the water quality model using actual flows and median concentrations for all river and WwTP's are shown in Figure 4-27 for the discharge in the bottom layer and Figure

4-28 in the surface layer. This shows that the model is estimating the surface concentration of MRP reasonably well with values in the lower estuary within 0.005 mg/l of the EPA monitoring data with the discharge to the surface is a slight improvement.

The observed data for January 2020 recorded values as high as 4.6 mg/l at Cappoquin and concentrations as high as 0.9 mg/l at Dunnes Park and Paxes Lane on the same day. The EPA data shows a maximum value of 0.53 mg/l at Cappoquin and 0.070 mg/l at Paxes Lane. There is therefore likelihood that as with other parameters the concentration can increase for short periods of time due to discharges from other sources.

A simulation of a pulse load of 5 mg/l at Cappoquin was undertaken and the results are shown in Figure 4-29 and Figure 4-30. This shows that a pulse load can result in elevated concentrations in the lower estuary and persists for approximately one week.

The model using the median concentrations for all discharges is a reasonable model of MRP within the estuary with estimated concentrations significantly in excess of the concentrations from the WwTP. The model using the discharge to the surface layer is considered in the calibrated model for further investigations.

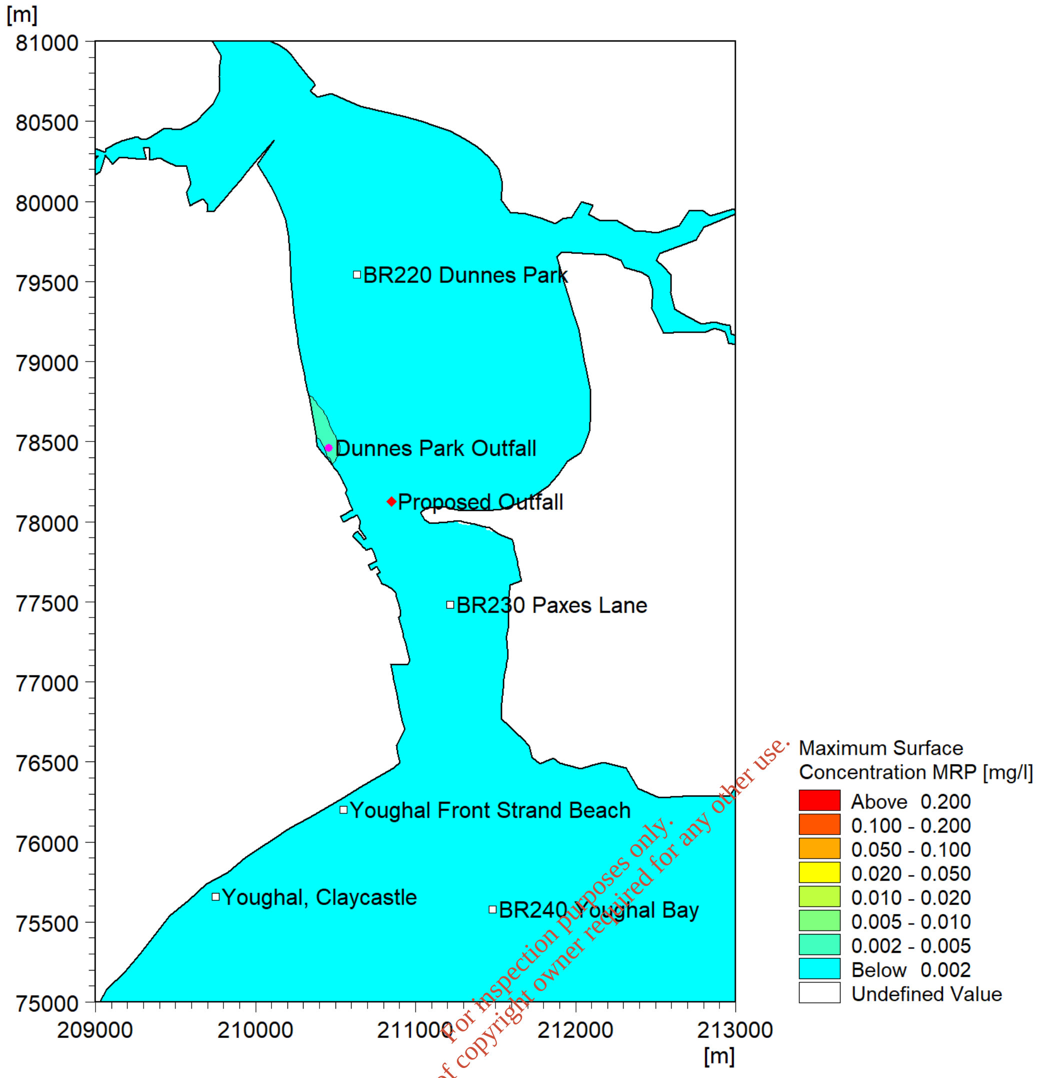


Figure 4-25. Maximum surface concentration of MRP (mg/l) for the discharge from Youghal WwTP through Dunnes Park Outfall over the 15 days of Event B (run code 05.00).

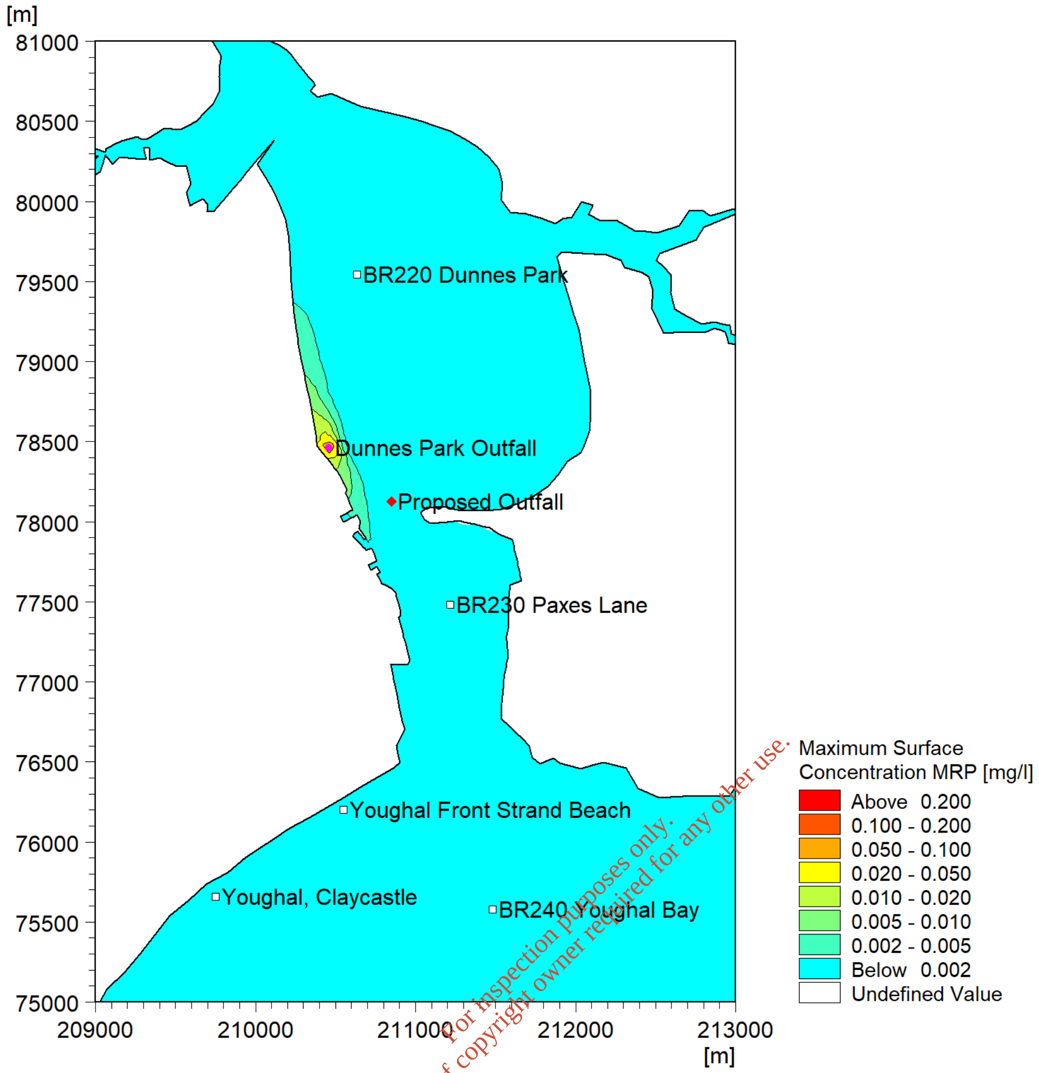
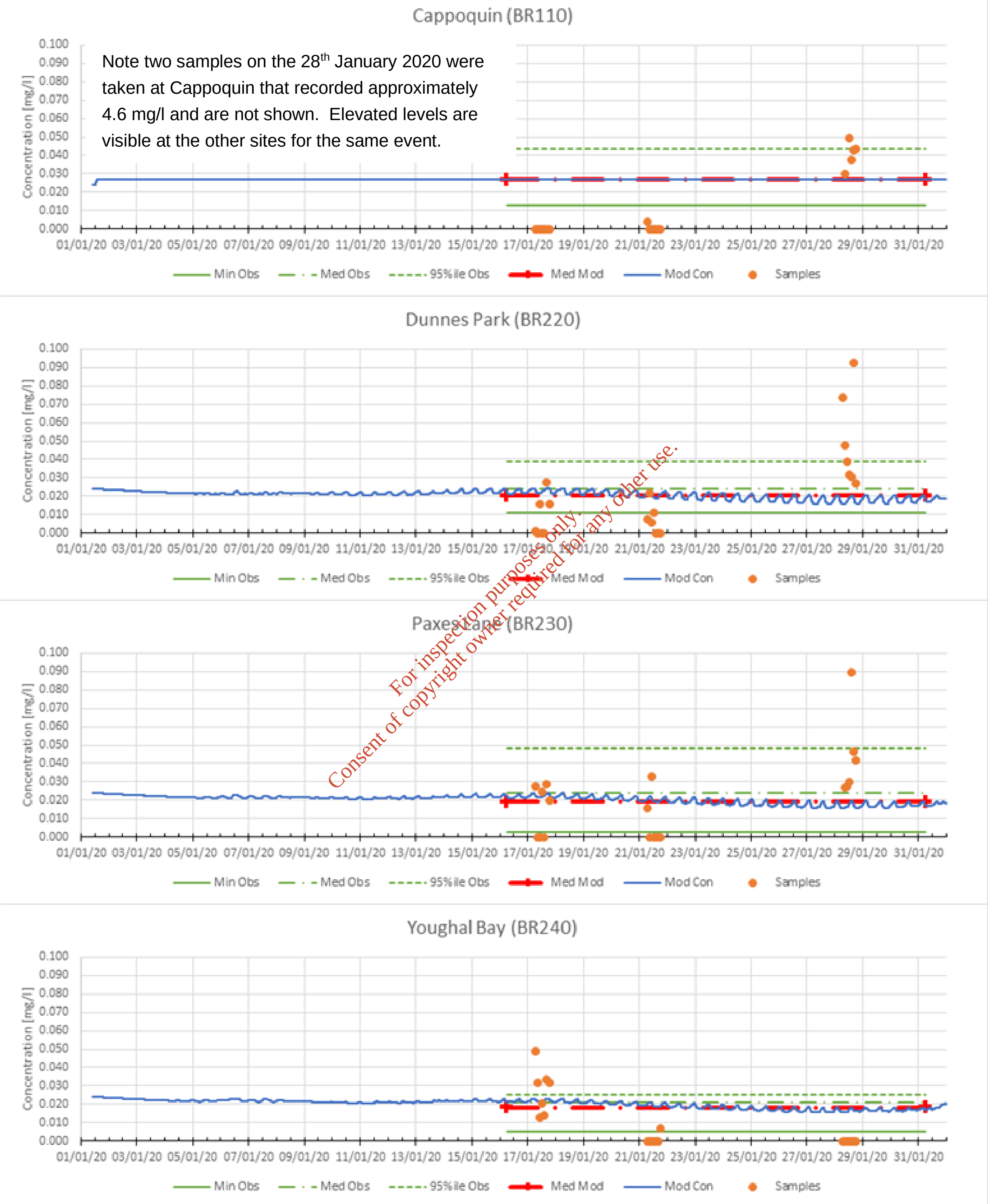


Figure 4-26. Maximum surface concentration of MRP (mg/l) for the discharge from Youghal WwTP through Dunnes Park Outfall over the 15 days of Event B (run code 05.80).

MRP [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	0.013	0.028	0.027	0.043	0.053	0.027	0.027	0.027	0.027	0.027	0.000	0%	-0.016	-38%
Dunnes Park (BR220)	0.011	0.025	0.024	0.039	0.047	0.016	0.020	0.020	0.024	0.024	-0.004	-16%	-0.015	-39%
Paxes Lane (BR230)	0.003	0.025	0.024	0.048	0.070	0.016	0.019	0.019	0.023	0.024	-0.005	-20%	-0.025	-53%
Youghal Bay (BR240)	0.005	0.019	0.021	0.025	0.026	0.015	0.019	0.018	0.022	0.023	-0.003	-13%	-0.003	-12%

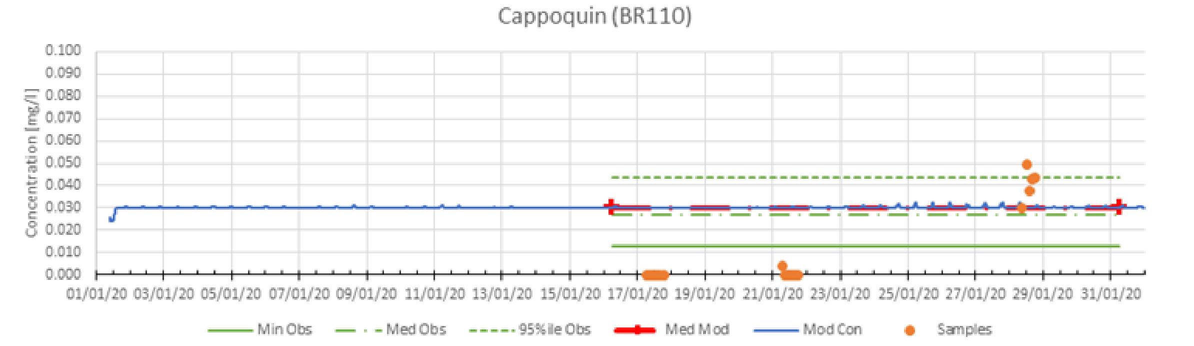


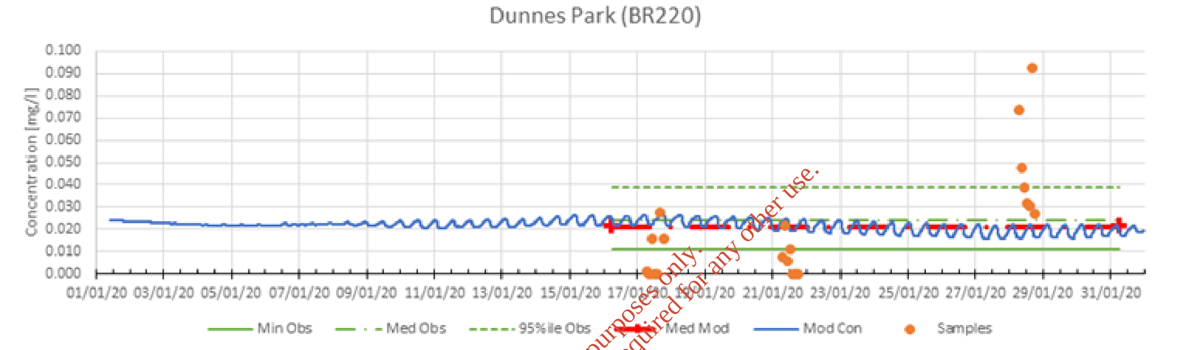
02.05.01_MRP_Base case of estimated values

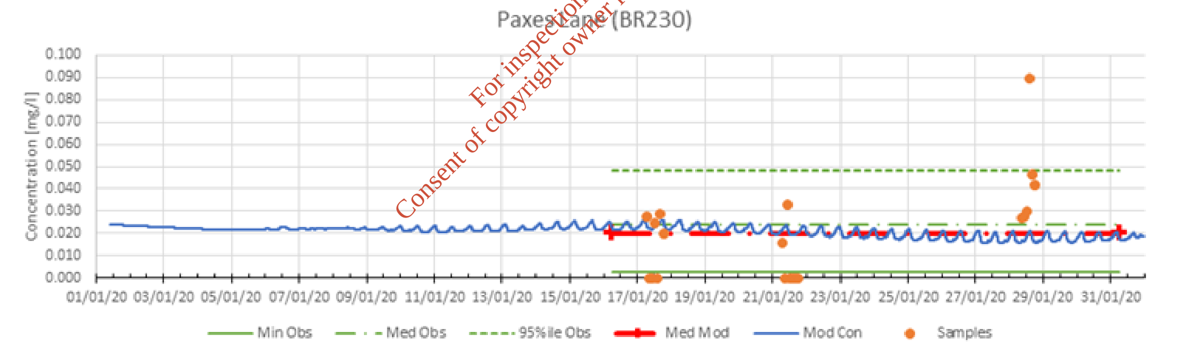
Figure 4-27. Summary statistics (mg/l) and plots for the initial model using median concentrations for MRP (run code 05.01).

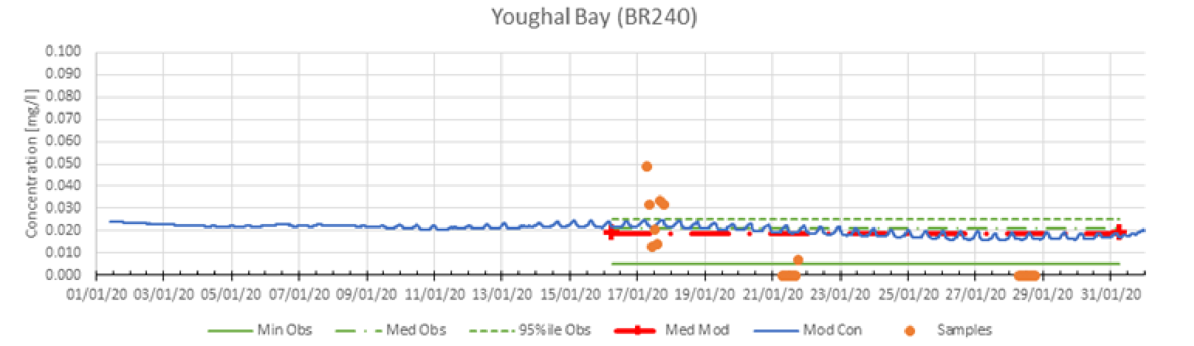
MRP [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	0.013	0.028	0.027	0.043	0.053	0.030	0.030	0.030	0.031	0.032	0.003	11%	-0.013	-29%
Dunnes Park (BR220)	0.011	0.025	0.024	0.039	0.047	0.016	0.021	0.021	0.026	0.026	-0.003	-12%	-0.013	-34%
Paxes Lane (BR230)	0.003	0.025	0.024	0.048	0.070	0.016	0.020	0.020	0.024	0.026	-0.004	-17%	-0.024	-49%
Youghal Bay (BR240)	0.005	0.019	0.021	0.025	0.026	0.016	0.019	0.019	0.023	0.025	-0.002	-10%	-0.002	-8%







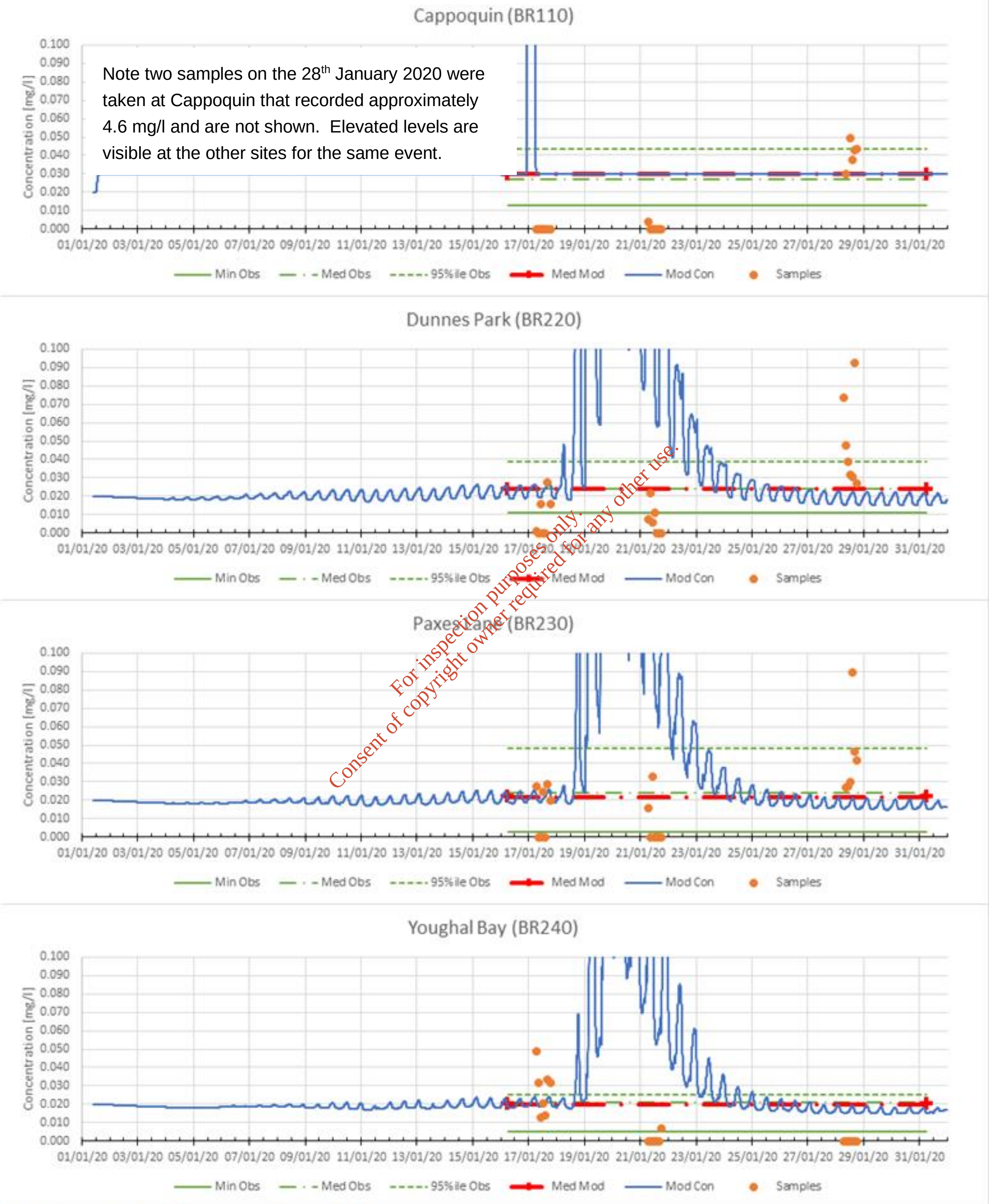


02.05.81_MRP_Surface Discharge Median values

Figure 4-28. Summary statistics (mg/l) and plots for the initial model using median concentrations for MRP discharged to the surface layer (run code 05.81).

MRP [mg/l]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	0.013	0.028	0.027	0.043	0.053	0.030	0.099	0.030	0.030	4.591	0.003	11%	-0.013	-31%
Dunnes Park (BR220)	0.011	0.025	0.024	0.039	0.047	0.015	0.083	0.024	0.464	0.893	0.000	-1%	0.425	1093%
Paxes Lane (BR230)	0.003	0.025	0.024	0.048	0.070	0.015	0.065	0.022	0.317	0.674	-0.002	-9%	0.269	558%
Youghal Bay (BR240)	0.005	0.019	0.021	0.025	0.026	0.015	0.049	0.020	0.202	0.452	-0.001	-5%	0.177	700%



02.05.04_MRP_Pulse discharge in River Blackwater 2.YY.04

Figure 4-29. Summary statistics (mg/l) and plots for a 6-hour pulse of 5 mg/l to coincide with a high fluvial flow event at the start of Event B for MRP (run code 05.04). Note: Pulse discharge is 5 mg/l and all axes are scaled to allow other values to be readable.

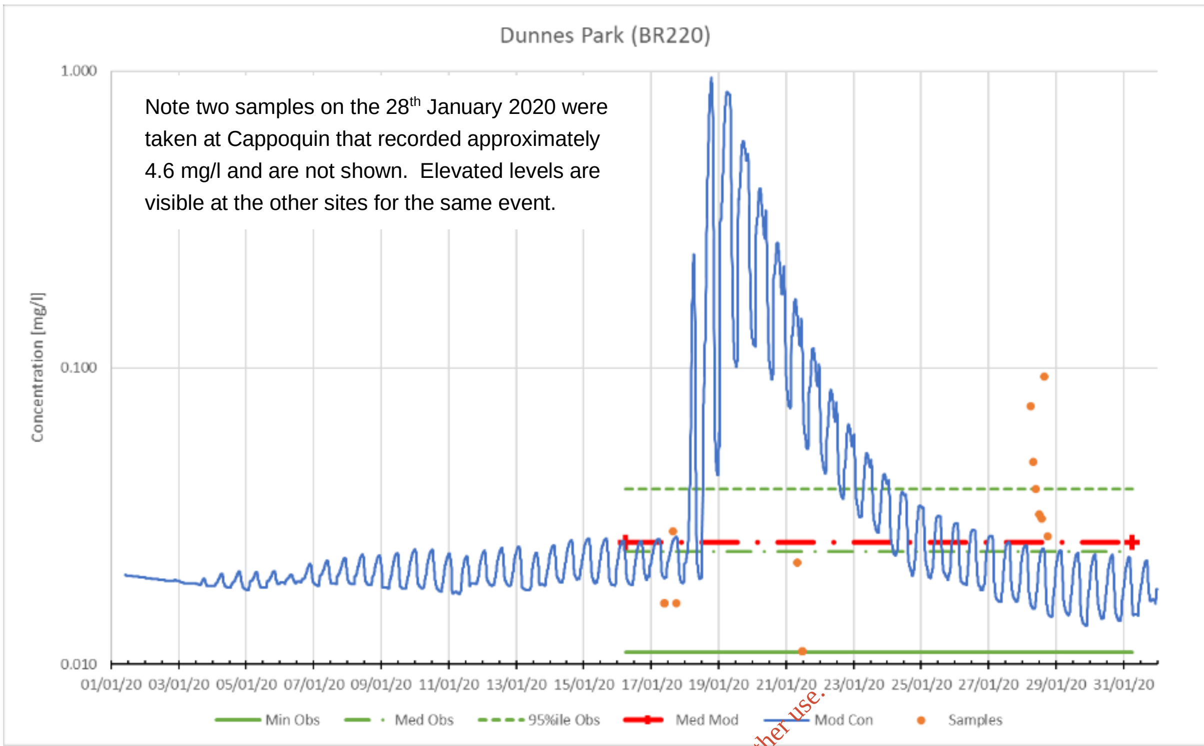


Figure 4-30. Surface concentration at Dunnes Park for a 6-hour pulse of 5 mg/l to coincide with a high fluvial flow event at the start of Event B for MRP (run code 05.04).

4.11 E. coli

A summary of the model runs simulating EC is provided in Table 4.8.

The maximum surface concentration of EC for the discharge from Youghal WwTP is shown in Figure 4-31 for the discharge to the bottom layer and in Figure 4-32 for the discharge to the surface layer. These plots show a significant difference between the two models with discharge to the upper layer resulting in higher concentrations within the lower estuary with a significant gradient across the estuary suggesting that the location of a sample point could be critical to the observed concentration. The discharge in the bottom layer results in the maximum surface concentration in the lower estuary of generally below 5 cfu / 100ml with an area around the outfall that has higher maximum concentrations, but still less than 250 cfu/100ml. For the discharge in the surface layer the results are an order of magnitude higher, but still showing significant decrease away from the outfall.

The results of the water quality model using actual flows and median concentrations for all river and WwTP's are shown in Figure 4-33 (discharge to the bottom layer) and show that the concentrations are reasonable at Cappoquin, suggesting that the river boundary condition is suitable. However, in the lower estuary the results are one to two orders of magnitude too low and this suggests that the model was not accurately simulating EC within the area. A longer T_{90} of 48 hours does increase the values slightly but not by an order of magnitude. Increasing the initial conditions and the boundary conditions of the open sea does not alter the results significantly either.

Table 4.8. Summary of the simulations for calibration of EC against the EPA monitoring data and Irish Water survey data.

Run Code	Description	Initial Conditions [mg/l]	Open Sea Boundary [mg/l]	T_{90} [hours]
02.00	Youghal WwTP only	0.00	0.00	24
02.01	Median concentrations for all rivers and WwTP's with actual flows.	100	100	24
02.02	As 02.01 with decreased T_{90}	100	100	12
02.03	As 02.01 with increased T_{90}	100	100	48
02.04	As 02.01 with a pulse discharge (River Blackwater) of 10 000 cfu/100ml for 6 hours during a high flow fluvial event.	100	100	24
02.05	As 02.01 with increased T_{90}	100	100	96
02.06	As 02.01 with increased T_{90}	100	100	144
02.07	As 02.01 with increased T_{90}	100	100	192
02.11	As 02.01 with changed initial and open sea boundary values	1000	1000	24
02.41	As 02.01 with increased concentrations in the rivers	1000	1000	24
02.80	As 02.00 but with Youghal WwTP discharge in surface layer of water column	0.00	0.00	24
02.81	As 02.01 but with Youghal WwTP discharge in surface layer of water column	100	100	24

As discussed in section 4.2 the decay rate of bacteria in freshwater is potentially much longer than in sea water. A sensitivity analysis for discharges to both the surface and bottom layer of the model was undertaken for a range of T_{90} values. The results are shown in Figure 4-34 and show that the discharge to the surface or bottom layer does not affect the results at the sampling locations significantly (the markers appear on the line but are slightly off of the line). The data also shows that the increase in T_{90} is not sufficient to explain the difference in the statistics as the modelled values are levelling off below the 95%ile values for the EPA data. This suggests that the 95%ile of the EPA data is a consequence of events that increase the concentration periodically, such as large pluvial or fluvial events, possibly similar to the ones that happened in January 2020. Additionally, this review suggests that the discharge to the surface layer does affect the maximum concentration close to the discharge location, but that the hydrodynamic processes of advection and dispersion dominate further from the discharge location. A review of the modelled surface salinity for the summer and winter at each of the three EPA sampling locations is shown in Figure 4-35. This shows that the 50%ile of salinity varies in summer and winter due to the river flow; however, the salinity is not dominated by freshwater flow and therefore the selection of a decay rate purely based on the presence of freshwater is not appropriate.

The 95%ile plot of the surface concentration for the most conservative of model runs is shown in Figure 4-36 with the comparison of the summary statistics in Figure 4-37. The results show that the model reproduces the median values reasonably well however the 95%iles are low. It is not considered appropriate to simply select the longest decay rate to try and correct for low values in the model compared to the observed data. It is considered more likely that there are additional sources that could affect the background concentrations for which additional data would be required.

The model was also used to evaluate the summer conditions and compared to the EPA monitoring data for Youghal Front Strand and Clay Castle beaches. The summary statistics for the monitoring data were presented in section 2.3. These show very low median values for EC of 10 and 20 cfu /100 ml at Clay Castle and Front Strand beach, respectively. The model for all decay rates (12, 24 and 48 hours) shows a maximum concentration of 1 cfu /100 ml.

The review of all the data and sensitivity tests of the models suggests that whilst the median concentrations for the winter and summer are achieved, the 95%ile concentrations are being under-estimated. The reason is not fully explained by the decay rate but is more likely due to missing sources of EC.

The Technical Standard (Table 10-1, Irish Water, 2020) provides the range of decay rates for bacteria in coastal and estuarine waters for summer and winter. For the purpose of scenario testing it is recommended that the decay rates of 24 hours and 48 hours are used for the summer and winter respectively. The range of values and selected value are summarised in The model can reproduce the changes in concentration of EC in the estuary due to the WwTP; however, the absolute concentration in the estuary is highly dependent on the other sources. The model has demonstrated that the warm-up period is of sufficient duration to achieve a “steady state” solution irrespective of the initial conditions. The model should be used to evaluate the dispersion of EC from the existing and proposed outfalls with due regard to the uncertainty in the other sources entering the receiving waters.

Table 4-9.

The model can reproduce the changes in concentration of EC in the estuary due to the WwTP; however, the absolute concentration in the estuary is highly dependent on the other sources. The model has demonstrated that the warm-up period is of sufficient duration to achieve a “steady state” solution irrespective of the initial conditions. The model should be used to evaluate the dispersion of EC from the existing and proposed outfalls with due regard to the uncertainty in the other sources entering the receiving waters.

Table 4-9. Summary of the decay rates (T_{90}) for EC from the Technical Standard (Irish Water, 2020) and the values to be used for investigations.

Summer		Winter	
Technical Standard Range	**Selected value**	**Technical Standard Range**	**Selected value**
12 to 24 hours	24 hours	24 to 48 hours	48 hours

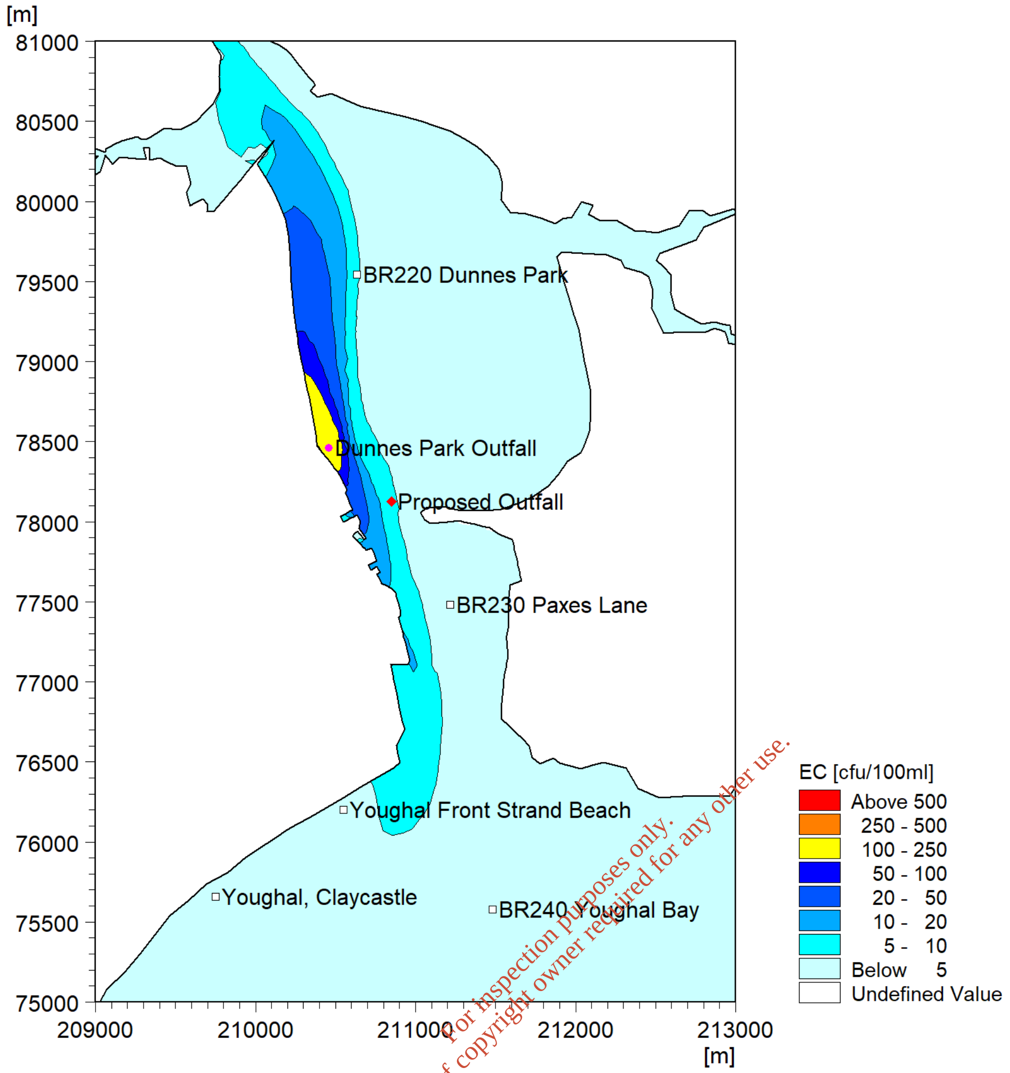


Figure 4-31. Maximum surface concentration of EC (cfu/100ml) for the discharge from Youghal WwTP through Dunnes Park Outfall over the 15 days of Event B (run code 02.00).

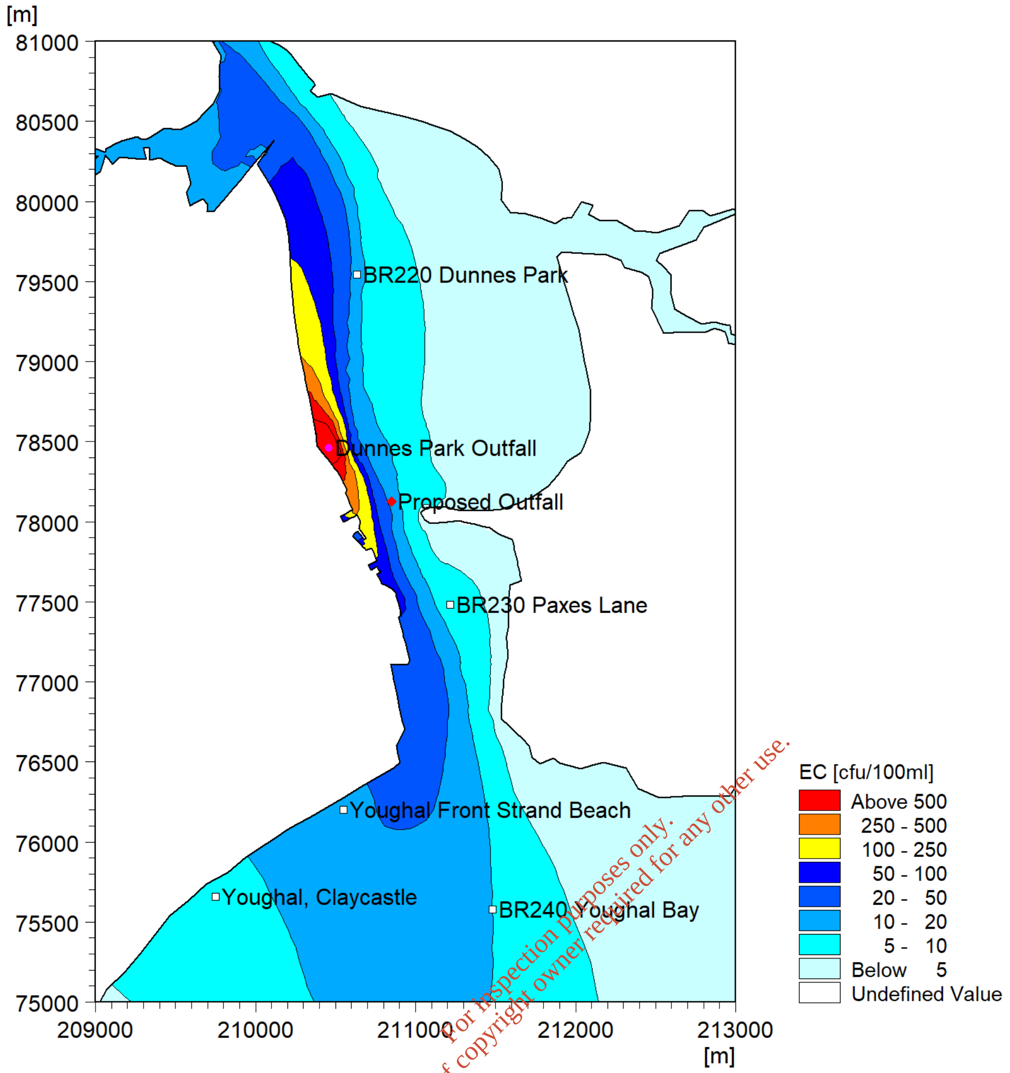
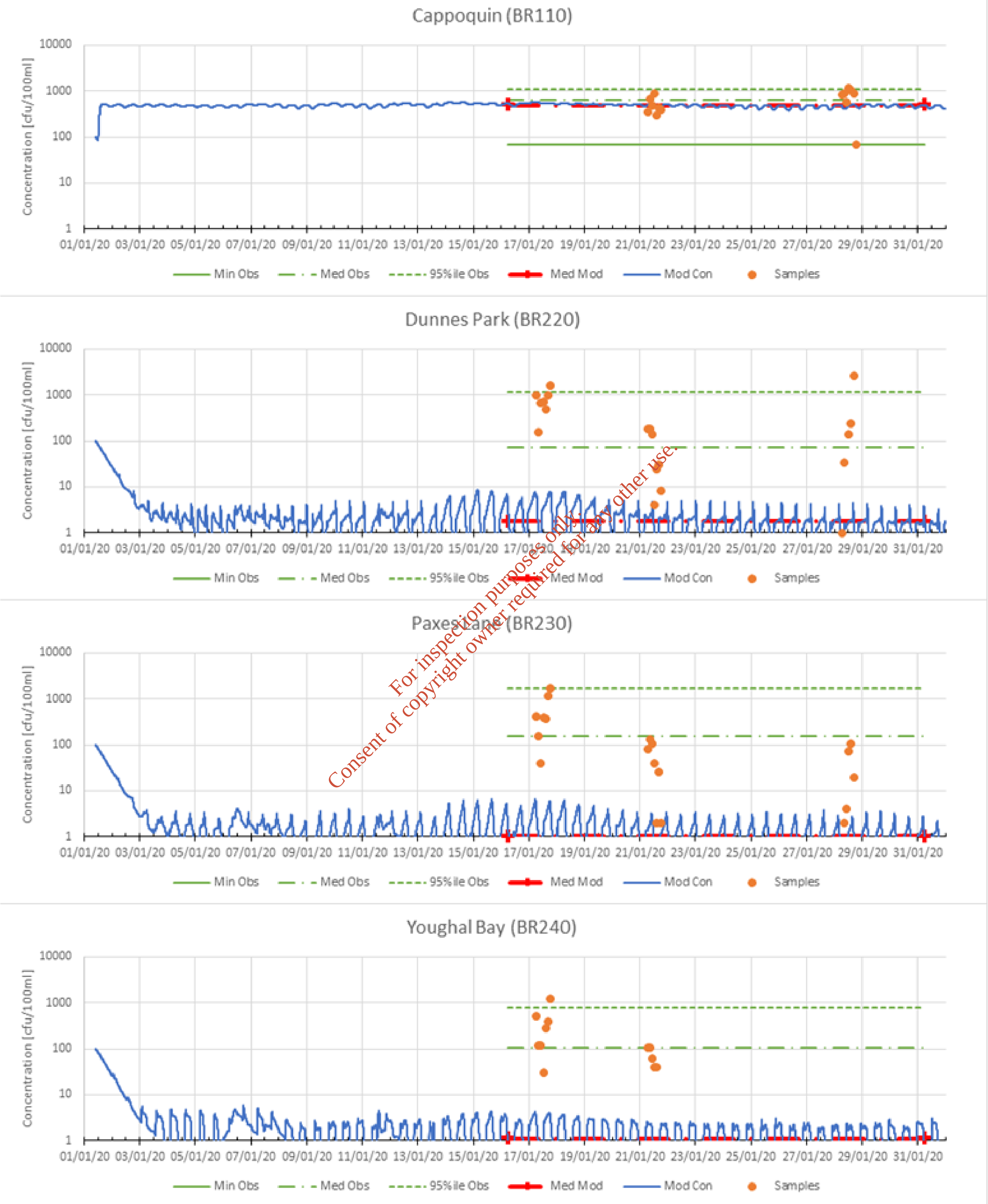


Figure 4-32. Maximum surface concentration of EC (cfu/100ml) for the discharge (to the surface layer) from Youghal WwTP through Dunnes Park Outfall over the 15 days of Event B (run code 02.80).

E. Coli [cfu /100 ml]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	70	657	643	1,094	1,169	380	486	493	545	568	-150	-23%	-549	-50%
Dunnes Park (BR220)	0	237	72	1,169	1,785	0	2	2	5	8	-71	-98%	-1,164	-100%
Paxes Lane (BR230)	0	451	156	1,664	2,755	0	1	1	3	7	-155	-99%	-1,661	-100%
Youghal Bay (BR240)	0	222	109	781	1,267	0	1	1	3	4	-107	-99%	-779	-100%



02.02.01_EC_Base case of estimated values

Figure 4-33. Summary statistics (cfu/100ml) and plots for the initial model using median concentrations for EC (run code 02.01).

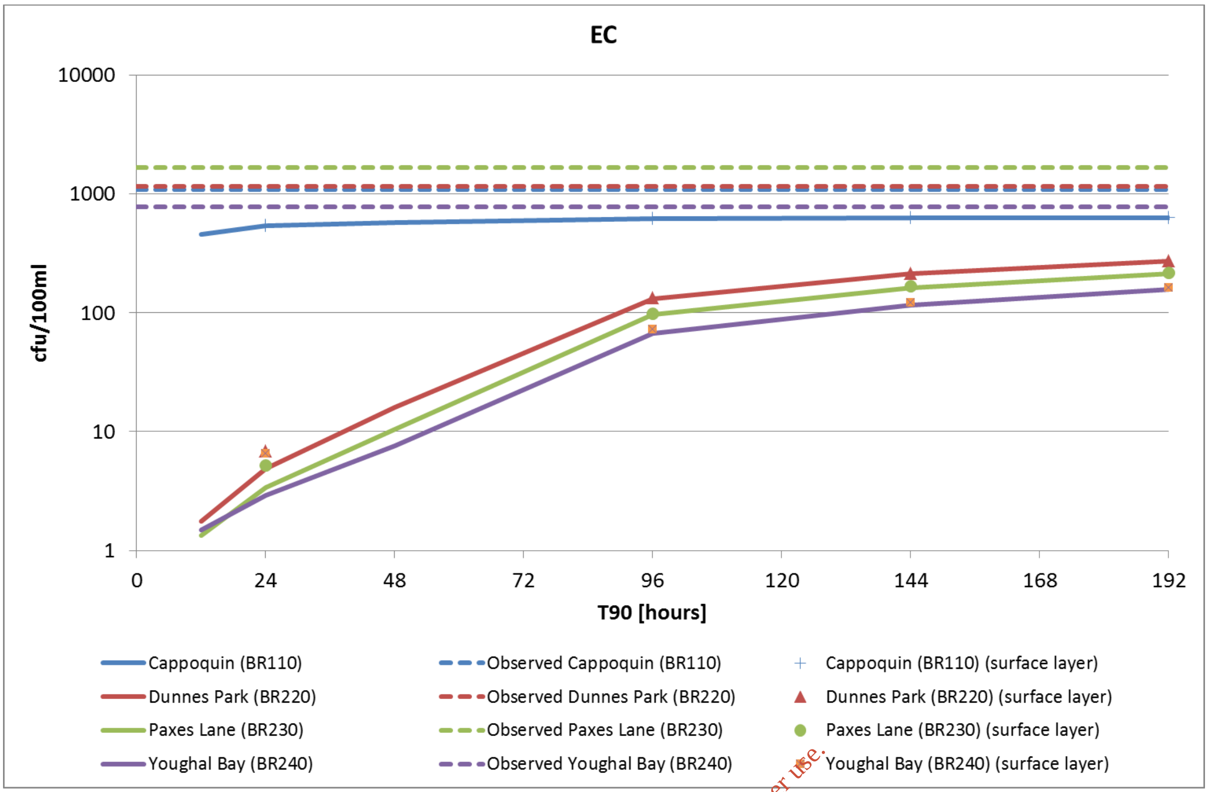


Figure 4-34. Comparison of the 95%ile concentrations of EC at the sampling locations for different T_{90} values and discharge to the surface (markers only) and bottom layer (solid line without markers) with the EPA data (dashed lines) for each point.

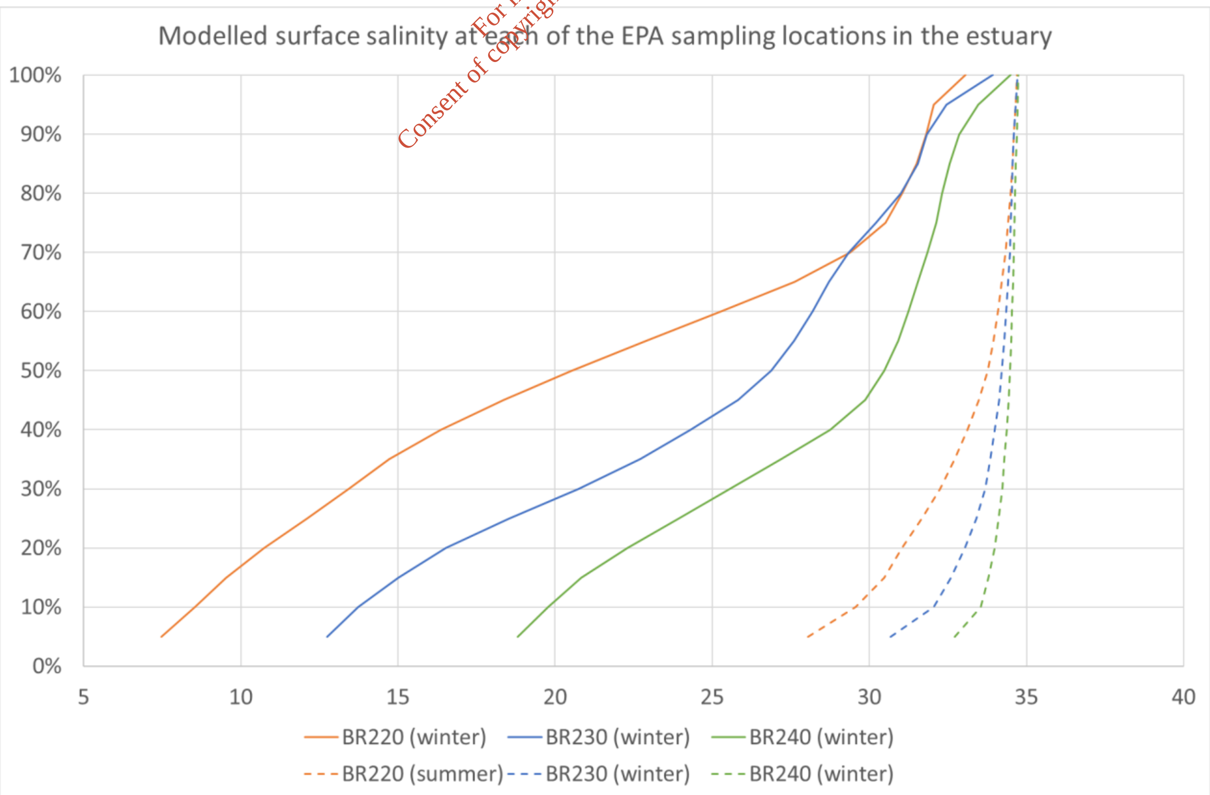


Figure 4-35. Modelled surface salinity at each of the three EPA monitoring stations.

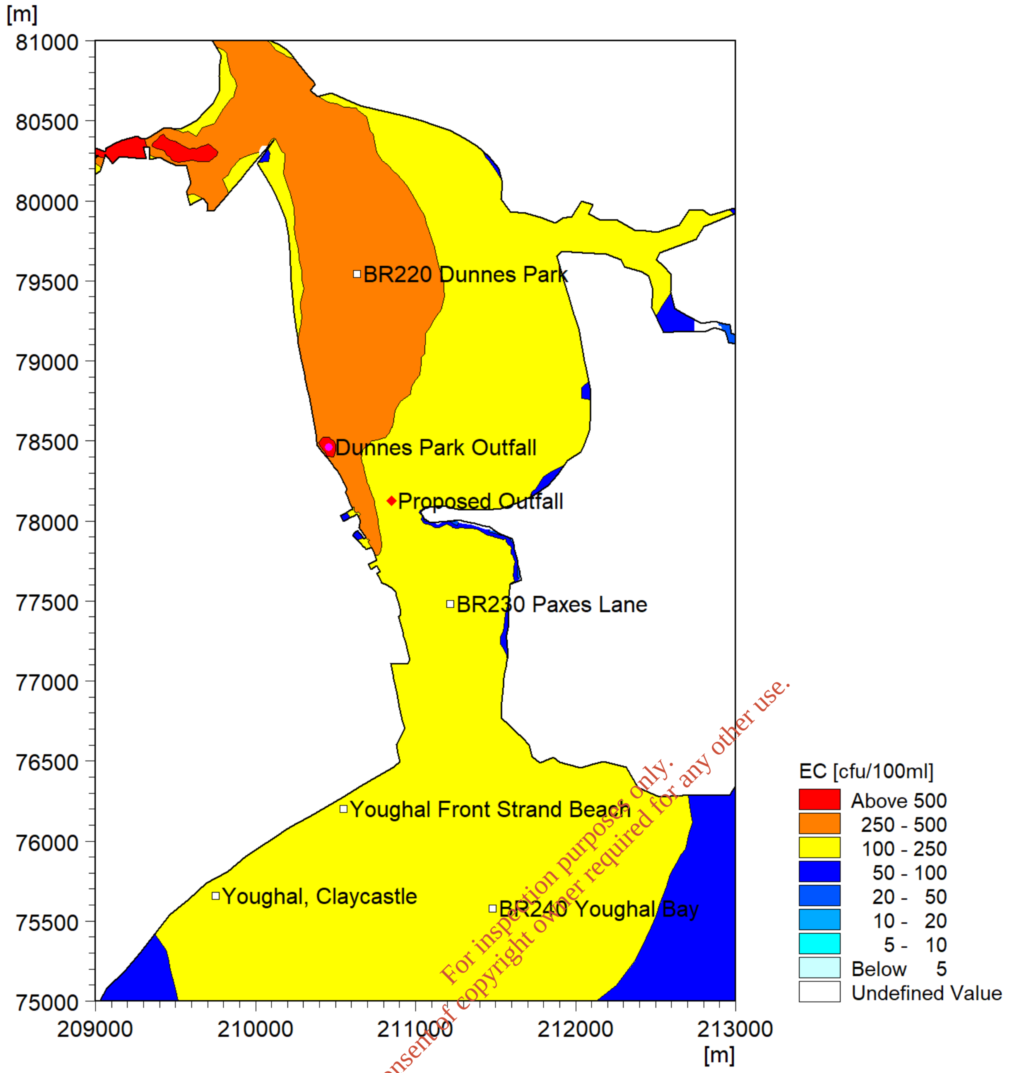
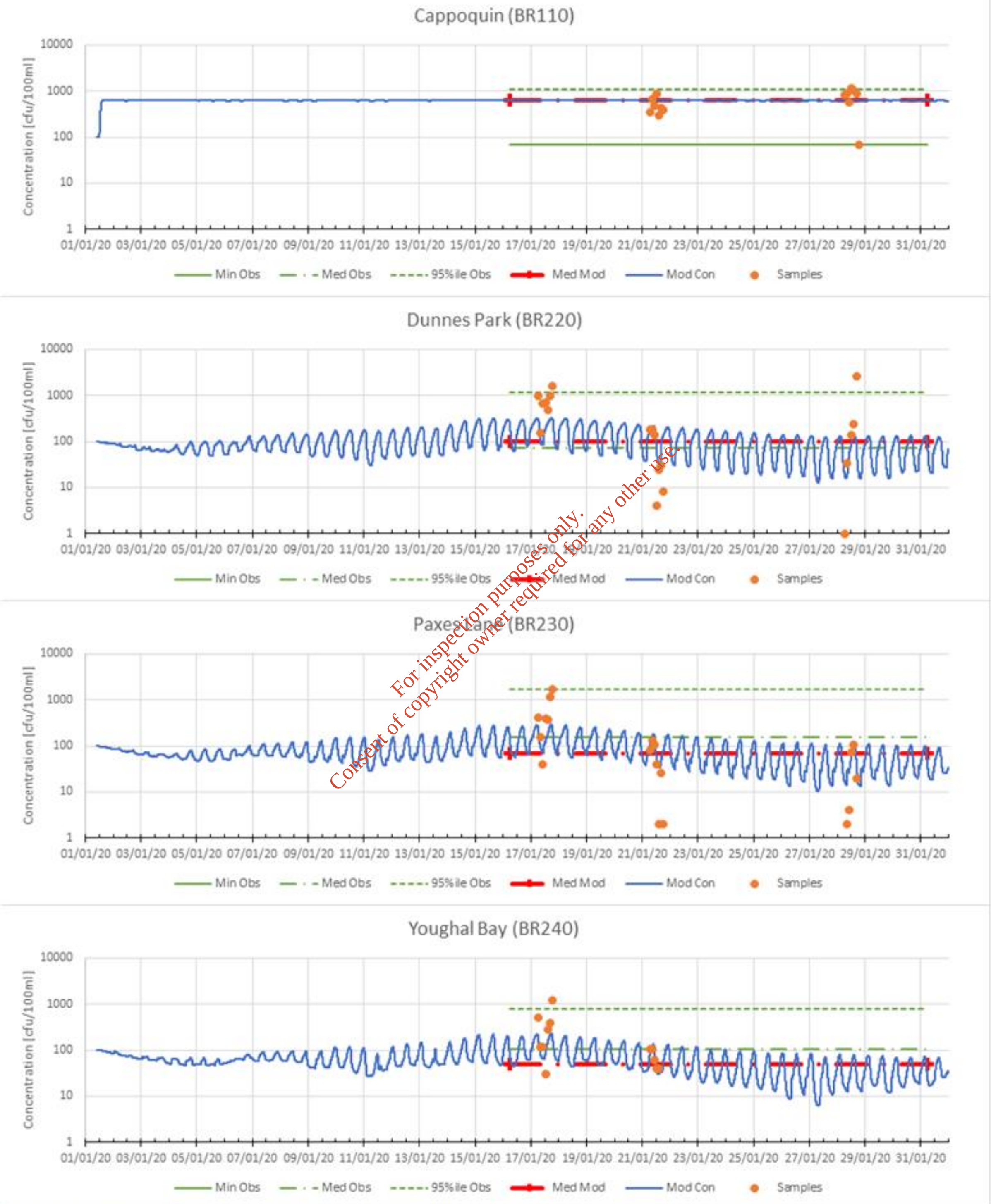


Figure 4-36. 95%ile concentration for the discharge to the surface layer and T_{90} = 192 hours with all sources (run code 02.87).

E. Coli [cfu /100 ml]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	70	657	643	1,094	1,169	608	627	628	636	639	-15	-2%	-458	-42%
Dunnes Park (BR220)	0	237	72	1,169	1,785	12	112	99	276	326	26	37%	-893	-76%
Paxes Lane (BR230)	0	451	156	1,664	2,755	10	84	67	219	290	-89	-57%	-1,445	-87%
Youghal Bay (BR240)	0	222	109	781	1,267	6	61	49	163	229	-60	-55%	-619	-79%



02.02.87_EC_Surface Discharge Revised Decay Rates (EC 192 hrs IE 384 hrs)

Figure 4-37. Summary statistics (cfu/100ml) and plots for the initial model using median concentrations for EC with the discharge to the surface layer and conservative decay rate of T_{90} = 192 hours (run code 02.87).

4.12 Intestinal Enterococci (IE)

A summary of the model runs simulating IE is provided in Table 4.10.

Table 4.10. Summary of the simulations for calibration of IE against the EPA monitoring data and Irish Water survey data.

Run Code	Description	Initial Conditions [mg/l]	Open Sea Boundary [mg/l]	T_{90} [hours]
03.00	Youghal WwTP only	0.00	0.00	48
03.01	Median concentrations for all rivers and WwTP's with actual flows.	50	50	48
03.02	As 03.01 with decreased T_{90}	50	50	24
03.03	As 03.01 with increased T_{90}	50	50	96
03.04	As 03.01 with a pulse discharge (River Blackwater) of 5 000 cfu/100ml for 6 hours during a high flow fluvial event.	50	50	48
03.05	As 03.01 with increased T_{90}	50	50	192
03.06	As 03.01 with increased T_{90}	50	50	288
03.07	As 03.01 with increased T_{90}	50	50	384
03.80	As 03.00 but with Youghal WwTP discharge in surface layer of water column	0.00	0.00	48
03.81	As 03.01 but with Youghal WwTP discharge in surface layer of water column	50	50	48

The maximum surface concentration of IE for the discharge from Youghal WwTP is shown in Figure 4-38 for the discharge to the bottom layer of the model and in Figure 4-39 for the discharge to the surface layer of the model. This shows that the surface concentration in the lower estuary is generally below 20 cfu /100ml with an area close to the outfall that has higher maximum concentrations.

The results of the water quality model using actual flows and median concentrations for all river and WwTP's are shown in Figure 4-40 and show that the concentrations are reasonable at Cappoquin, suggesting that the river boundary condition is reasonable. However, in the lower estuary the results are one to two orders of magnitude low and this suggests that the model is not accurately simulating IE within the area. A longer T_{90} of 96 hours does increase the values slightly but not by an order of magnitude.

A sensitivity analysis of the decay rate and the discharge to the bottom or surface layer of the model is presented in Figure 4-41. This shows that the 95%ile is not being achieved in the model however the decay rate does not fully explain the difference. It is considered likely that fluvial events provide the additional load to increase the concentration for the higher percentiles.

The summary statistics for the run using the longest decay rate of T_{90}=384 hours and a discharge to the surface layer of the model are presented in Figure 4-42.

The model was also used to evaluate the summer conditions and compared to the EPA monitoring data for Youghal Front Strand and Clay Castle beaches. The summary statistics for the monitoring data were presented in section 2.3. These show very low median values for IE of 4 and 3 cfu /100 ml at Clay Castle and Front Strand beach, respectively. The model for all decay rates (24, 48 and 96 hours) shows a maximum concentration of <1 cfu /100 ml.

The review of all the data and sensitivity tests of the models suggests that whilst the median concentrations for the winter and summer are achieved, the 95%ile concentrations are being under-estimated. The reason is not fully explained by the decay rate but is more likely due to missing sources of IE.

The Technical Standard (Table 10-1, Irish Water, 2020) provides the range of decay rates for bacteria in coastal and estuarine waters for summer and winter. For the purpose of scenario testing it is recommended that the decay rates of 24 hours and 48 hours are used for the summer and winter respectively. The range of values and selected value are summarised in Table 4-11.

The model can reproduce the changes in concentration of IE in the estuary due to the WwTP; however, the absolute concentration in the estuary is highly dependent on the other sources. The model has demonstrated that the warm-up period is of sufficient duration to achieve a "steady state" solution irrespective of the initial conditions. The model should be used to evaluate the dispersion of IE from the existing and proposed outfalls with due regard to the uncertainty in the other sources entering the receiving waters.

Table 4-11. Summary of the decay rates (T_{90}) for IE from the Technical Standard (Irish Water, 2020) and the values to be used for investigations.

Summer		Winter	
Technical Standard Range	**Selected value**	**Technical Standard Range**	**Selected value**
24 to 48 hours	48 hours	48 to 96 hours	96 hours

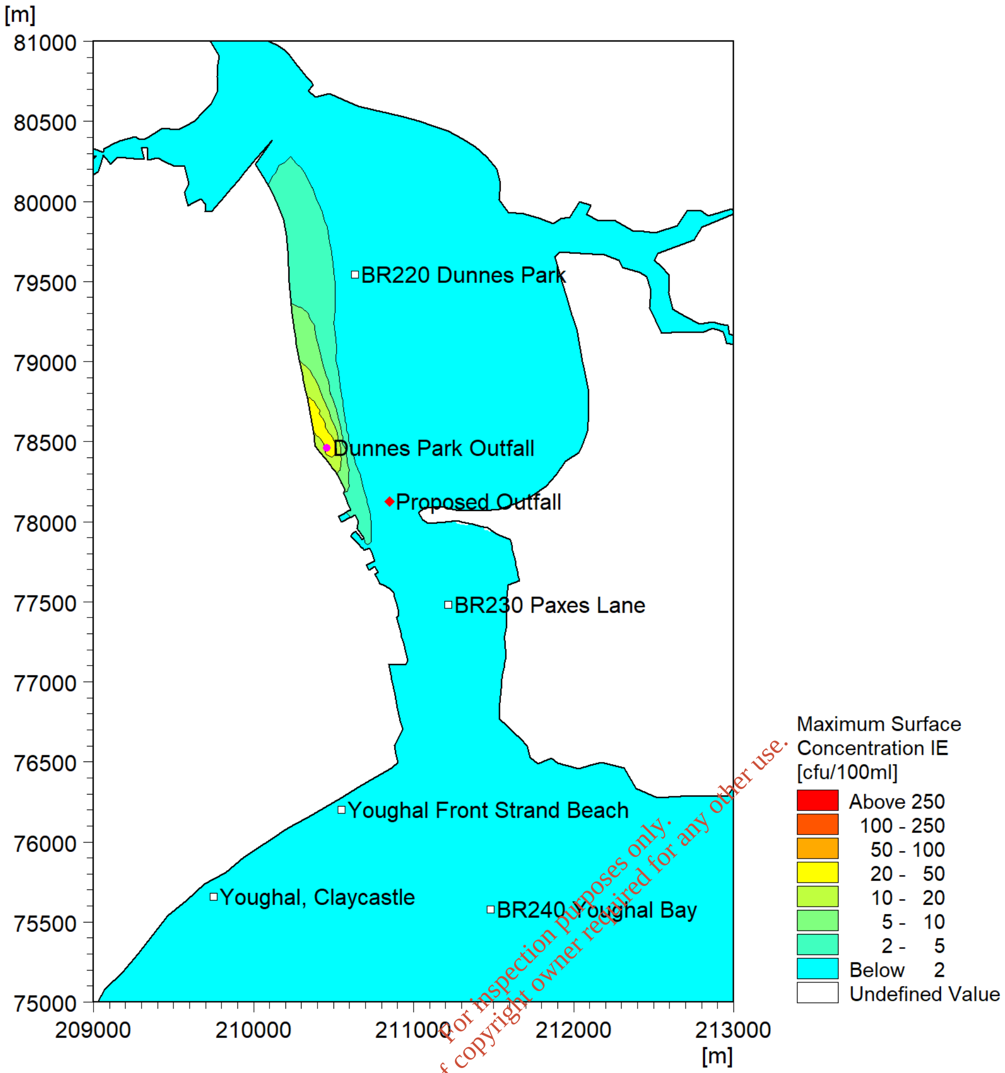


Figure 4-38. Maximum surface concentration of IE (cfu/100ml) for the discharge to the bottom layer from Youghal WwTP through Dunnes Park Outfall over the 15 days of Event B (run code 03.00).

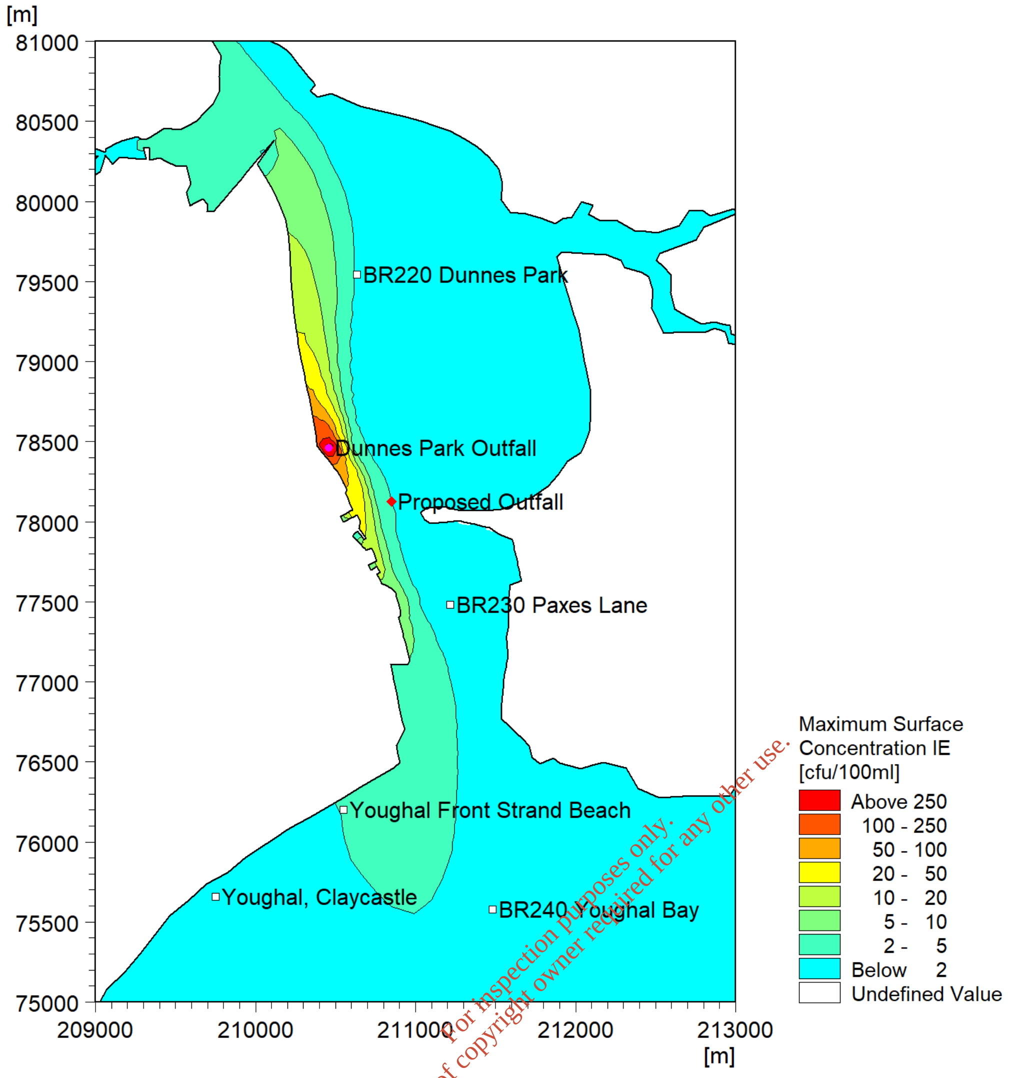


Figure 4-39. Maximum surface concentration of IE (cfu/100ml) for the discharge to the surface layer from Youghal WwTP through Dunnes Park Outfall over the 15 days of Event B (run code 03.80).

Intestinal Enterococci [cfu/100 ml]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	42	164	140	376	590	118	132	134	139	142	-6	-5%	-236	-63%
Dunnes Park (BR220)	2	113	30	160	1,480	0	3	2	10	17	-28	-94%	-150	-94%
Paxes Lane (BR230)	2	86	70	310	310	0	2	1	7	12	-69	-98%	-303	-98%
Youghal Bay (BR240)	7	49	45	101	120	0	1	1	5	8	-44	-98%	-95	-95%

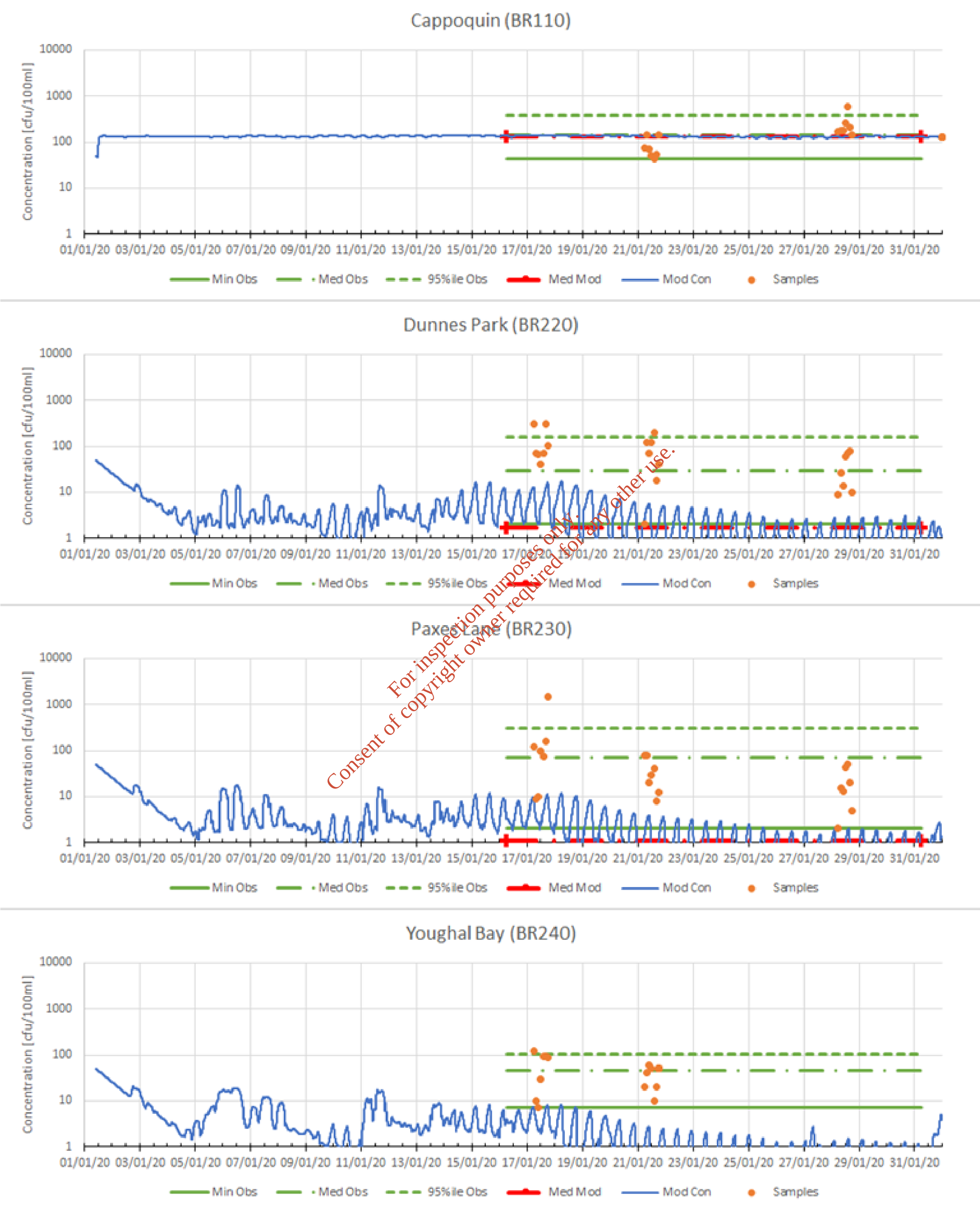


Figure 4-40. Summary statistics (cfu/100ml) and plots for the initial model using median concentrations for IE.

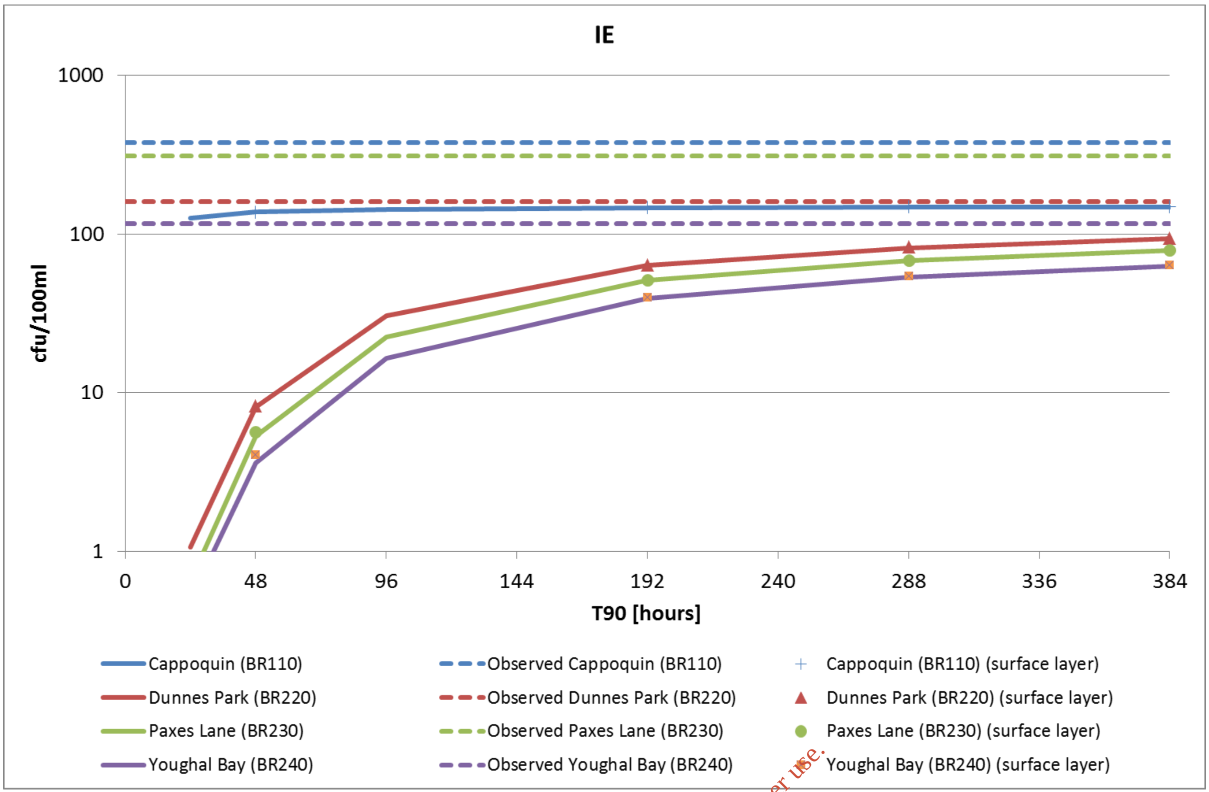
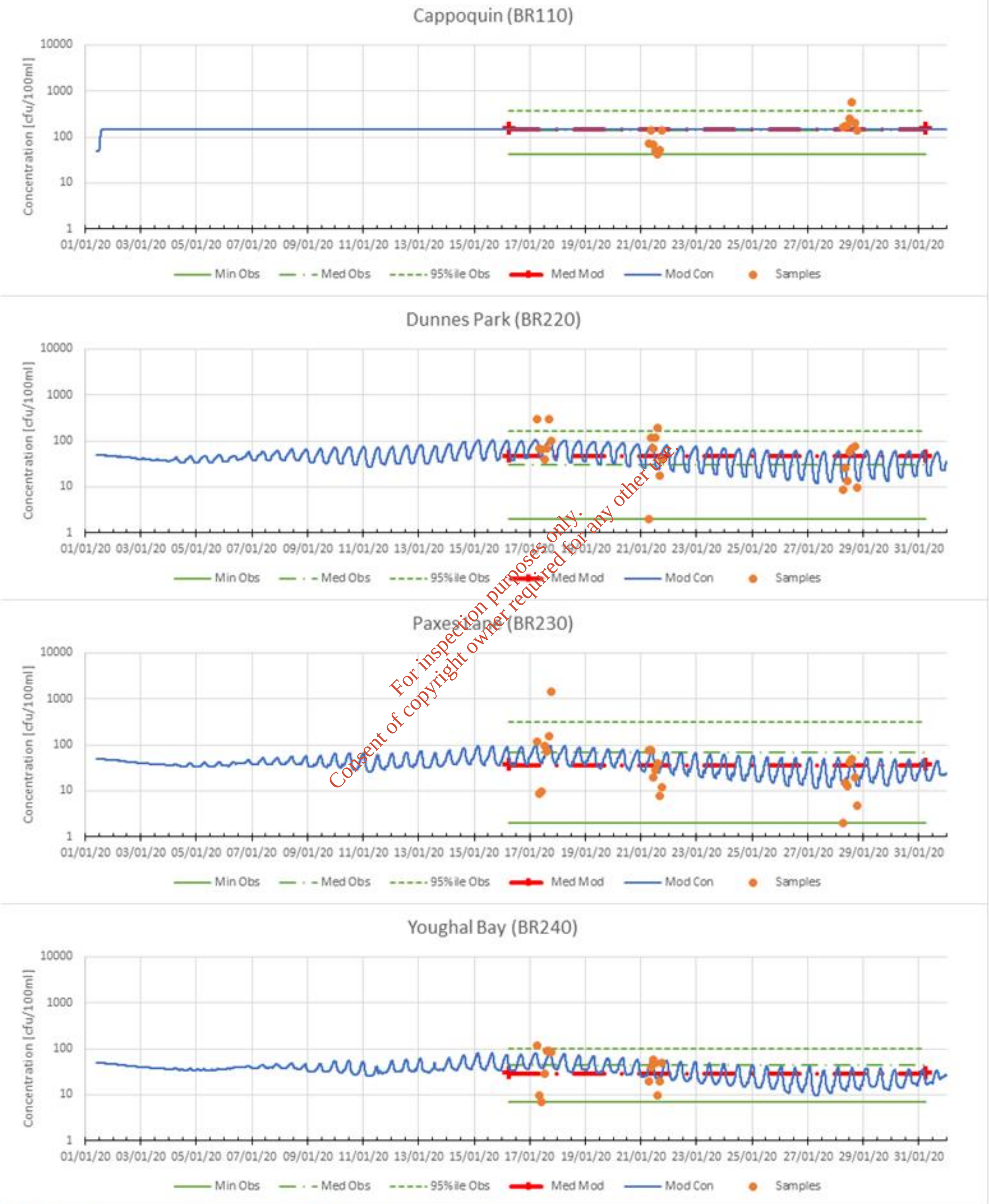


Figure 4-41. Comparison of the 95%ile concentrations of IE at the sampling locations for different T_{90} values and discharge to the surface (markers only) and bottom layer (solid line without markers) with the EPA data (dashed lines) for each point.

Intestinal Enterococci [cfu/100 ml]

Location	Calibration Data					Modelled					Median		95%ile	
	Min	Mean	Median	95%ile	Max	Min	Mean	Median	95%ile	Max	Mod-Obs	% Obs	Mod-Obs	% Obs
Cappoquin (BR110)	42	164	140	376	590	145	147	147	148	149	7	5%	-227	-60%
Dunnes Park (BR220)	2	113	30	160	1,480	12	48	46	94	105	16	54%	-66	-42%
Paxes Lane (BR230)	2	86	70	310	310	11	39	36	79	97	-34	-49%	-231	-74%
Youghal Bay (BR240)	7	49	45	101	120	10	31	29	64	82	-16	-35%	-37	-37%



02.03.87_IE_Surface Discharge Revised Decay Rates (EC 192 hrs IE 384 hrs)

Figure 4-42. Summary statistics (cfu/100ml) and plots for the initial model using median concentrations for IE with the discharge to the surface layer and conservative decay rate of T_{90} = 384 hours (run code 02.87).

4.13 Conclusion

The hydrodynamic model showed that the lower estuary and area just outside of the mouth are dynamic mixing zones between freshwater from the rivers and the sea water. The mixing zone has periods of being vertically well mixed and periods of being stratified. The balance of this mixing is critical to the advection and dispersion of the different parameters.

The water quality model has been developed for each parameter individually using the same underlying hydrodynamics. The water quality model has been calibrated for the five parameters of BOD, DIN, MRP, EC and IE. For ammonia (and therefore unionised ammonia) the model demonstrates that the observed concentration in the receiving waters is significantly higher than the increase attributable to the WwTP and therefore the model may be used to investigate the dispersion of ammonia with due consideration of the relative loads from other sources.

A common feature for all parameters is that the primary discharge from Youghal WwTP discharges a relatively low total load of each parameter to the estuary and compared to the discharges from the rivers. Additionally, the relationship between the river discharges and concentration of the different parameters is not established and the magnitude of the variation is considered to be much larger than that of the contribution from the Youghal WwTP. The hydrodynamics of the estuary have demonstrated that the estuary is flushed by freshwater and therefore it is unlikely that the primary discharge from the WwTP would accumulate over time within the estuary.

The water quality model is considered to have been calibrated and validated and is suitable for use in investigations of the impact of the Youghal WwTP on the receiving waters.

5. Proposed investigations

The final production runs that are to be evaluated have been set as listed below. The calibrated model will be used to investigate these scenarios. The input parameters for the scenarios are presented in the Model Log in Appendix A.

1. Existing (Baseline) Summer
2. Existing (Baseline) Winter
3. Future (16,000PE Capacity) Summer
4. Future (16,000PE Capacity) Winter
5. Future (16,000PE) Summer + New outfall

6. References

AECOM, 2020a, “Youghal Water Quality Modelling Study: Model Scoping Report”.

AECOM, 2020b, “Youghal Water Quality Modelling Study: Survey Interpretive Report”

EPA, 2012, “Integrated Water Quality Report 2012 - Monaghan & Louth”

Irish Water, March 2020, “Technical Standards: Marine Modelling”, IW-TEC-100-015 Rev 2.

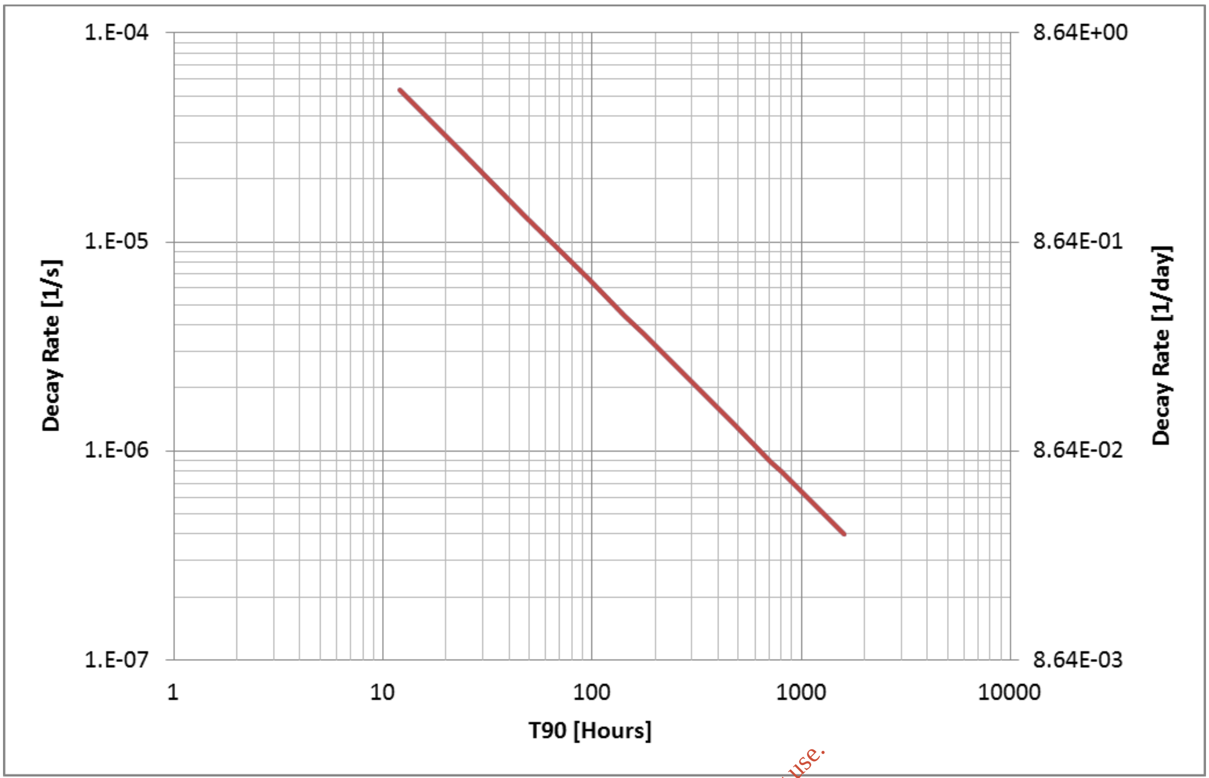
WRc, 1990, “Design Guide for Marine Treatment Schemes”, Report Number UM 1990 Volumes I and II.

Appendix A Model Run Log

Run Codes					Decay Rates		Discharges				
							WwTP		Rivers (listed on "River and Coastal Inputs")		
Number	Season	Params	IW System	Description	T90 [hrs]	/s	Youghal	Cappoquin	Discharge	Temperature	Salinity
				Temperature Calibration			12.0 deg C	12.0 deg C			
				Temperature Summer			15.0 deg C	15.0 deg C			
				Easting							
				Northing							
2.00	BCDE	HD		Calibration Events BCD			**YoughalWwTPDischargeRate_15mins.dfs0**	**0.003 m³/s**	Scaled River Flows v4.dfs0	**Camphire Bed Non-equidistant Temperature.dfs0**	0
2.01	BCDE	BOD		Calibration Events BCD + BOD	550.0	1.16E-06	8.11 mg/l	2. mg/l		**Cappoquin Bed Non-equidistant Temperature.dfs0**	0
2.02	BCDE	EC		Calibration Events BCD + EC	24.0	2.67E-05	89,301 cfu/100ml	500 cfu/100ml			0
2.03	BCDE	IE		Calibration Events BCD + IE	48.0	1.33E-05	9,713 cfu/100ml	125 cfu/100ml	**See "River Concentrations" worksheet**		0
2.04	BCDE	DIN		Calibration Events BCD + DIN	800.0	8.00E-07	2.34 mg N /l	3.63 mg N /l			0
2.05	BCDE	MRP		Calibration Events BCD + MRP	1600.0	4.00E-07	1.12 mg P /l	1.02 mg P /l			0
2.06	BCDE	Amm		Calibration Events BCD + Amm	275.0	2.33E-06	1.08 mg N /l	0.07 mg N /l			0
3.00	Summer	HD	A01s	Existing (Baseline) Summer out of Dunnes Park			**0.054 m³/s**	**0.003 m³/s**	Q95 "River and Coastal Inputs" worksheet	**15.0 deg C**	0
3.01	Summer	BOD	A01s _BOD		550.0	1.163E-06	3.9 mg/l	2. mg/l	See "River and Coastal Inputs" worksheet		
3.02	Summer	EC	A01s _EC		24.0	2.665E-05	2,460 cfu/100ml	500 cfu/100ml			
3.03	Summer	IE	A01s _IE		48.0	1.333E-05	2,330 cfu/100ml	125 cfu/100ml			
3.04	Summer	DIN	A01s _DIN		800.0	7.995E-07	2.22 mg N /l	3.63 mg N /l			
3.05	Summer	MRP	A01s _MRP		1600.0	3.998E-07	1.35 mg P /l	1.02 mg P /l			
3.06	Summer	Amm	A01s _Amm		275.0	2.326E-06	0.3 mg N /l	0.07 mg N /l			
4.00	Winter	HD	B01w	Existing (Baseline) Winter out of Dunnes Park			0.054 m³/s	0.003 m³/s	Q30 "River and Coastal Inputs" worksheet	8.0 deg C	0
4.01	Winter	BOD	B01w _BOD		550.0	1.163E-06	3.9 mg/l	2. mg/l	See "River and Coastal Inputs" worksheet		
4.02	Winter	EC	B01w _EC		48.0	1.333E-05	89,301 cfu/100ml	500 cfu/100ml			
4.03	Winter	IE	B01w _IE		96.0	6.663E-06	9,713 cfu/100ml	125 cfu/100ml			
4.04	Winter	DIN	B01w _DIN		800.0	7.995E-07	2.22 mg N /l	3.63 mg N /l			
4.05	Winter	MRP	B01w _MRP		1600.0	3.998E-07	1.35 mg P /l	1.02 mg P /l			
4.06	Winter	Amm	B01w _Amm		275.0	2.326E-06	0.3 mg N /l	0.07 mg N /l			
5.00	Summer	HD	A03s	Future (16,000PE Capacity) Summer out of Dunnes Park			0.125 m³/s	0.003 m³/s	Q95 "River and Coastal Inputs" worksheet	15.0 deg C	0
5.01	Summer	BOD	A03s _BOD		550.0	1.163E-06	3.9 mg/l	2. mg/l	See "River and Coastal Inputs" worksheet		
5.02	Summer	EC	A03s _EC		24.0	2.665E-05	2,460 cfu/100ml	500 cfu/100ml			
5.03	Summer	IE	A03s _IE		48.0	1.333E-05	2,330 cfu/100ml	125 cfu/100ml			
5.04	Summer	DIN	A03s _DIN		800.0	7.995E-07	2.22 mg N /l	3.63 mg N /l			
5.05	Summer	MRP	A03s _MRP		1600.0	3.998E-07	1.35 mg P /l	1.02 mg P /l			
5.06	Summer	Amm	A03s _Amm		275.0	2.326E-06	0.3 mg N /l	0.07 mg N /l			
6.00	Winter	HD	B03w	Future (16,000PE Capacity) Winter out of Dunnes Park			0.125 m³/s	0.003 m³/s	Q30 "River and Coastal Inputs" worksheet	8.0 deg C	0
6.01	Winter	BOD	B03w _BOD		550.0	1.163E-06	3.9 mg/l	2. mg/l	See "River and Coastal Inputs" worksheet		
6.02	Winter	EC	B03w _EC		48.0	1.333E-05	89,301 cfu/100ml	500 cfu/100ml			
6.03	Winter	IE	B03w _IE		96.0	6.663E-06	9,713 cfu/100ml	125 cfu/100ml			
6.04	Winter	DIN	B03w _DIN		800.0	7.995E-07	2.22 mg N /l	3.63 mg N /l			
6.05	Winter	MRP	B03w _MRP		1600.0	3.998E-07	1.35 mg P /l	1.02 mg P /l			
6.06	Winter	Amm	B03w _Amm		275.0	2.326E-06	0.3 mg N /l	0.07 mg N /l			
6.00	Summer	HD	C03s	Future (16,000PE) Summer + New outfall			0.125 m³/s	0.003 m³/s	Q95 "River and Coastal Inputs" worksheet	15.0 deg C	0
6.01	Summer	BOD	C03s _BOD		550.0	1.163E-06	3.9 mg/l	2. mg/l	See "River and Coastal Inputs" worksheet		
6.02	Summer	EC	C03s _EC		24.0	2.665E-05	2,460 cfu/100ml	500 cfu/100ml			
6.03	Summer	IE	C03s _IE		48.0	1.333E-05	2,330 cfu/100ml	125 cfu/100ml			
6.04	Summer	DIN	C03s _DIN		800.0	7.995E-07	2.22 mg N /l	3.63 mg N /l			
6.05	Summer	MRP	C03s _MRP		1600.0	3.998E-07	1.35 mg P /l	1.02 mg P /l			
6.06	Summer	Amm	C03s _Amm		275.0	2.326E-06	0.3 mg N /l	0.07 mg N /l			

Appendix B Decay rate conversion

T90 [hours	1/s	1/day
12	5.33E-05	4.61
24	2.67E-05	2.30
48	1.33E-05	1.15
96	6.66E-06	0.58
144	4.44E-06	0.38
175	3.65E-06	0.32
192	3.33E-06	0.29
275	2.33E-06	0.20
288	2.22E-06	0.19
300	2.13E-06	0.18
384	1.67E-06	0.14
480	1.33E-06	0.12
720	8.88E-07	0.08
800	8.00E-07	0.07
950	6.73E-07	0.06
1200	5.33E-07	0.05
1600	4.00E-07	0.03


1.E-04
1.E-05
1.E-06
1.E-07
Decay Rate [1/s]
8.64E+00
8.64E-01
8.64E-02
8.64E-03
Decay Rate [1/day]
1
10
100
1000
10000
T90 [Hours]

Appendix C Time series comparisons

C.1 Events B and C

The TSC for Events B and C are the same as Event B is 15 days and covers all three events C, D and E. The final accepted calibration run is S1b MI Adjusted Data.

Comparison of model data with

Baseline: Youghal OPW Tide Gauge (15 minutes)

Event: B (C Spring)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used		Time step of data [mins]	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
			Date and Time		HW Elevation		LW Elevation		Range										
No	Label		Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Youghal OPW Tide Gauge (15 minutes)		15	21/01/20 15:00		1.12		-1.74		2.85			0	0						
S1a MI Data Unadjusted		5	21/01/20 14:30	-30	0.62	-0.49	-1.88	-0.14	2.50	-0.35	-12%	0	0	0.36	0.06	0.53	-45	-4	30
S1b MI Adjusted Data		5	21/01/20 14:30	-30	1.11	-0.01	-1.88	-0.15	2.99	0.14	5%	0	0	0.11	0.09	0.09	-45	-3	60
S1c MI Adjusted Data + Detailed Mesh		5	21/01/20 14:30	-30	1.11	-0.01	-1.87	-0.14	2.98	0.13	5%	0	0	0.12	0.10	0.08	-45	-3	60
Not used												0	0						
Not used												0	0						
			Tolerance	15		0.10		0.10		0.10	15%			0.1	0.1	0.1		15	

Parameters defining the analysis

) Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat	
End Date Time	31/01/2020 06:00	All datasets end after analysis end date	
Axis Label time step	48	hrs	
Threshold	0.00	mOD	
Target HW No	11	21/01/2020 15:00	1.12
		21/01/2020 15:00	0.00

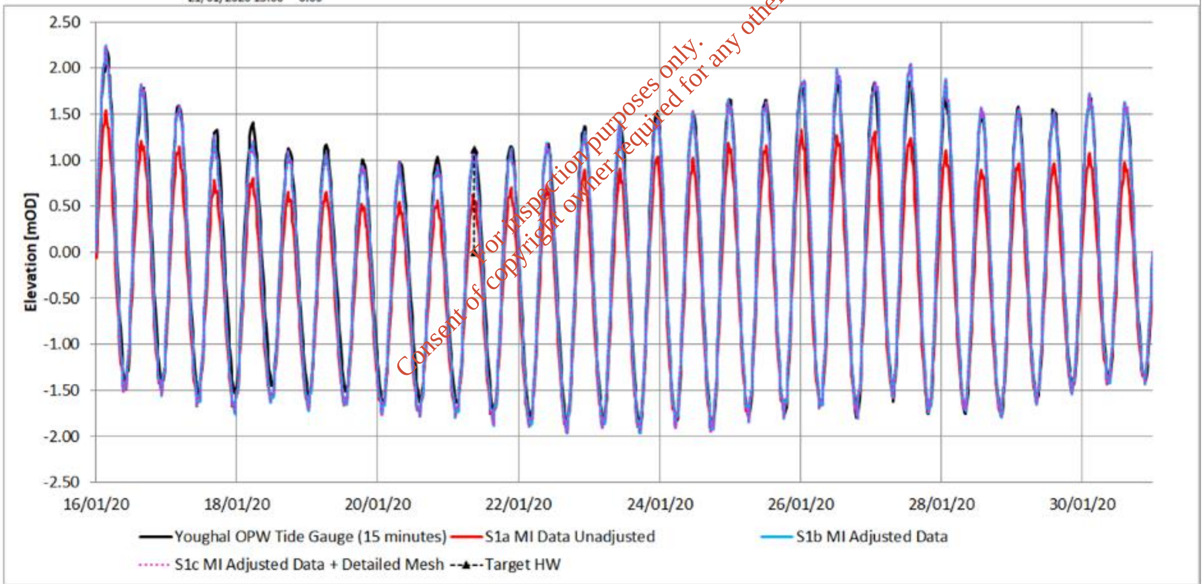
Location

Estuary (mouth)

Tide type

Spring

Comments



Comparison of model data with

Baseline: Cappoquin Tide Gauge

Event: B (C Spring)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used		Time step of data [mins]	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
			Date and Time		HW Elevation		LW Elevation		Range										
No	Label		Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Cappoquin Tide Gauge		15	21/01/20 15:00		1.12		-1.73		2.85			0	0						
S1a MI Data Unadjusted		5	21/01/20 14:30	-30	0.62	-0.49	-1.88	-0.14	2.50	-0.35	-12%	0	0	0.36	0.06	0.53	-45	-4	30
S1b MI Adjusted Data		5	21/01/20 14:30	-30	1.11	-0.01	-1.88	-0.15	2.99	0.14	5%	0	0	0.11	0.09	0.09	-45	-3	60
S1c MI Adjusted Data + Detailed Mesh		5	21/01/20 14:30	-30	1.11	-0.01	-1.87	-0.14	2.98	0.13	5%	0	0	0.12	0.10	0.08	-45	-3	60
Not used												0	0						
Not used												0	0						
			Tolerance	25		0.30		0.30		0.30	15%			0.3	0.3	0.3		25	

Parameters defining the analysis

) Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat
End Date Time	31/01/2020 06:00	All datasets end after analysis end date
Axis Label time step	48	hrs
Threshold	0.00	mOD
Target HW No	11	21/01/2020 15:00 1.12
		21/01/2020 15:00 0.00

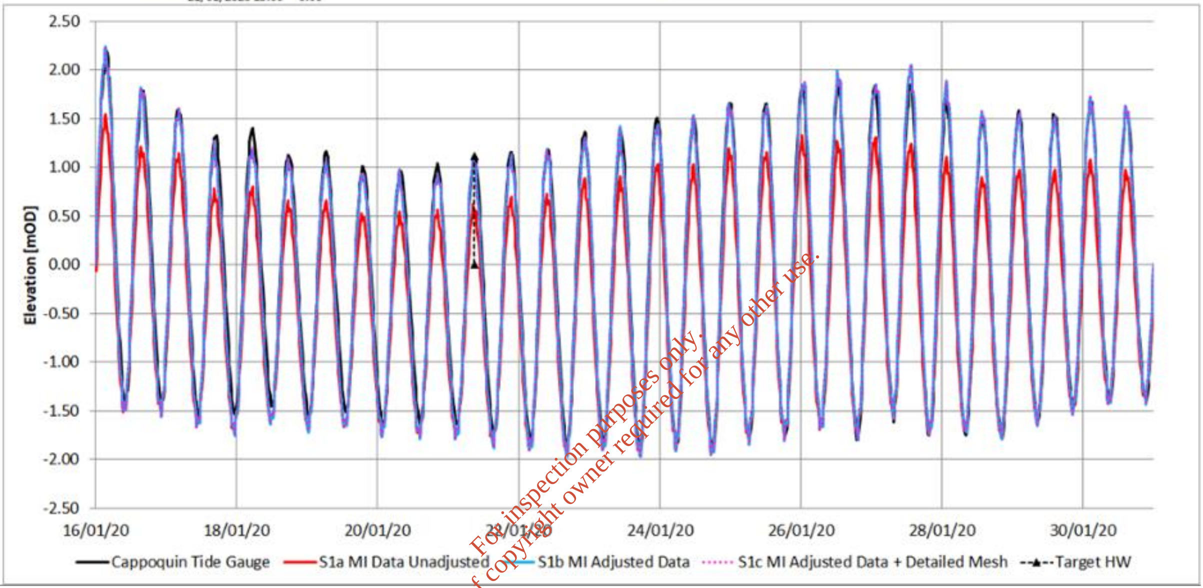
Location

Estuary (head)

Tide type

Spring

Comments



Comparison of model data with

Baseline: Camphire Bridge CTD

Event: B (C Spring)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used	Time step of data	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
		Date and Time		HW Elevation		LW Elevation		Range										
No / Label	[mins]	Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Camphire Bridge CTD	15	21/01/20 15:30		1.45		-1.05		2.50			0	0						
S1a MI Data Unadjusted	5	21/01/20 15:15	-15	0.74	-0.71	-1.31	-0.26	2.06	-0.44	-18%	0	0	0.50	0.04	0.71	-30	2	60
S1b MI Adjusted Data	5	21/01/20 15:15	-15	1.22	-0.23	-1.30	-0.25	2.52	0.02	1%	0	0	0.26	0.12	0.21	-30	6	60
S1c MI Adjusted Data + Detailed Mesh	5	21/01/20 16:00	30	1.26	-0.19	-1.25	-0.20	2.51	0.01	0%	0	0	0.31	0.21	0.17	-30	14	60
Not used											0	0						
Not used											0	0						
		Tolerance	25		0.30		0.30		0.30	15%			0.3	0.3	0.3		25	

Parameters defining the analysis

Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat
End Date Time	31/01/2020 06:00	All datasets end after analysis end date
Axis Label time step	48	hrs
Threshold	0.00	mOD
Target HW No	11	21/01/2020 15:30 1.45
		21/01/2020 15:30 0.00

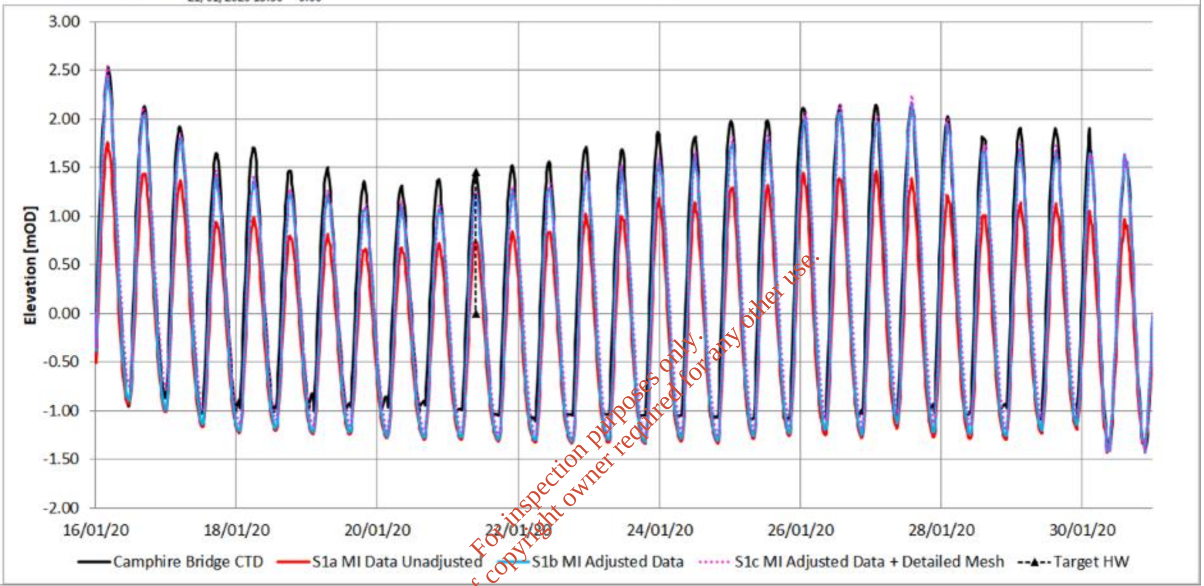
Location

Estuary (head)

Tide type

Spring

Comments



C.2 Event D

Comparison of model data with

Baseline: Youghal OPW Tide Gauge (15 minutes)

Event: B (D Neap)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used		Time step of data [mins]	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
			Date and Time		HW Elevation		LW Elevation		Range										
No	Label		Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Youghal OPW Tide Gauge (15 minutes)		15	21/01/20 15:00		1.12		-1.74		2.85			0	0						
S1a MI Data Unadjusted		5	21/01/20 14:30	-30	0.62	-0.49	-1.88	-0.14	2.50	-0.35	-12%	0	0	0.36	0.06	0.53	-45	-4	30
S1b MI Adjusted Data		5	21/01/20 14:30	-30	1.11	-0.01	-1.88	-0.15	2.99	0.14	5%	0	0	0.11	0.09	0.09	-45	-3	60
S1c MI Adjusted Data + Detailed Mesh		5	21/01/20 14:30	-30	1.11	-0.01	-1.87	-0.14	2.98	0.13	5%	0	0	0.12	0.10	0.08	-45	-3	60
Not used												0	0						
Not used												0	0						
			Tolerance	15		0.10		0.10		0.10	20%			0.1	0.1	0.1		15	

Parameters defining the analysis

Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat
End Date Time	31/01/2020 06:00	All datasets end after analysis end date
Axis Label time step	48	hrs
Threshold	0.00	mOD
Target HW No	11	21/01/2020 15:00 1.12
		21/01/2020 15:00 0.00

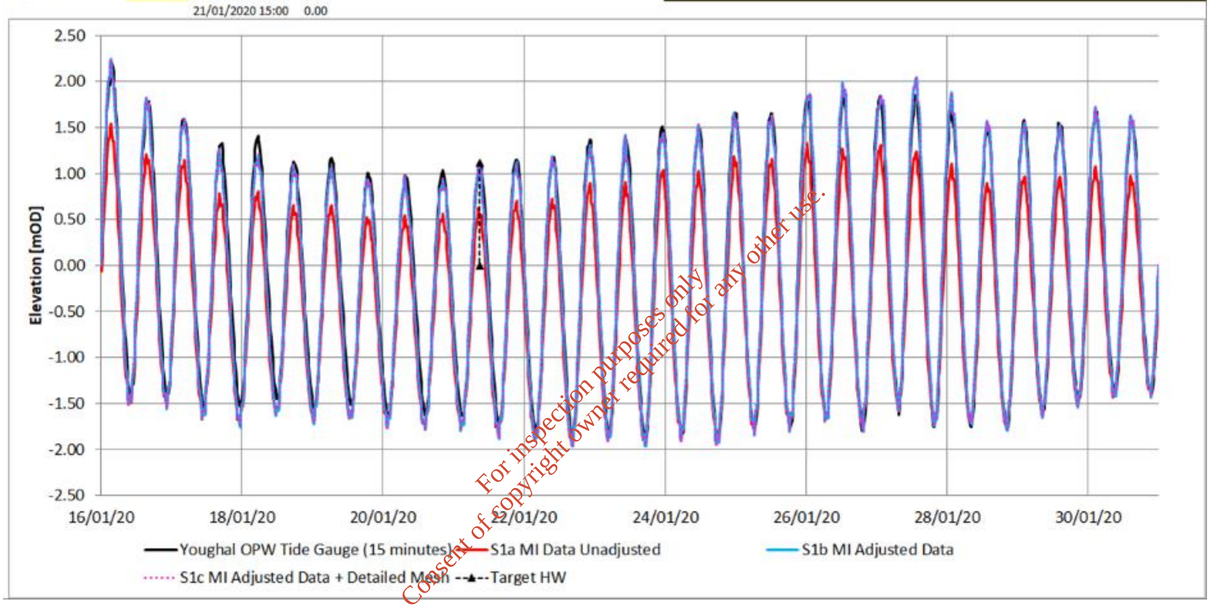
Location

Estuary (mouth)

Tide type

Neap

Comments



Comparison of model data with

Baseline: Camphire Bridge CTD

Event: B (D Neap)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used	Time step of data	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
		Date and Time		HW Elevation		LW Elevation		Range										
No / Label	[mins]	Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Camphire Bridge CTD	15	28/01/20 08:15		2.02		-1.04		3.06			0	0						
S1a MI Data Unadjusted	5	28/01/20 08:00	-15	1.21	-0.81	-1.29	-0.25	2.50	-0.56	-18%	0	0	0.50	0.04	0.71	-30	2	60
S1b MI Adjusted Data	5	28/01/20 08:00	-15	1.96	-0.06	-1.24	-0.20	3.20	0.14	4%	0	0	0.26	0.12	0.21	-30	6	60
S1c MI Adjusted Data + Detailed Mesh	5	28/01/20 08:15	0	2.01	-0.01	-1.15	-0.11	3.16	0.10	3%	0	0	0.31	0.21	0.17	-30	14	60
Not used											0	0						
Not used											0	0						
		Tolerance	25		0.30		0.30		0.30	20%			0.3	0.3	0.3		25	

Parameters defining the analysis

Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat	
End Date Time	31/01/2020 06:00	All datasets end after analysis end date	
Axis Label time step	48	hrs	
Threshold	0.00	mOD	
Target HW No	24	28/01/2020 08:15	2.02
		28/01/2020 08:15	0.00

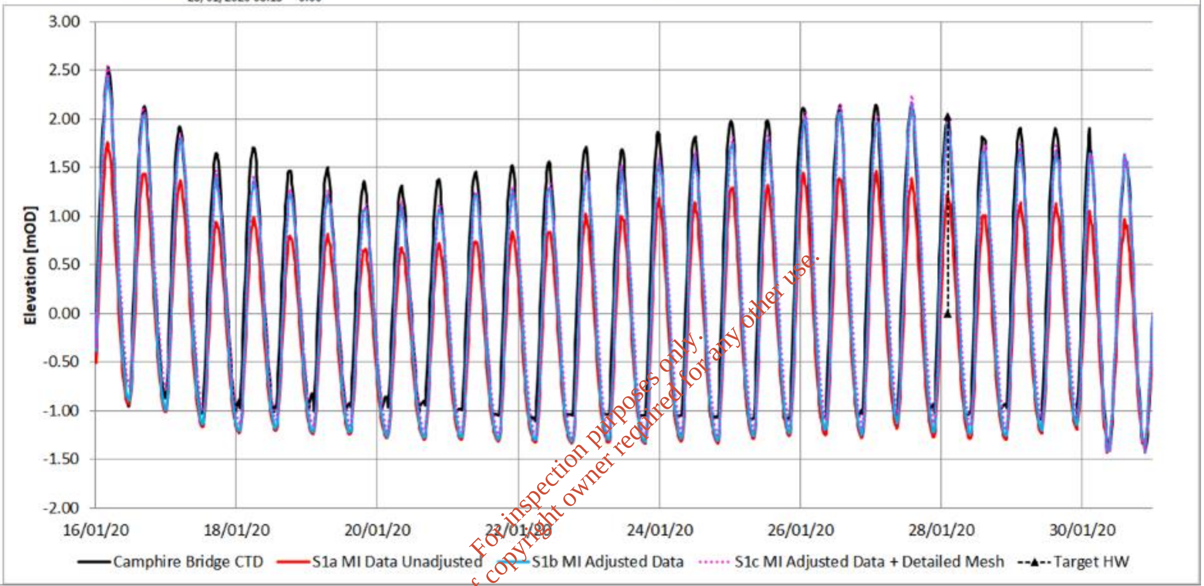
Location

Estuary (head)

Tide type

Neap

Comments



Comparison of model data with

Baseline: Cappoquin Tide Gauge

Event: B (D Neap)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used	Time step of data	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
		Date and Time		HW Elevation		LW Elevation		Range										
No / Label	[mins]	Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Cappoquin Tide Gauge	15	28/01/20 07:30		1.69		-1.75		3.44			0	0						
S1a MI Data Unadjusted	5	28/01/20 07:30	0	1.10	-0.59	-1.72	0.03	2.82	-0.62	-18%	0	0	0.36	0.06	0.53	-45	-4	30
S1b MI Adjusted Data	5	28/01/20 07:30	0	1.88	0.19	-1.72	0.03	3.60	0.16	5%	0	0	0.11	0.09	0.09	-45	-3	60
S1c MI Adjusted Data + Detailed Mesh	5	28/01/20 07:30	0	1.88	0.19	-1.70	0.05	3.58	0.14	4%	0	0	0.12	0.10	0.08	-45	-3	60
Not used											0	0						
Not used											0	0						
		Tolerance	25		0.30		0.30		0.30	20%			0.3	0.3	0.3		25	

Parameters defining the analysis

Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat
End Date Time	31/01/2020 06:00	All datasets end after analysis end date
Axis Label time step	48	hrs
Threshold	0.00	mOD
Target HW No	24	28/01/2020 07:30 1.69
		28/01/2020 07:30 0.00

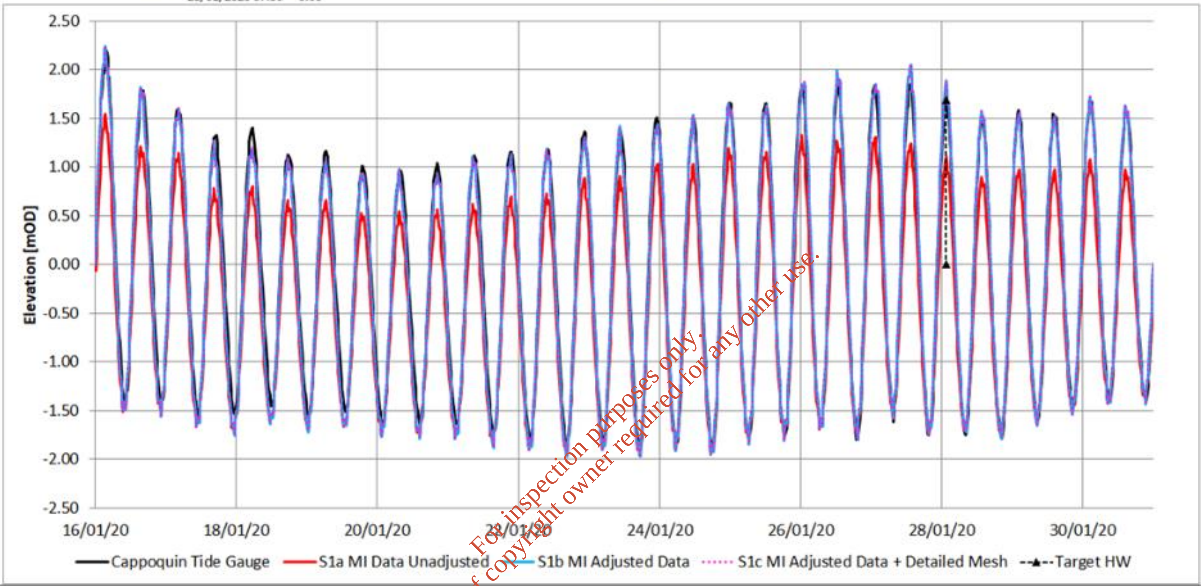
Location

Estuary (head)

Tide type

Neap

Comments



C.3 Event E

Comparison of model data with

Baseline: Youghal OPW Tide Gauge (15 minutes)

Event: B (E Spring)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used		Time step of data [mins]	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
			Date and Time		HW Elevation		LW Elevation		Range										
No	Label		Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Youghal OPW Tide Gauge (15 minutes)		15	28/01/20 07:30		1.69		-1.75		3.44			0	0						
S1a MI Data Unadjusted		5	28/01/20 07:30	0	1.10	-0.59	-1.72	0.03	2.82	-0.62	-18%	0	0	0.36	0.06	0.53	-45	-4	30
S1b MI Adjusted Data		5	28/01/20 07:30	0	1.88	0.19	-1.72	0.03	3.60	0.16	5%	0	0	0.11	0.09	0.09	-45	-3	60
S1c MI Adjusted Data + Detailed Mesh		5	28/01/20 07:30	0	1.88	0.19	-1.70	0.05	3.58	0.14	4%	0	0	0.12	0.10	0.08	-45	-3	60
Not used												0	0						
Not used												0	0						
			Tolerance	15		0.10		0.10		0.10	15%			0.1	0.1	0.1		15	

Parameters defining the analysis

Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat
End Date Time	31/01/2020 06:00	All datasets end after analysis end date
Axis Label time step	48	hrs
Threshold	0.00	mOD
Target HW No	24	28/01/2020 07:30 1.69
		28/01/2020 07:30 0.00

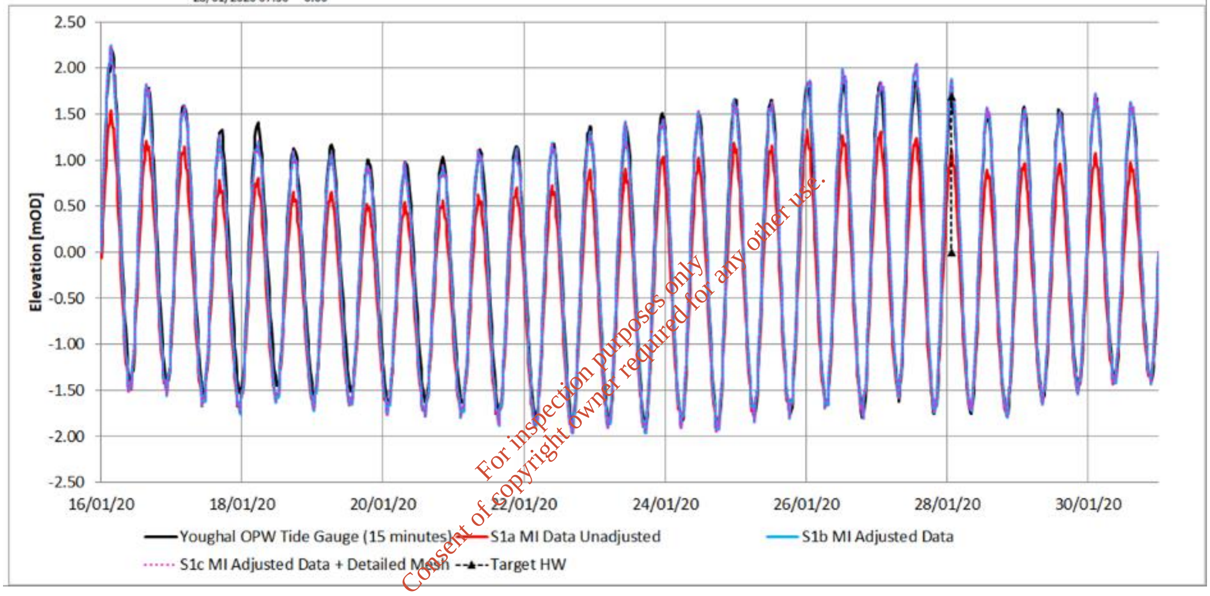
Location

Estuary (mouth)

Tide type

Spring

Comments



Comparison of model data with

Baseline: Camphire Bridge CTD

Event: B (E Spring)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used	Time step of data	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
		Date and Time		HW Elevation		LW Elevation		Range										
No / Label	[mins]	Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Camphire Bridge CTD	15	28/01/20 08:15		2.02		-1.04		3.06			0	0						
S1a MI Data Unadjusted	5	28/01/20 08:00	-15	1.21	-0.81	-1.29	-0.25	2.50	-0.56	-18%	0	0	0.50	0.04	0.71	-30	2	60
S1b MI Adjusted Data	5	28/01/20 08:00	-15	1.96	-0.06	-1.24	-0.20	3.20	0.14	4%	0	0	0.26	0.12	0.21	-30	6	60
S1c MI Adjusted Data + Detailed Mesh	5	28/01/20 08:15	0	2.01	-0.01	-1.15	-0.11	3.16	0.10	3%	0	0	0.31	0.21	0.17	-30	14	60
Not used											0	0						
Not used											0	0						
		Tolerance	25		0.30		0.30		0.30	15%			0.3	0.3	0.3		25	

Parameters defining the analysis

Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat
End Date Time	31/01/2020 06:00	All datasets end after analysis end date
Axis Label time step	48	hrs
Threshold	0.00	mOD
Target HW No	24	28/01/2020 08:15 2.02
		28/01/2020 08:15 0.00

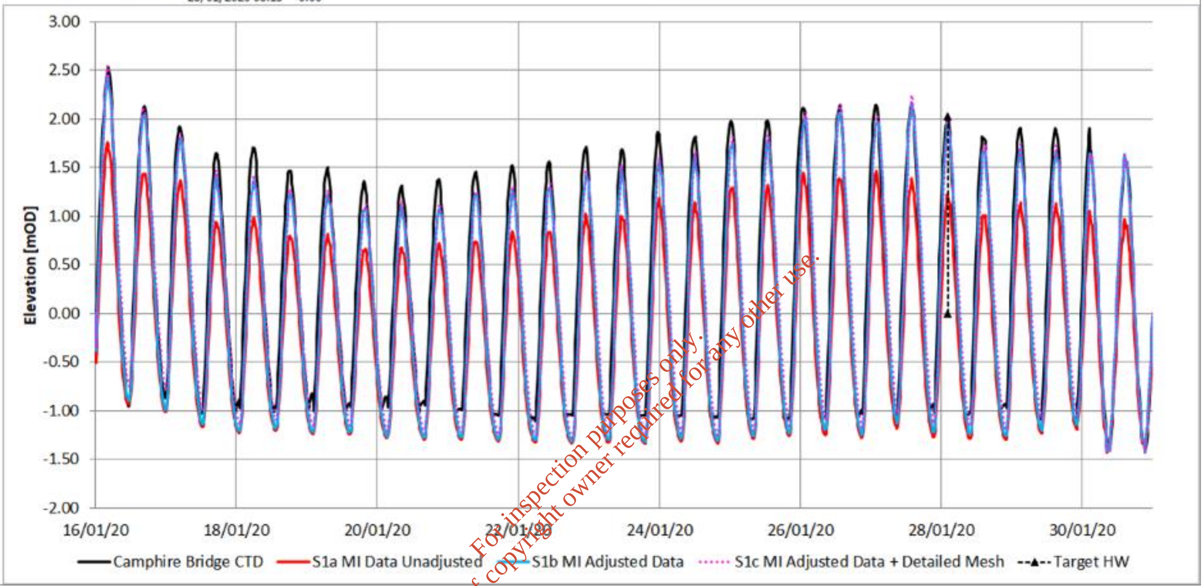
Location

Estuary (head)

Tide type

Spring

Comments



Comparison of model data with

Baseline: Cappoquin Tide Gauge

Event: B (E Spring)

During: 16/01/2020 06:00 to 31/01/2020 06:00

Datasets used		Time step of data [mins]	Target HW and following LW									Adjust. dataset time and value		RMSE of each dataset to Dataset 1			Time Difference of all HWs		
			Date and Time		HW Elevation		LW Elevation		Range										
No	Label		Actual	Diff [mins]	Actual [mOD]	Diff [m]	Actual [mOD]	Diff [m]	Range [m]	Diff. [m]	Diff %	Time [mins]	Vertical [m]	All Data [m]	>0.00 mOD [m]	All HWs [m]	Min [mins]	Avg [mins]	Max [mins]
Cappoquin Tide Gauge		15	28/01/20 07:30		1.69		-1.75		3.44			0	0						
S1a MI Data Unadjusted		5	28/01/20 07:30	0	1.10	-0.59	-1.72	0.03	2.82	-0.62	-18%	0	0	0.36	0.06	0.53	-45	-4	30
S1b MI Adjusted Data		5	28/01/20 07:30	0	1.88	0.19	-1.72	0.03	3.60	0.16	5%	0	0	0.11	0.09	0.09	-45	-3	60
S1c MI Adjusted Data + Detailed Mesh		5	28/01/20 07:30	0	1.88	0.19	-1.70	0.05	3.58	0.14	4%	0	0	0.12	0.10	0.08	-45	-3	60
Not used												0	0						
Not used												0	0						
			Tolerance	25		0.30		0.30		0.30	15%			0.3	0.3	0.3		25	

Parameters defining the analysis

Start Date Time	16/01/2020 06:00	All datasets start before analysis start dat
End Date Time	31/01/2020 06:00	All datasets end after analysis end date
Axis Label time step	48	hrs
Threshold	0.00	mOD
Target HW No	24	28/01/2020 07:30 1.69
		28/01/2020 07:30 0.00

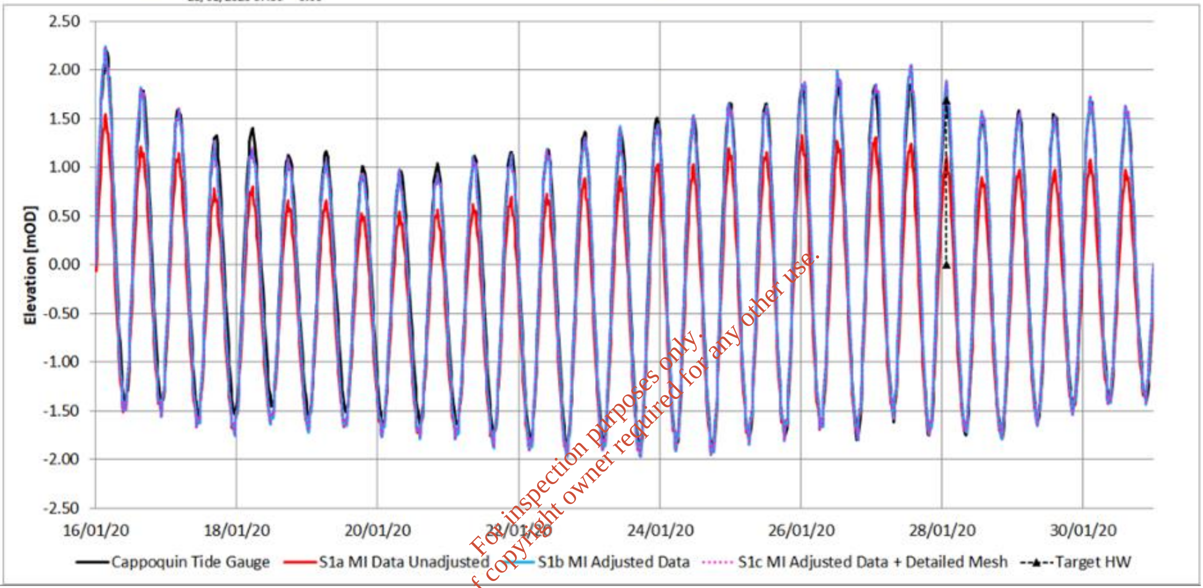
Location

Estuary (head)

Tide type

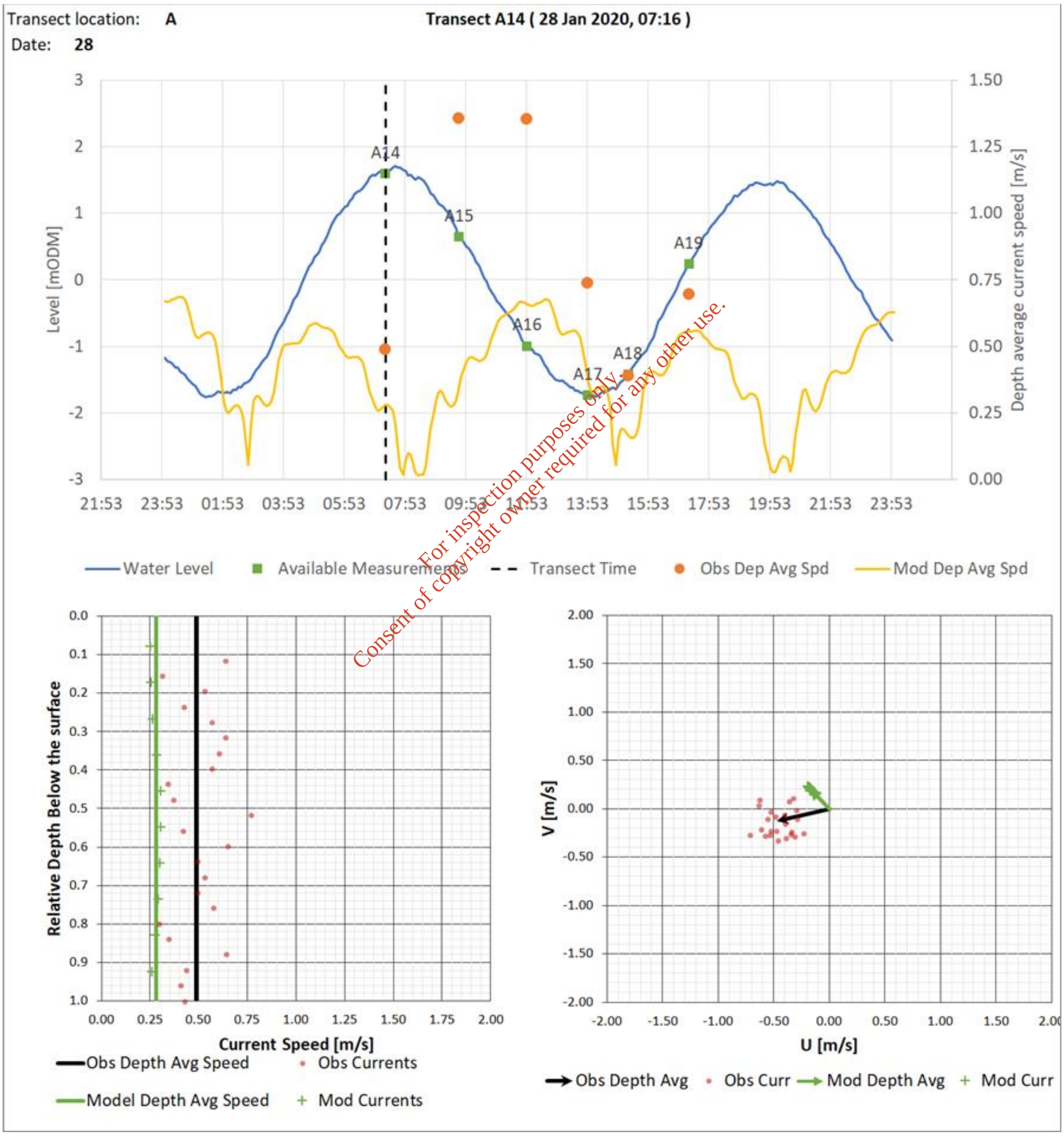
Spring

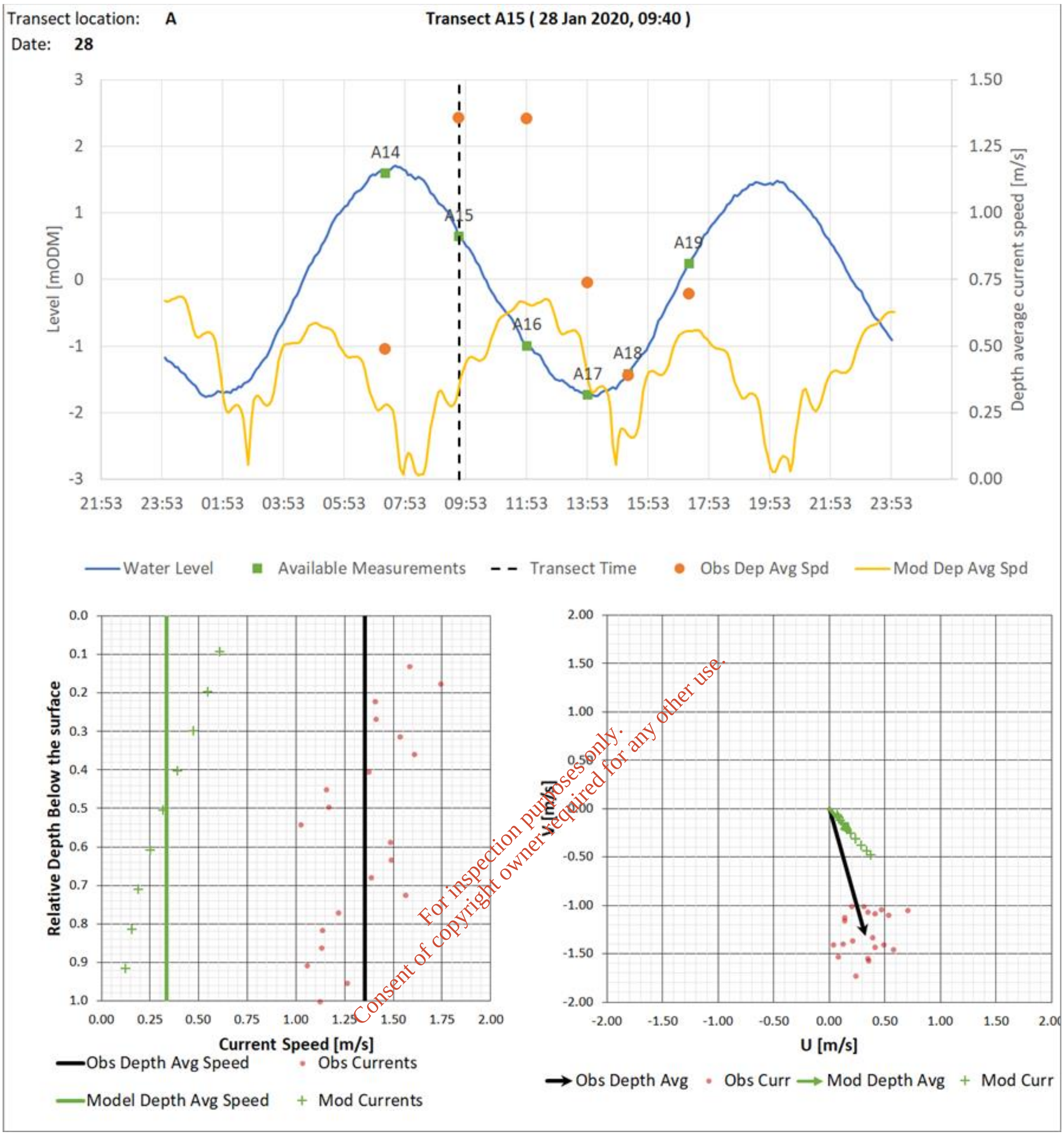
Comments

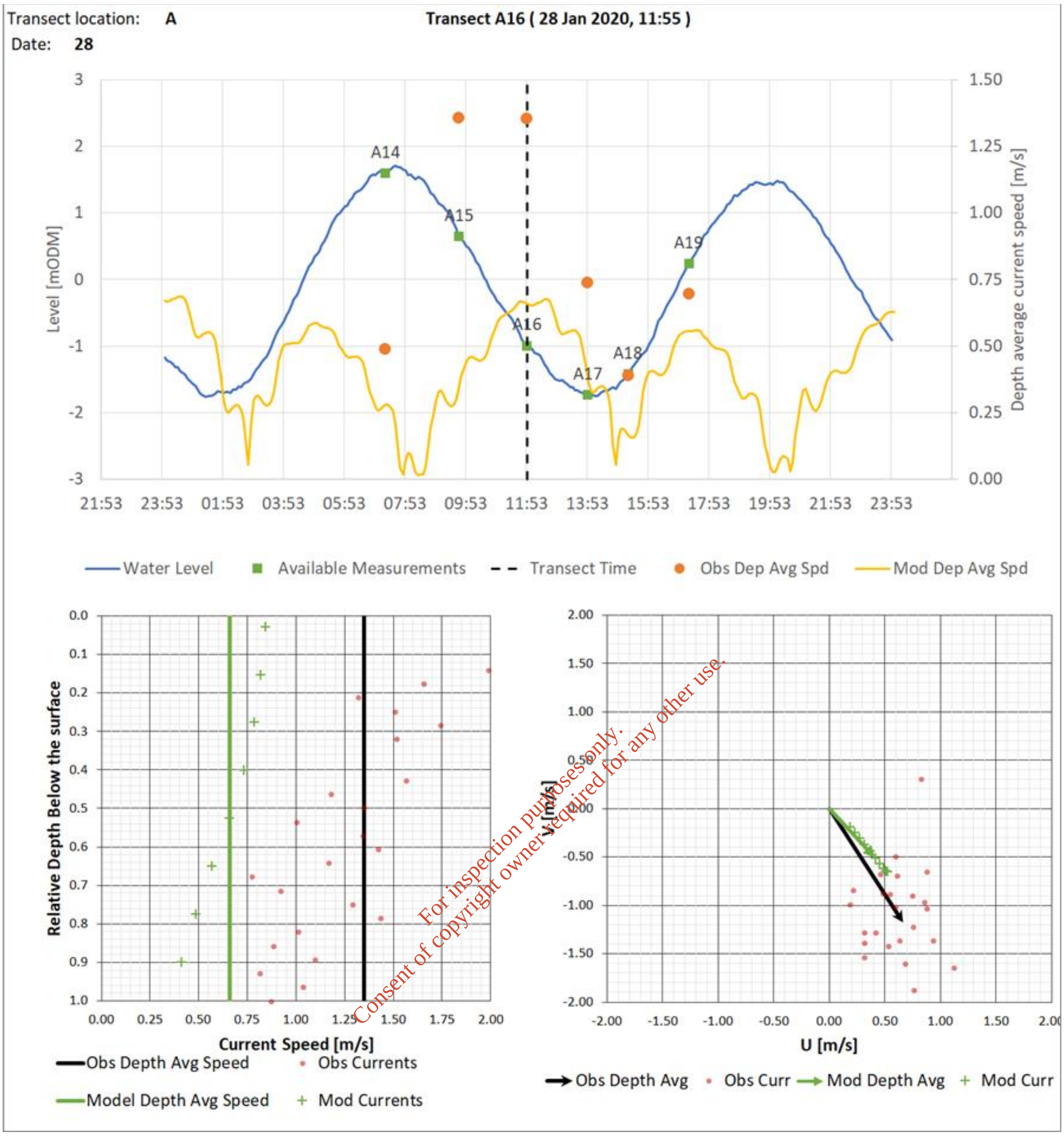


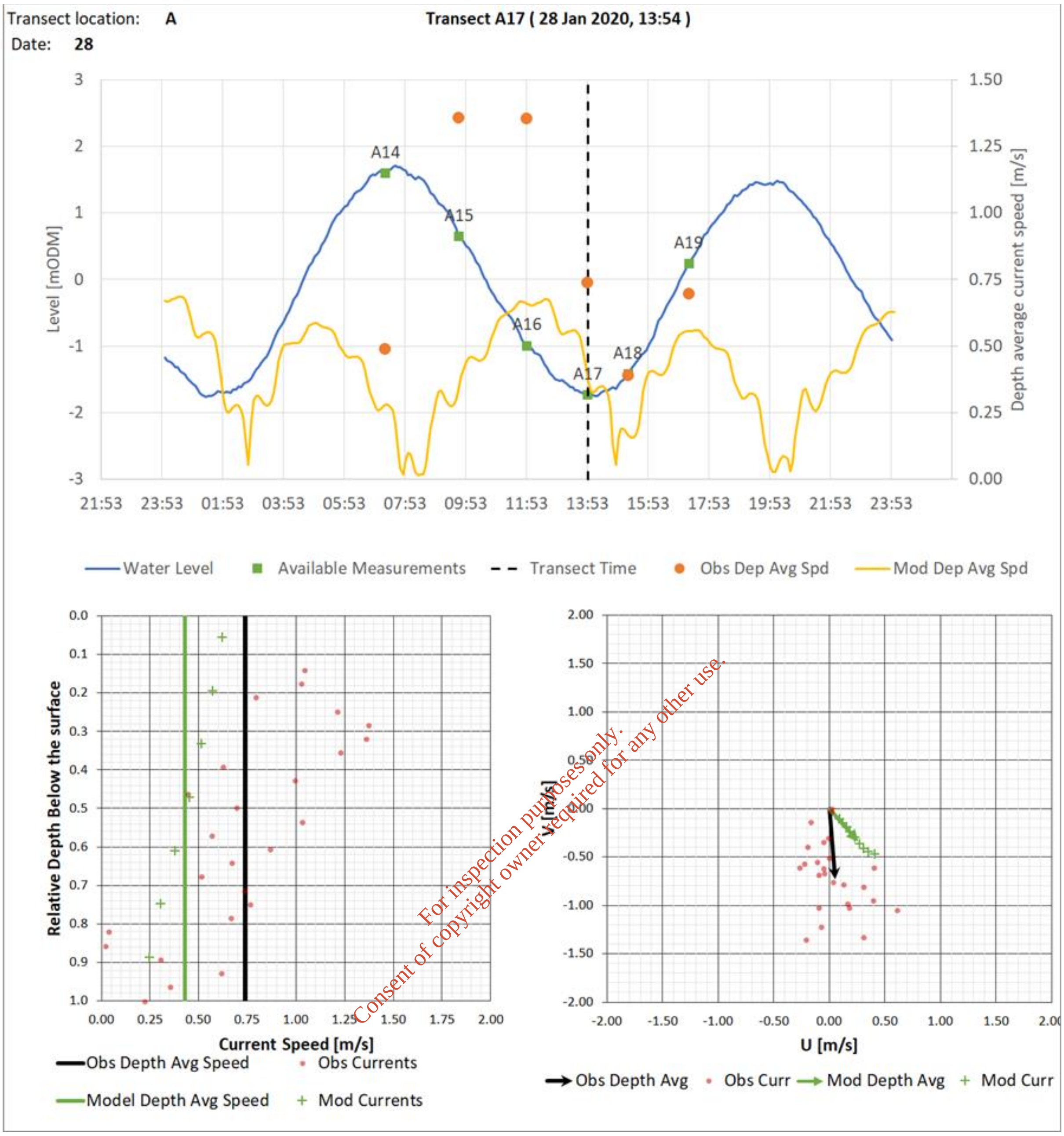
Appendix D Current speed, vertical profile and velocity components for Event C: spring tide (28th January) Event D: neap tide (21st January) and Event E: spring tide (17th January).

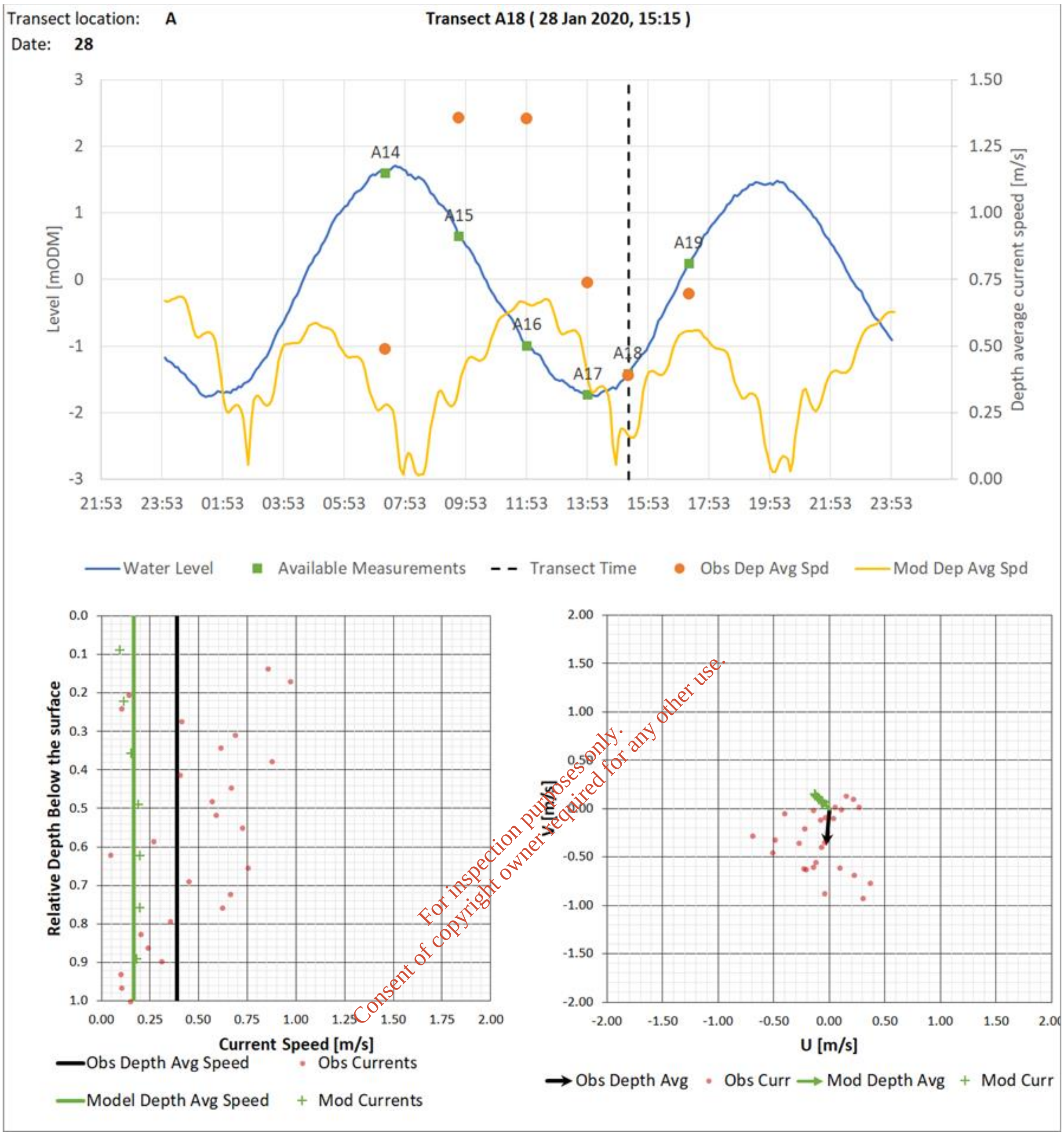
D.1 Event C: Transect A

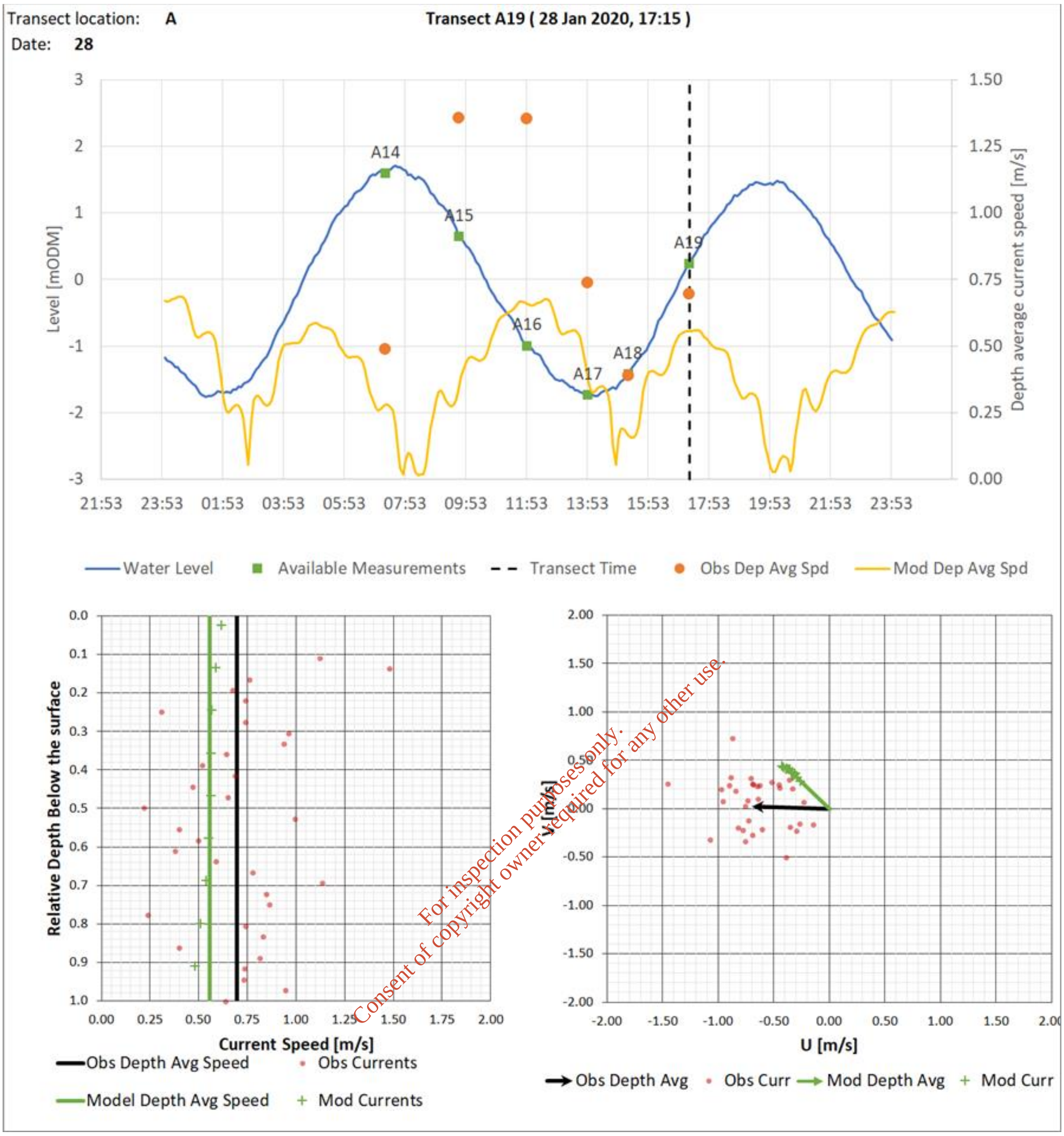



Transect location: A
Date: 28
Transect A15 (28 Jan 2020, 09:40)
Level [mODM]
Depth average current speed [m/s]
A14
A15
A16
A17
A18
A19
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

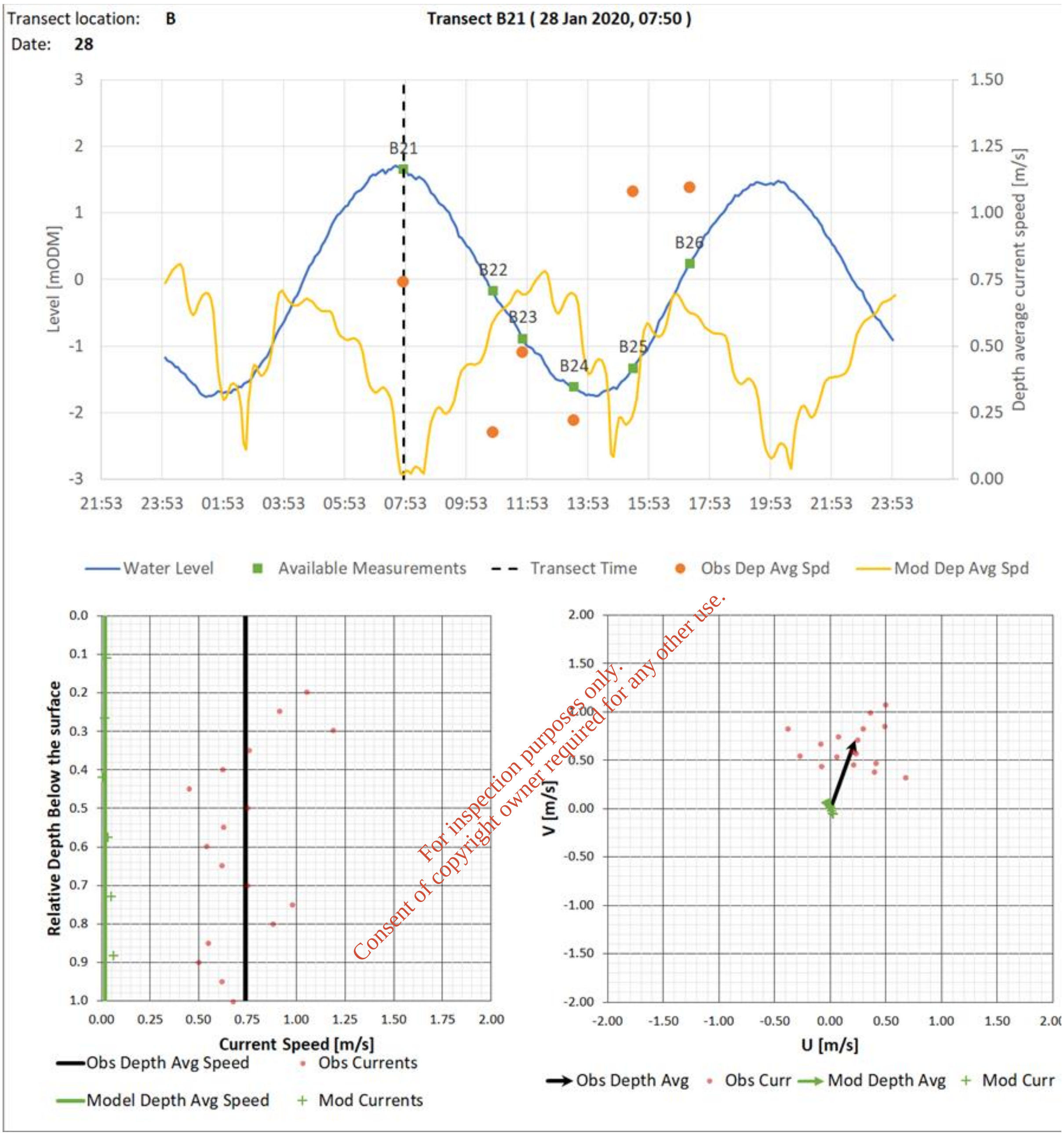

Transect location: A
Date: 28
Transect A16 (28 Jan 2020, 11:55)
Level [mODM]
Depth average current speed [m/s]
A14
A15
A16
A17
A18
A19
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

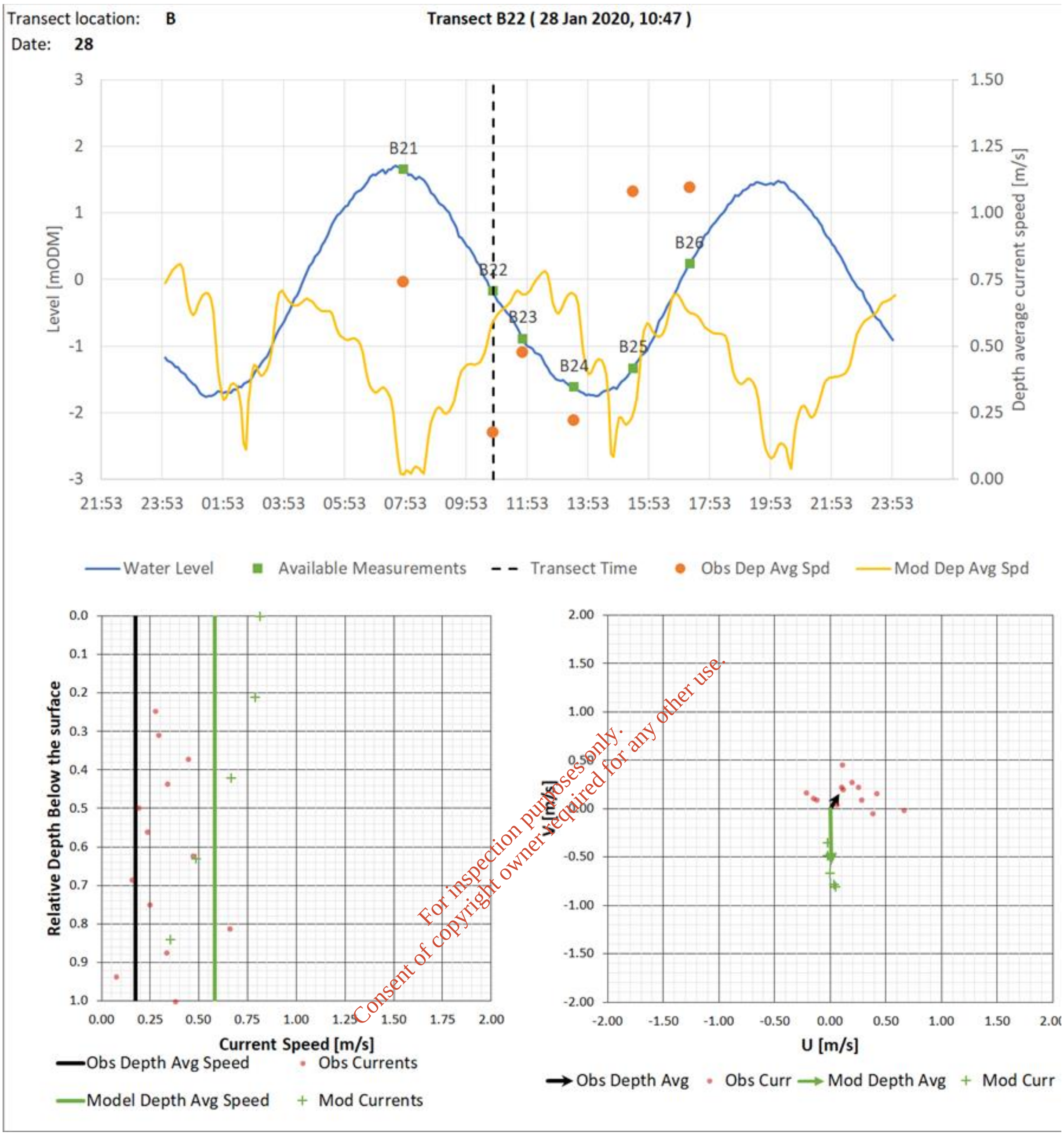

Transect location: A
Date: 28
Transect A17 (28 Jan 2020, 13:54)
Level [mODM]
Depth average current speed [m/s]
A14
A15
A16
A17
A18
A19
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

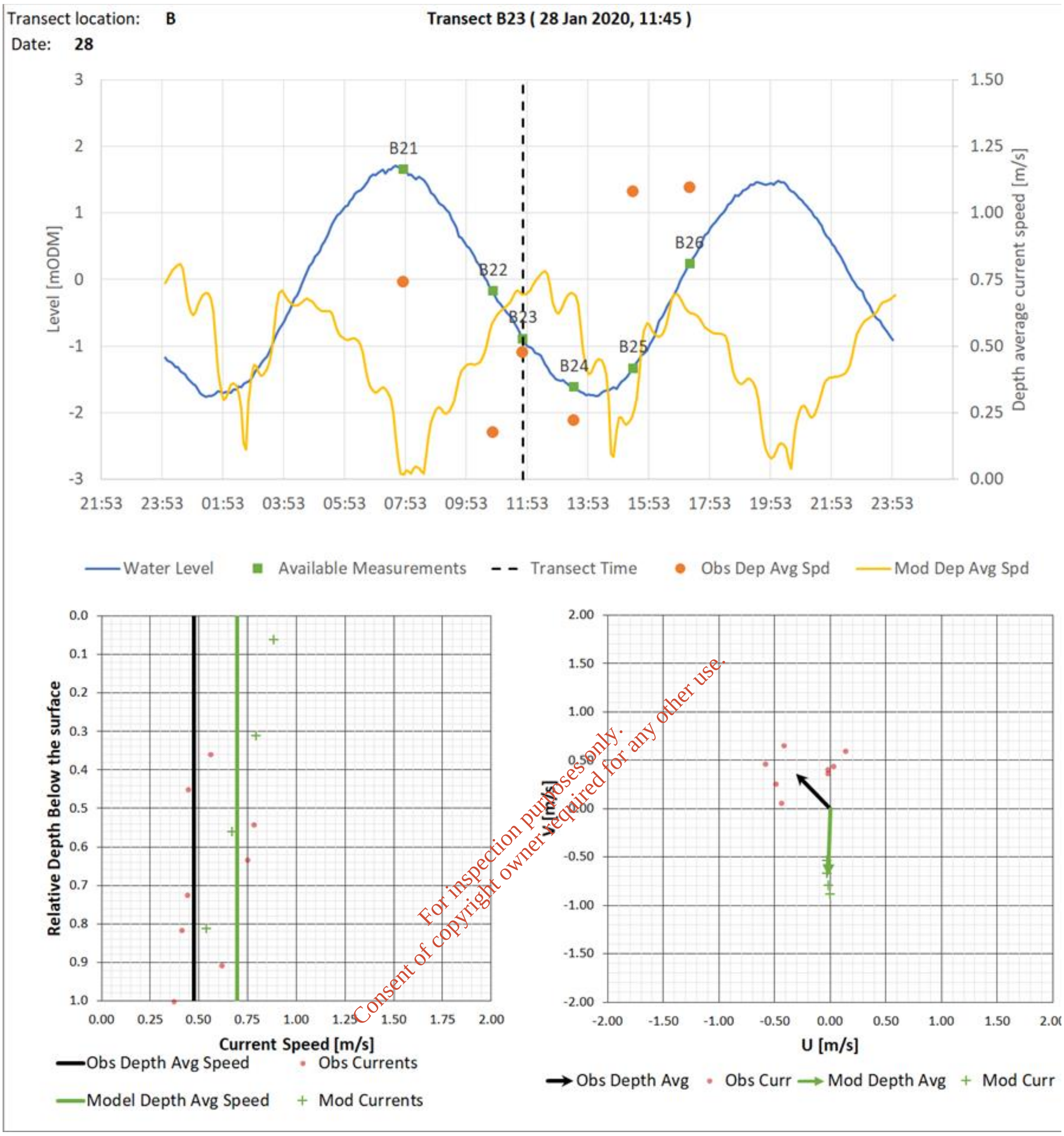

Transect location: A
Date: 28
Transect A18 (28 Jan 2020, 15:15)
Level [mODM]
Depth average current speed [m/s]
A14
A15
A16
A17
A18
A19
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

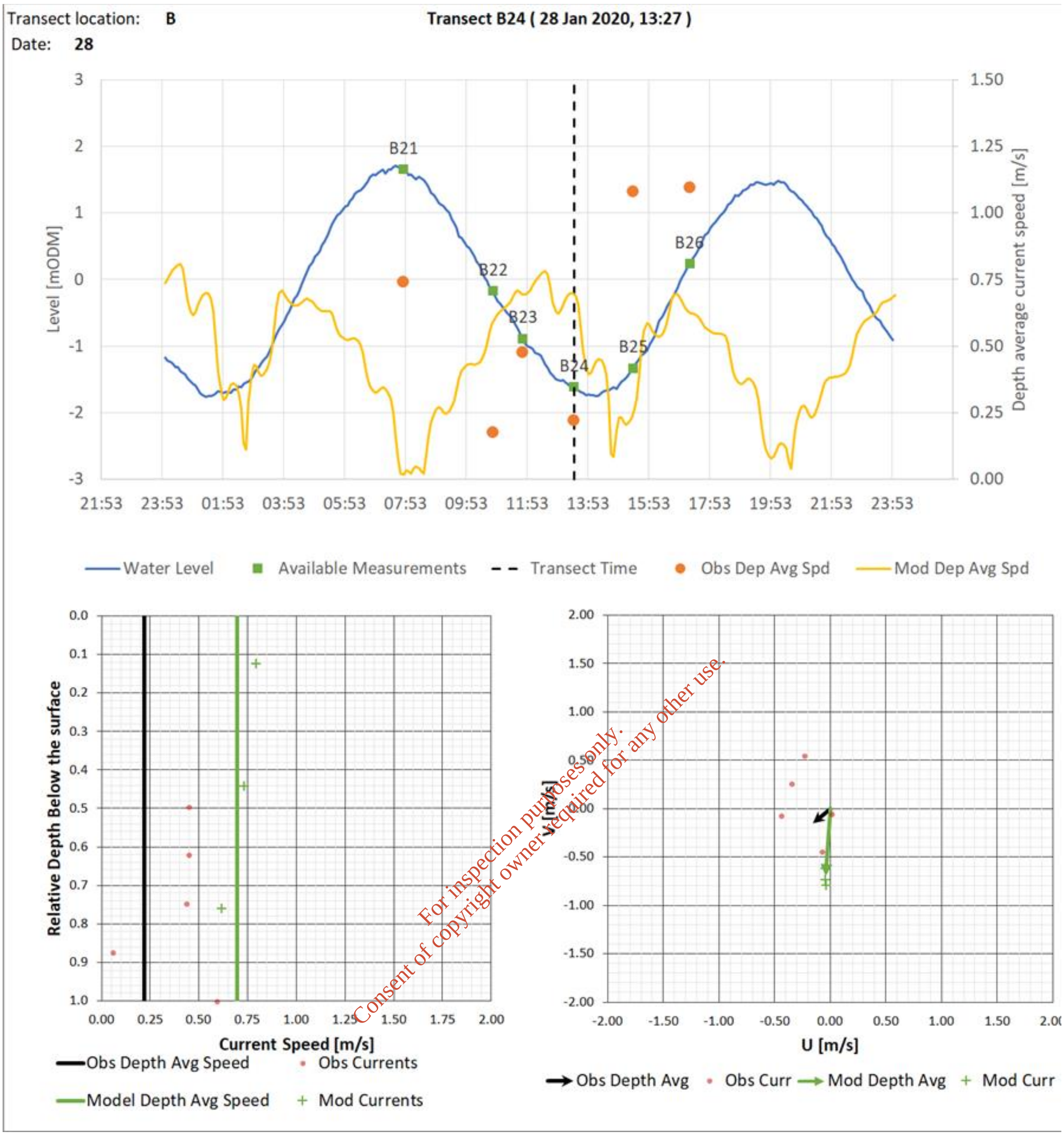

Transect location: A
Transect A19 (28 Jan 2020, 17:15)
Date: 28
Level [mODM]
Depth average current speed [m/s]
A14
A15
A16
A17
A18
A19
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

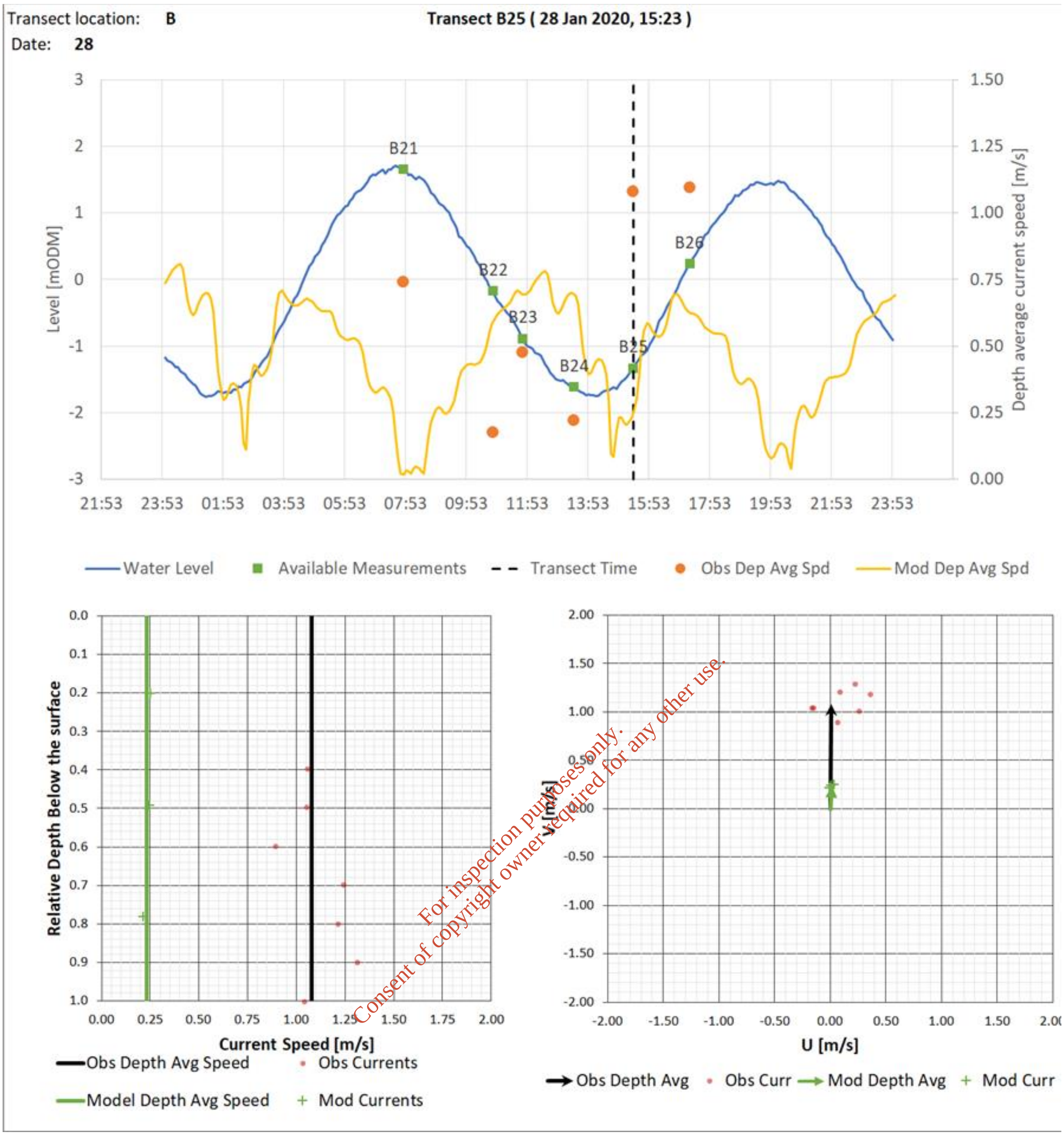
D.2 Event C: Transect B

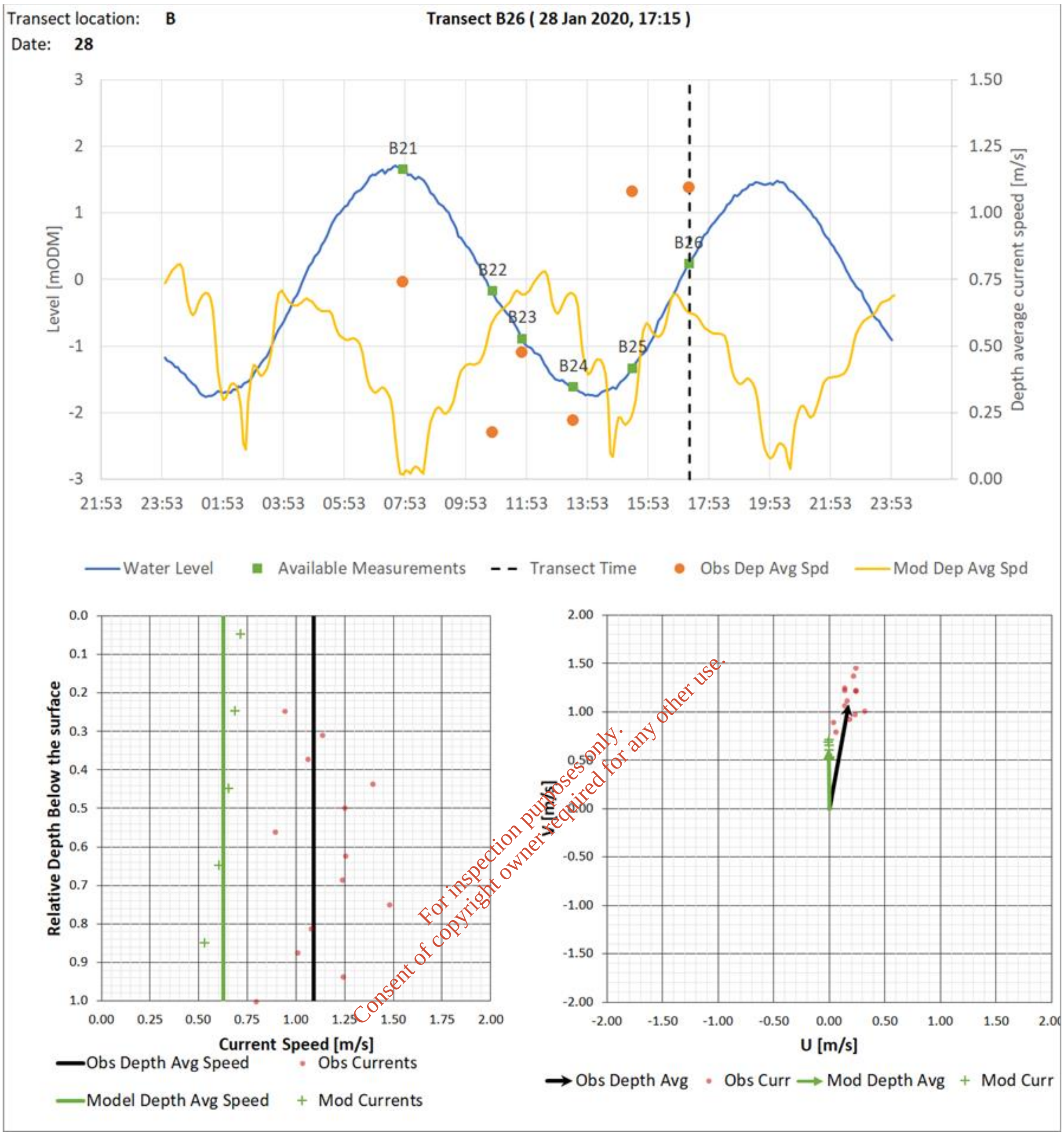



Transect location: B
Date: 28
Transect B22 (28 Jan 2020, 10:47)
Level [mODM]
Depth average current speed [m/s]
B21
B22
B23
B24
B25
B26
21:53 23:53 01:53 03:53 05:53 07:53 09:53 11:53 13:53 15:53 17:53 19:53 21:53 23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

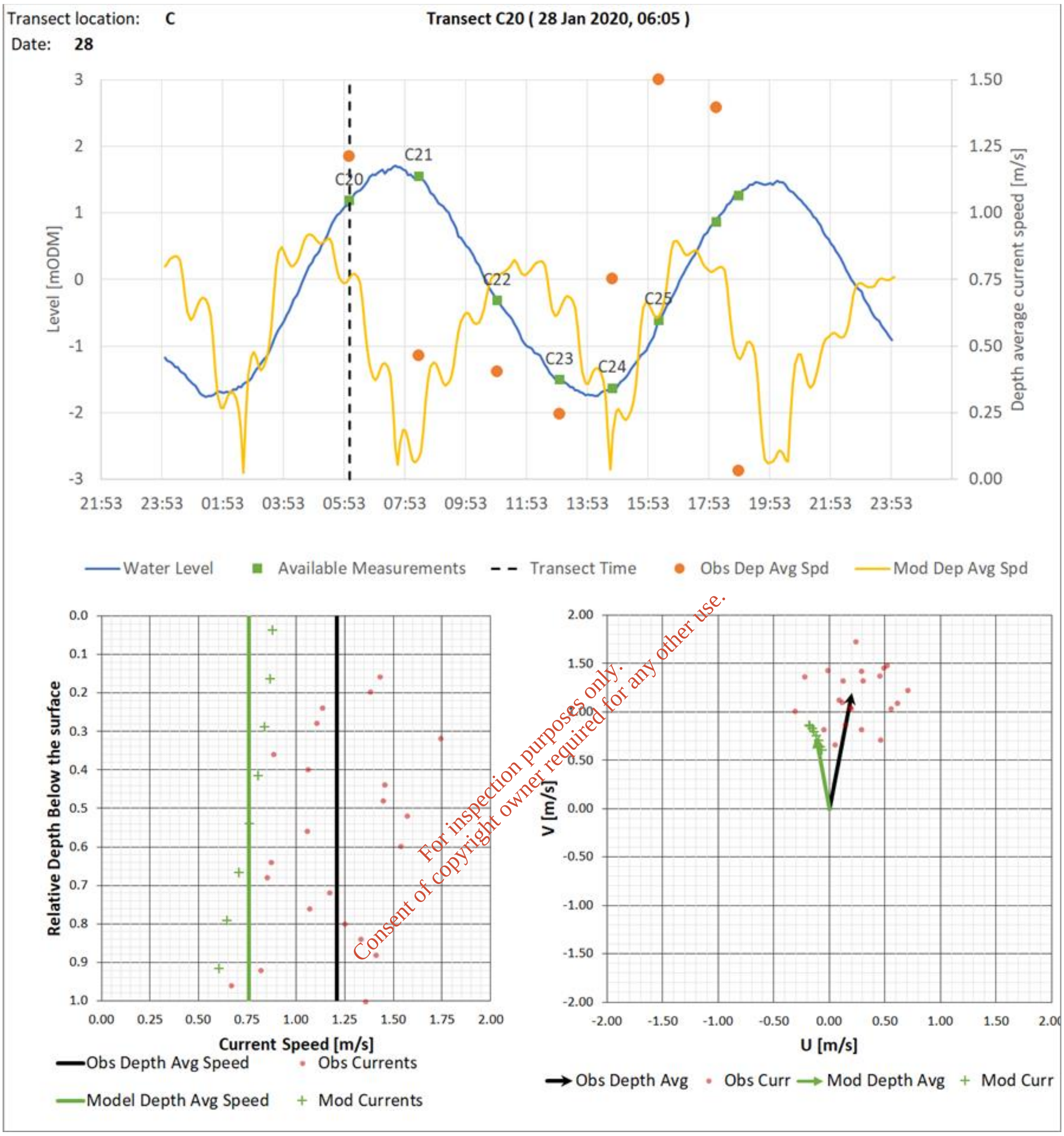

Transect location: B
Date: 28
Transect B23 (28 Jan 2020, 11:45)
Level [mODM]
Depth average current speed [m/s]
B21
B22
B23
B24
B25
B26
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

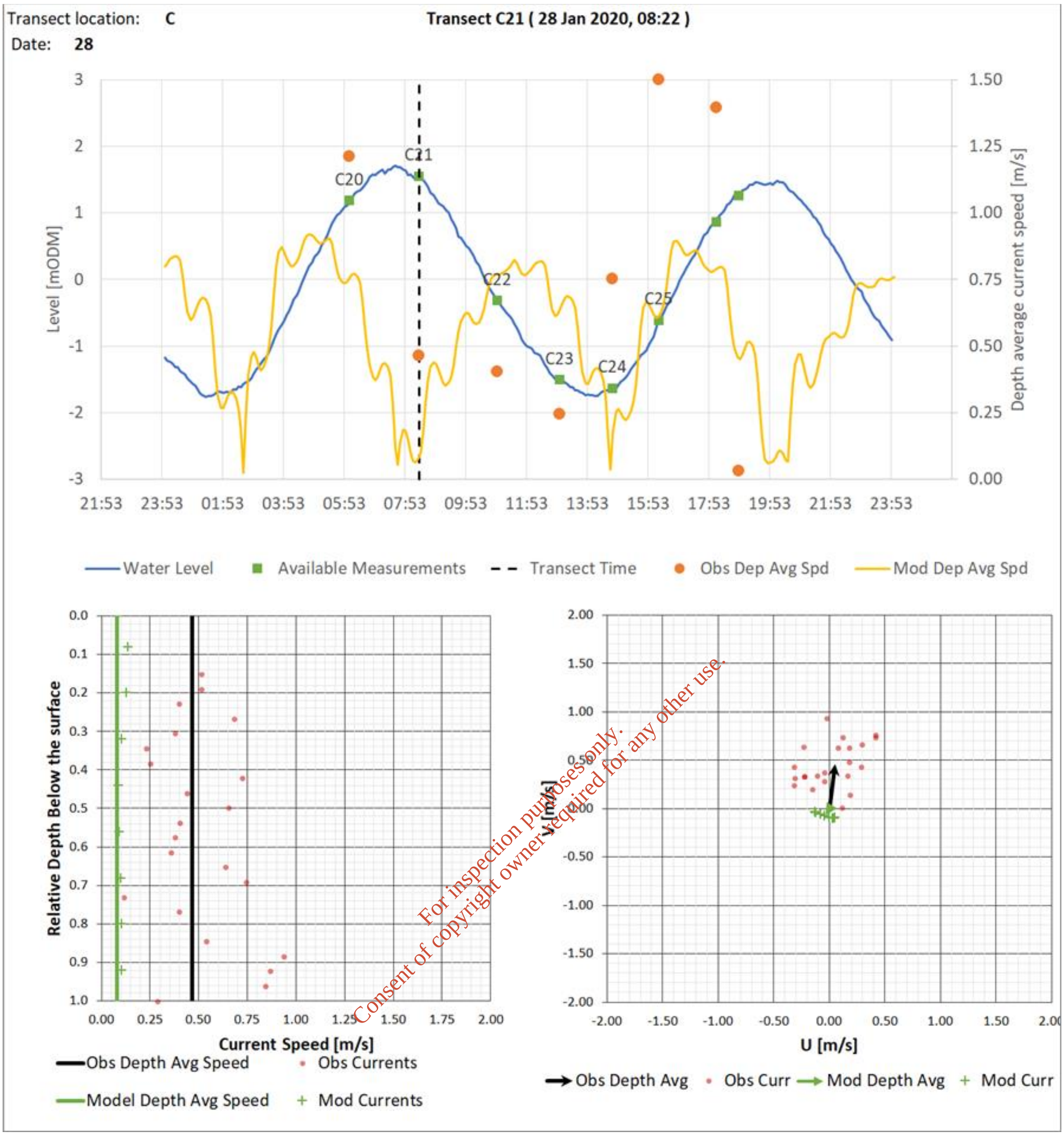

Transect location: B
Date: 28
Transect B24 (28 Jan 2020, 13:27)
Level [mODM]
Depth average current speed [m/s]
B21
B22
B23
B24
B25
B26
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

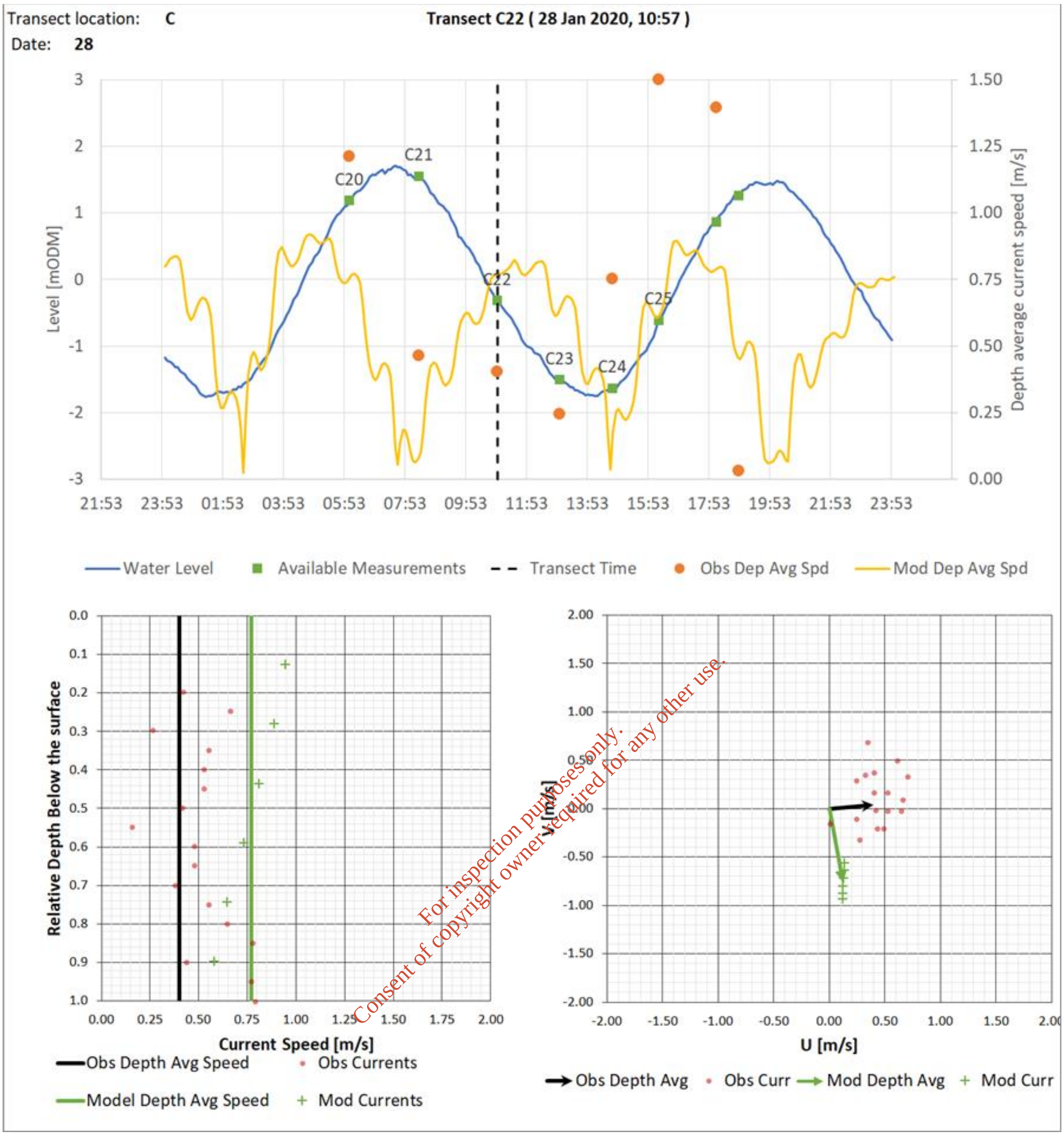

Transect location: B
Date: 28
Transect B25 (28 Jan 2020, 15:23)
Level [mODM]
Depth average current speed [m/s]
B21
B22
B23
B24
B25
B26
21:53 23:53 01:53 03:53 05:53 07:53 09:53 11:53 13:53 15:53 17:53 19:53 21:53 23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

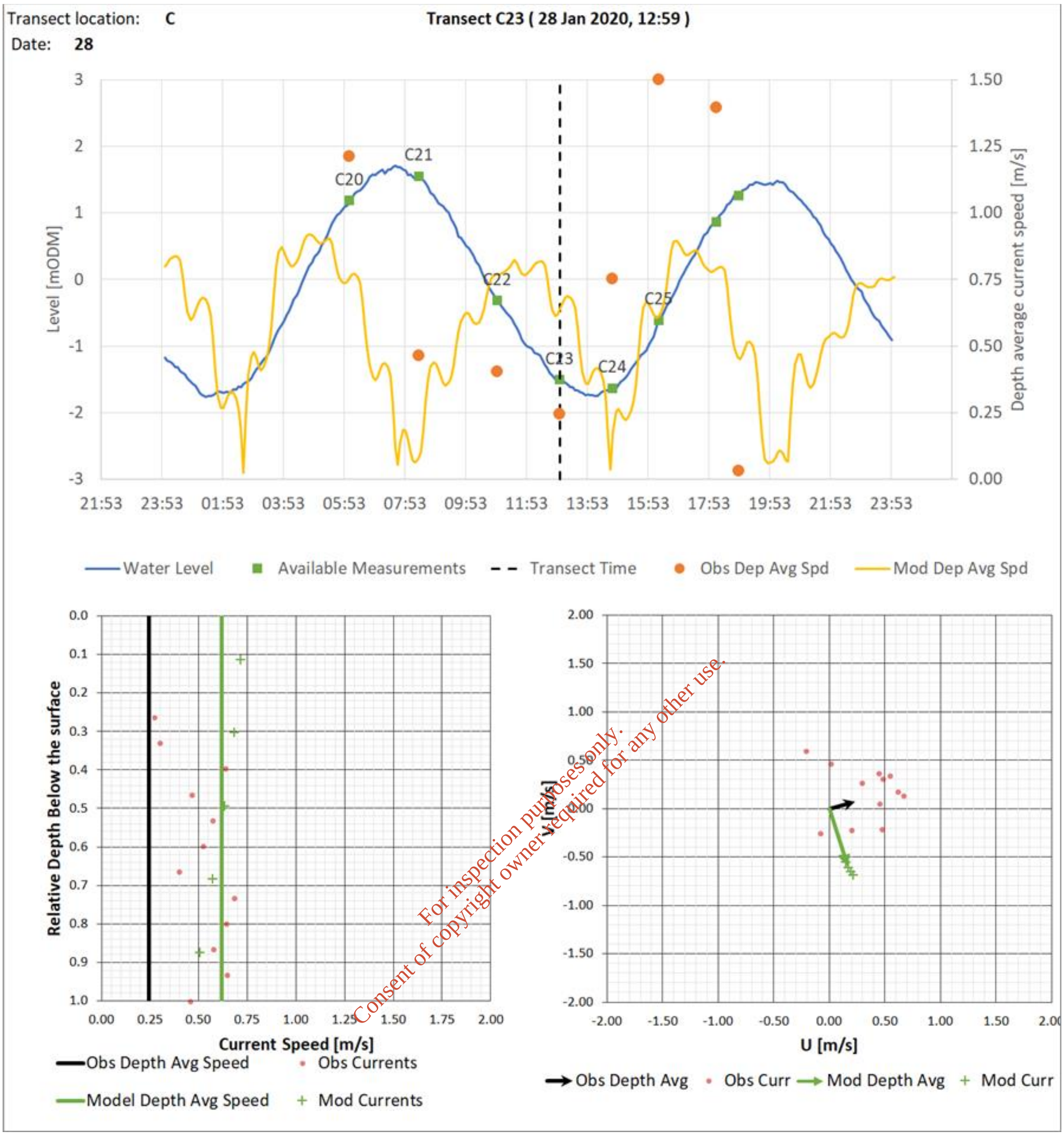

Transect location: B
Date: 28
Transect B26 (28 Jan 2020, 17:15)
Level [mODM]
Depth average current speed [m/s]
B21
B22
B23
B24
B25
B26
21:53 23:53 01:53 03:53 05:53 07:53 09:53 11:53 13:53 15:53 17:53 19:53 21:53 23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

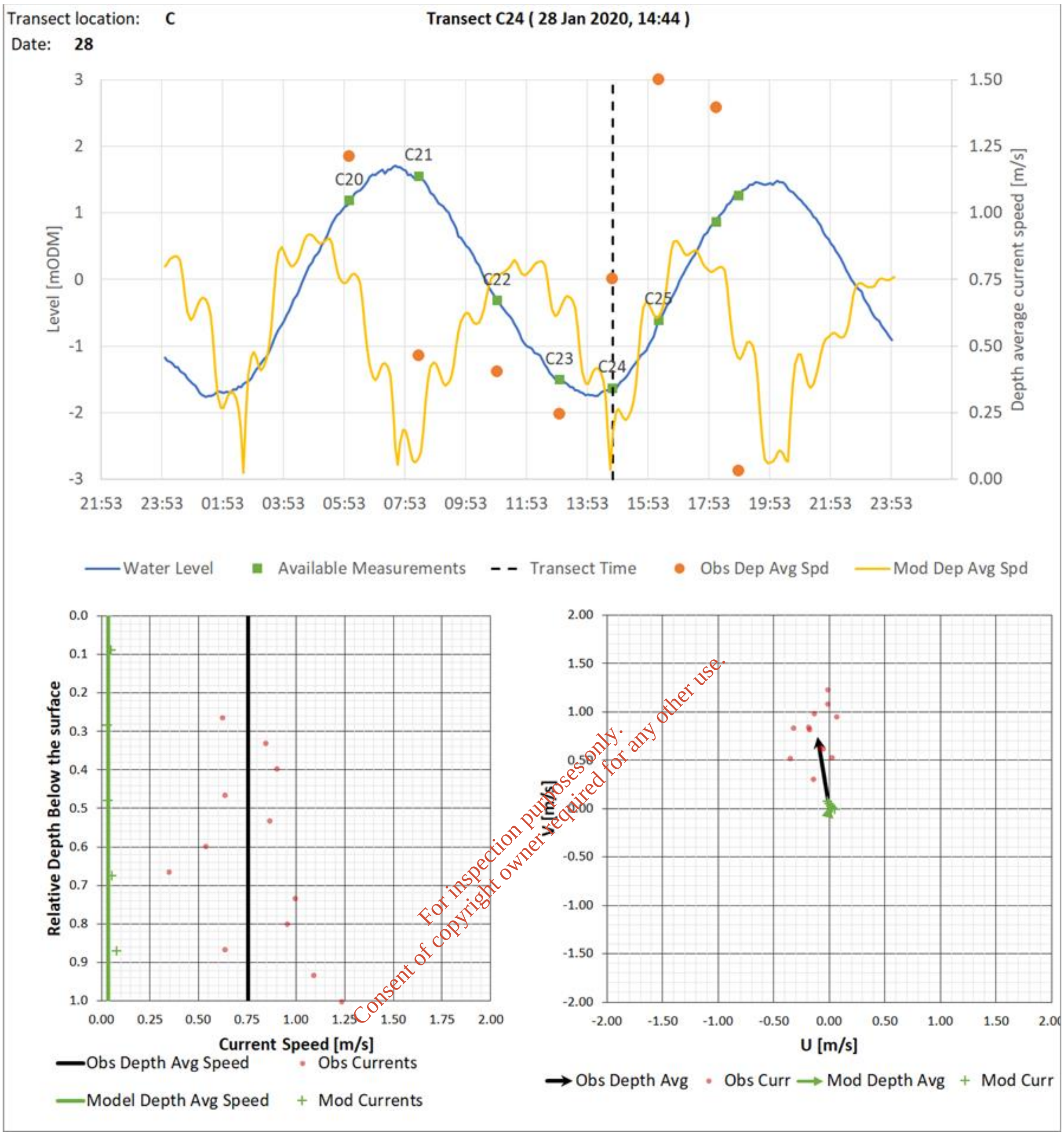
D.3 Event C: Transect C

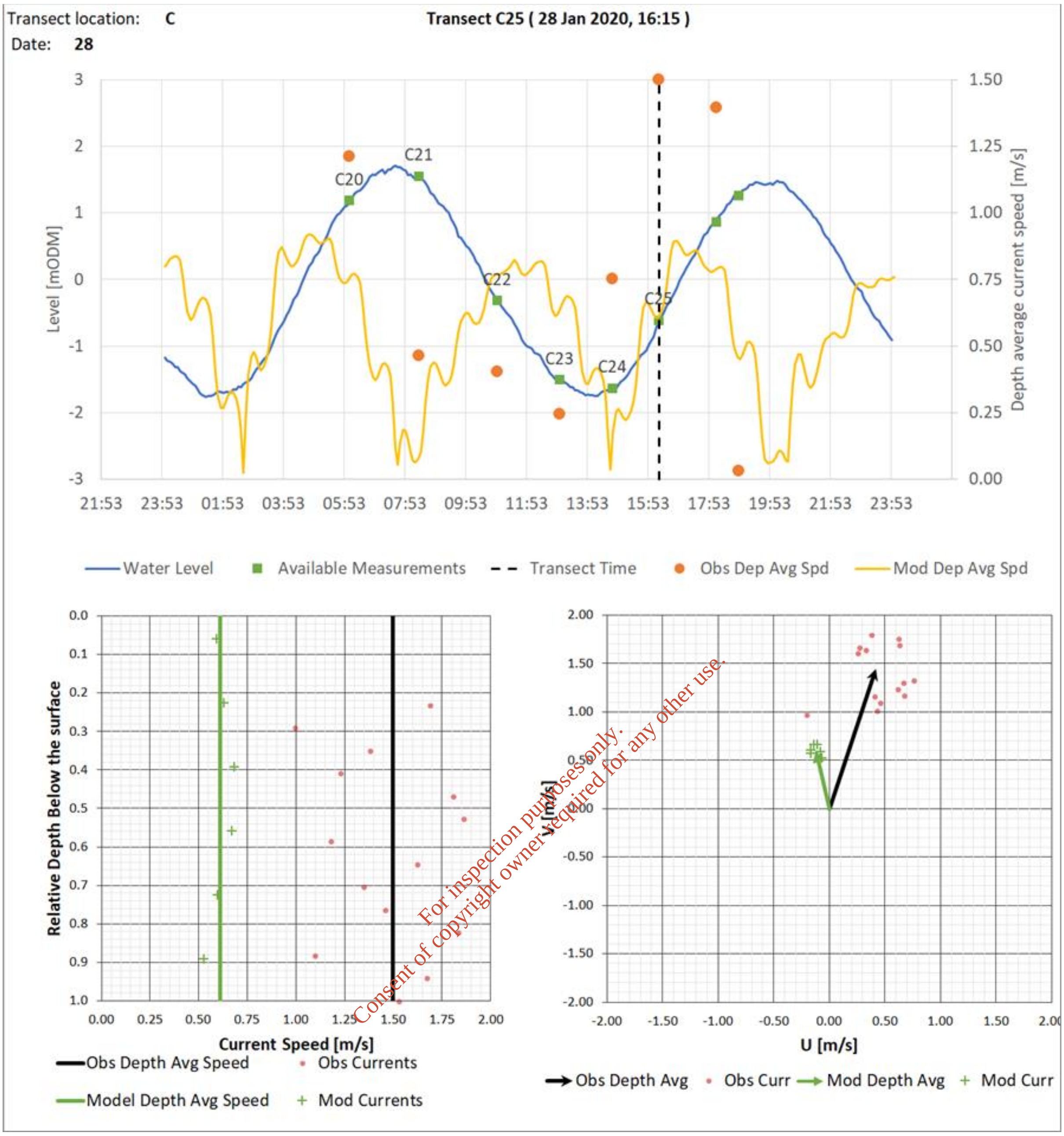


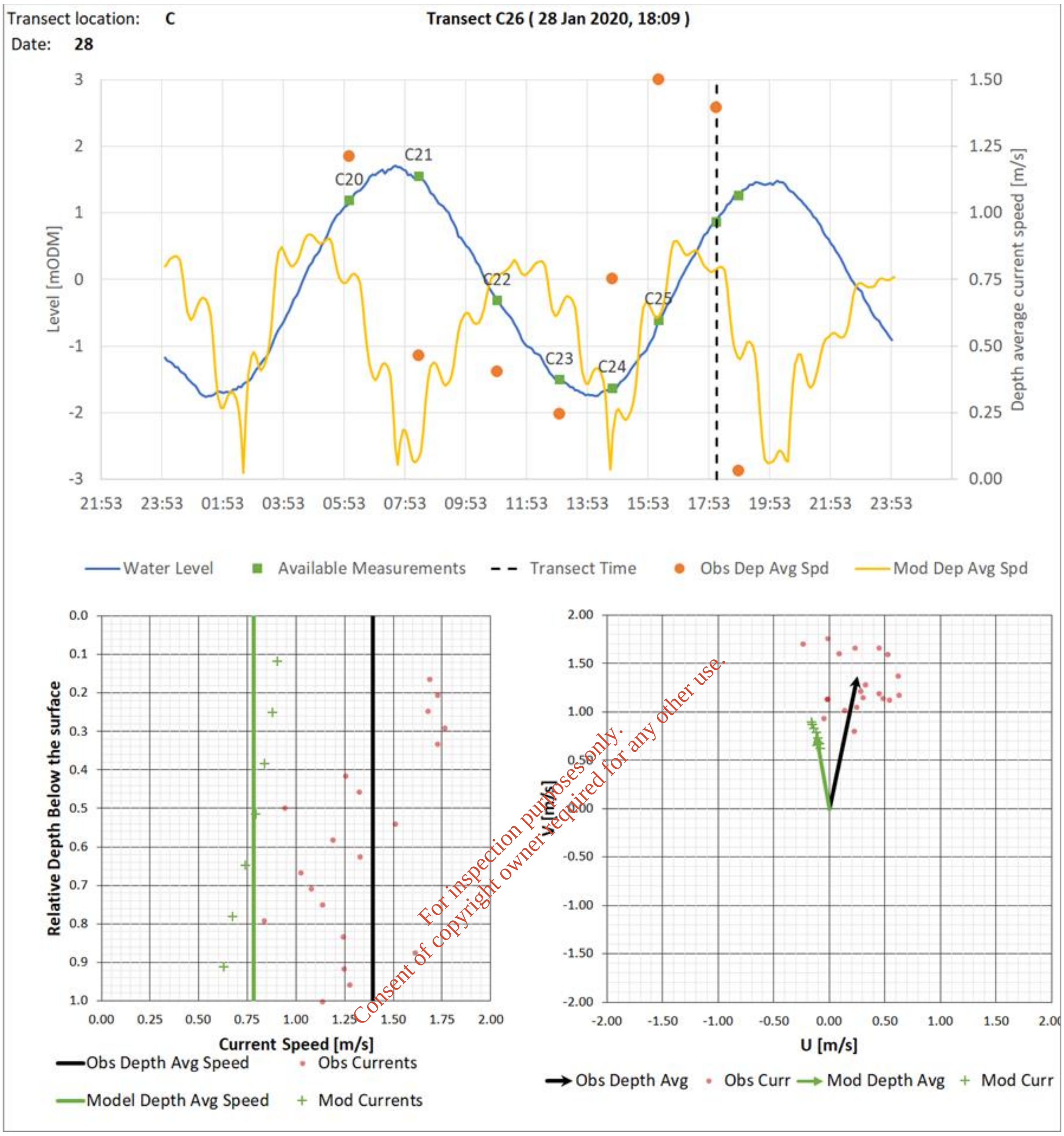

Transect location: C
Date: 28
Transect C21 (28 Jan 2020, 08:22)
Level [mODM]
Depth average current speed [m/s]
C20
C21
C22
C23
C24
C25
21:53 23:53 01:53 03:53 05:53 07:53 09:53 11:53 13:53 15:53 17:53 19:53 21:53 23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

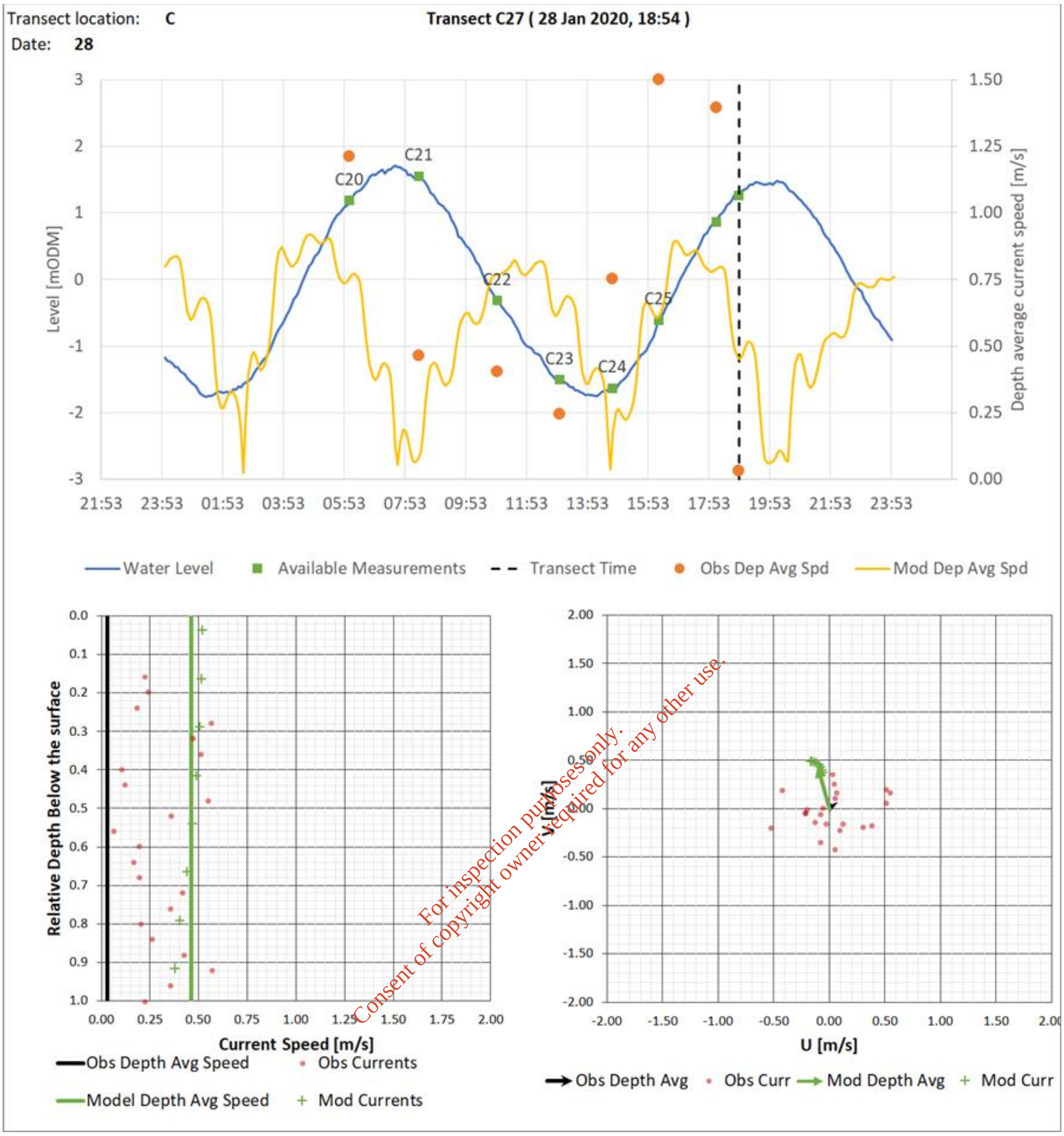

Transect location: C
Date: 28
Transect C22 (28 Jan 2020, 10:57)
Level [mODM]
Depth average current speed [m/s]
C20
C21
C22
C23
C24
C25
21:53 23:53 01:53 03:53 05:53 07:53 09:53 11:53 13:53 15:53 17:53 19:53 21:53 23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr


Transect location: C
Date: 28
Transect C23 (28 Jan 2020, 12:59)
Level [mODM]
Depth average current speed [m/s]
C20
C21
C22
C23
C24
C25
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

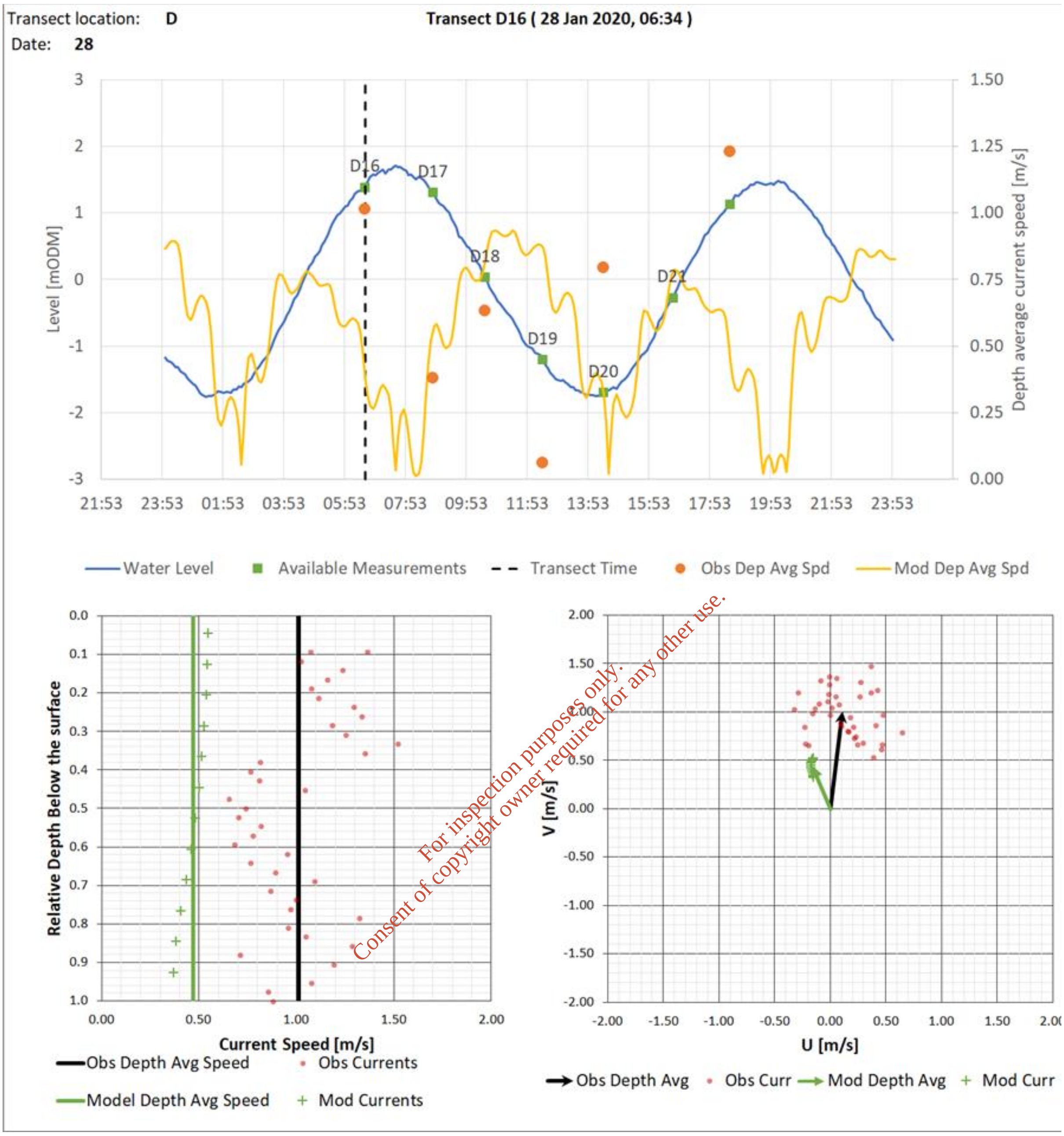

Transect location: C
Date: 28
Transect C24 (28 Jan 2020, 14:44)
Level [mODM]
Depth average current speed [m/s]
C20
C21
C22
C23
C24
C25
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

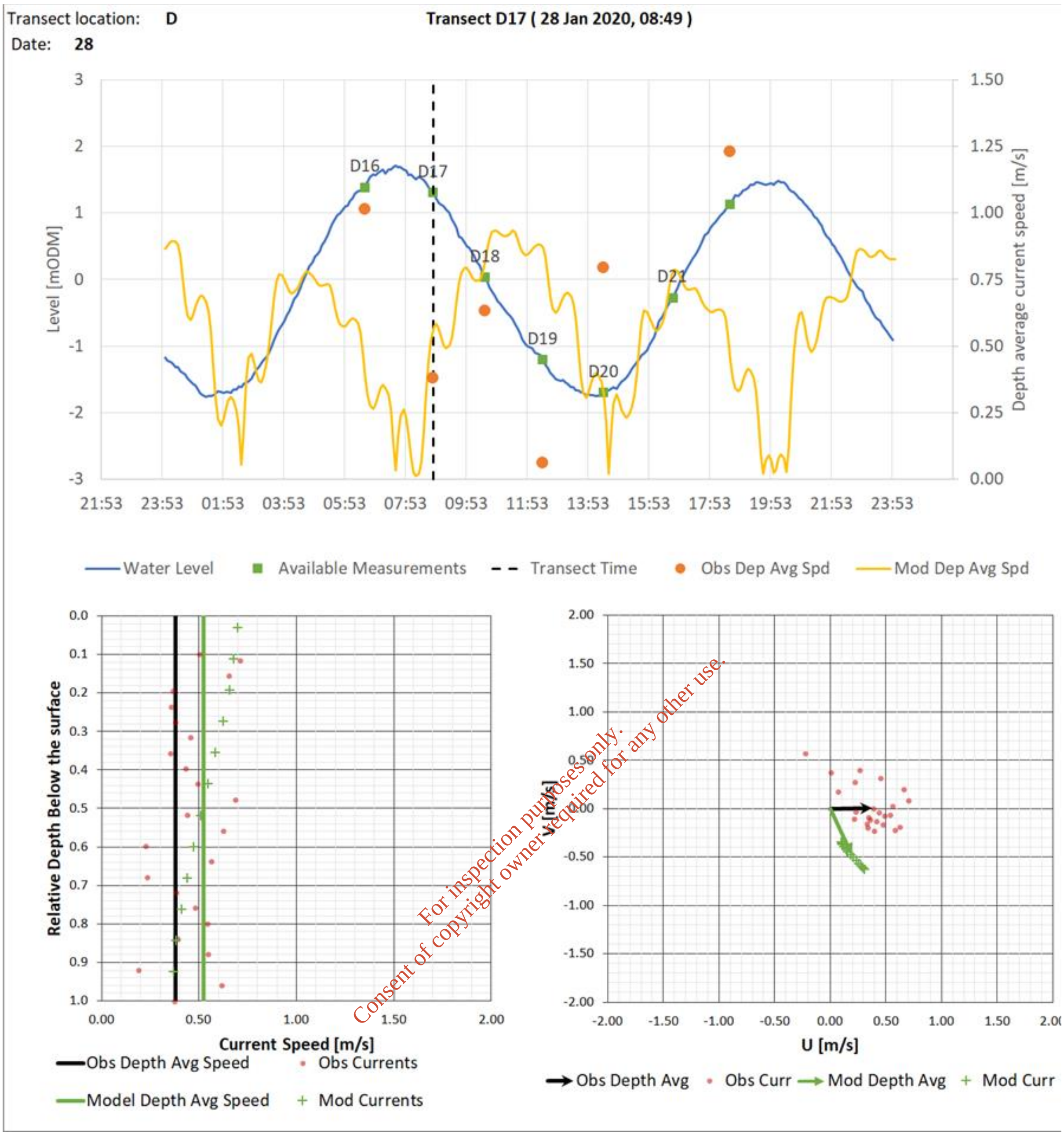

Transect location: C
Date: 28
Transect C25 (28 Jan 2020, 16:15)
Level [mODM]
Depth average current speed [m/s]
C20
C21
C22
C23
C24
C25
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

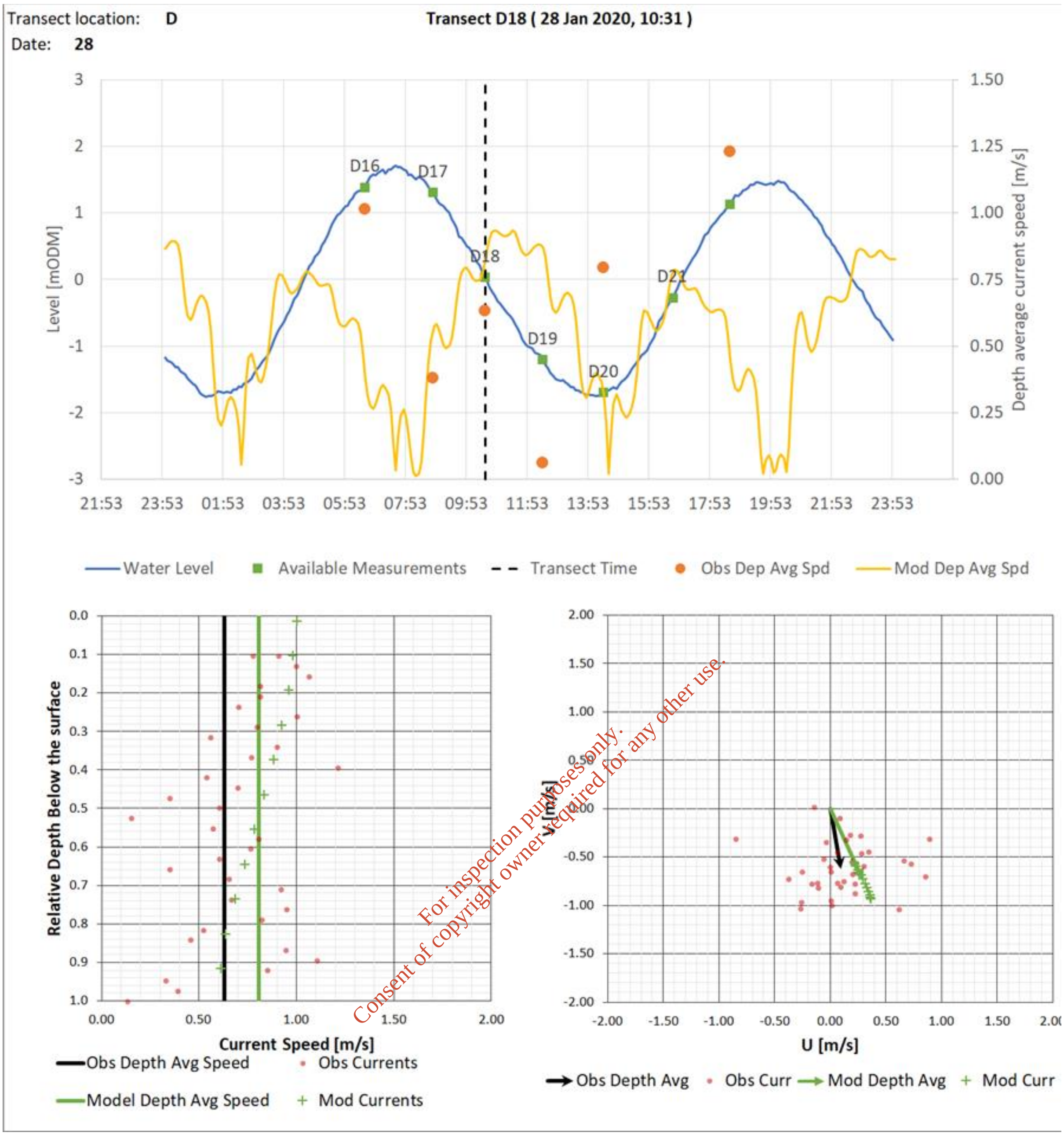

Transect location: C
Date: 28
Transect C26 (28 Jan 2020, 18:09)
Level [mODM]
Depth average current speed [m/s]
C20
C21
C22
C23
C24
C25
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

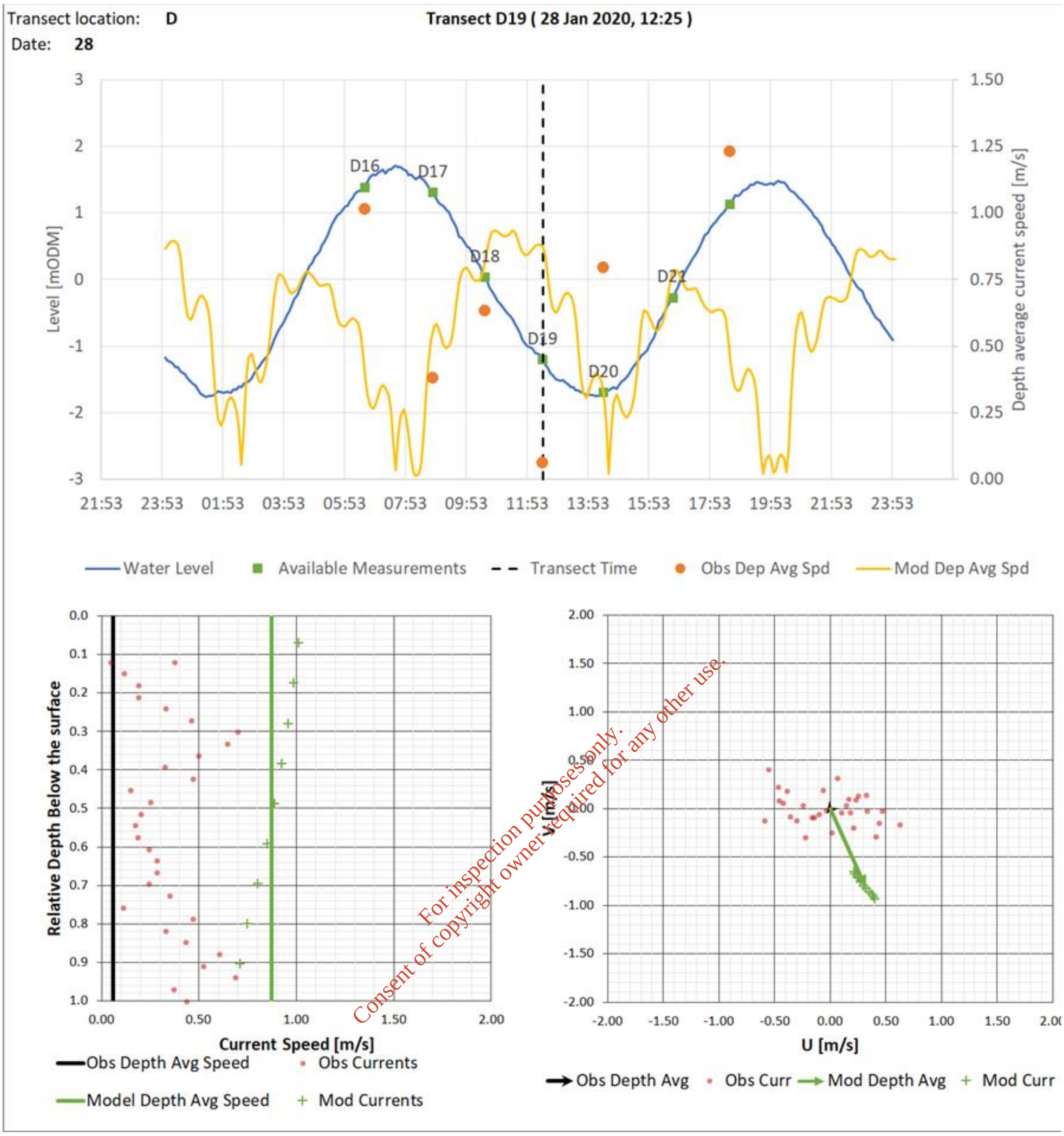

Transect location: C
Date: 28
Transect C27 (28 Jan 2020, 18:54)
Level [mODM]
Depth average current speed [m/s]
C20
C21
C22
C23
C24
C25
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

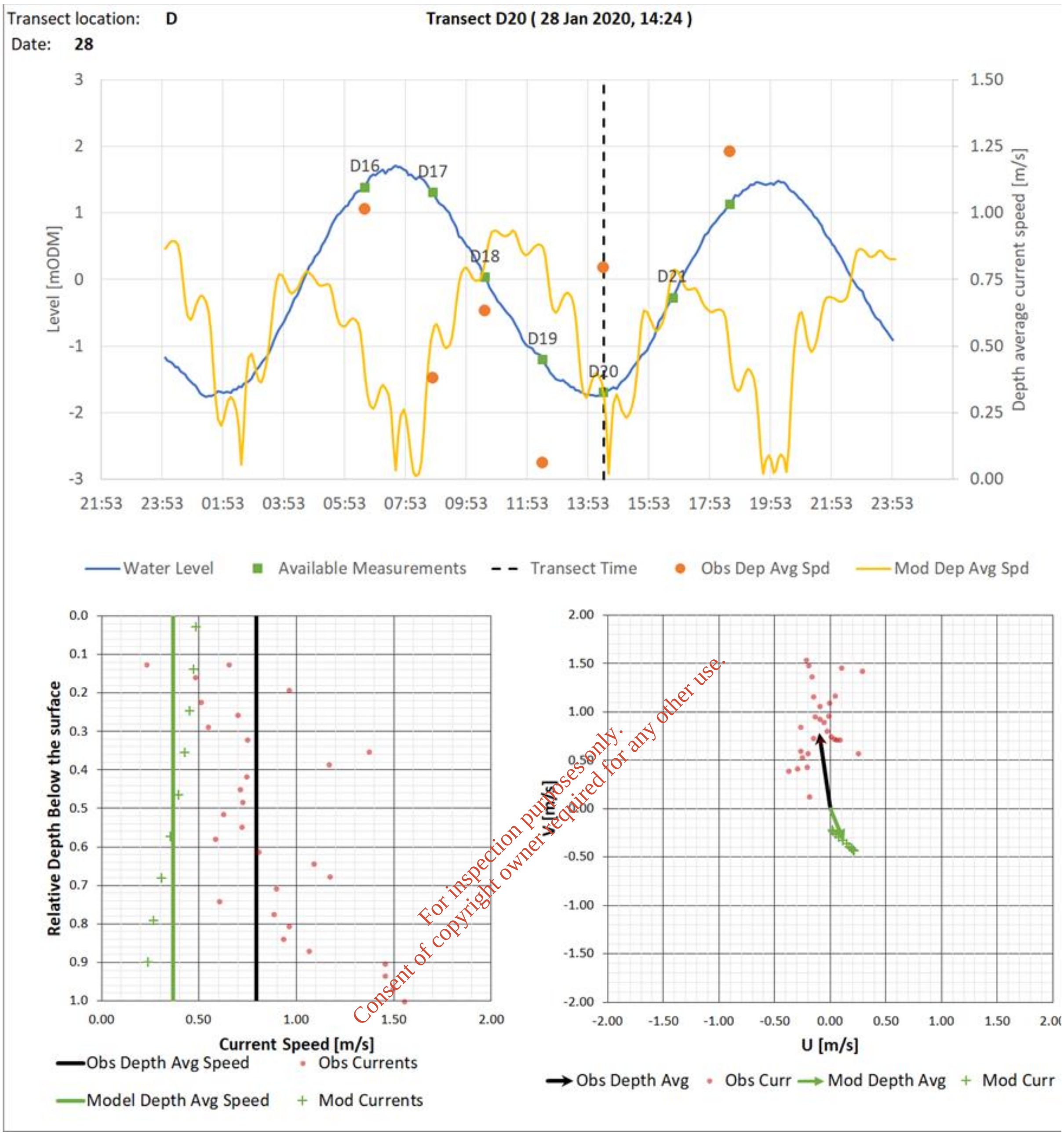
D.4 Event C: Transect D

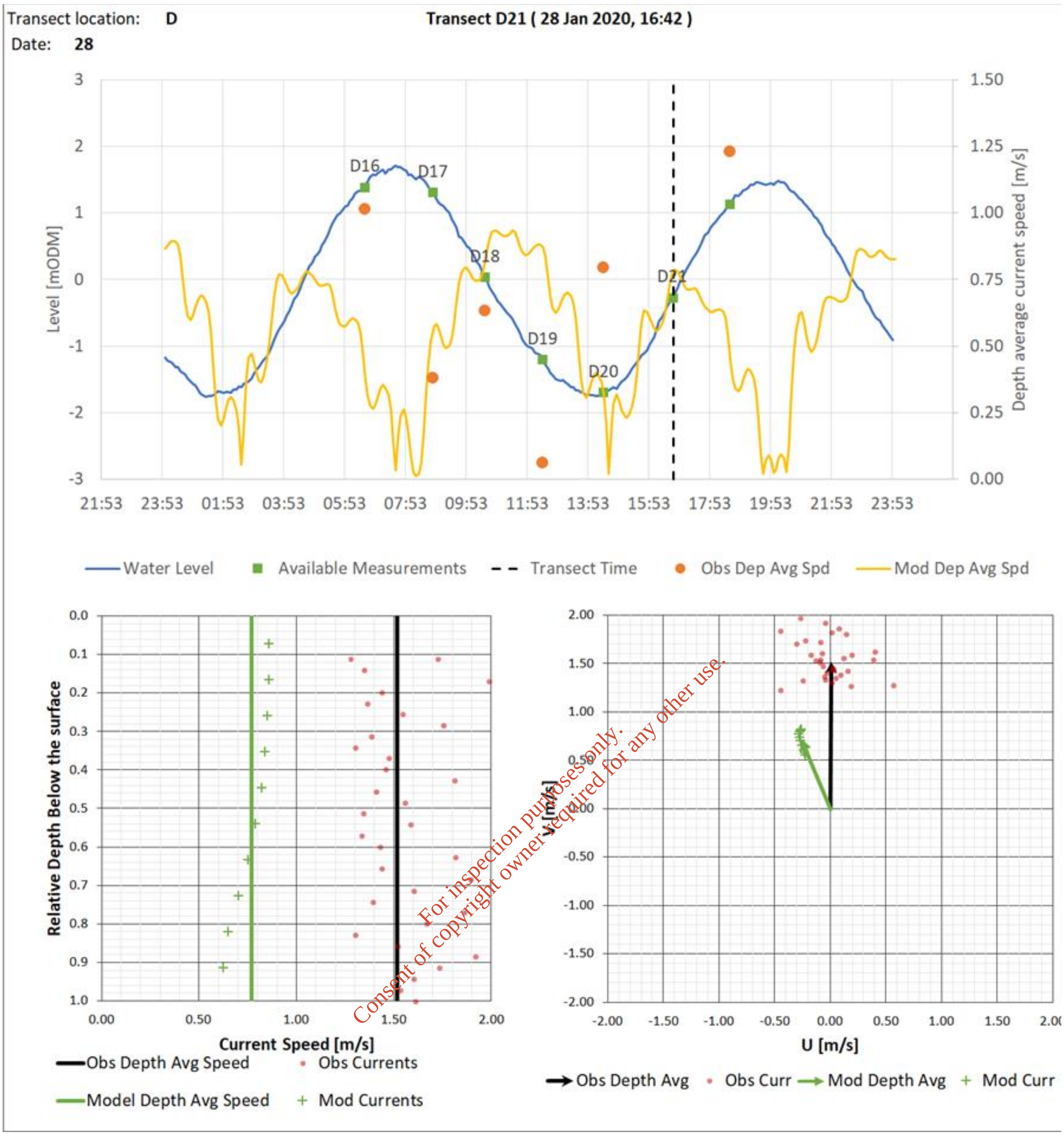


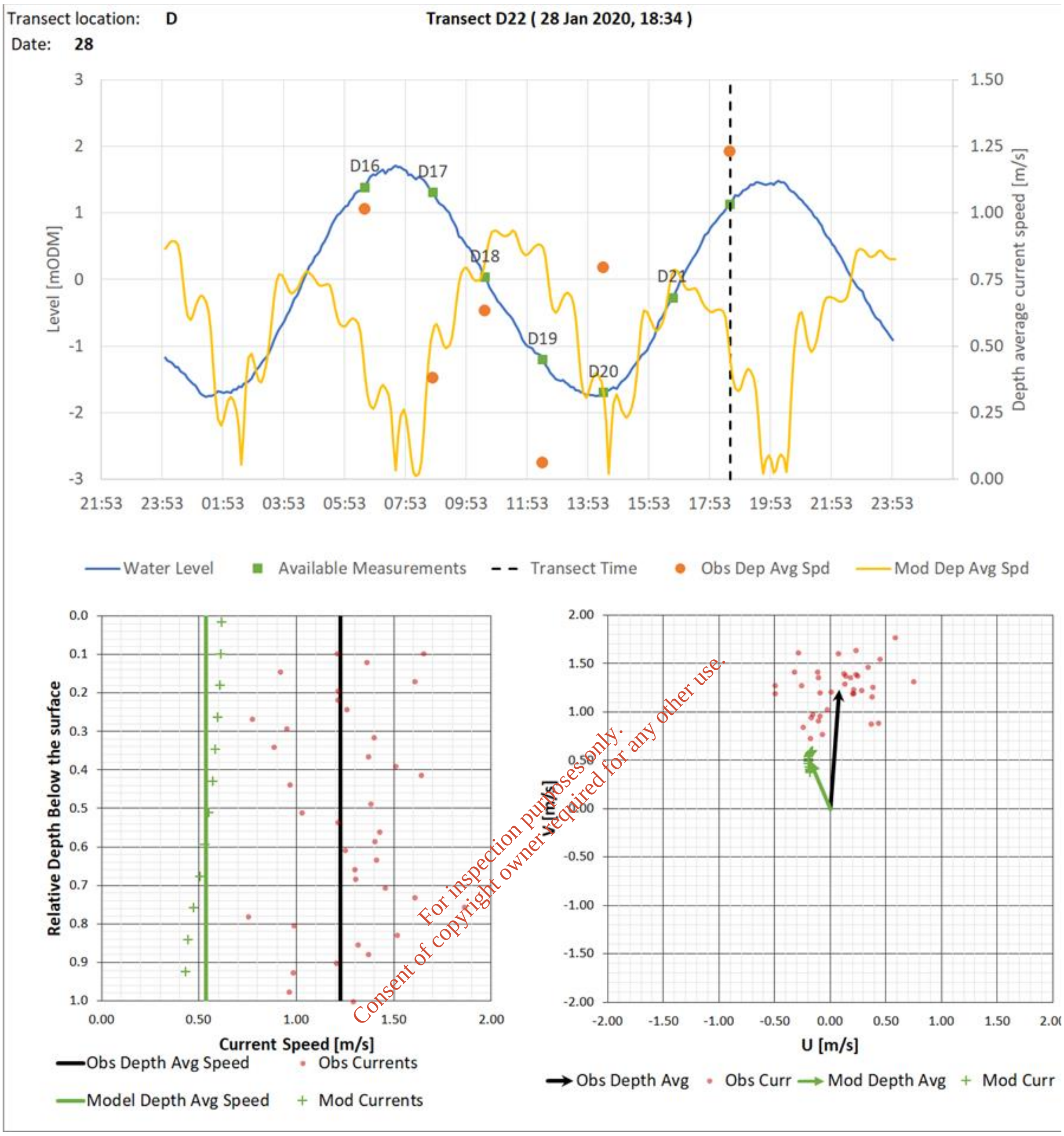

Transect location: D
Date: 28
Transect D17 (28 Jan 2020, 08:49)
Level [mODM]
Depth average current speed [m/s]
D16
D17
D18
D19
D20
D21
21:53 23:53 01:53 03:53 05:53 07:53 09:53 11:53 13:53 15:53 17:53 19:53 21:53 23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr


Transect location: D
Date: 28
Transect D18 (28 Jan 2020, 10:31)
Level [mODM]
Depth average current speed [m/s]
D16
D17
D18
D19
D20
D21
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

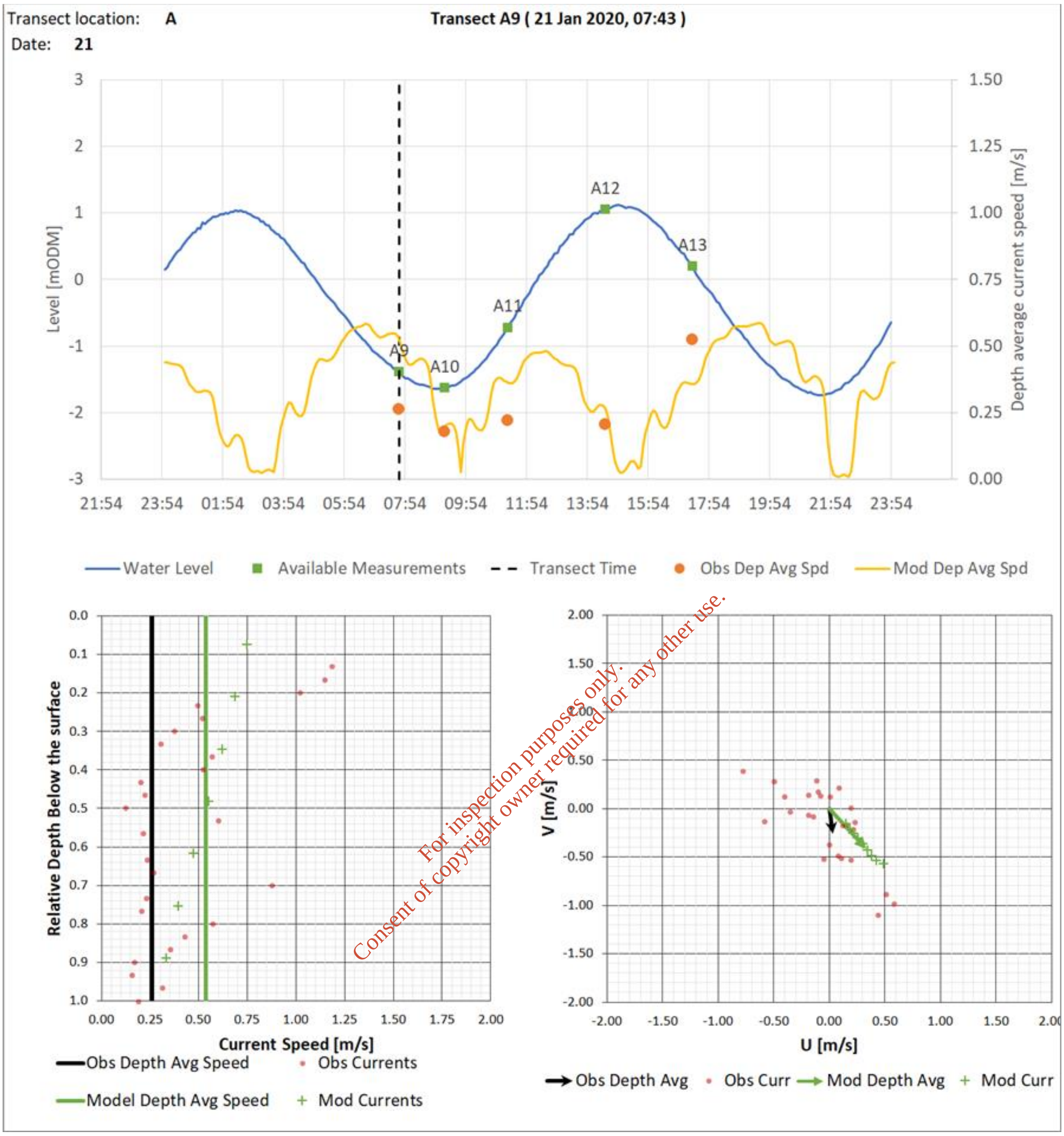

Transect location: D
Date: 28
Transect D19 (28 Jan 2020, 12:25)
Level [mODM]
Depth average current speed [m/s]
D16
D17
D18
D19
D20
D21
21:53
23:53
01:53
03:53
05:53
07:53
09:53
11:53
13:53
15:53
17:53
19:53
21:53
23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

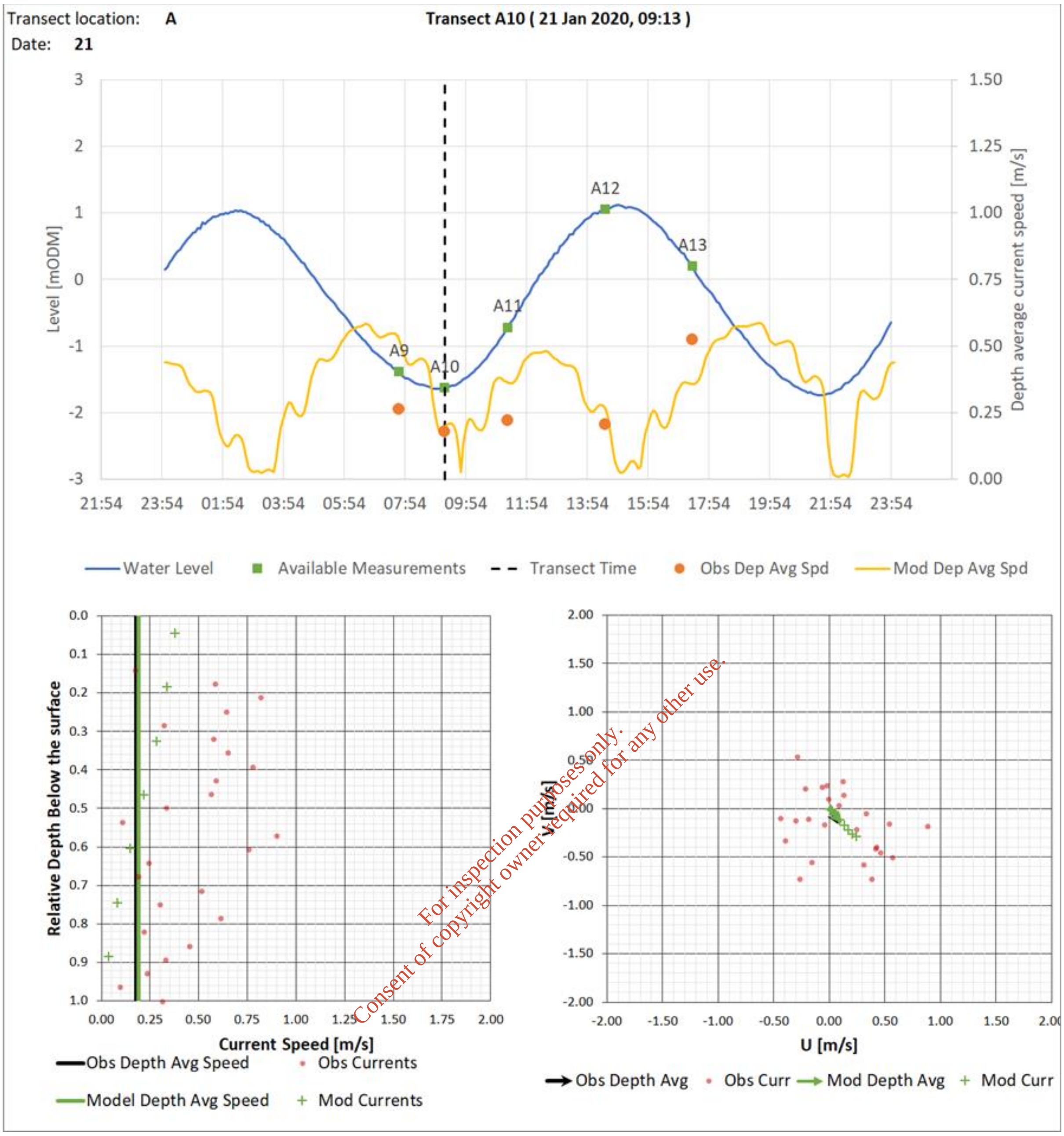

Transect location: D
Date: 28
Transect D20 (28 Jan 2020, 14:24)
Level [mODM]
Depth average current speed [m/s]
D16
D17
D18
D19
D20
D21
21:53 23:53 01:53 03:53 05:53 07:53 09:53 11:53 13:53 15:53 17:53 19:53 21:53 23:53
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

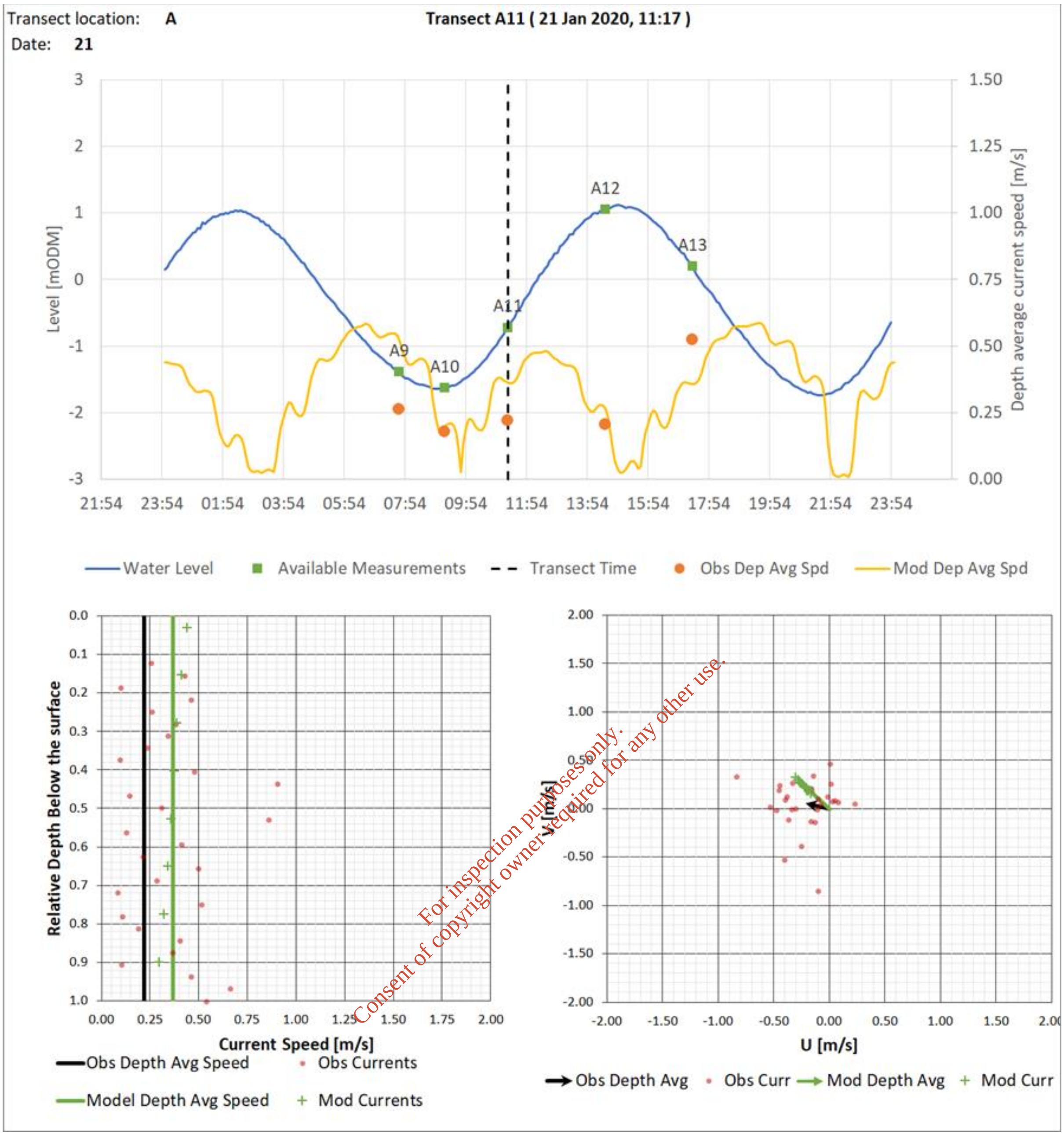

Transect location: D
Date: 28
Transect D21 (28 Jan 2020, 16:42)
Level [mODM]
Depth average current speed [m/s]
D16
D17
D18
D19
D20
D21
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

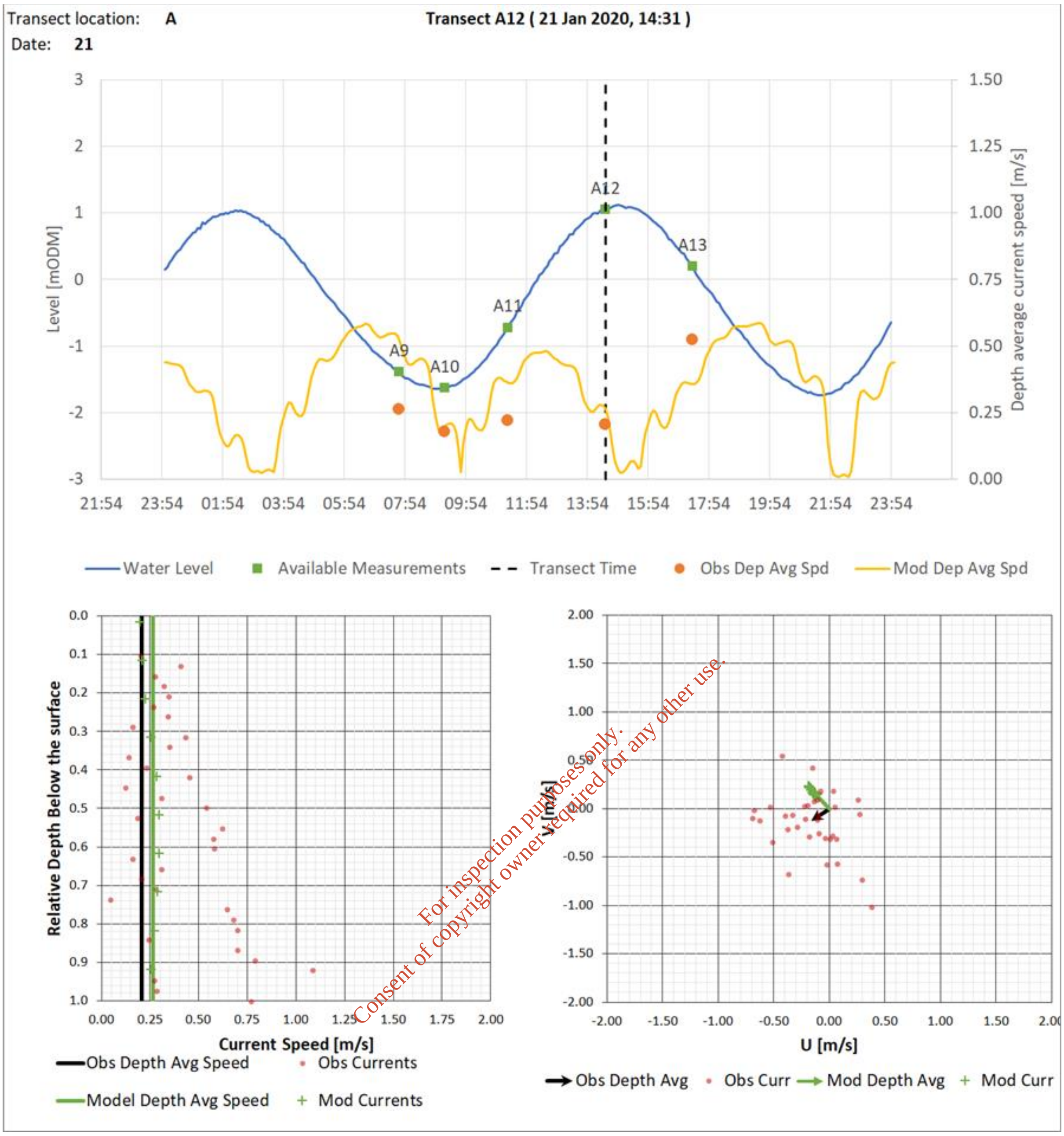

Transect location: D
Date: 28
Transect D22 (28 Jan 2020, 18:34)
Level [mODM]
Depth average current speed [m/s]
D16
D17
D18
D19
D20
D21
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

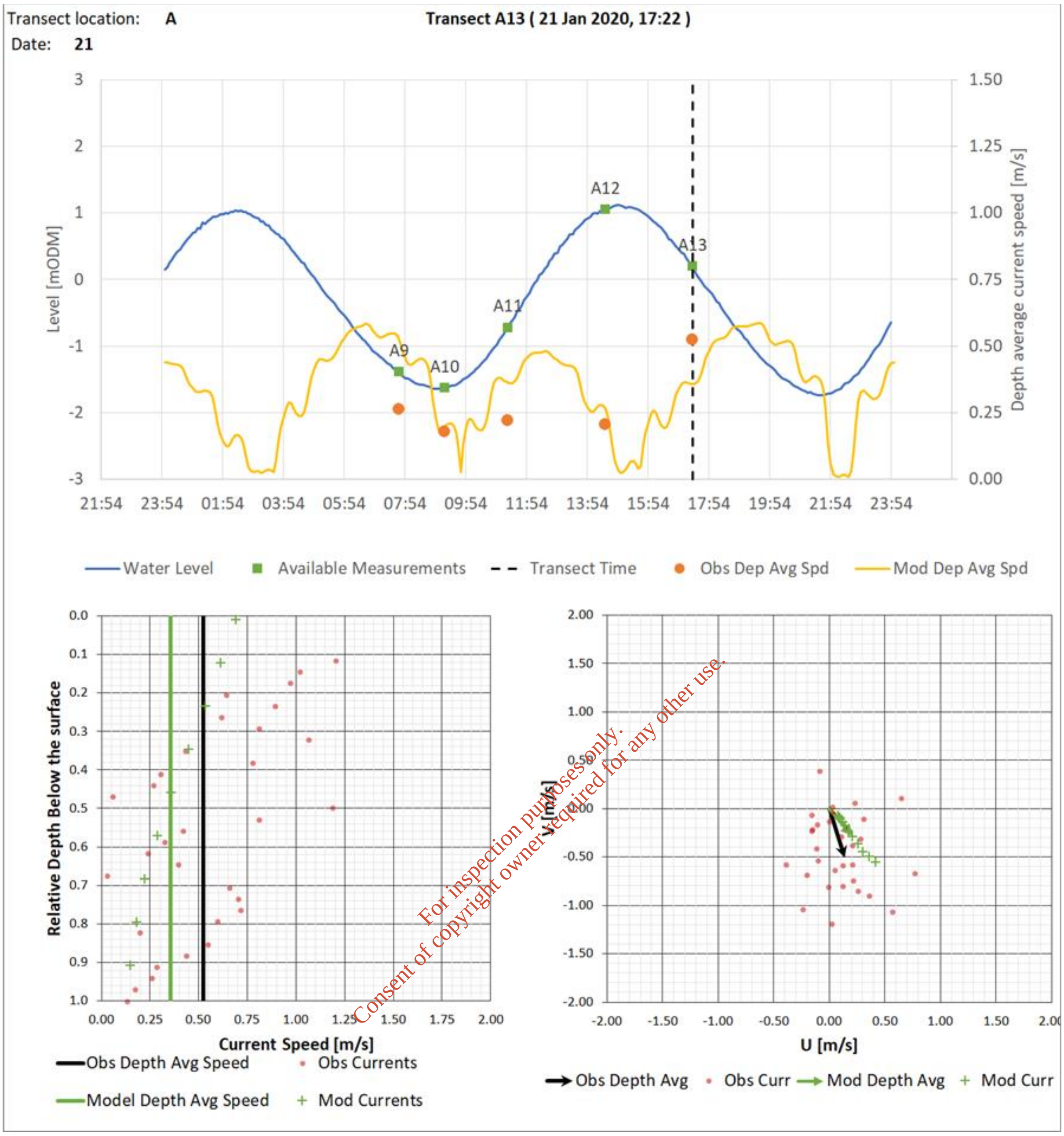
D.5 Event D: Transect A



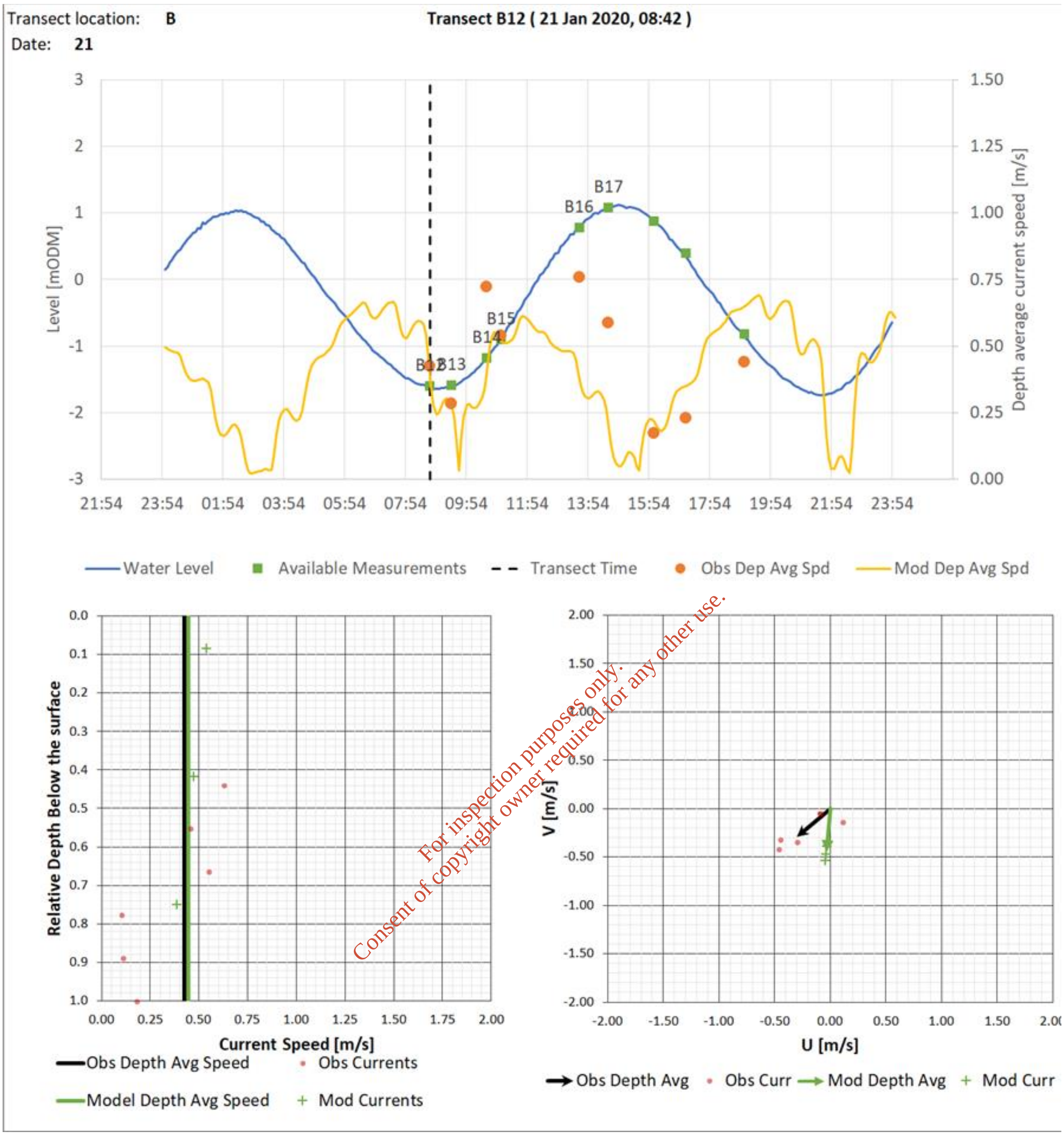

Transect location: A
Date: 21
Transect A10 (21 Jan 2020, 09:13)
Level [mODM]
Depth average current speed [m/s]
A9
A10
A11
A12
A13
21:54 23:54 01:54 03:54 05:54 07:54 09:54 11:54 13:54 15:54 17:54 19:54 21:54 23:54
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

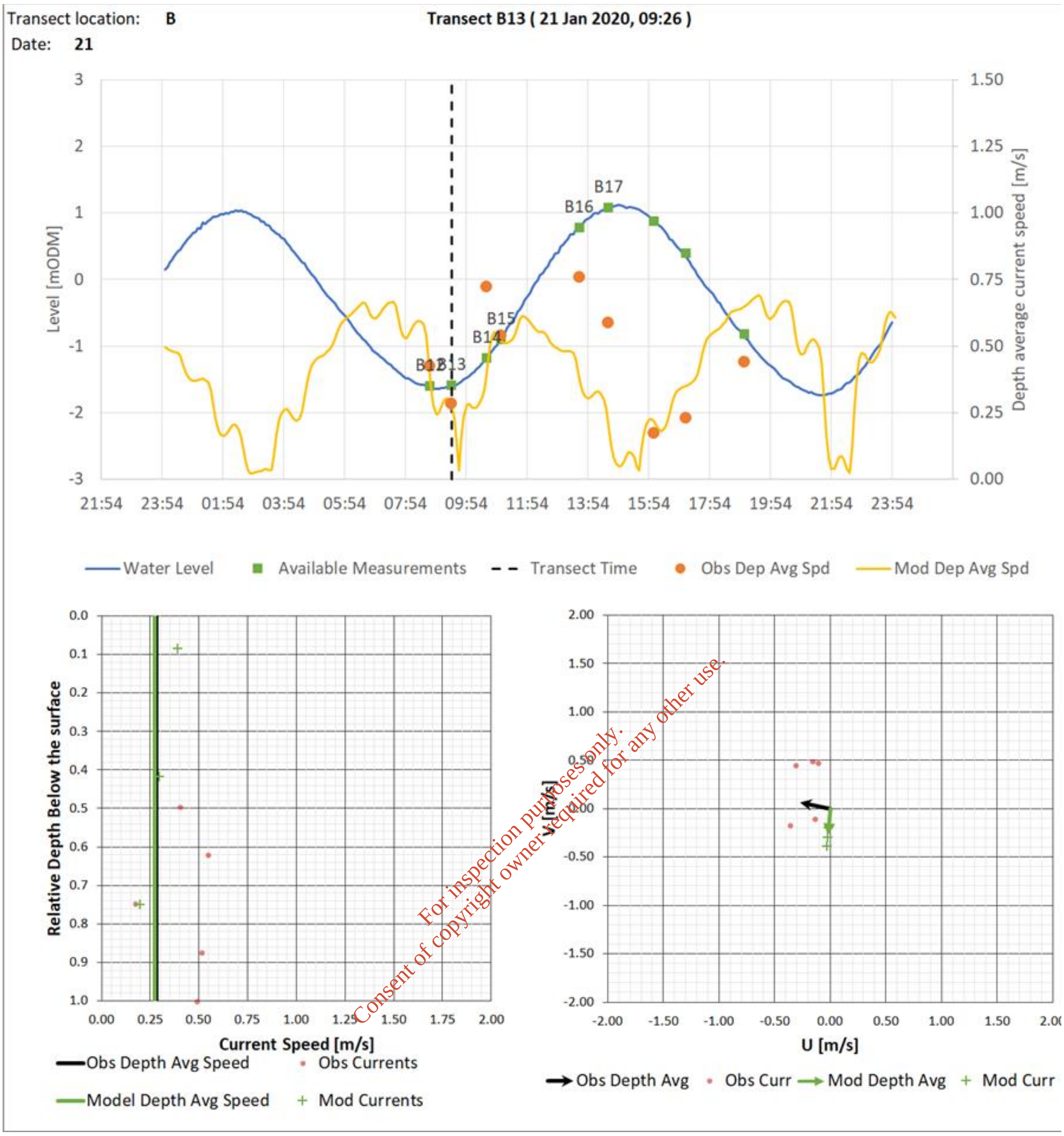

Transect location: A
Date: 21
Transect A11 (21 Jan 2020, 11:17)
Level [mODM]
Depth average current speed [m/s]
A9
A10
A11
A12
A13
21:54 23:54 01:54 03:54 05:54 07:54 09:54 11:54 13:54 15:54 17:54 19:54 21:54 23:54
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr


Transect location: A
Date: 21
Transect A12 (21 Jan 2020, 14:31)
Level [mODM]
Depth average current speed [m/s]
A9
A10
A11
A12
A13
21:54 23:54 01:54 03:54 05:54 07:54 09:54 11:54 13:54 15:54 17:54 19:54 21:54 23:54
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

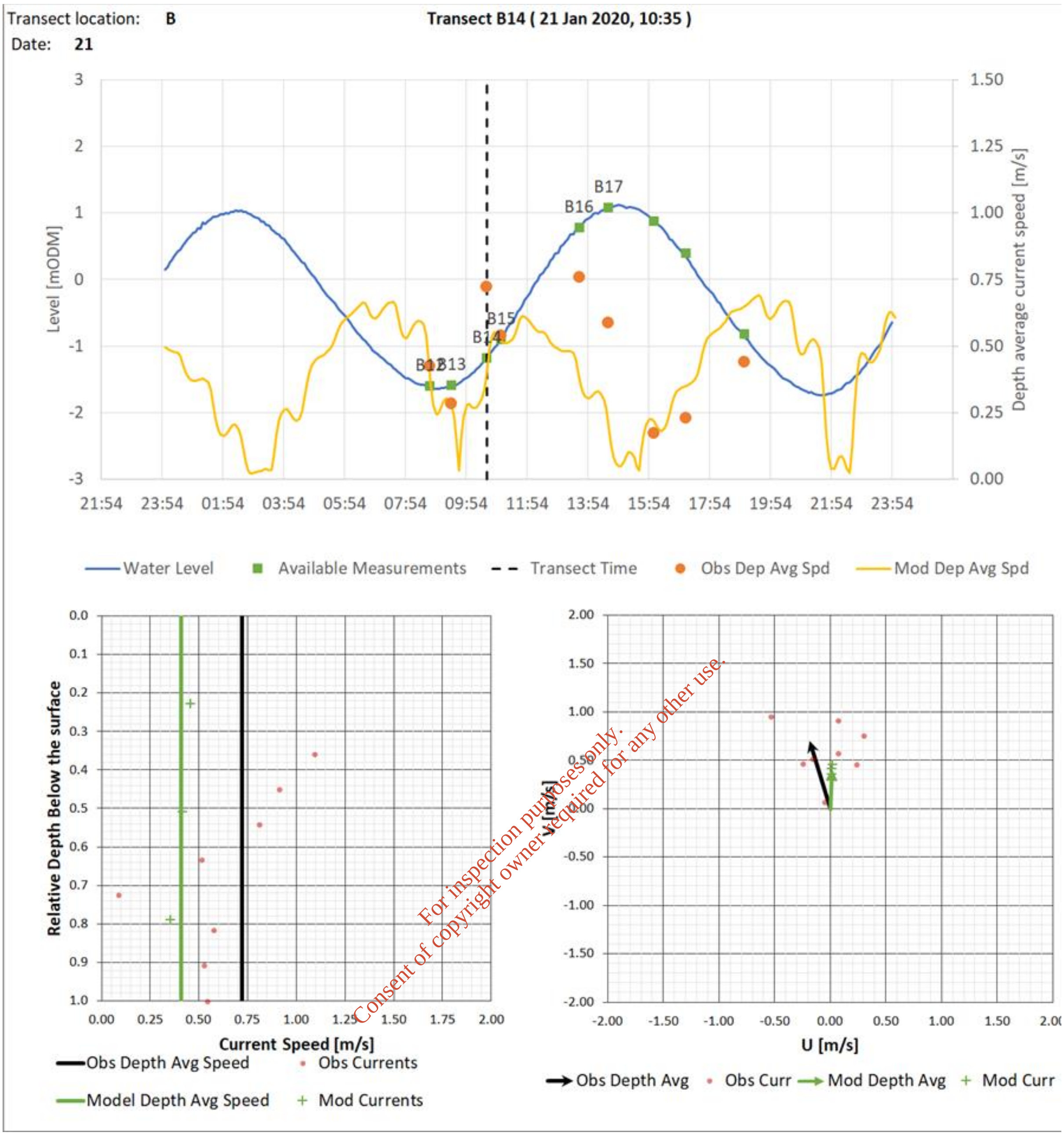

Transect location: A
Date: 21
Transect A13 (21 Jan 2020, 17:22)
Level [mODM]
Depth average current speed [m/s]
A9
A10
A11
A12
A13
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr

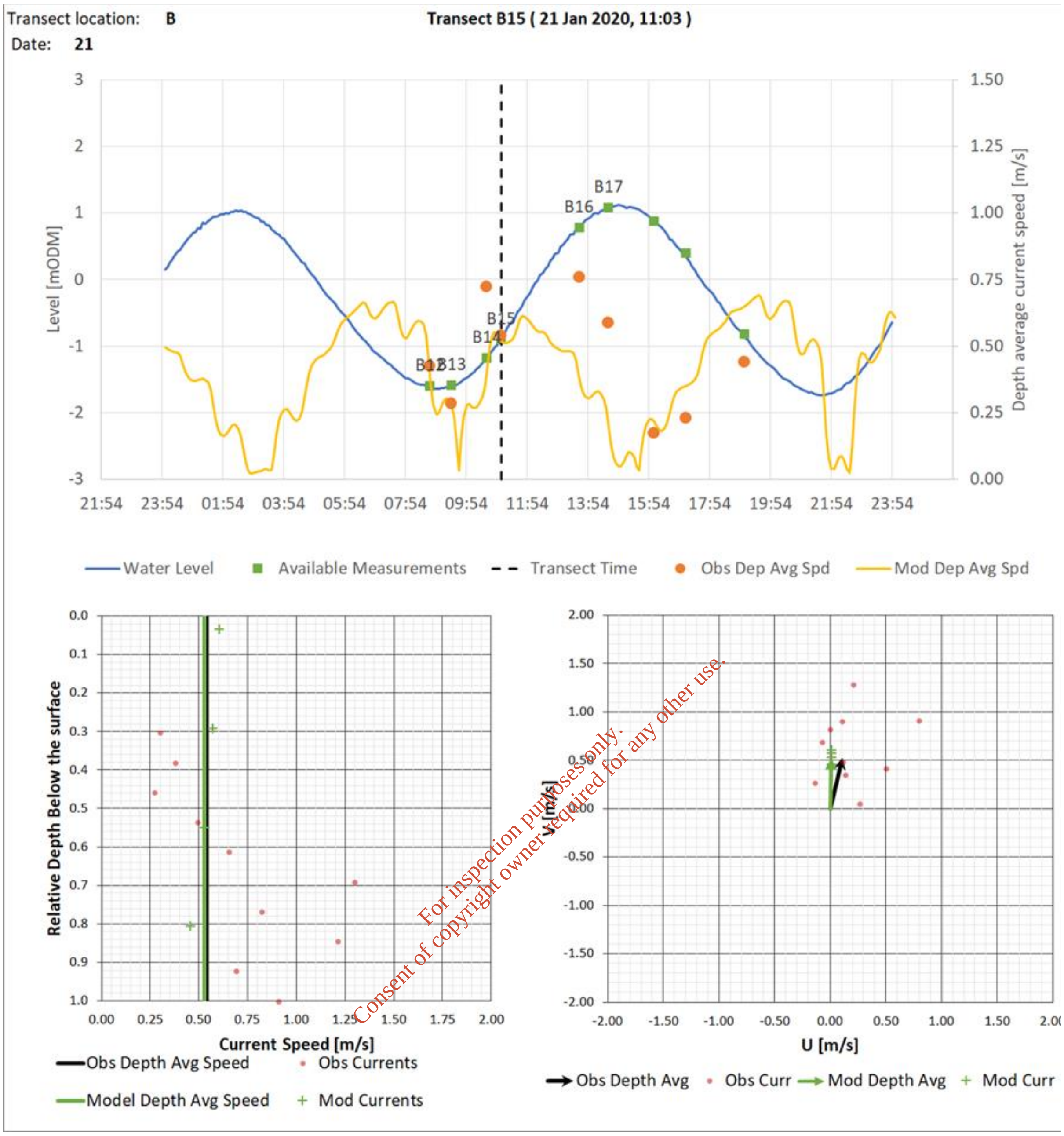
D.6 Event D: Transect B

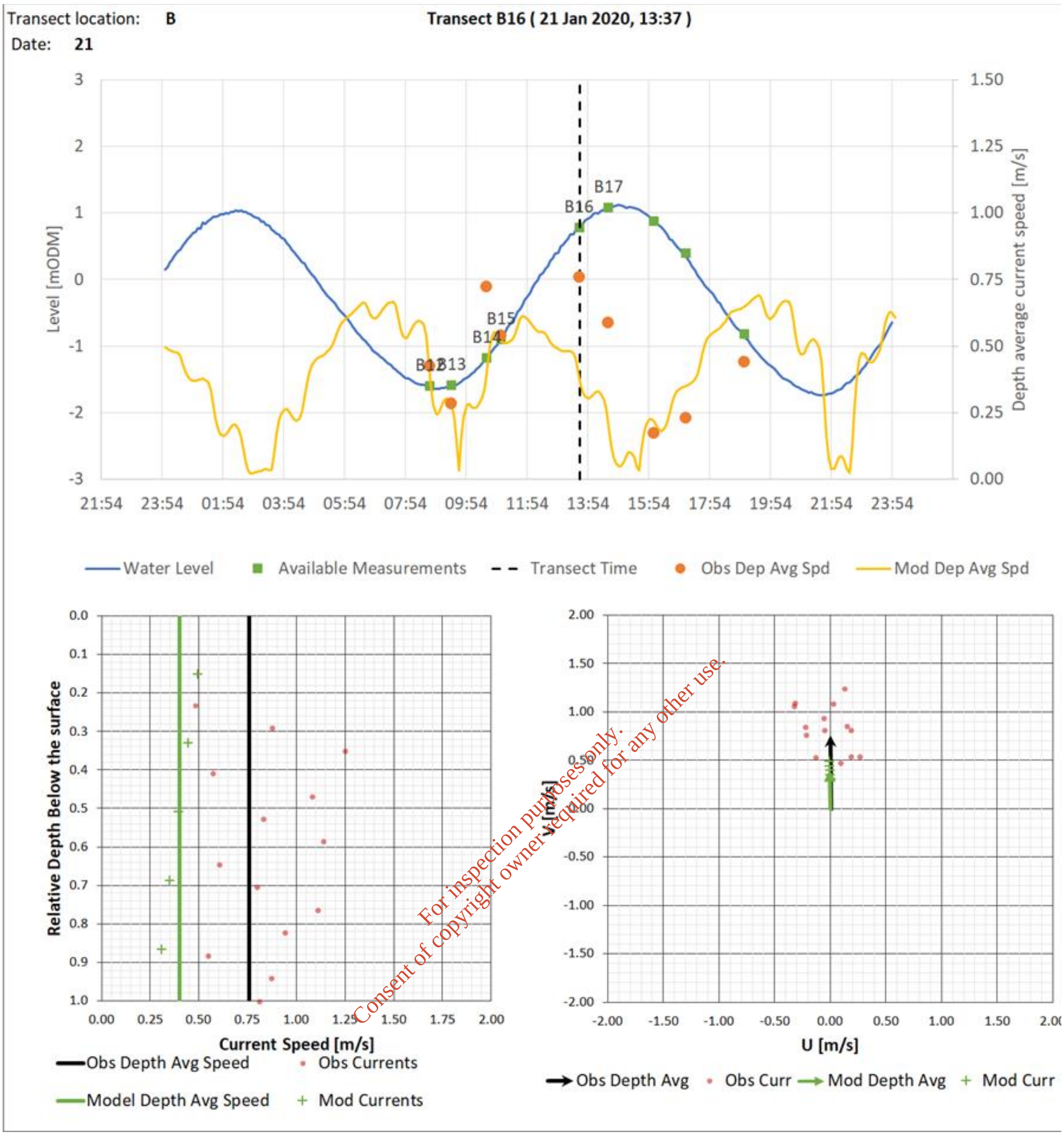


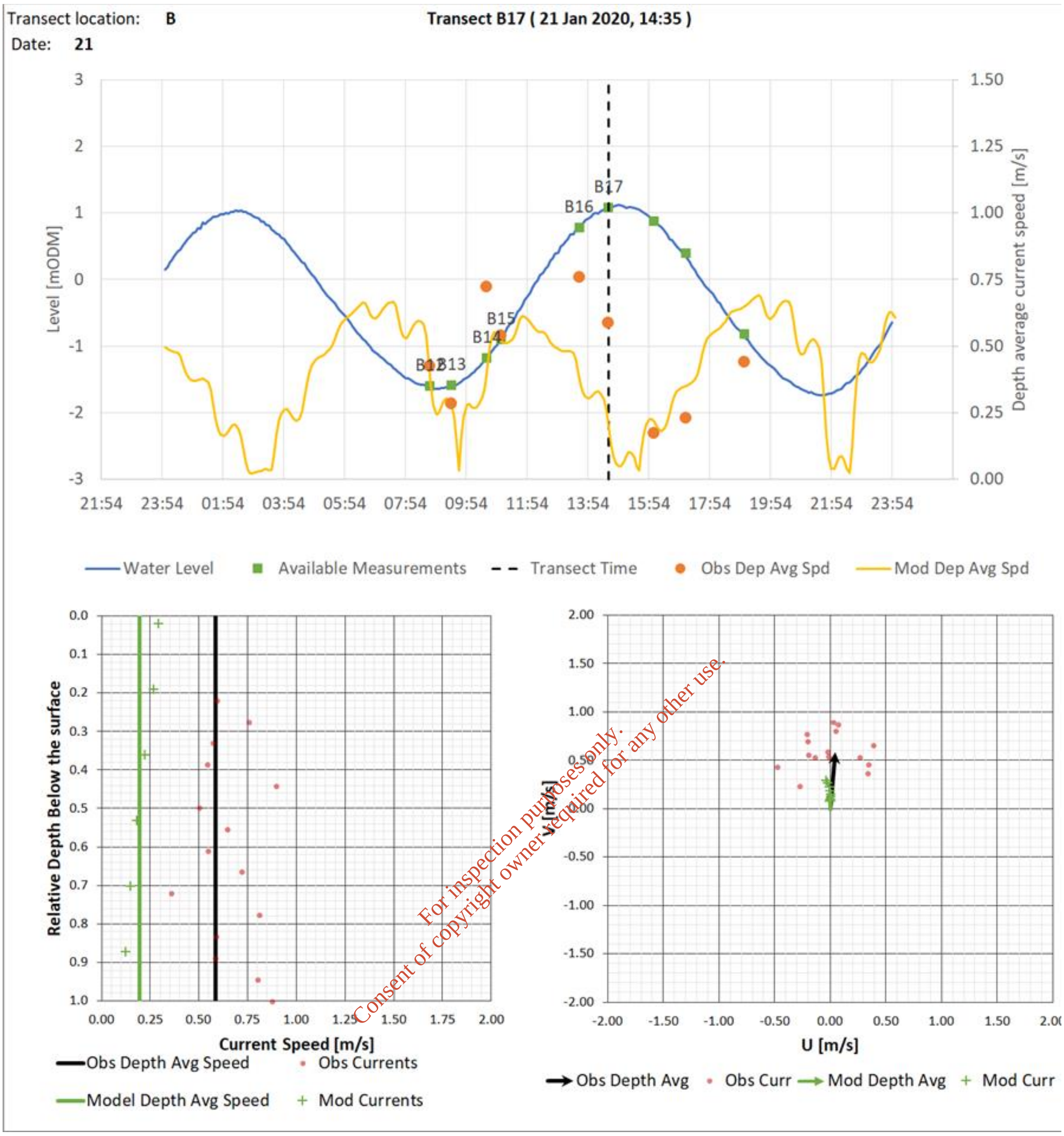


Transect location: B
Date: 21
Transect B13 (21 Jan 2020, 09:26)
Level [mODM]
Depth average current speed [m/s]
B12
B13
B14
B15
B16
B17
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr


Transect location: B
Date: 21
Transect B14 (21 Jan 2020, 10:35)
Level [mODM]
Depth average current speed [m/s]
B12 B13 B14 B15 B16 B17
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr


Transect location: B
Date: 21
Transect B15 (21 Jan 2020, 11:03)
Level [mODM]
Depth average current speed [m/s]
B12
B13
B14
B15
B16
B17
21:54 23:54 01:54 03:54 05:54 07:54 09:54 11:54 13:54 15:54 17:54 19:54 21:54 23:54
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr


Transect location: B
Date: 21
Transect B16 (21 Jan 2020, 13:37)
Level [mODM]
Depth average current speed [m/s]
B12
B13
B14
B15
B16
B17
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr


Transect location: B
Date: 21
Transect B17 (21 Jan 2020, 14:35)
Level [mODM]
Depth average current speed [m/s]
B12
B13
B14
B15
B16
B17
21:54 23:54 01:54 03:54 05:54 07:54 09:54 11:54 13:54 15:54 17:54 19:54 21:54 23:54
Water Level
Available Measurements
Transect Time
Obs Dep Avg Spd
Mod Dep Avg Spd
Relative Depth Below the surface
Current Speed [m/s]
Obs Depth Avg Speed
Obs Currents
Model Depth Avg Speed
Mod Currents
V [m/s]
U [m/s]
Obs Depth Avg
Obs Curr
Mod Depth Avg
Mod Curr