Electronic Transmission

From:	Michael Barry	To:	Tamar Lake
Date:	27 January 2016	CC:	
Subject:	Tamar Lake Scenarios Update		

Dear Robin,

The following memorandum describes the methodology adopted and sedimentation and water quality results for the Tamar Lake Scenarios.

Sediment impact results are presented, comparing a base case and developed case for sediment concentrations within the water column, as well as sedimentation changes in the Home Reach and downstream of the lake.

Water quality results presented have been extracted from scenarios using an updated model sediment set up to that presented in the Tamar Estuary 3D Calibration Report (BMT WBM, 2015). This updated sediment setup was adapted to better reflect likely sediment nutrient flux parameters found in lake environments. Importantly, we have undertaken an additional simulation which is the developed case (with barrage) that uses the sediment nutrient release properties of the original calibrated water quality model. This provides a ‘best case’ in terms of water quality outcomes in this regard for the developed case. This simulation was undertaken at no cost to Tamar Lake.

Please let me know if you have any queries.

Yours Faithfully
BMT WBM

Michael Barry

1 Scenario Configuration

The model was adjusted so that a barrage was placed at Rowella, creating a fresh-water lake upstream. The barrage was allowed to release water on ebb-tides only (twice per day), using flow controls, and artificial structures were simulated in the TUFLOW-FV model to achieve this. Barrage ebb-tide flows were defined to be of a sufficient flow rate to achieve a daily balance with the incoming flows from the North Esk, the South Esk and the Tail-Race. Controls were set in place to adjust this flow to be greater or lesser if the water level upstream of the barrage either exceeded 1 mAHD or fell below 0.8 mAHD. These prescribed flows were applied over the top two meters of the water column.

Following recent advice from Tamar Lake Inc, additional scenarios were simulated to determine water quality dynamics across the system if a pipe were to be constructed at the base of the damming wall. For these scenarios, flows were applied to the bottom two meters of the water column at an approximate depth of 20m. The details of these water quality scenarios are described in further detail in Section 4.2.

Initial warm-up runs were undertaken to ensure the scenario runs were initialised with freshwater upstream of the barrage, and tidal saltwater downstream.

The barrage location is indicated in red below in Figure 1-1.

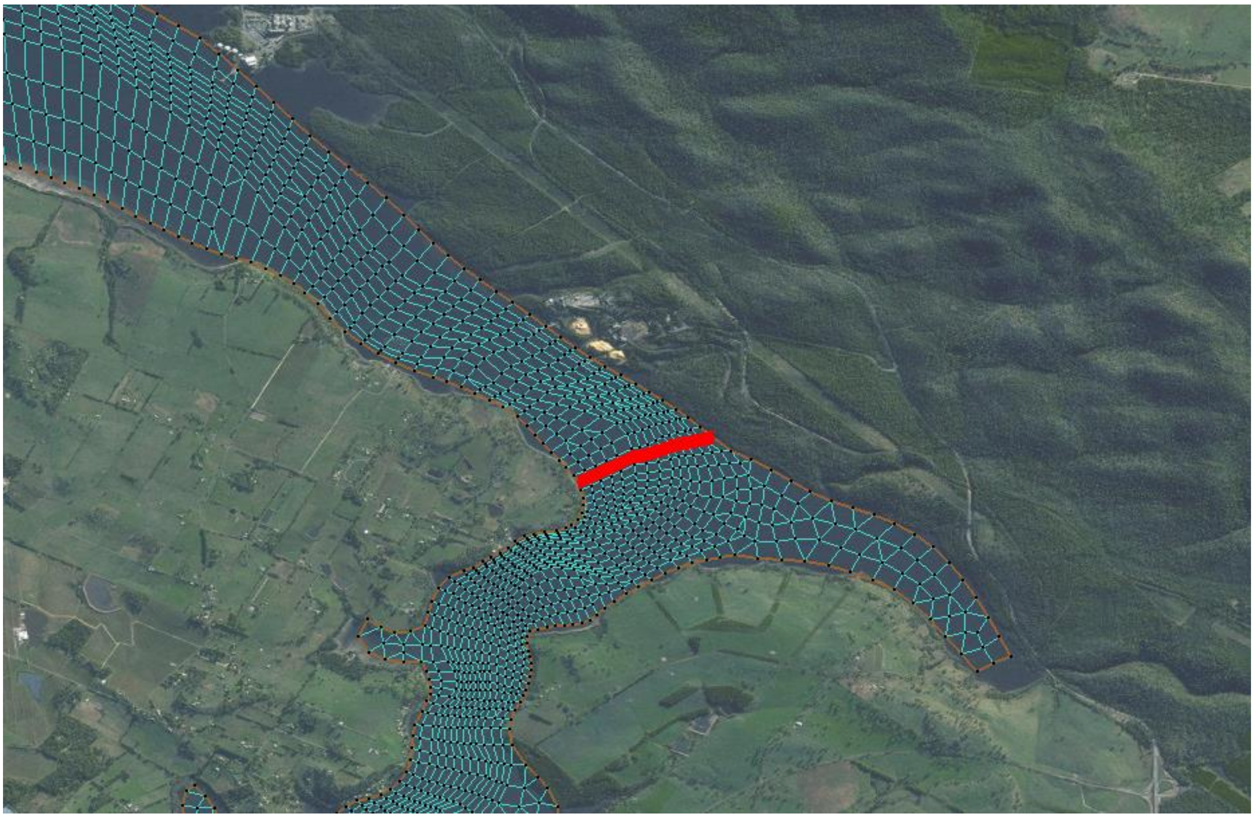


Figure 1-1 Barrage Location

2 Sedimentation

The model configuration as described above was run in parallel with a ‘base case’ scenario (without the lake and control structures) for the twelve months spanning July 2010 to June 2011. To investigate a dry period, the model was also run for the three months spanning January 2009 to March 2009. The sediment parameters and the initial distribution of bed sediments were in line with the previously calibrated parameter set.

2.1 Total Suspended Sediments

The concentration of suspended sediments near the water surface and near the bed for a range of sites is shown in Figure 2-2. The impacts are consistent with expectations of decreased suspended sediment due to quiescent conditions in the lake and reduced tidal currents downstream.

2.2 Sedimentation Impacts

Figures of the sedimentation over the twelve month scenario period are shown in Figure 2-2 and Figure 2-3 for both the Home Reach, and downstream of the barrage. Within the Home Reach, there is minor erosion, caused by high levels of activity with the tidal movements and the high flows described above. There is also slight sedimentation near the mouth of the North Esk, which doesn’t appear in the Tamar Lake scenario. The overall impact of the lake on sedimentation is actually to reduce the activity, reducing both erosion and deposition.

Downstream of the barrage, the reduction in the tidal prism has resulted in far lower activity and a more stable bed condition. This is particularly important immediately upstream from George Town, where tidal currents previously in excess of 2m/s now rarely exceed 0.7m/s.

Figure 2-4 shows the Homereach siltation during the three month dry period. The typical siltation pattern can be directly seen in the Base case, with the developed case experiencing no tide, and only very minor inflow events, showing limited sediment activity, resulting in a positive outcome for the developed case in mitigating Homereach siltation.

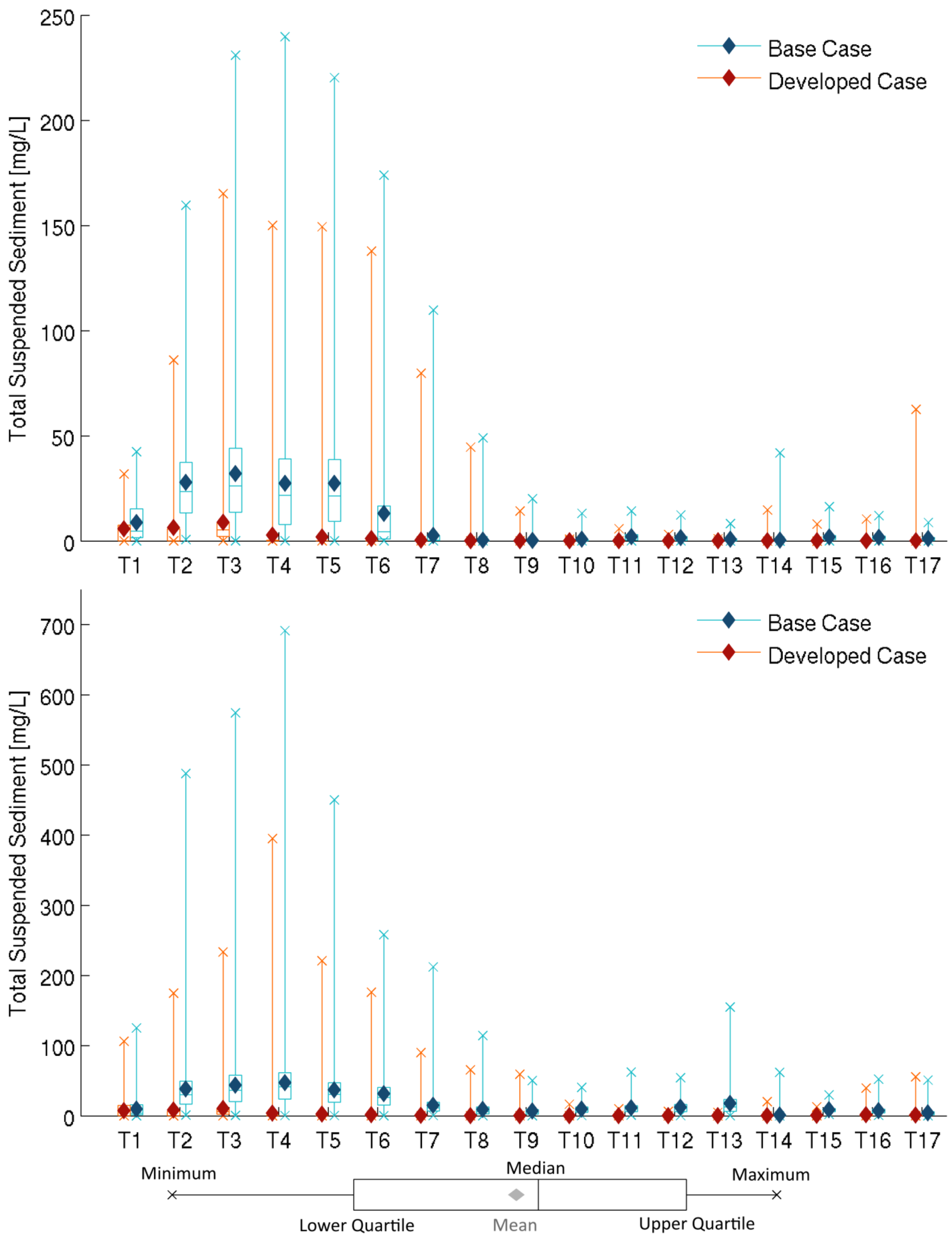


Figure 2-1 Box and Whisker Plots of TSS for the Surface (Top); and Bed (Bottom)

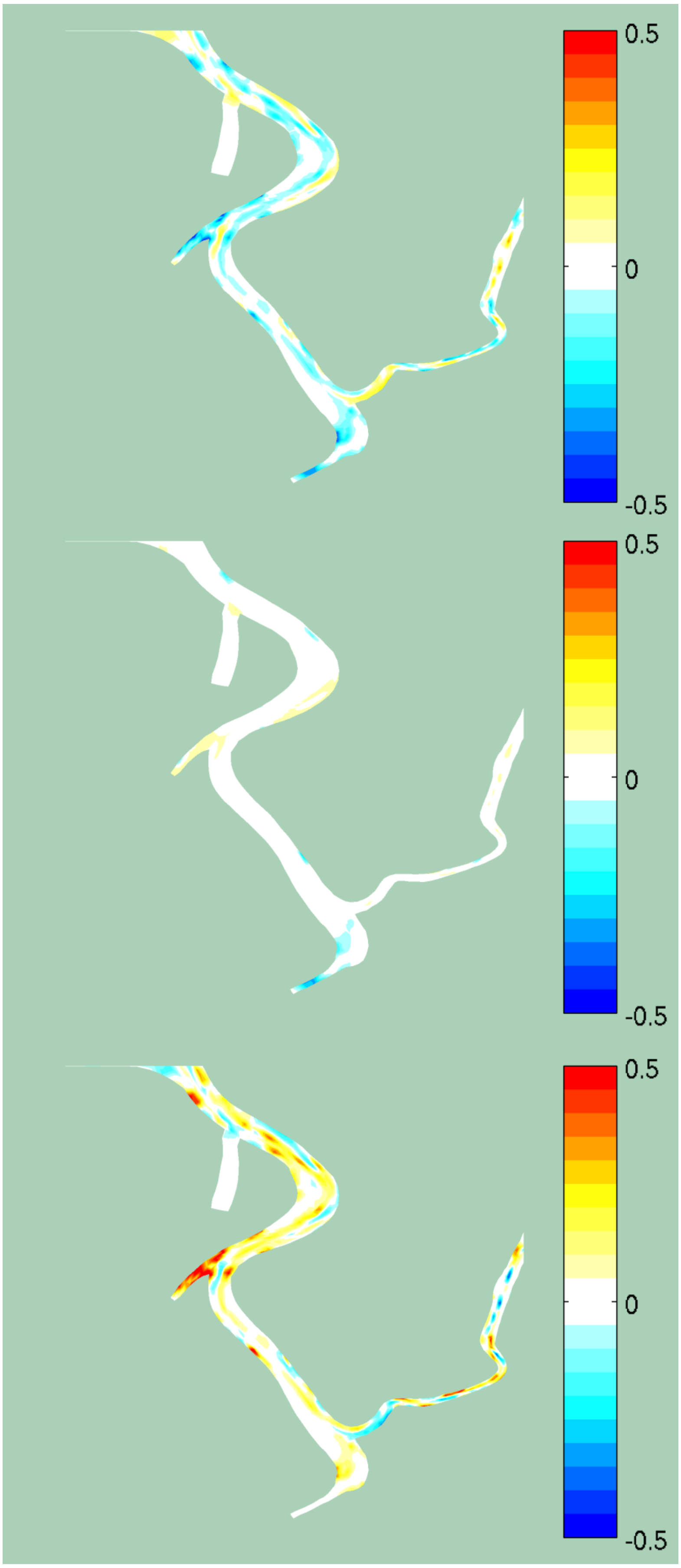


Figure 2-2 Home Reach Sedimentation for Base Case (Top); Developed Case (Middle); and the difference (Bottom) [meters]

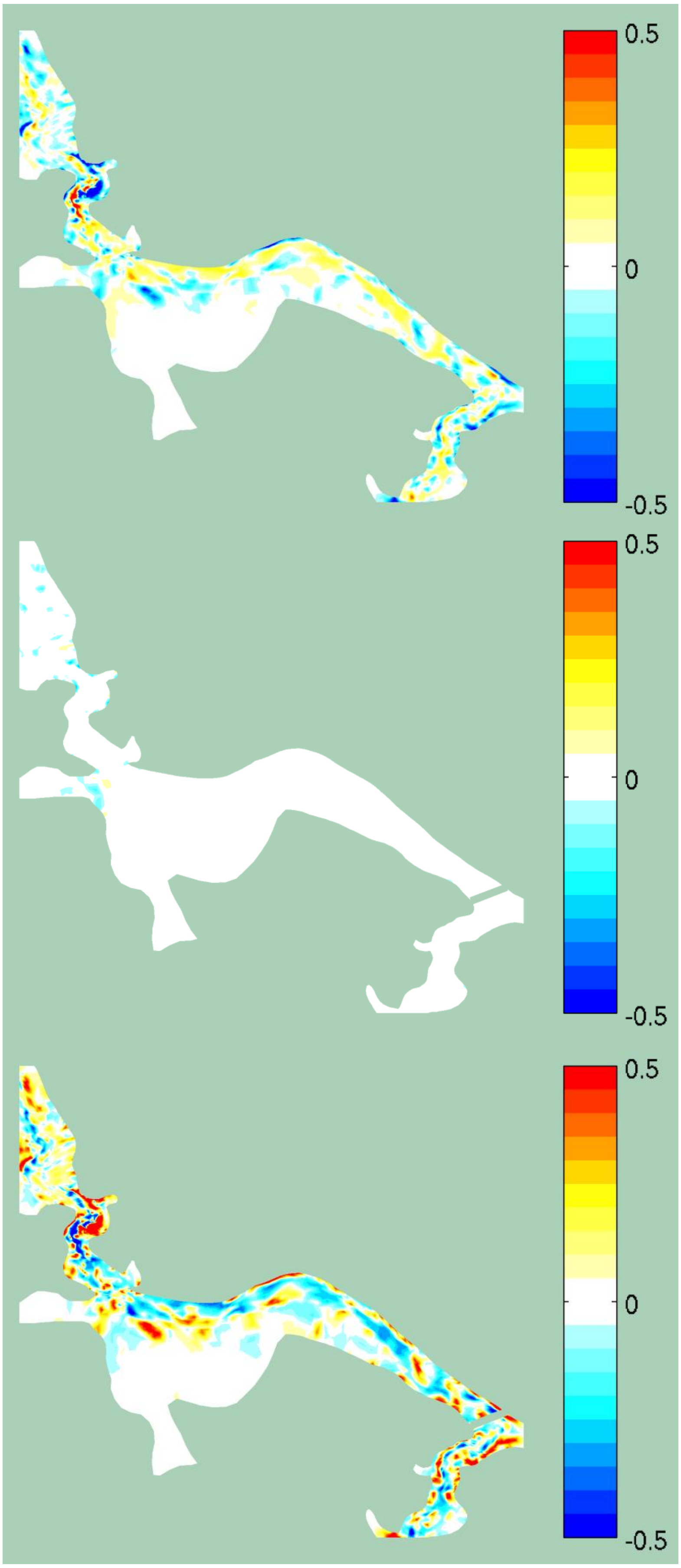


Figure 2-3 Downstream Sedimentation for Base Case (Top); Developed Case (Middle); and the difference (Bottom) [meters]

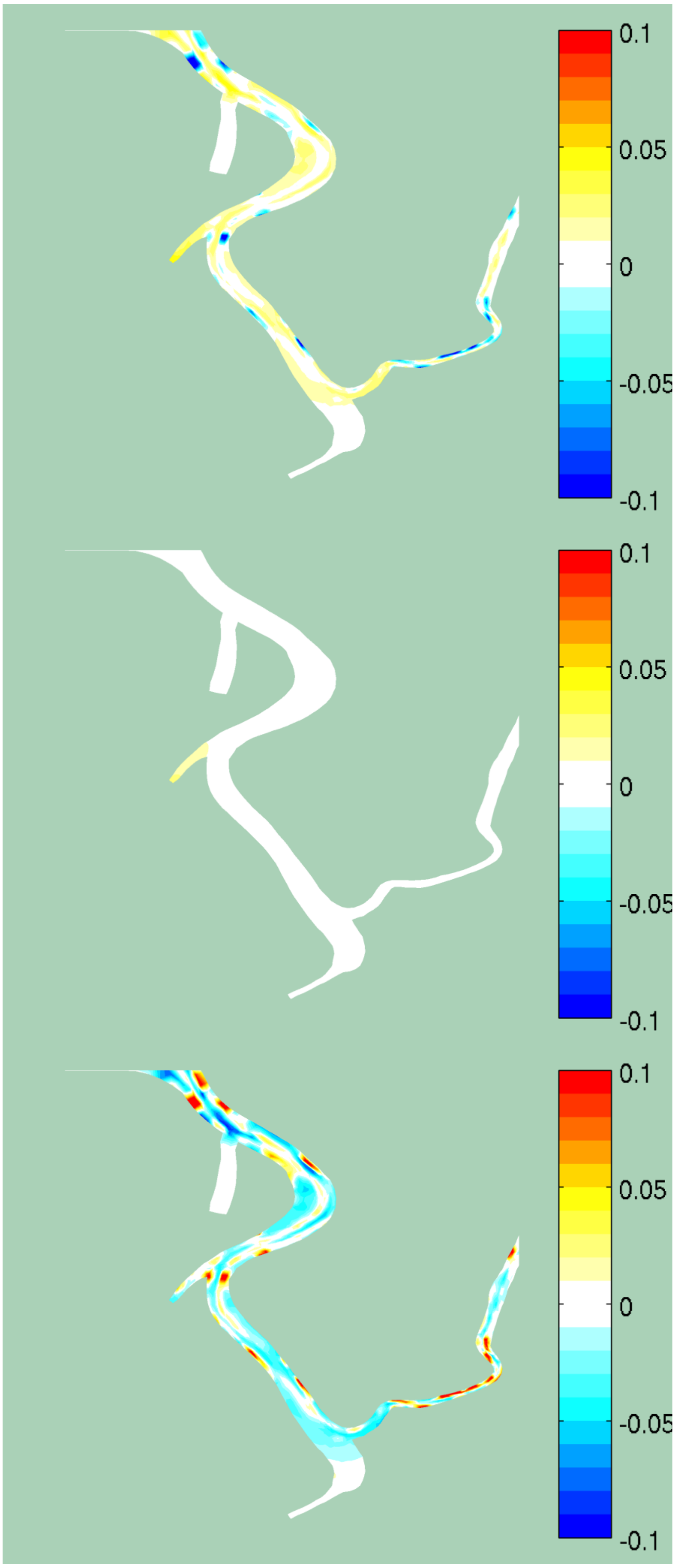


Figure 2-4 Dry Period Sedimentation for Base Case (Top); Developed Case (Middle); and the difference (Bottom) [meters]

3 Water Level

The twelve month period was also used to assess the impact of the barrage on the water levels downstream. The maximum and minimum water levels have been extracted downstream of the barrage and the tidal range compared. Figure 3-1 shows the maximum and minimum water levels, and Figure 3-2 shows the total tidal amplitude. It can be seen that there is a slight amplification in the tidal range for most of the downstream area, with a slight reduction immediately downstream from the barrage.

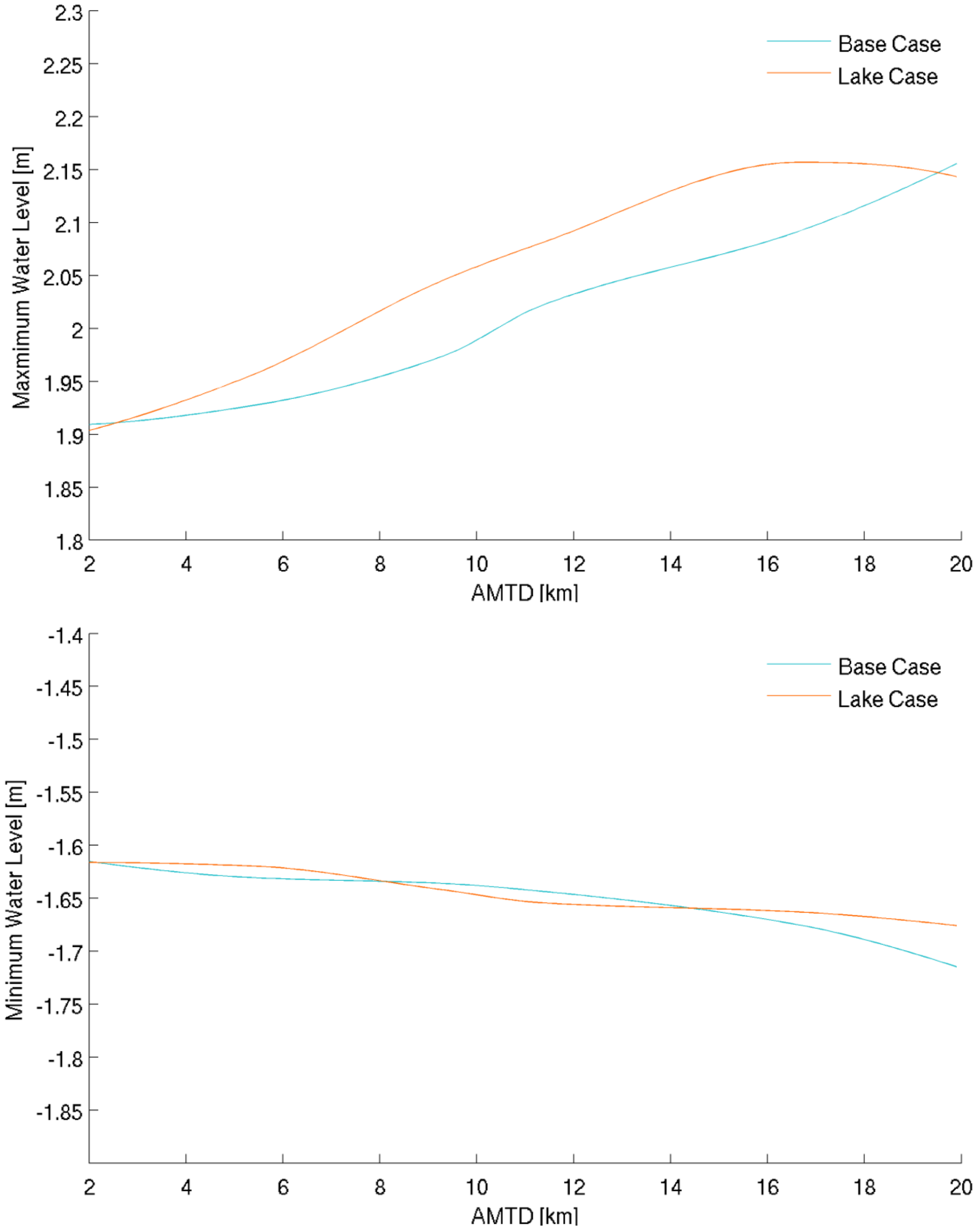


Figure 3-1 Maximum (Top) and Minimum (Bottom) water levels

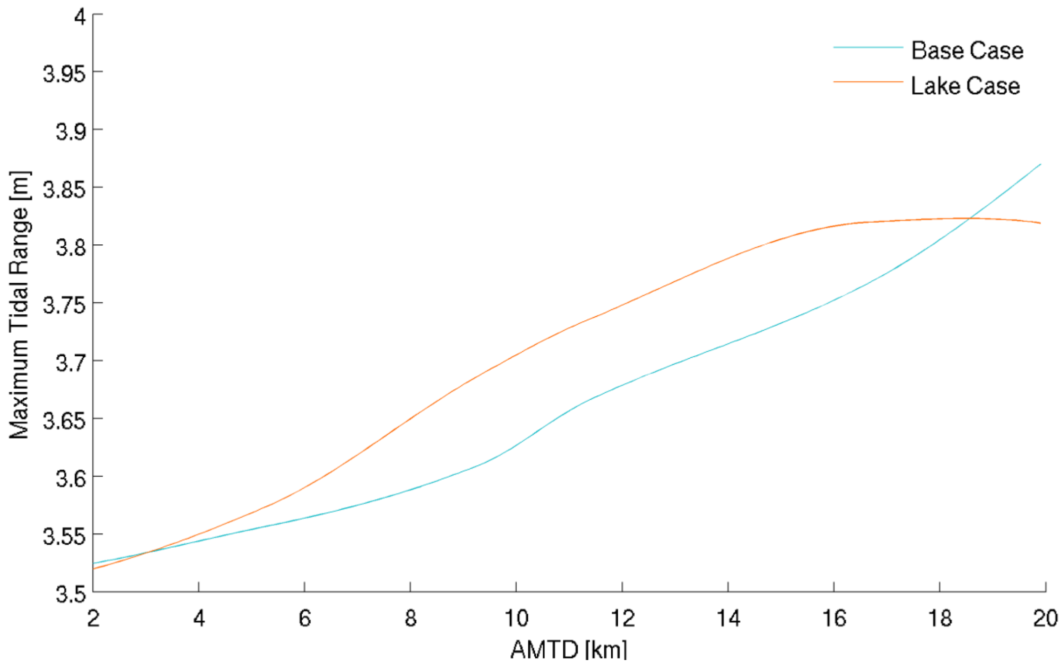


Figure 3-2 Total Tidal Range

4 Water Quality

4.1 Nutrient Sediment Flux

Runs from which results were extracted included adjustments to nutrient sediment flux parameters which better reflect those likely to be present in a lake environment. These updated sediment flux parameters were assigned from values prescribed in both the AED^2 manual as well as from various cited case studies.

Presented in Table 4-1 are sediment flux values from various field data according to the AED^2 manual for both estuarine and lake systems.

Table 4-2 indicates values from additional studies in which nutrient sediment flux data had been collected.

Table 4-1 Sediment parameter values (AED^2)

Sedimentation Flux	Estuarine Range (mmol/m^2/d)		Lake Range (mmol/m^2/d)	
	min	max	min	max
Fsed_oxgen	-79	-48	**-38**	**-6**
Fsed_ammonia	5	25	**1.35**	**6.42**
Fsed_nitrogen	-7.2	7.1	**-21.4**	**7.14**
Fsed_phosphorus	0	4	**0.080**	**0.125**
Fsed_dissolved_organic_nitrogen	1.28	2.2	**0.07**	**0.57**
Fsed_dissolved_organic_phosphorus	0.05	0.10	**0.03**	**0.03**

Table 4-2 Sediment parameter values (case studies)

Sedimentation Flux	Port Waterways SA Range [1] (mmol/m^2/d)		Bedford Basin Nova Scotia Range [2] (mmol/m^2/d)		Smiths Lake NSW Range [3] (mmol/m^2/d)		Lake Illawarra NSW Range [4] (mmol/m^2/d)	
	min	max	min	min	max	max	min	max
Fsed_oxgen	-	-	-	-	-	-	-	-
Fsed_ammonia	-8.0	71.4	-	-	0.16	3.62	10.99	63.12
Fsed_nitrogen	-34.4	2.67	2.77	5.77	-0.03	0.15	0.96	7.44
Fsed_phosphorus	-9.23	5.33	0.15	0.49	-0.04	0.09	-0.96	0.00
Fsed_dissolved_organic_nitrogen	-	-	-	-	-	-	-	-
Fsed_dissolved_organic_phosphorus	-	-	-	-	-	-	-	-

[1] Based on Jenkins (2005) assessment of data from Port Waterways, New South Wales
[2] Based on Burt et al. (2013) assessment of data from Bedford Basin, Nova Scotia
[3] Based on Smith et al. (2003) assessment of data from Smiths Lake, New South Wales
[4] Based on Qu et al. (2003) assessment of data from Lake Illawarra, New South Wales

An average of sediment fluxes used upstream for the barrage is displayed in Table 4-3. These values are also representative of sediment flux values used in the current run for which results have been presented. These sediment flux values are presented in comparison to values which have been adopted for running barrage scenarios. To give an indication of the models sensitivity to these parameters an additional simulation was executed in which those sediment nutrient flux values used for the final Tamar Estuary were applied the barrage scenario, these results were then compared to those which used the most likely nutrient sediment flux values.

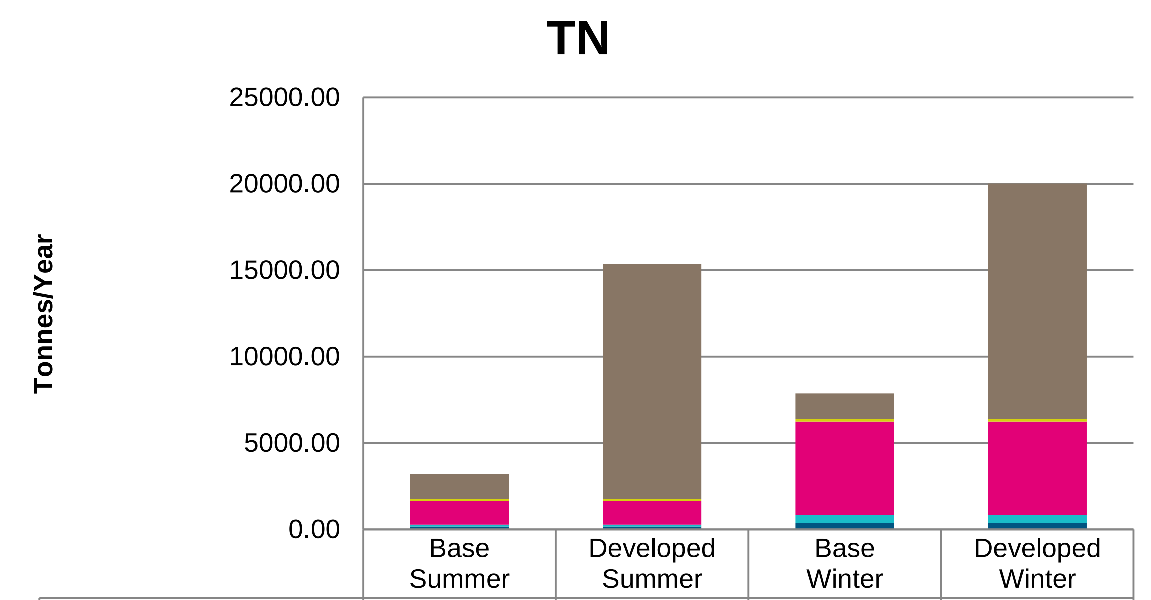
Table 4-3 Scenario Sediment Flux

Sedimentation Flux	Tamar 3D Model (Average upstream of Barrage) (mmol/m^2/d) – results below	Tamar 3D Model Scenarios (Average upstream of Barrage) (mmol/m^2/d) – pending results
Fsed_oxgen	-17	-38
Fsed_ammonia	6.23	63.12
Fsed_nitrogen	2.32	7.44
Fsed_phosphorus	0.001	0.125
Fsed_dissolved_organic_nitrogen	1.51	1.51
Fsed_dissolved_organic_phosphorus	0.057	0.057

4.2 Mass Balance

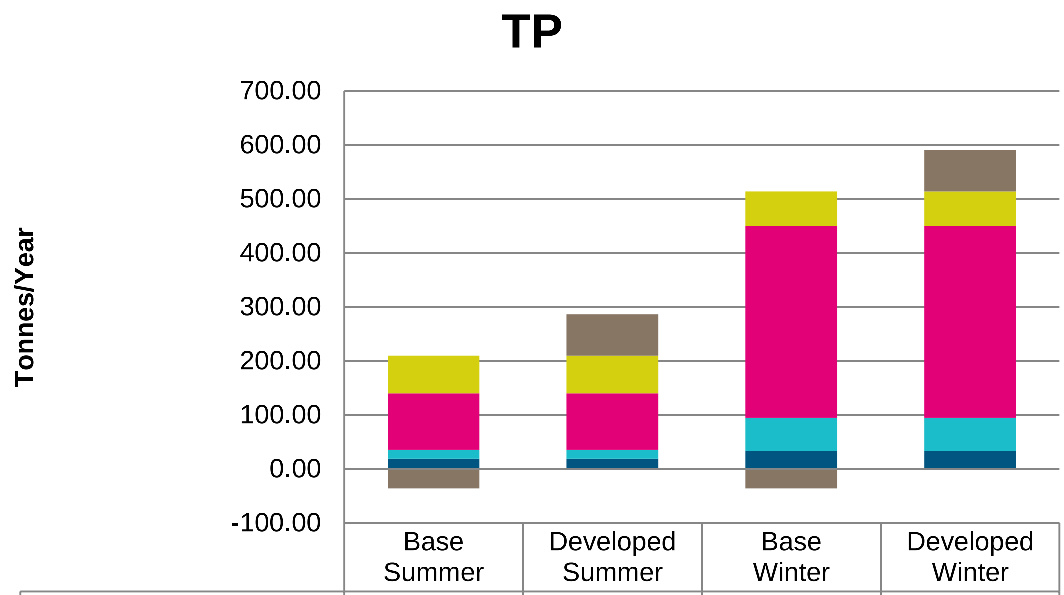
Using the release rates detailed in Table 4-3 comparisons were drawn for both TN and TP to indicate the increase in nutrients realised into the system from sediments after the implementation of the barrage structure. South Esk catchment loads are inclusive of nutrients entering the model from the South Esk tailrace.

4.2.1 Total Nitrogen



	Base Summer	Developed Summer	Base Winter	Developed Winter
Sediment	1473.86	13619.11	1473.86	13619.11
STP's	114.00	114.00	150.00	150.00
Catchments (South Esk)	1364.16	1364.16	5407.09	5407.09
Catchments (North Esk)	100.38	100.38	466.21	466.21
Catchments (Direct)	178.57	178.57	373.34	373.34

4.2.2 Total Phosphorus



	Base Summer	Developed Summer	Base Winter	Developed Winter
Sediment	-36.10	76.14	-36.10	76.14
STP's	70.00	70.00	64.00	64.00
Catchments (South Esk)	104.13	104.13	355.15	355.15
Catchments (North Esk)	16.60	16.60	61.39	61.39
Catchments (Direct)	19.44	19.44	33.70	33.70

4.3 Scenarios

The water quality scenarios were simulated over the same timeframe as presented in the Tamar Estuary 3D Calibration Report (BMTWBM 2015). The water quality scenarios executed are described below.

Scenario 1

Adaption of the barrage setup as described in Section 1 with flows applied to the top two meters. The model also incorporated the same flows and nutrient loads entering the model from both the catchments and Waste Water Treatment Plants.

As an indication of model sensitivity, a comparison is provided which represents results using the likely sediment nutrient flux release rates compared to those used for the calibrated Tamar estuary 3D model. Theses release rates are presented in Table 4-3.

Scenario 2

Adaption of the barrage setup as described in Section 1 with flows applied to the top two meters. The model also incorporated the same flows and nutrient loads entering the model from both the catchments. In order to adapt the Launceston Sewerage Improvement Plan (LSIP) flows from Hobblers Bridge, Norwood, Newnham, Riverside and Legana were redirected through Ti-Tree bend and reductions to total loads were applied as described in the Water Quality Improvement Plan for the Tamar Estuary and Esk Rivers Catchments (2015).

Scenario 3

Adaption of the barrage setup as described in Section 1 with flows applied to the bottom two meters. The model also incorporated the same flows and nutrient loads entering the model from both the catchments and Waste Water Treatment Plants.

Scenario 4

Adaption of the barrage setup as described in Section 1 with flows applied to the bottom two meters. The model also incorporated the same flows and nutrient loads entering the model from both the catchments and the LSIP flows and loads used in Scenario 2.

Scenario 5

Adaption of the barrage setup as described in Section 1 with flows applied to the top two meters. This scenario was simulated to indicate the transfer time from a salt water estuarine system to a fresh lake system. The model was executed over two different timeframes to provide a comparison in transfer times for both wet and dry periods.

4.4 Water Quality Results

Each plot presented below is a comparison between results from the previous calibrated run presented in the Tamar Estuary 3D report (2015) and the scenario run. For scenarios 1-4, results have been extracted from both the top surface layer and the bottom bed layer and results for scenario 5 have been depth averaged. The results for each parameter are presented in the following order, noting that some figures include changes in vertical (constituent) axes scales for presentation purposes.

Nutrient Sediment Flux Sensitivity Comparison

Box and Whiskers plots – Comparison between base case sediment nutrient flux releases and likely sediment nutrient flux releases - Dry summer period (2010/2011)

Box and Whiskers plots - Comparison between base case sediment nutrient flux releases and likely sediment nutrient flux releases - Wet winter period (2011)

Scenario 1-5

Box and Whiskers plots - Dry summer period (2010/2011)

Box and Whiskers plots - Wet winter period (2011)

Box and Whiskers plots – Dissolved Oxygen (% saturation) comparison for all scenarios over a dry summer period (2010/2011)

Box and Whiskers plots – Chlorophyll-a comparison for all scenarios over a dry summer period (2010/2011)

Temperature Profile View Contour Plots – (January 2011)

Dissolved Oxygen Profile View Contour Plots – (January 2011)

Total Nitrogen Profile View Contour Plots – (January 2011)

Scenario 5

Timeseries plots – Dry extended period (2008-2009)

Timeseries plots – Wet winter period (2010)

4.5 Nutrient Sediment Flux Comparison

Comparison of the base case scenario results to developed case scenario results both using base case nutrient sediment flux parameters.

4.5.1 Temperature

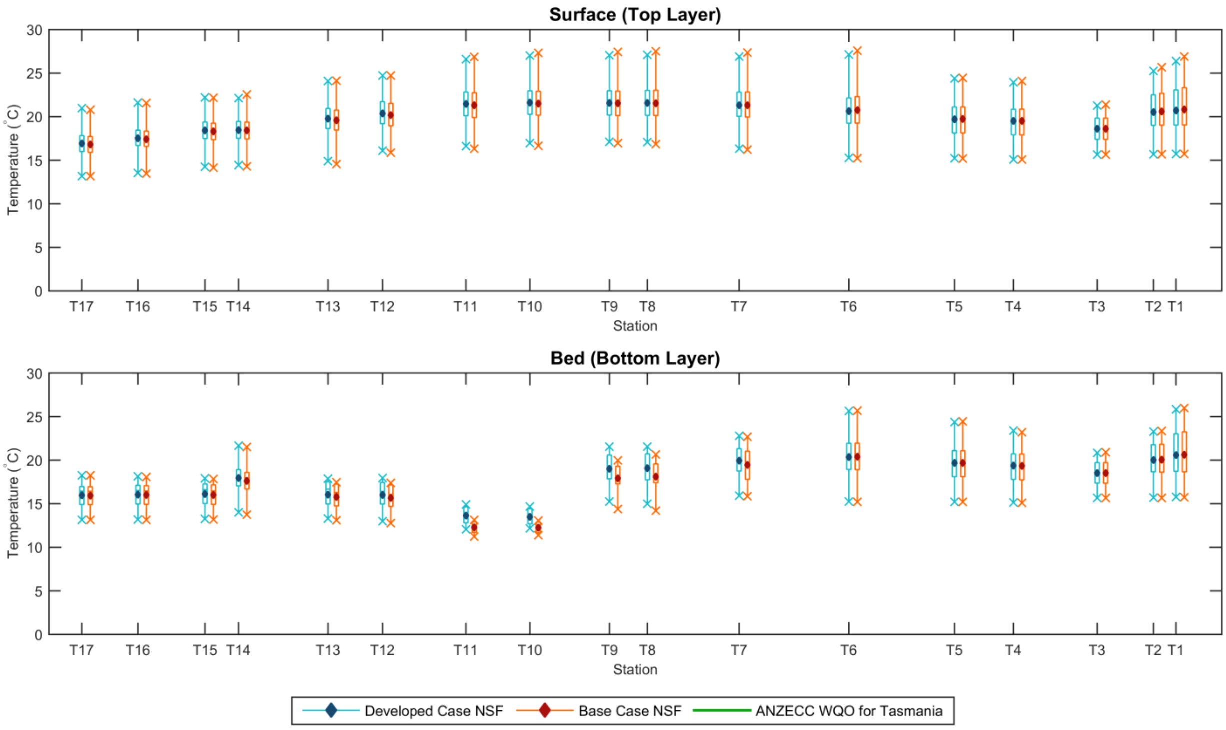


Figure 4-1 Scenario 1 – Temperature – Summer (Dry)

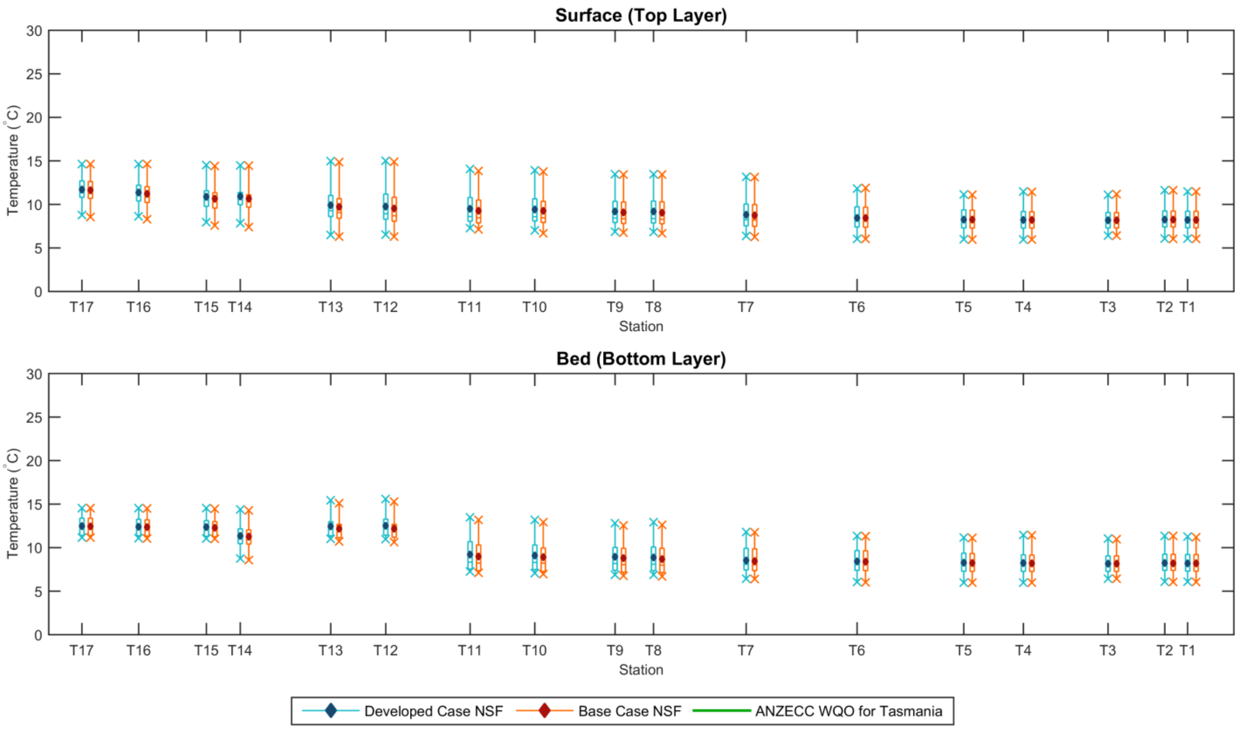


Figure 4-2 Scenario 1 – Temperature – Winter (Wet)

4.5.2 Dissolved Oxygen (mg/L)

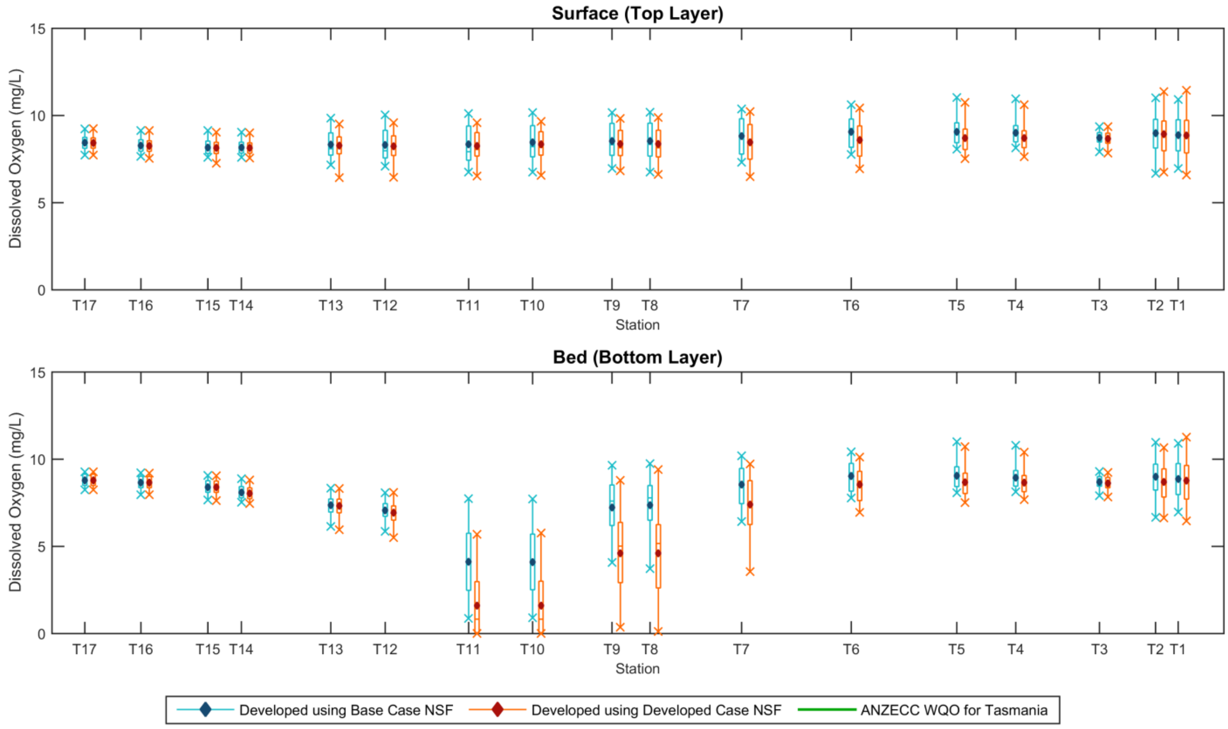


Figure 4-3 Scenario 1 – Dissolved Oxygen (mg/L) – Summer (Dry)

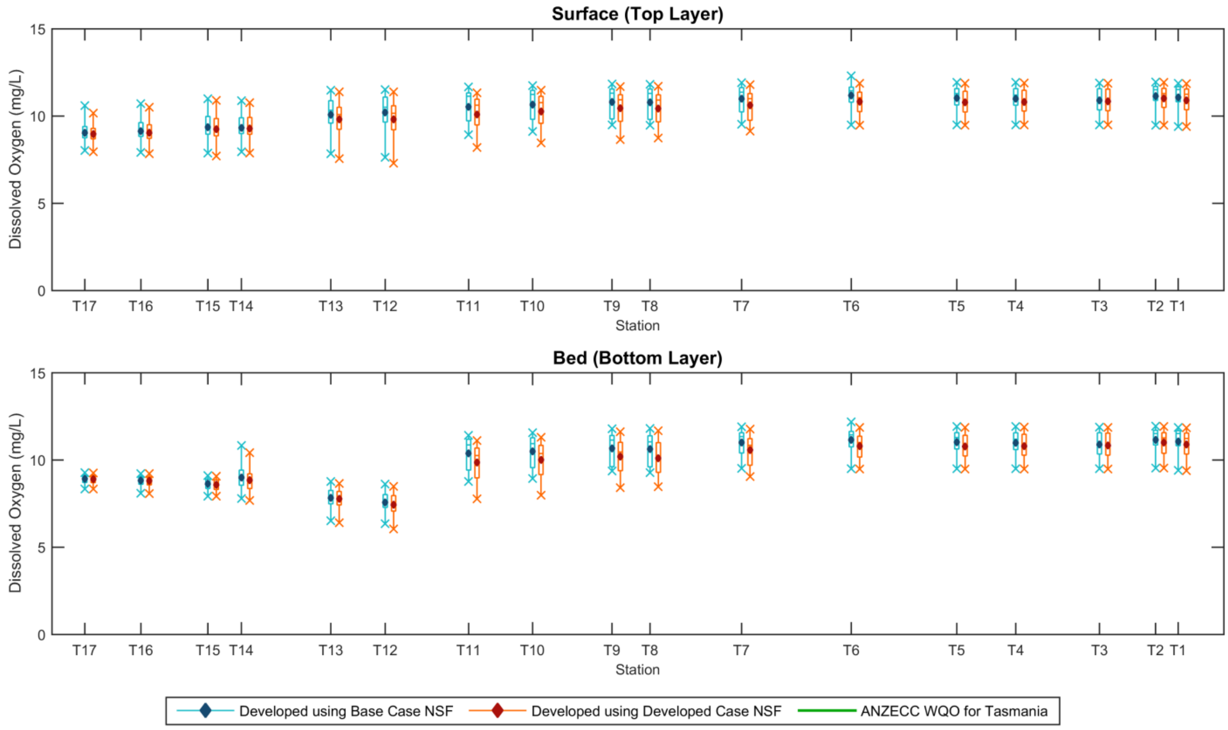


Figure 4-4 Scenario 1 – Dissolved Oxygen (mg/L) – Winter (Wet)

4.5.3 Dissolved Oxygen (% Saturation)

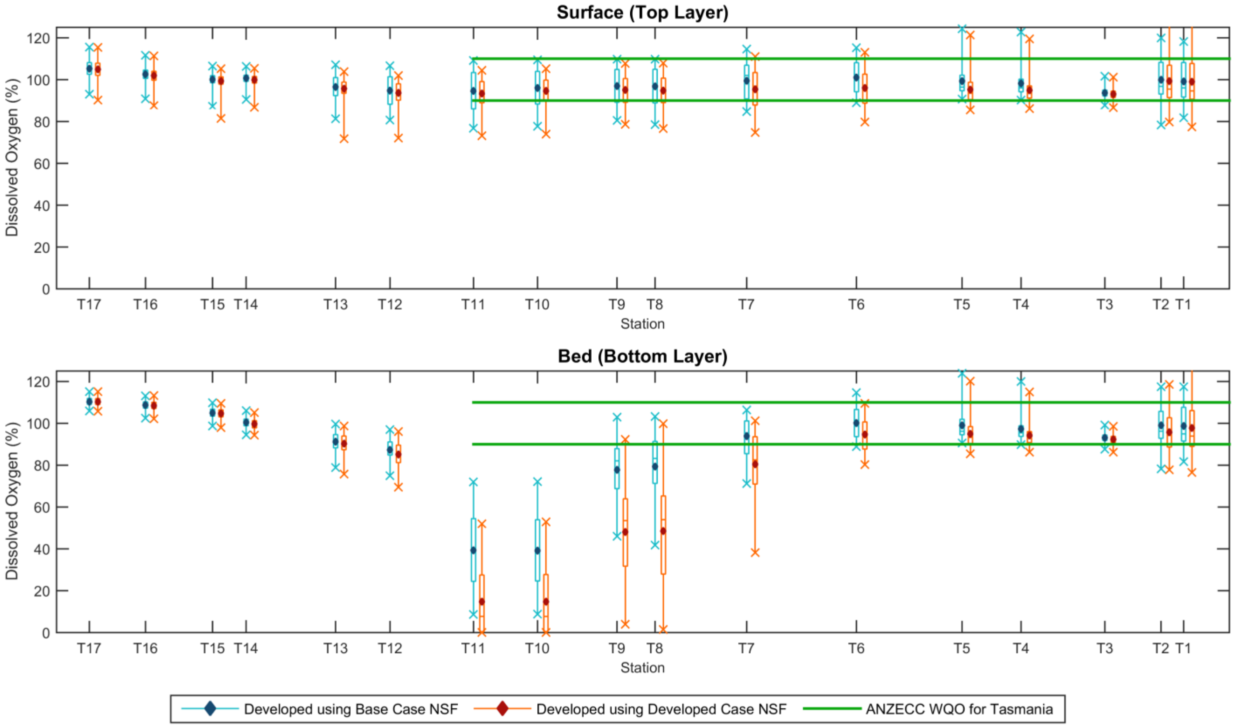


Figure 4-5 Scenario 1 – Dissolved Oxygen (% Saturated) – Summer (Dry)

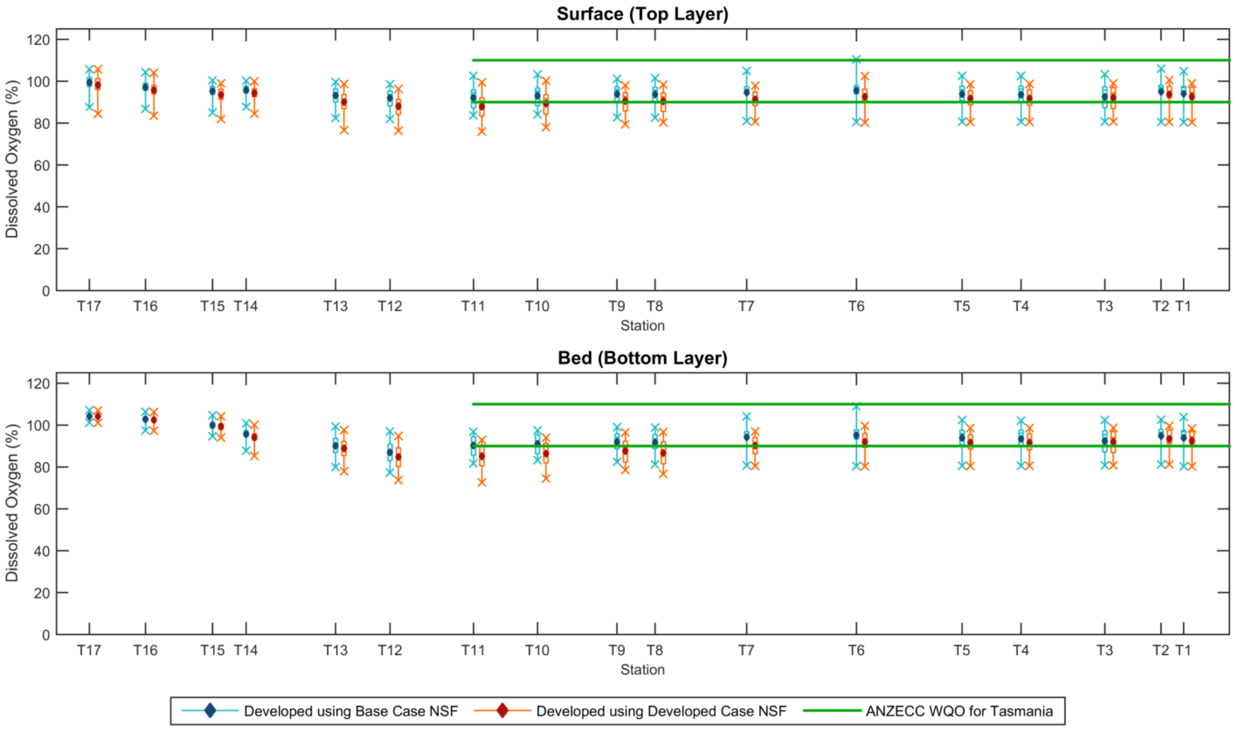


Figure 4-6 Scenario 1 – Dissolved Oxygen (% Saturated) – Winter (Wet)

4.5.4 Ammonia

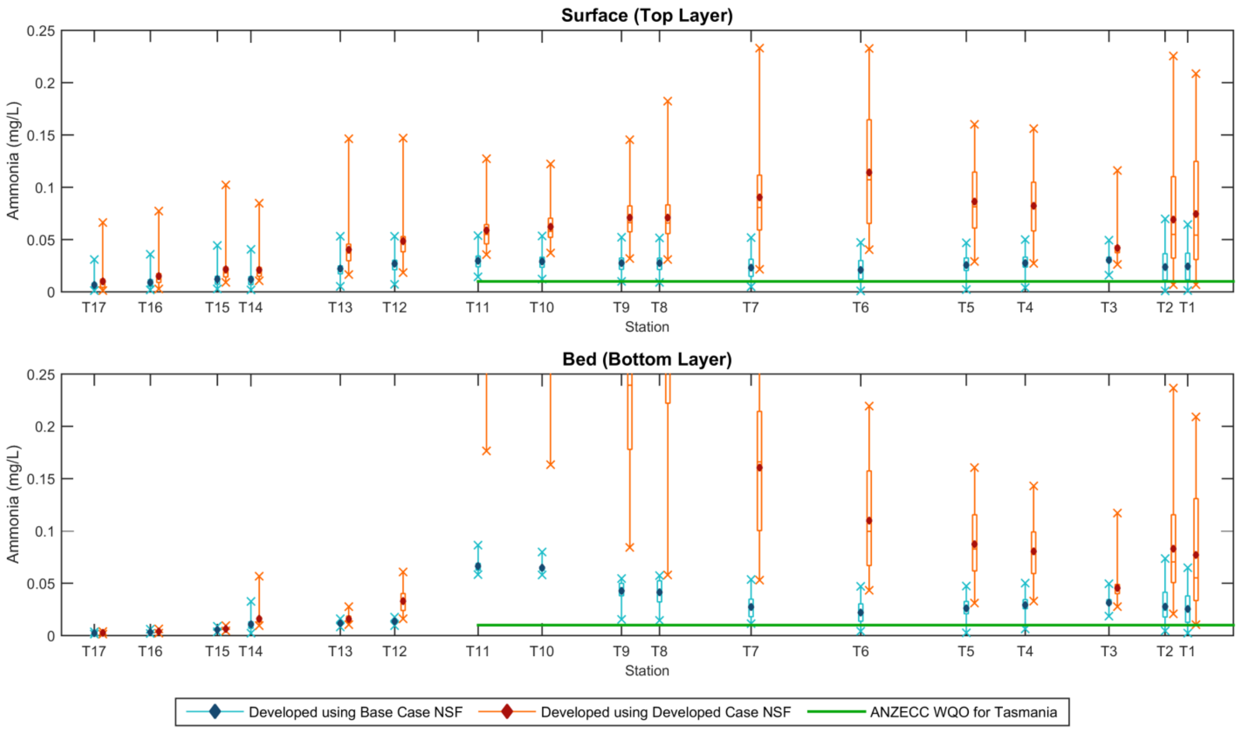


Figure 4-7 Scenario 1 – Ammonia – Summer (Dry)

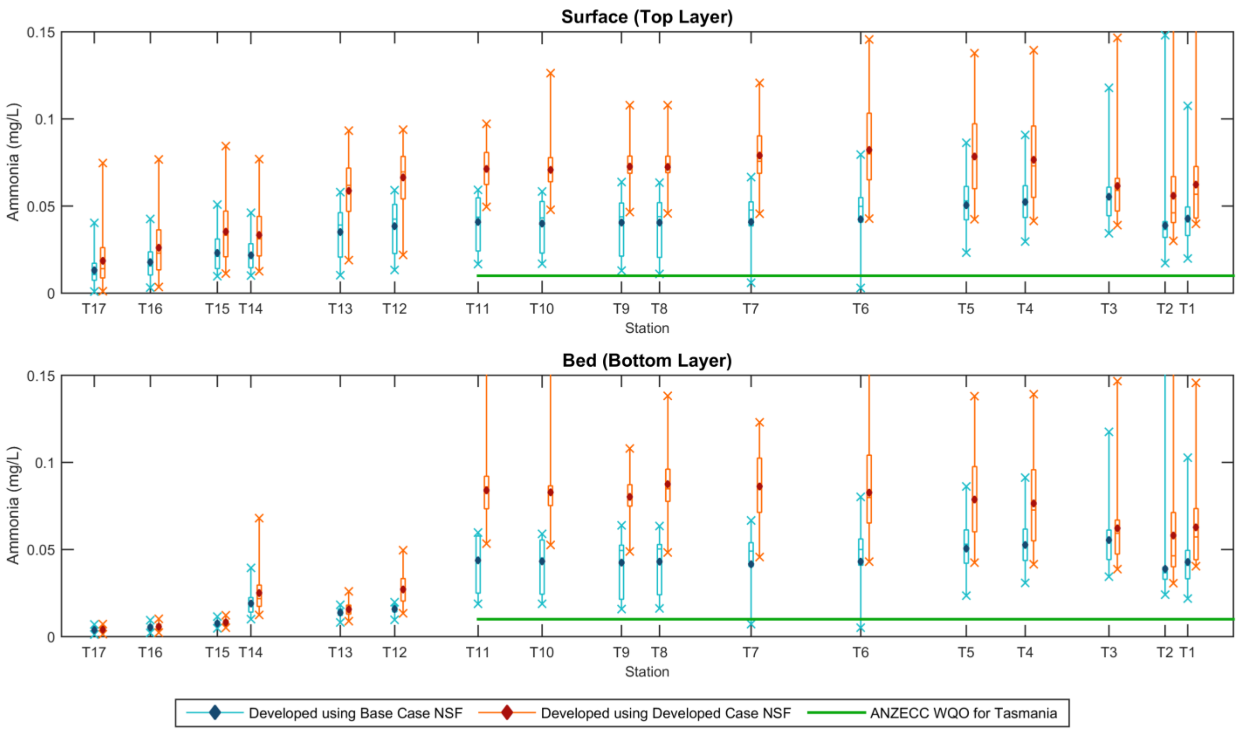


Figure 4-8 Scenario 1 – Ammonia – Winter (Wet)

4.5.5 Nitrate

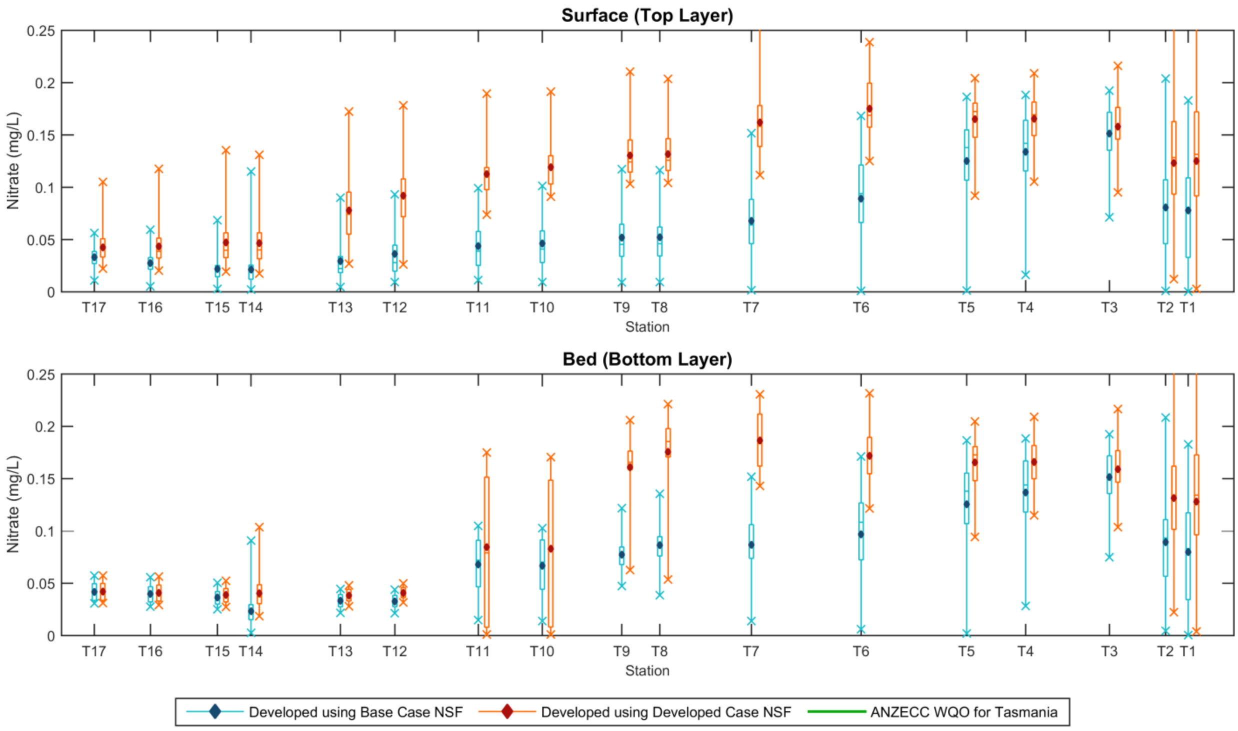


Figure 4-9 Scenario 1 – Nitrate – Summer (Dry)

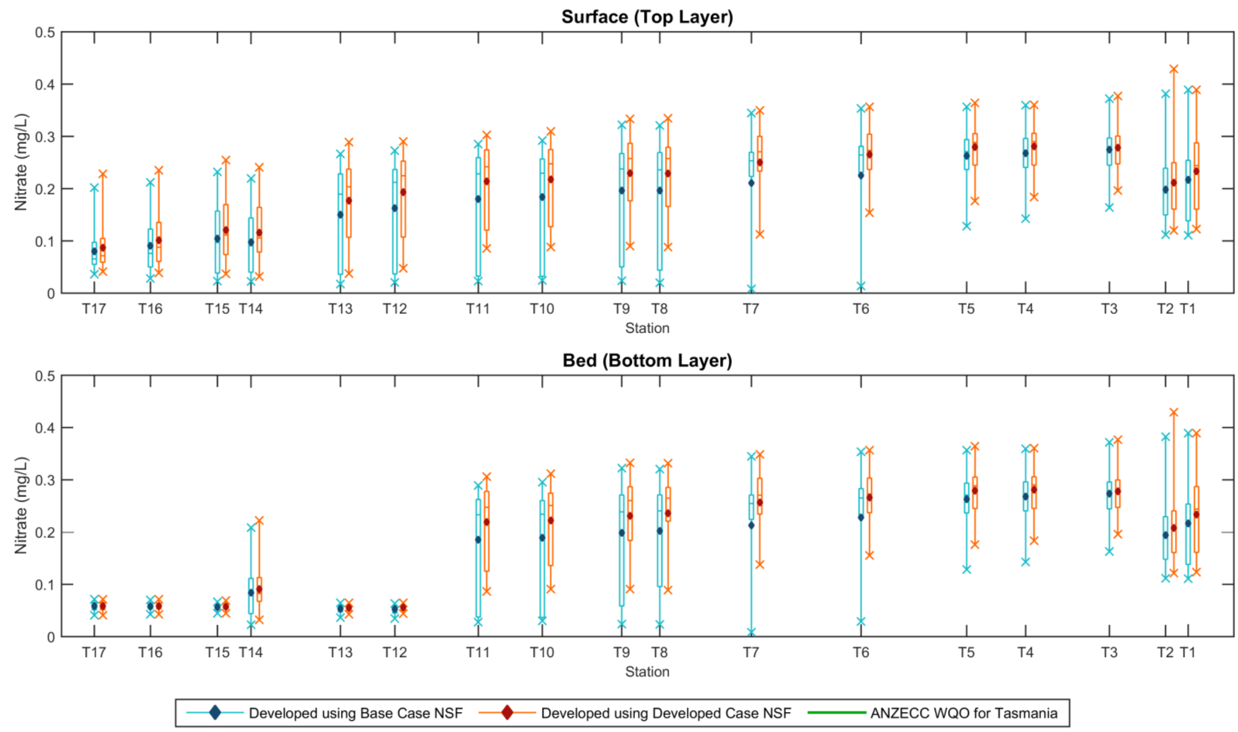


Figure 4-10 Scenario 1 – Nitrate – Winter (Wet)

4.5.6 Total Nitrogen

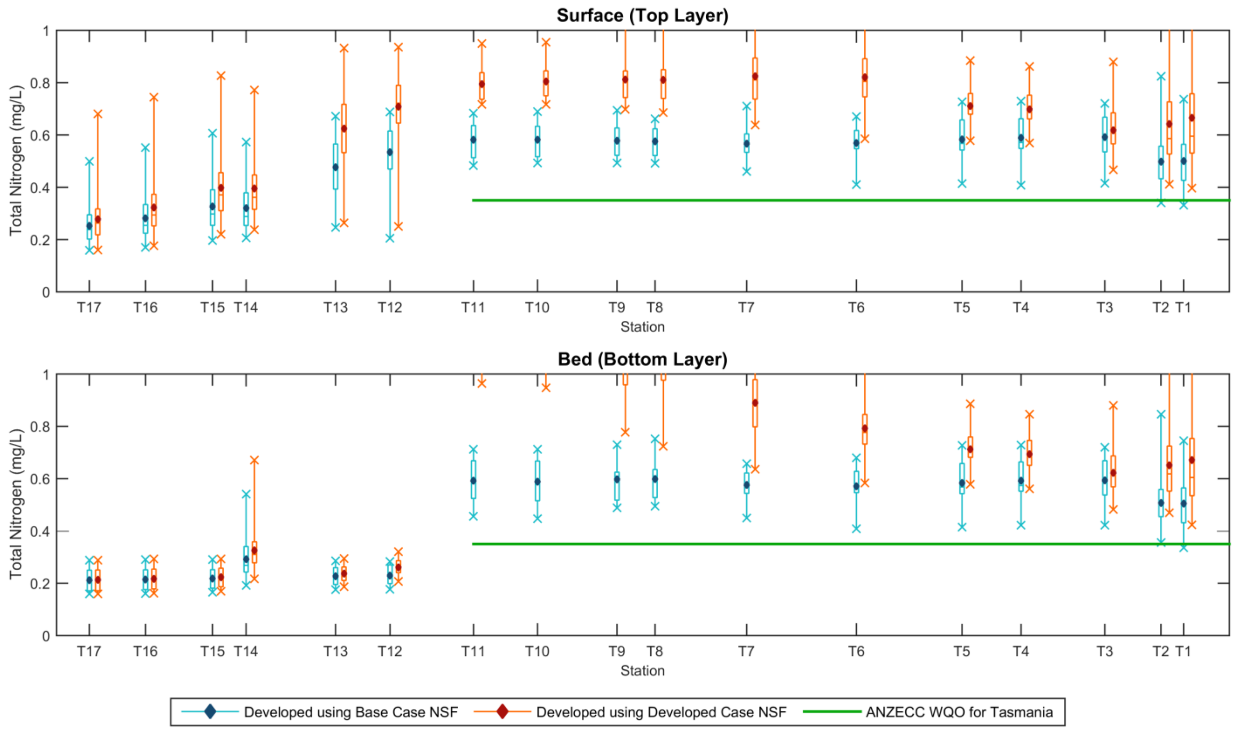


Figure 4-11 Scenario 1 – Total Nitrogen – Summer (Dry)

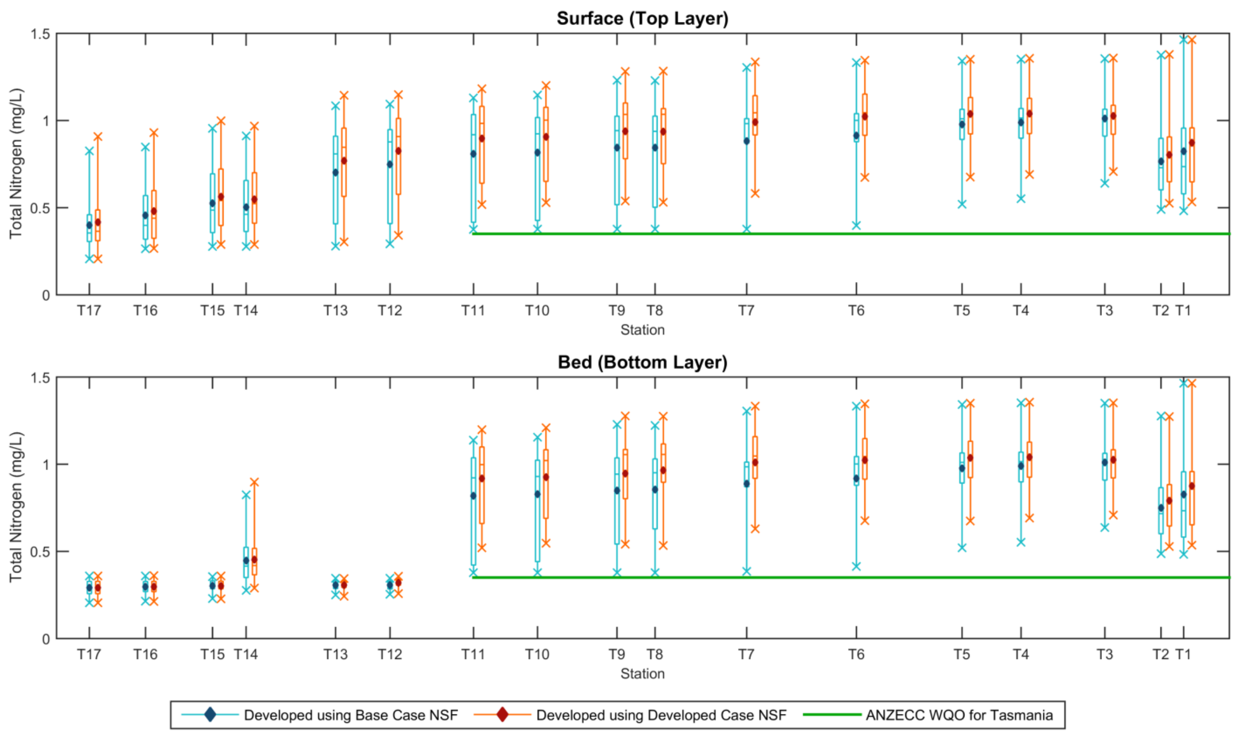


Figure 4-12 Scenario 1 – Total Nitrogen – Winter (Wet)

4.5.7 FRP

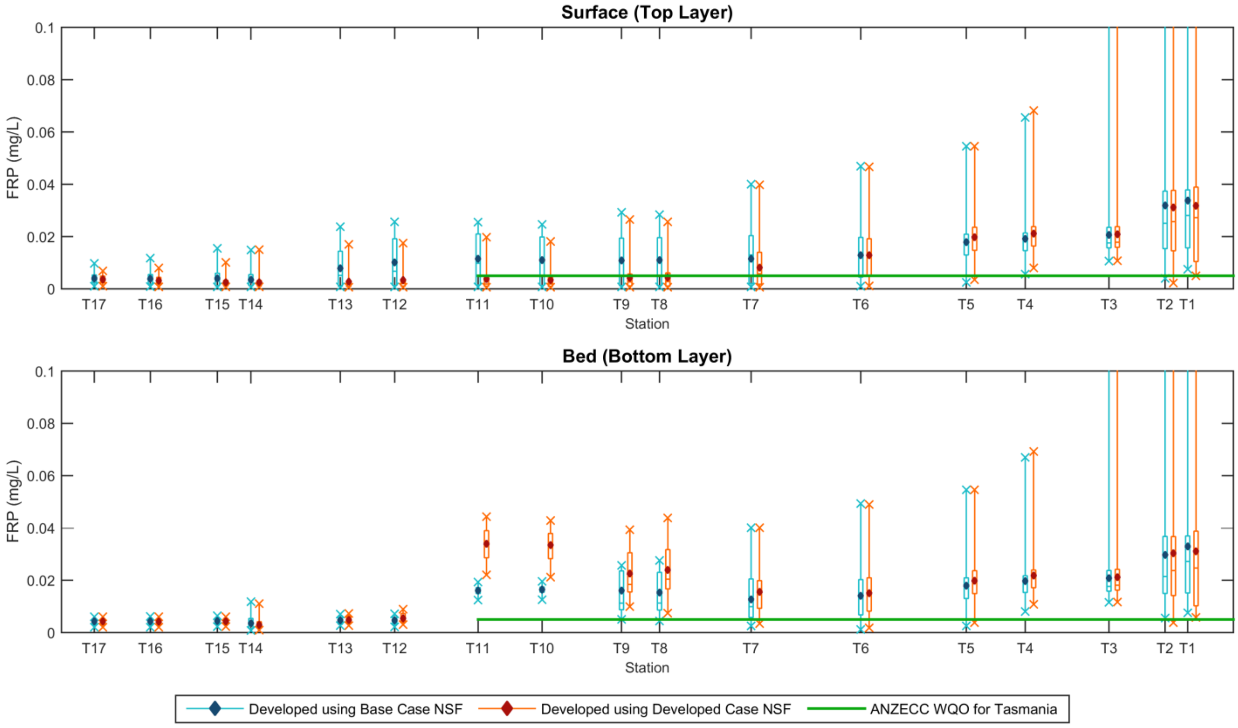


Figure 4-13 Scenario 1 – FRP – Summer (Dry)

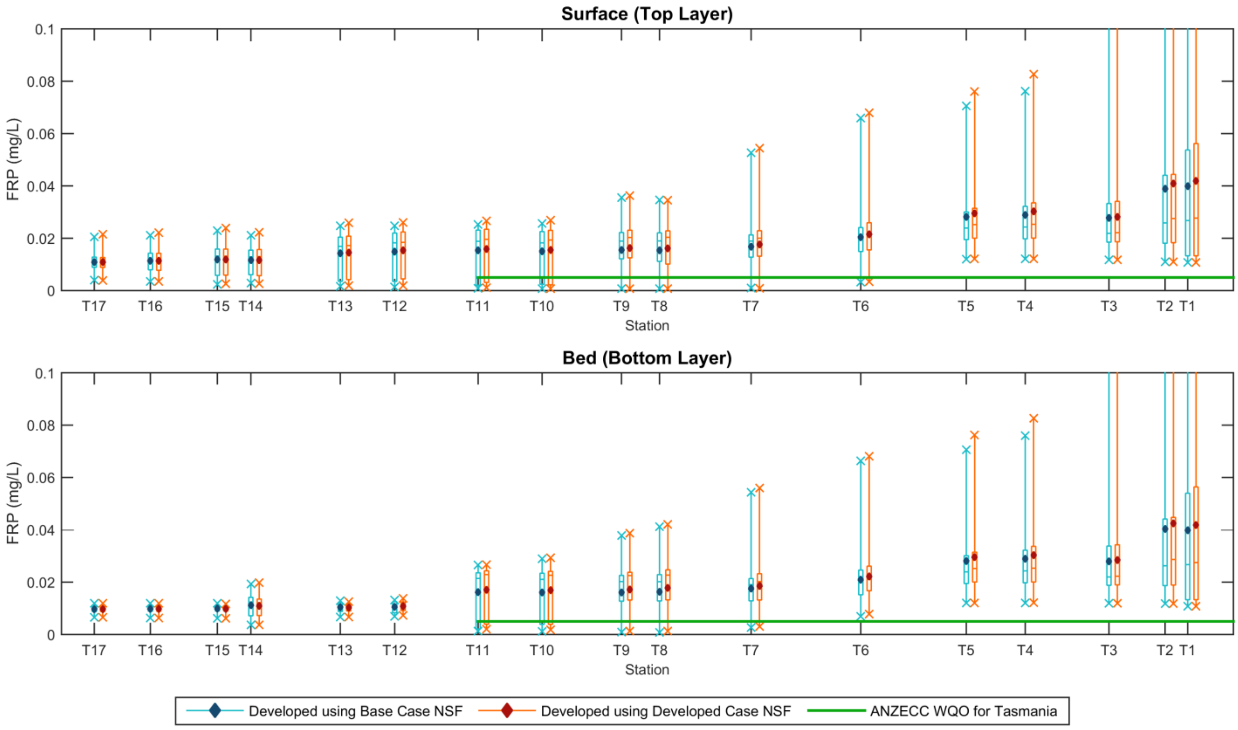


Figure 4-14 Scenario 1 – FRP – Winter (Wet)

4.5.8 Total Phosphorus

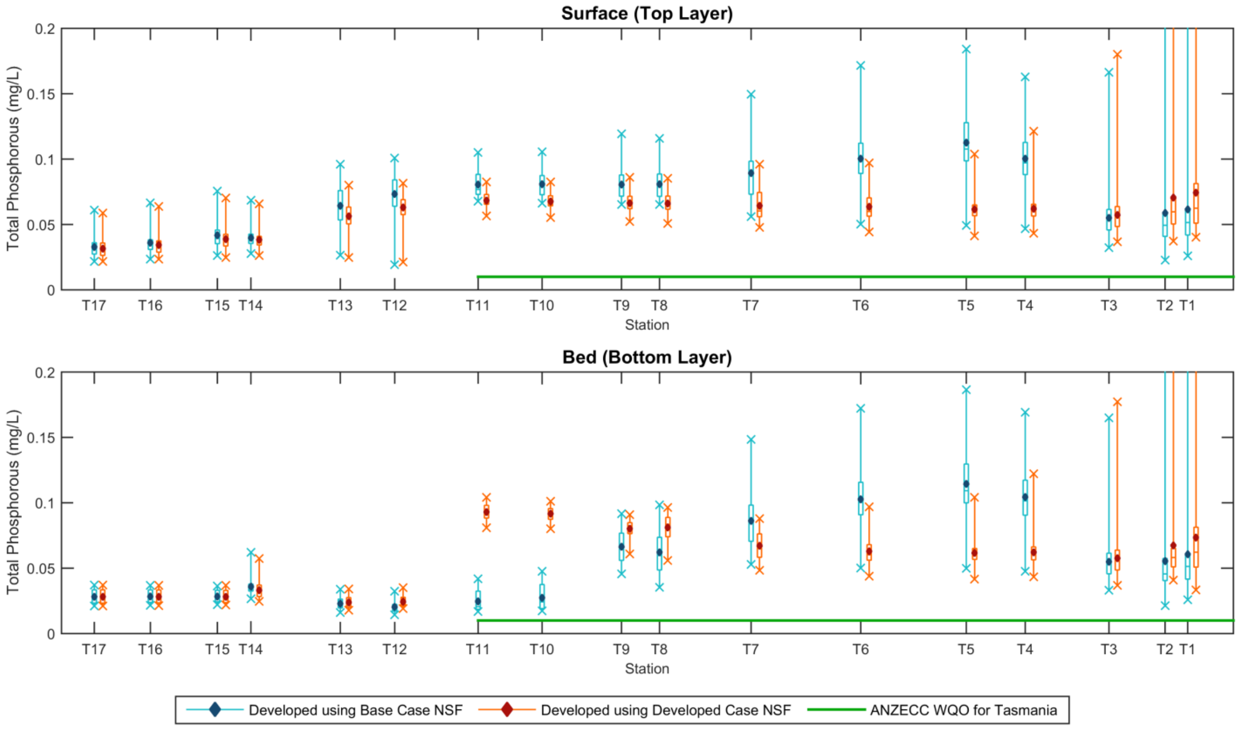


Figure 4-15 Scenario 1 – Total Phosphorus – Summer (Dry)

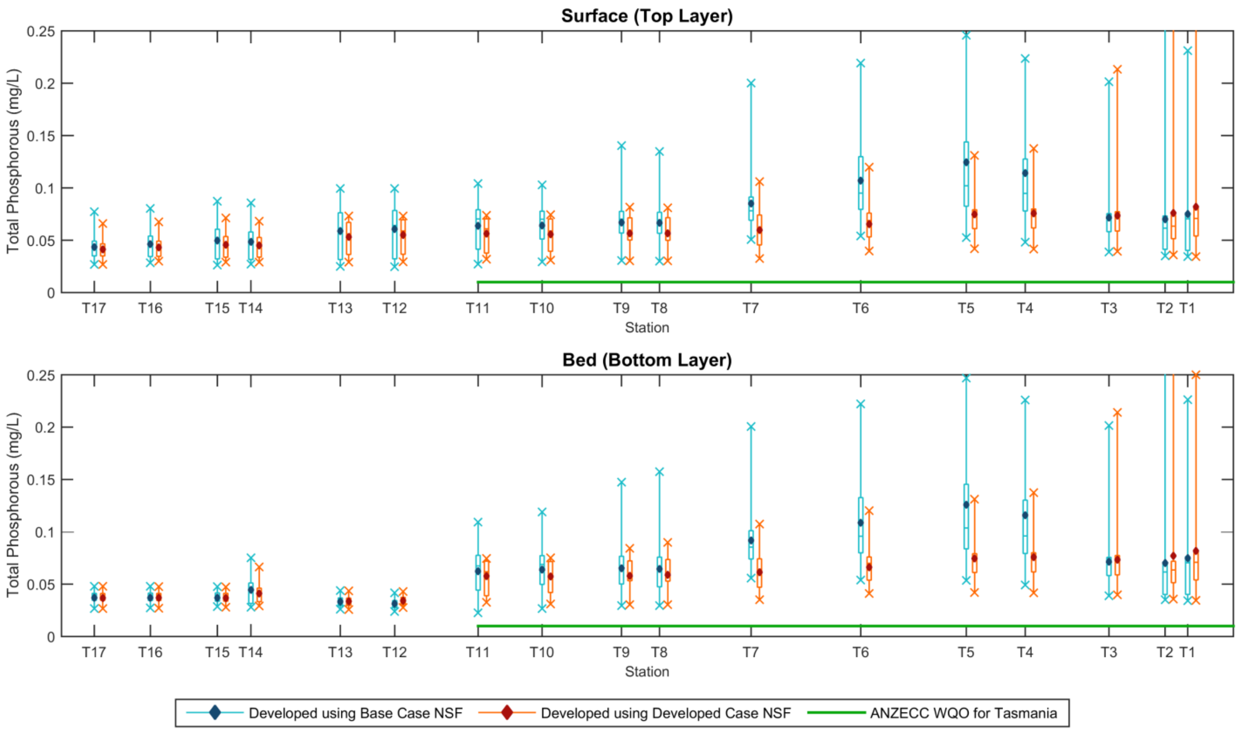


Figure 4-16 Scenario 1 – Total Phosphorus – Winter (Wet)

4.5.9 Chlorophyll-a

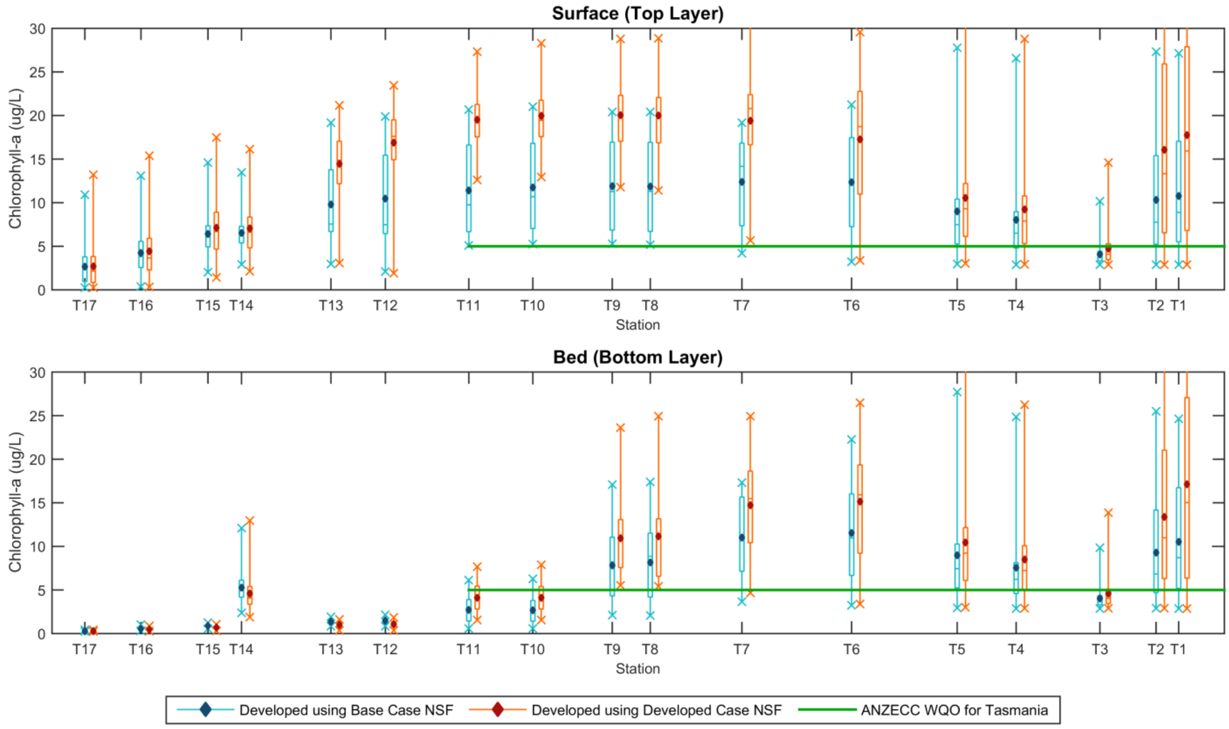


Figure 4-17 Scenario 1 – Chlorophyll-a – Summer (Dry)

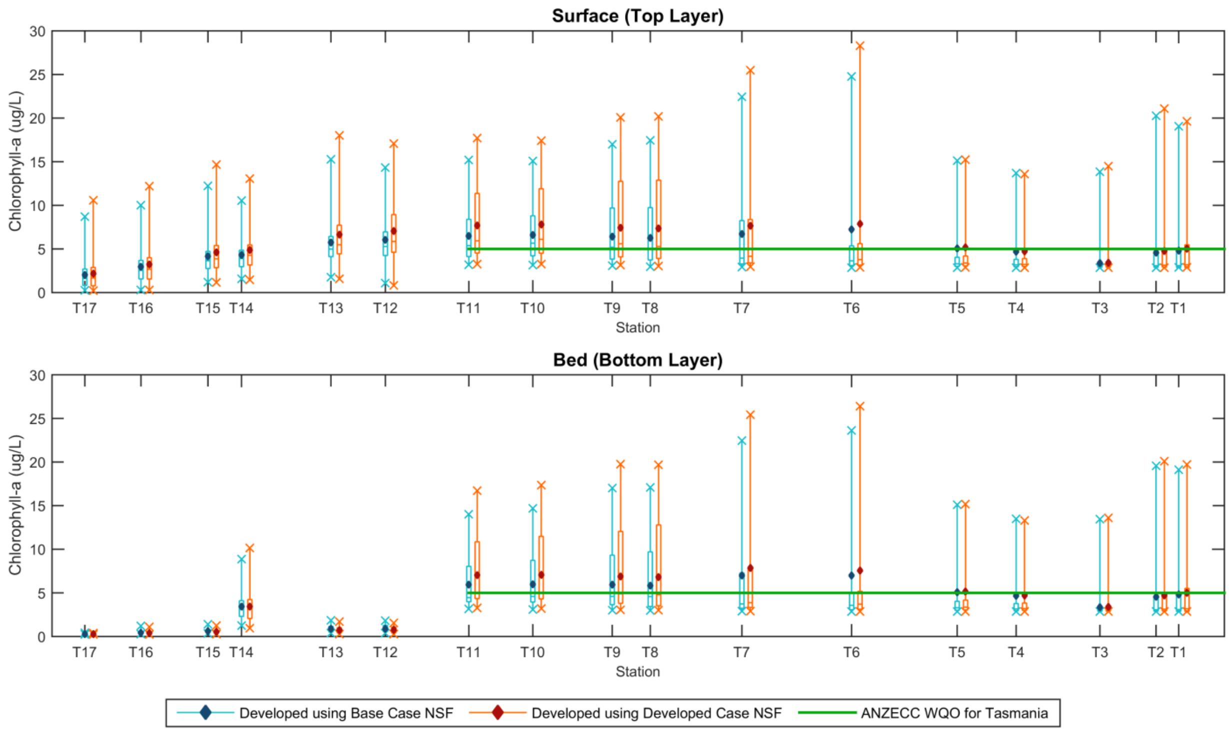


Figure 4-18 Scenario 1 – Chlorophyll-a – Winter (Wet)

4.5.10 Enterococci

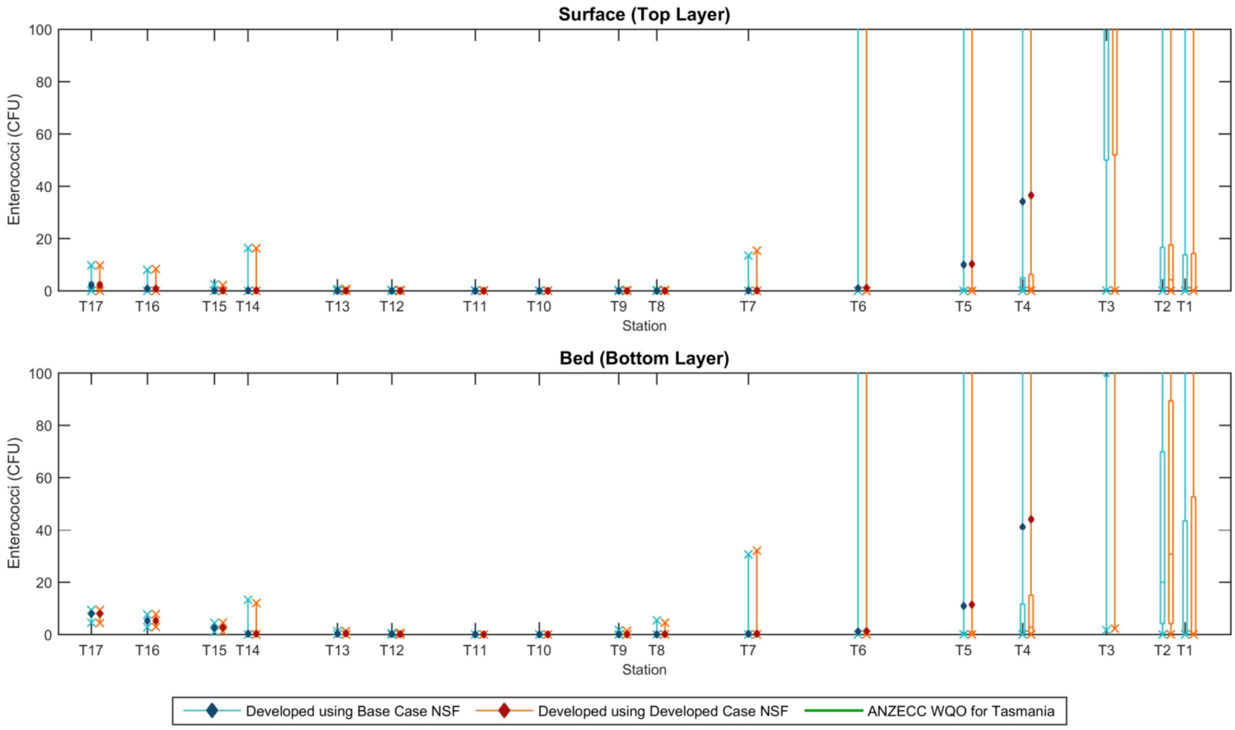


Figure 4-19 Scenario 1 – Enterococci – Summer (Dry)

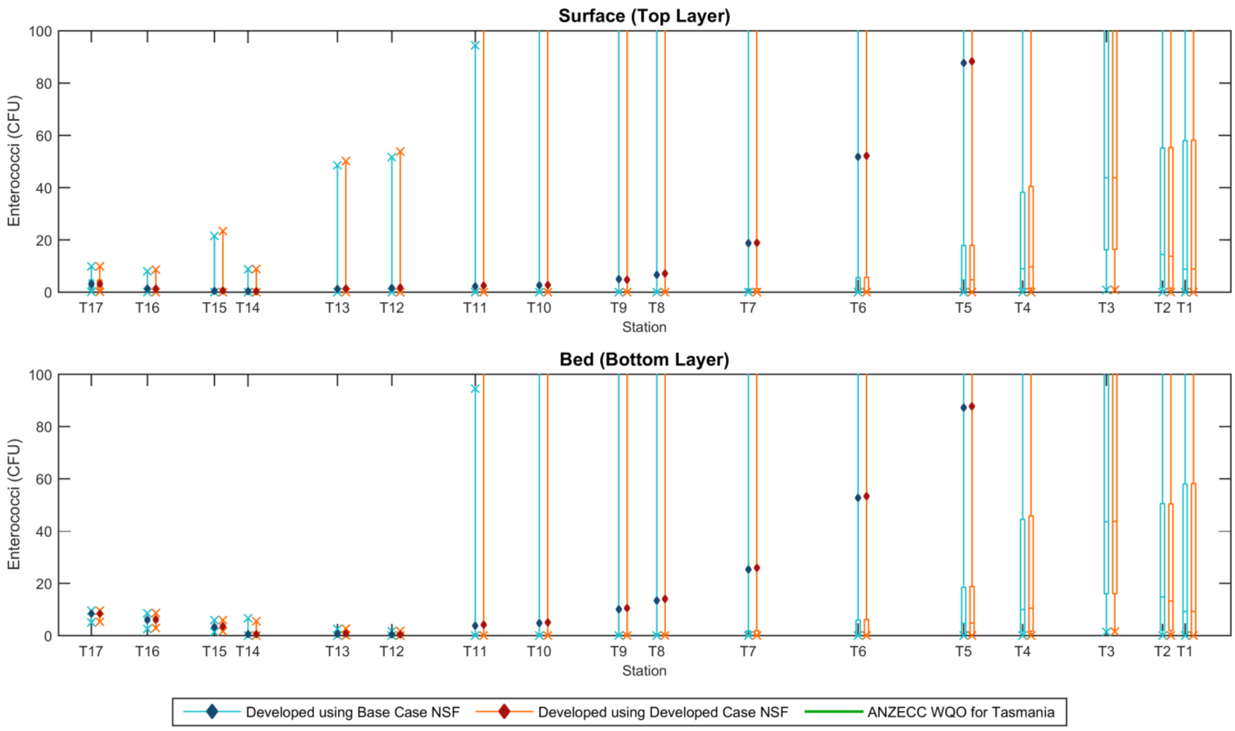


Figure 4-20 Scenario 1 – Enterococci – Winter (Wet)

4.6 Water Quality Scenario 1

Adaption of the barrage setup as described in Section 1 with flows applied to the top two meters.

4.6.1 Temperature

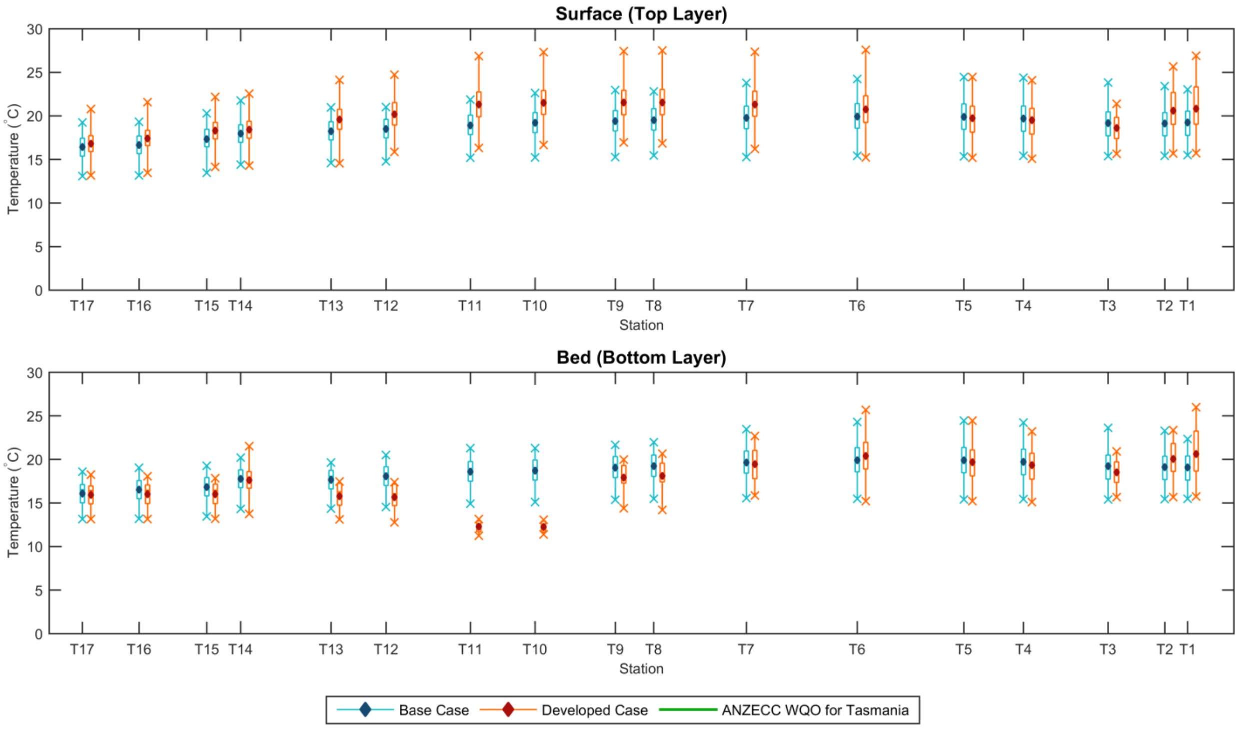


Figure 4-21 Scenario 1 – Temperature – Summer (Dry)

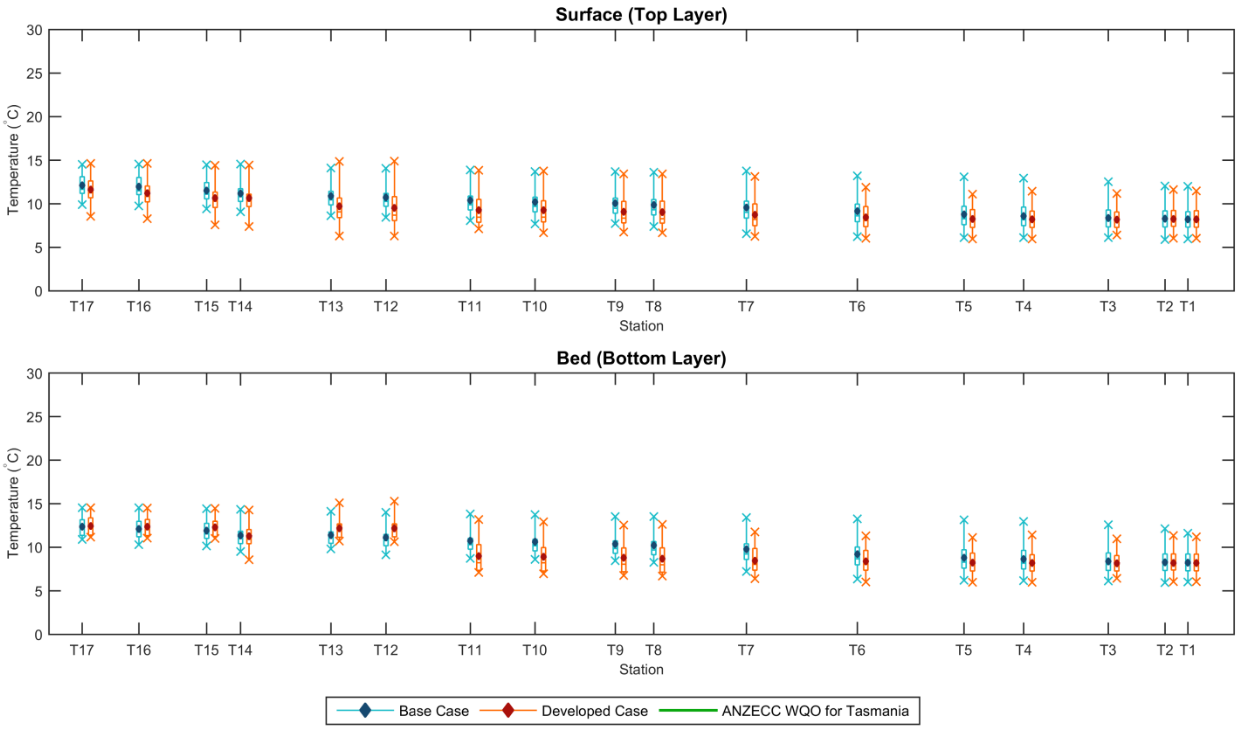


Figure 4-22 Scenario 1 – Temperature – Winter (Wet)

4.6.2 Dissolved Oxygen (mg/L)

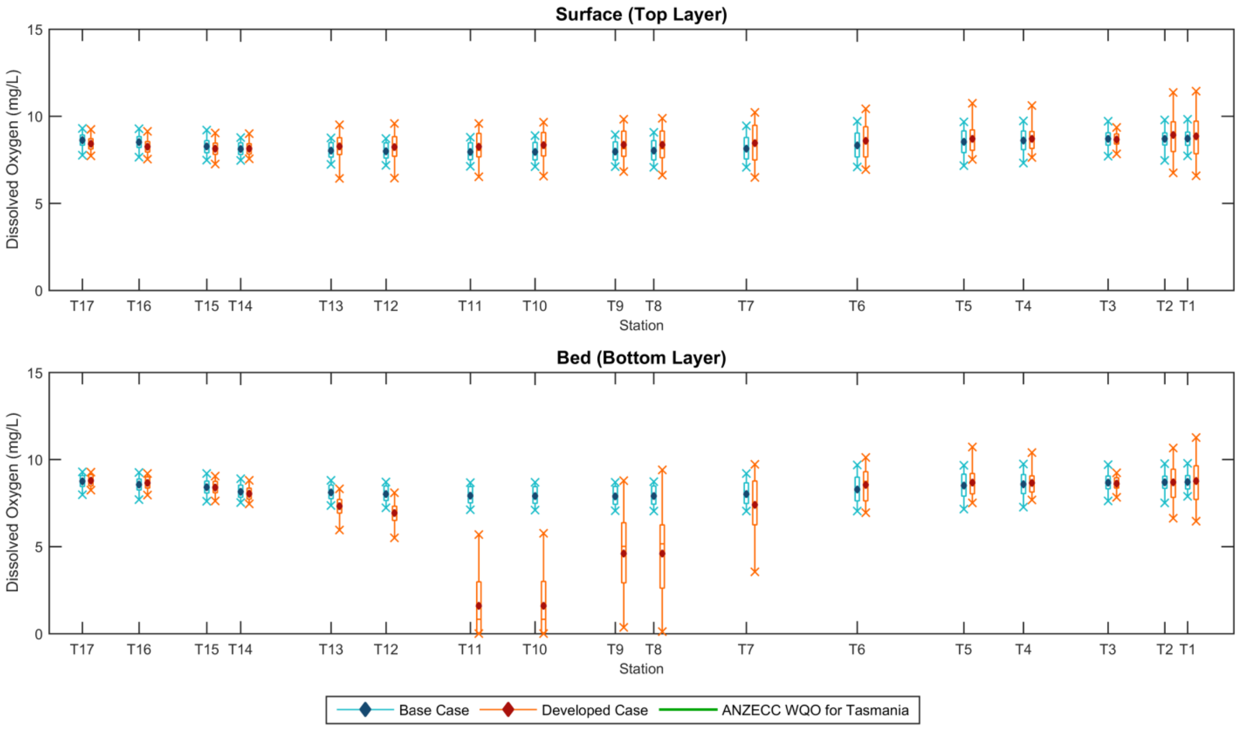


Figure 4-23 Scenario 1 – Dissolved Oxygen (mg/L) – Summer (Dry)

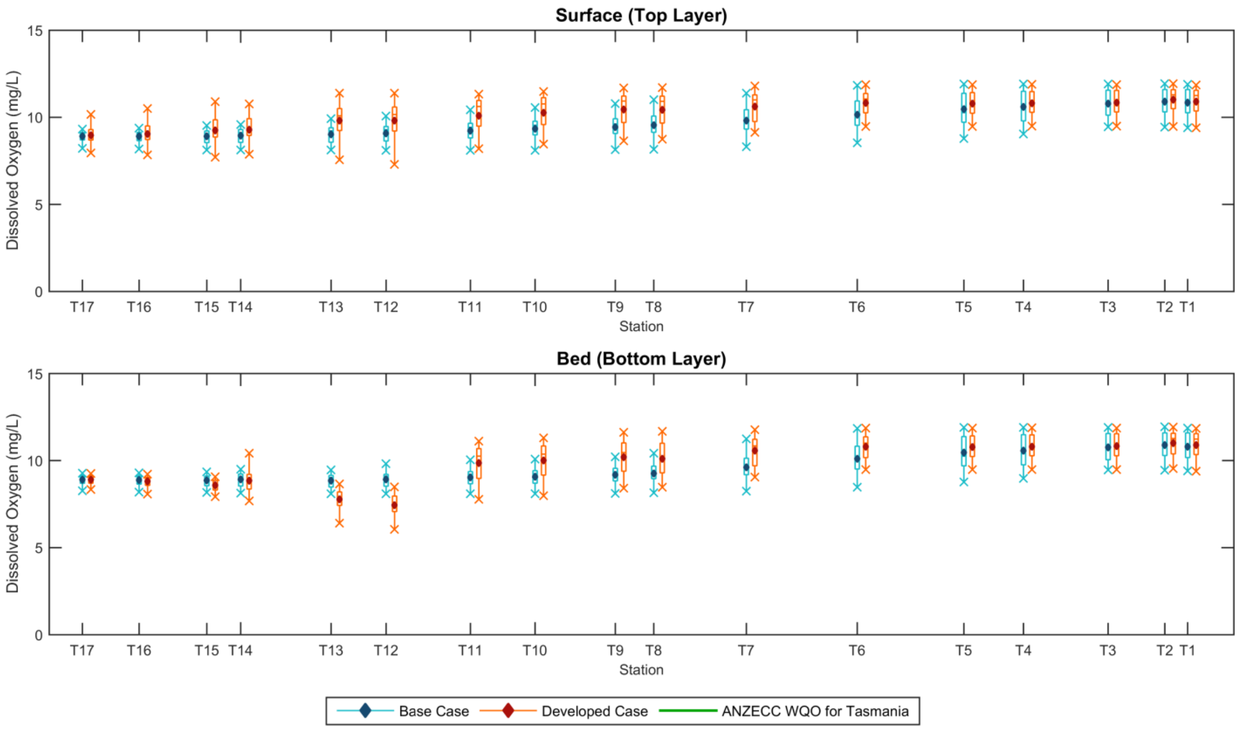


Figure 4-24 Scenario 1 – Dissolved Oxygen (mg/L) – Winter (Wet)

4.6.3 Dissolved Oxygen (% Saturation)

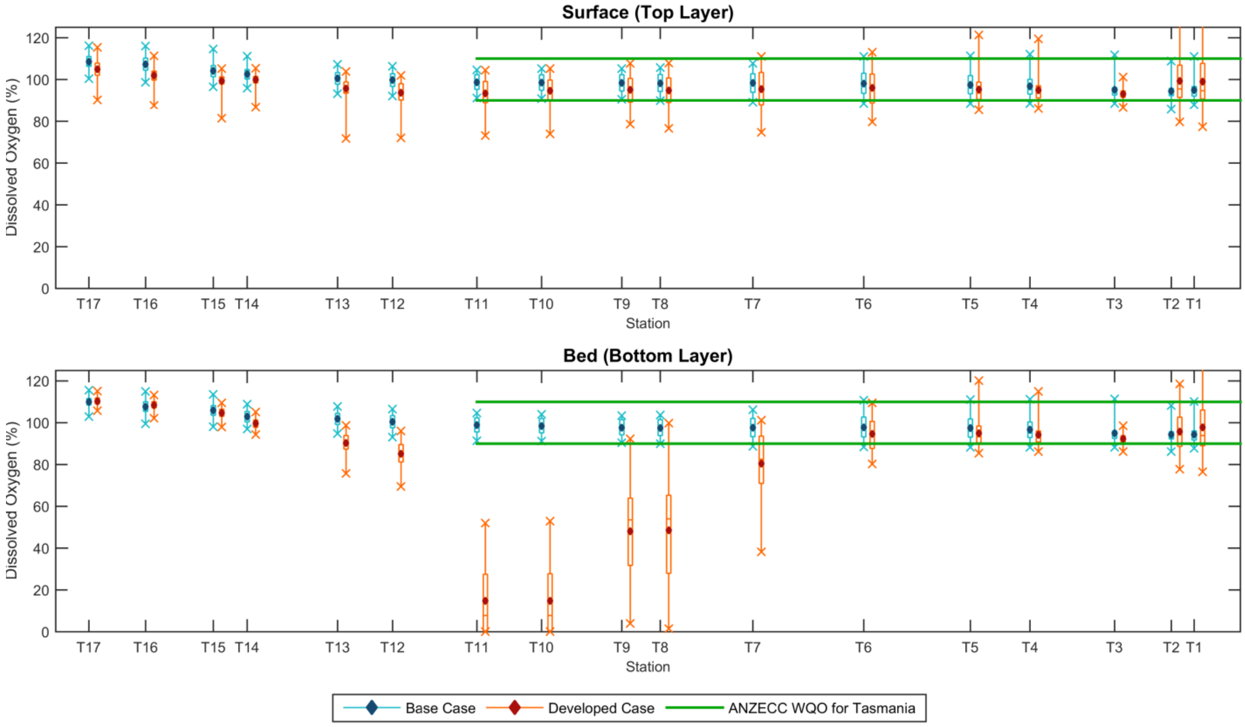


Figure 4-25 Scenario 1 – Dissolved Oxygen (% Saturated) – Summer (Dry)

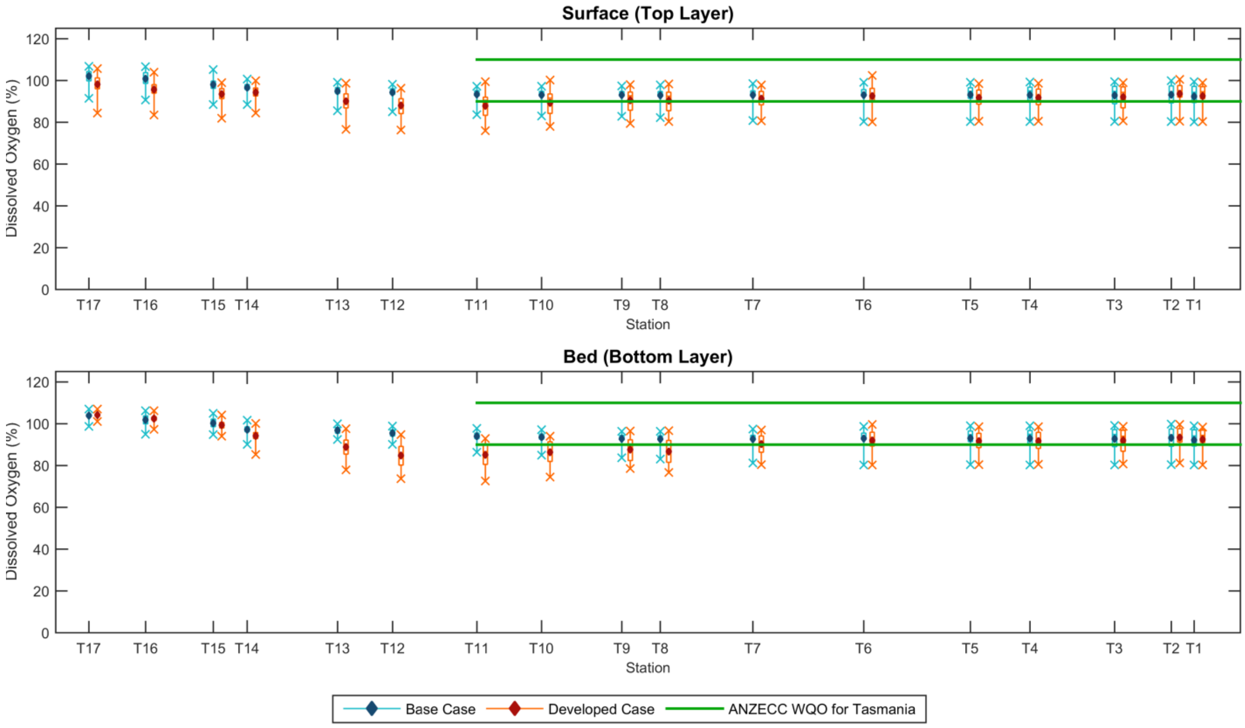


Figure 4-26 Scenario 1 – Dissolved Oxygen (% Saturated) – Winter (Wet)

4.6.4 Ammonia

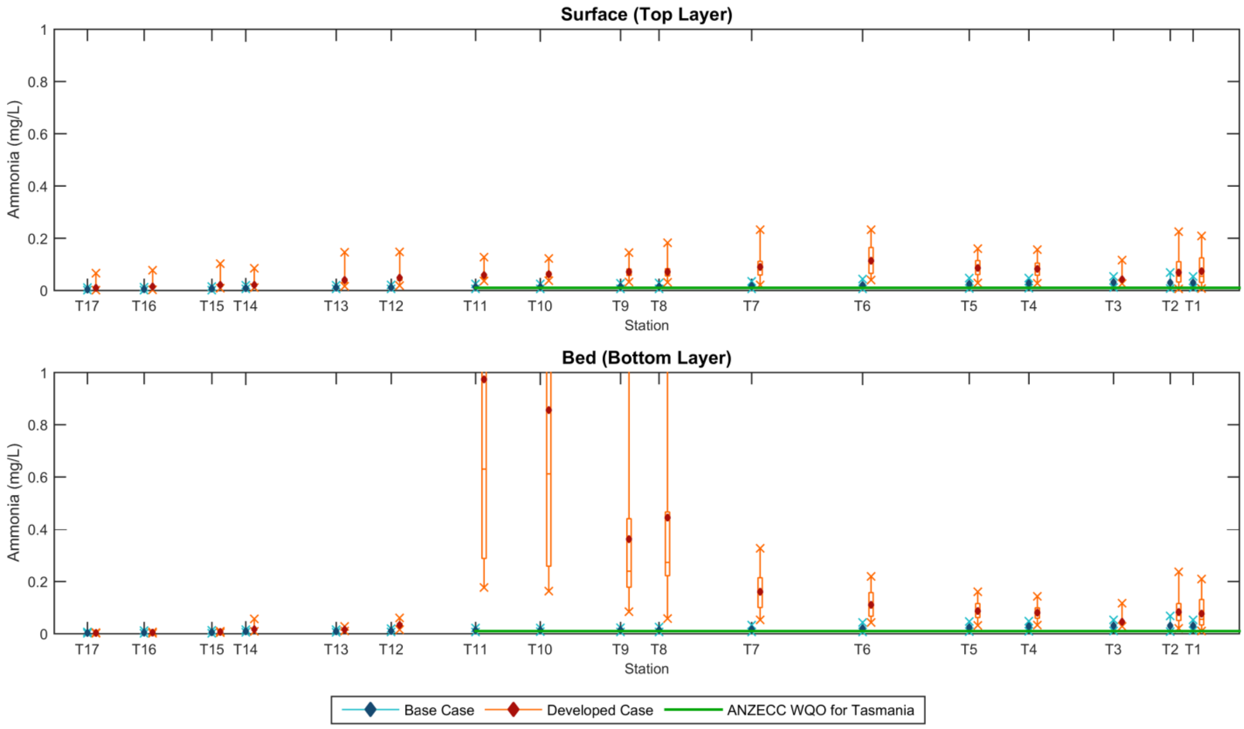


Figure 4-27 Scenario 1 – Ammonia – Summer (Dry)

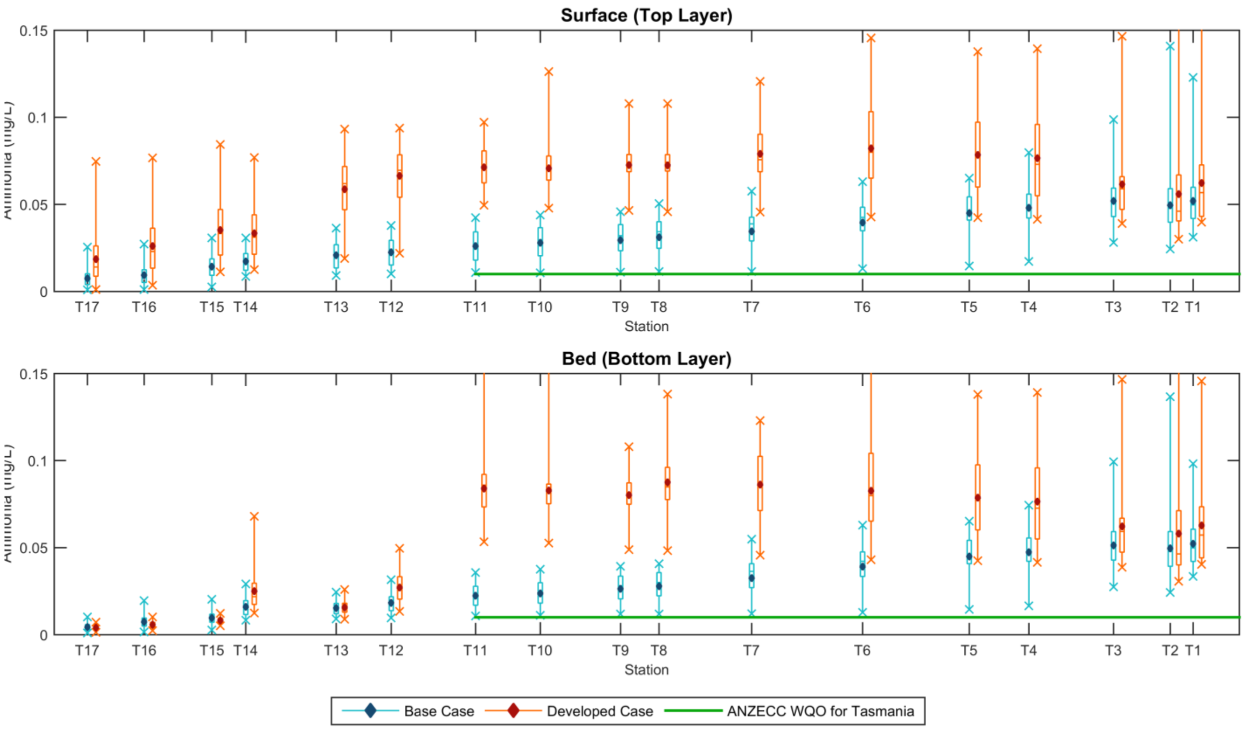


Figure 4-28 Scenario 1 – Ammonia – Winter (Wet)

4.6.5 Nitrate

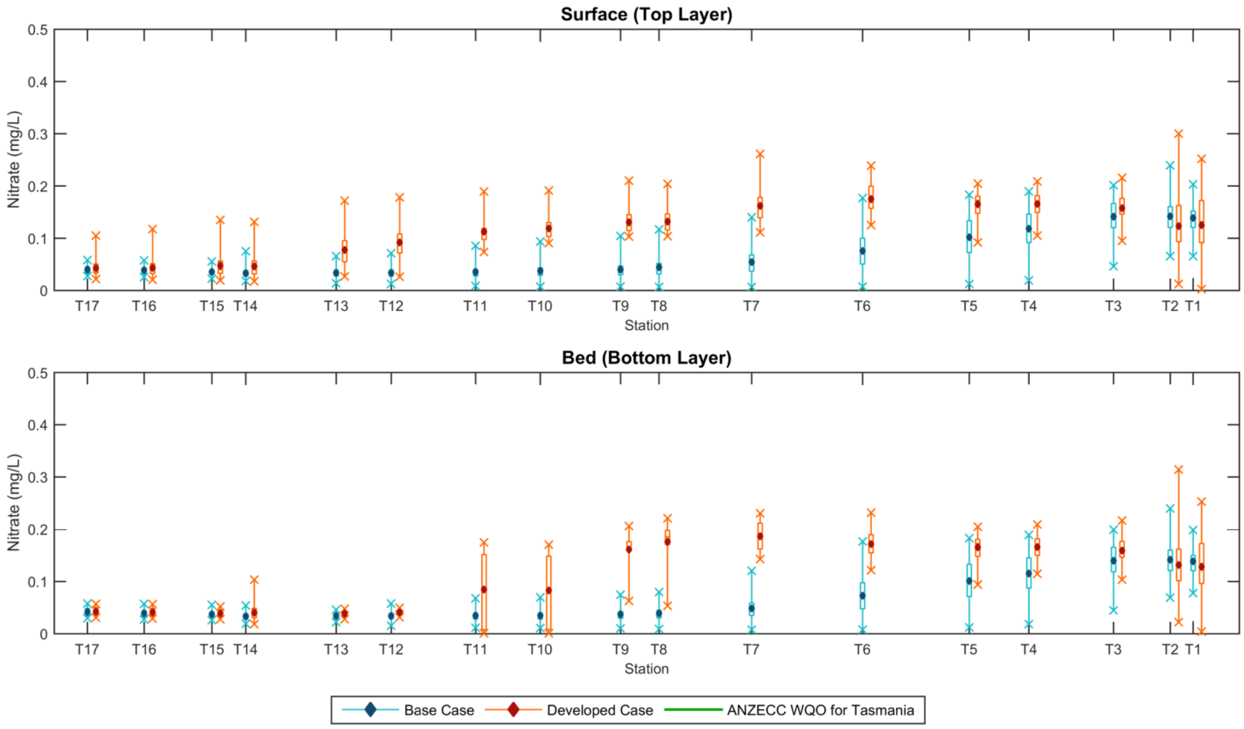


Figure 4-29 Scenario 1 – Nitrate – Summer (Dry)

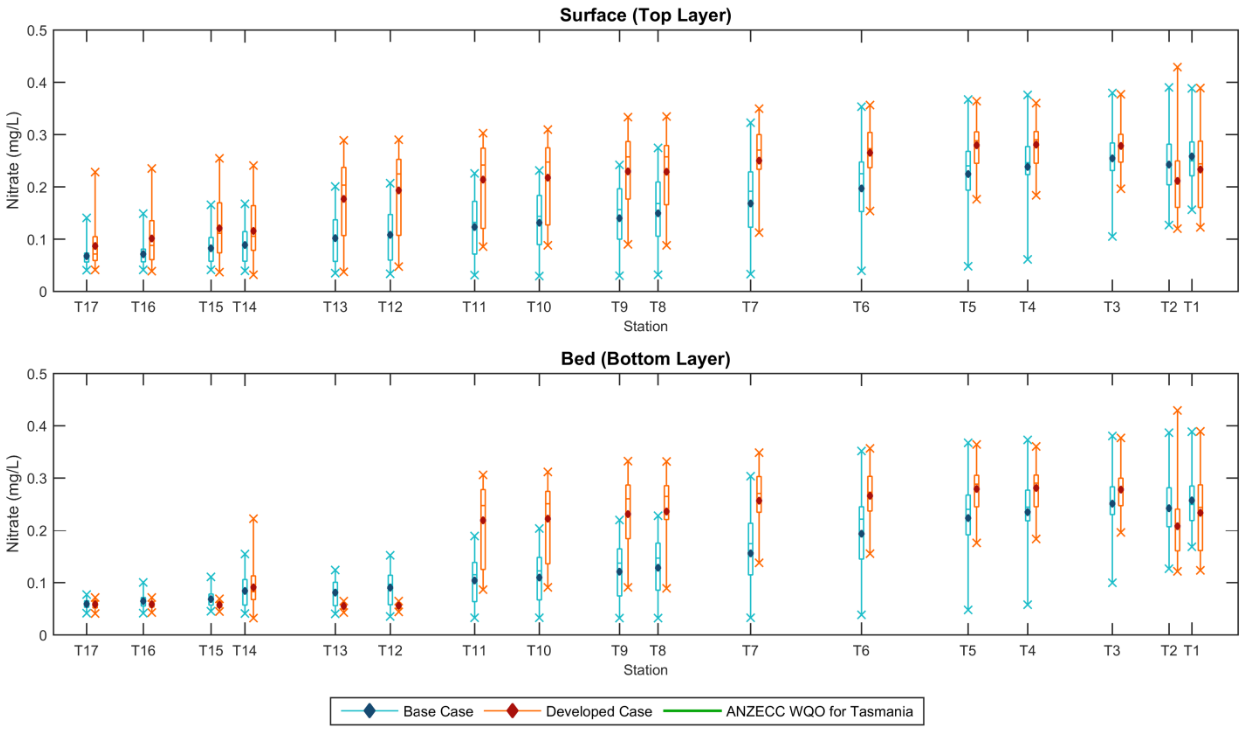


Figure 4-30 Scenario 1 – Nitrate – Winter (Wet)

4.6.6 Total Nitrogen

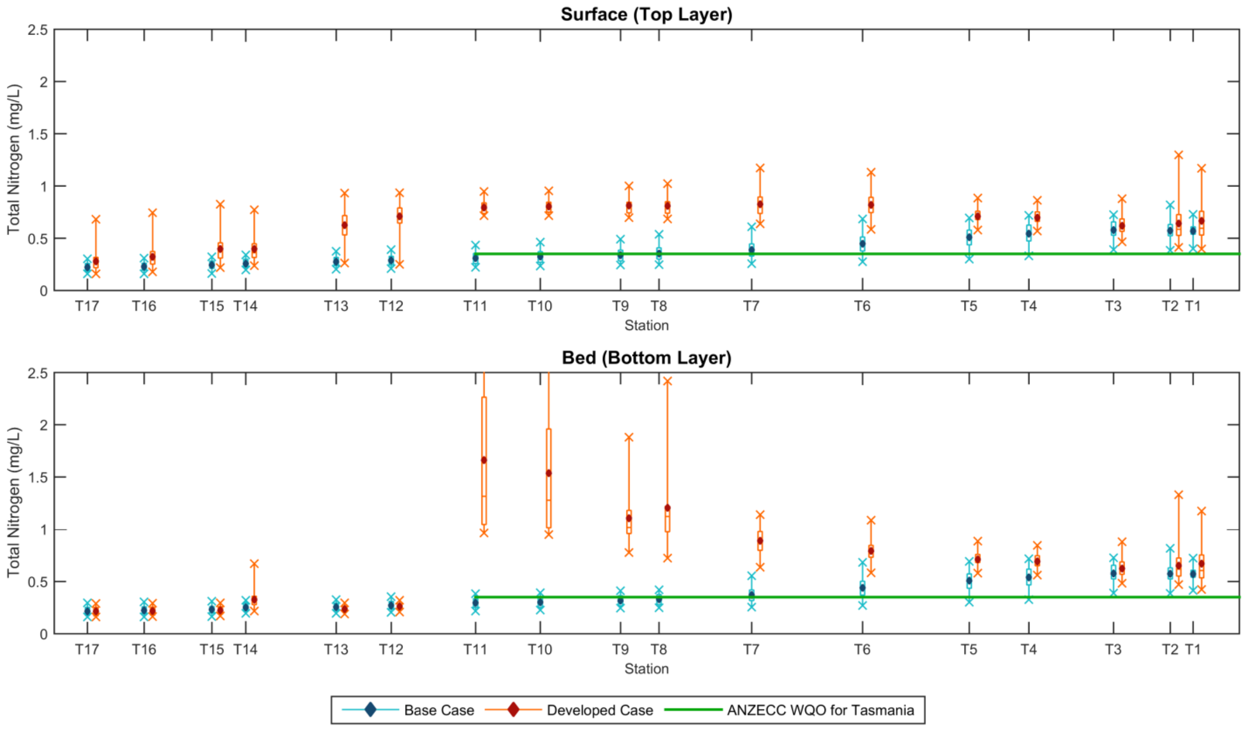


Figure 4-31 Scenario 1 – Total Nitrogen – Summer (Dry)

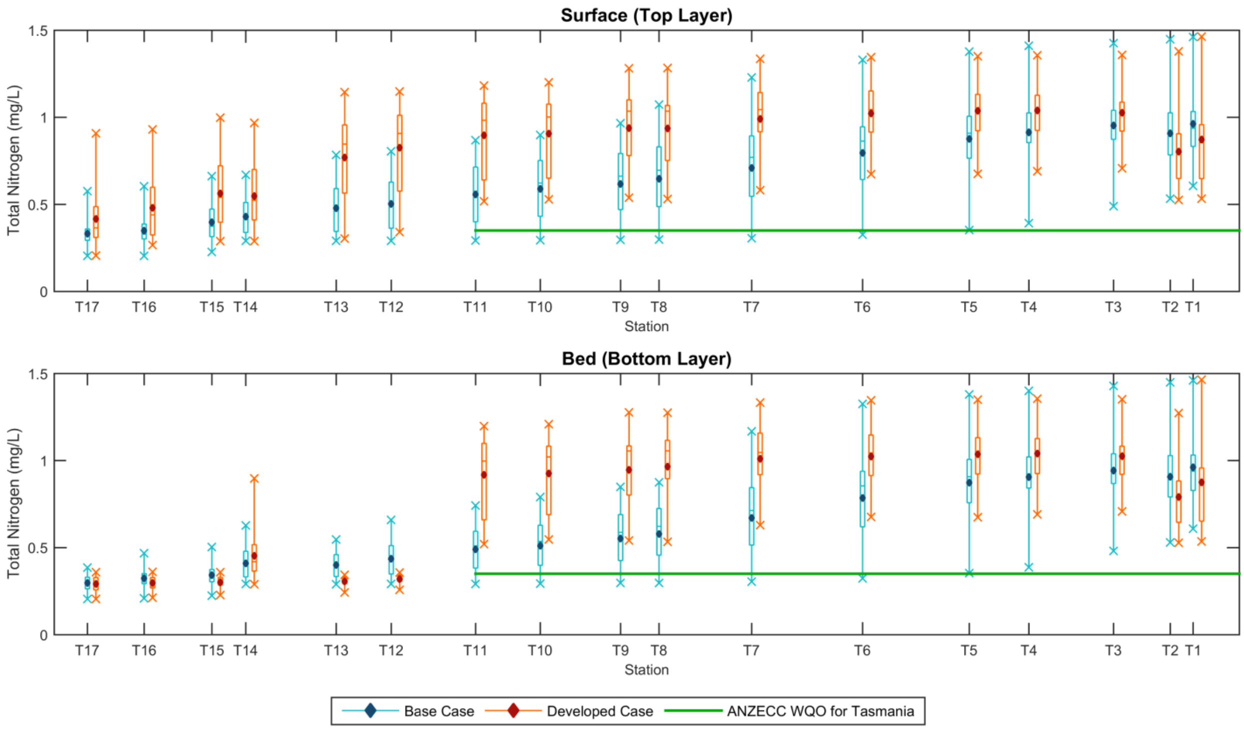


Figure 4-32 Scenario 1 – Total Nitrogen – Winter (Wet)

4.6.7 FRP

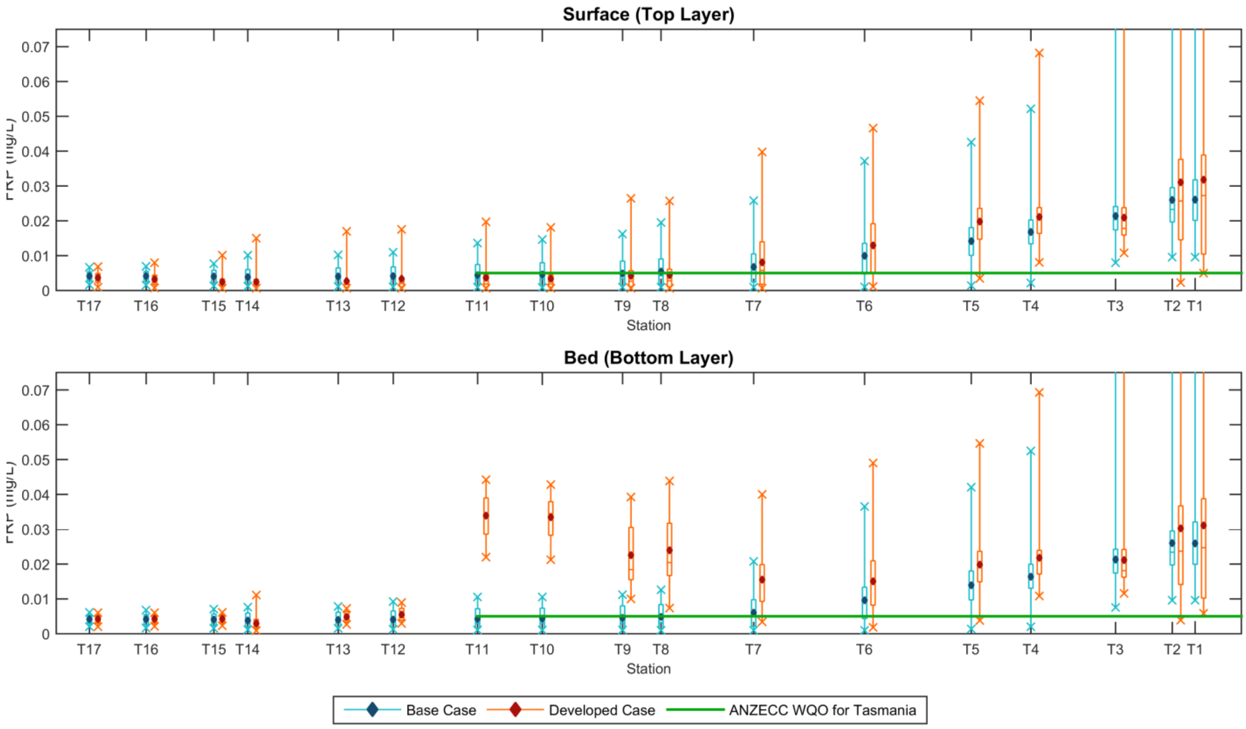


Figure 4-33 Scenario 1 – FRP – Summer (Dry)

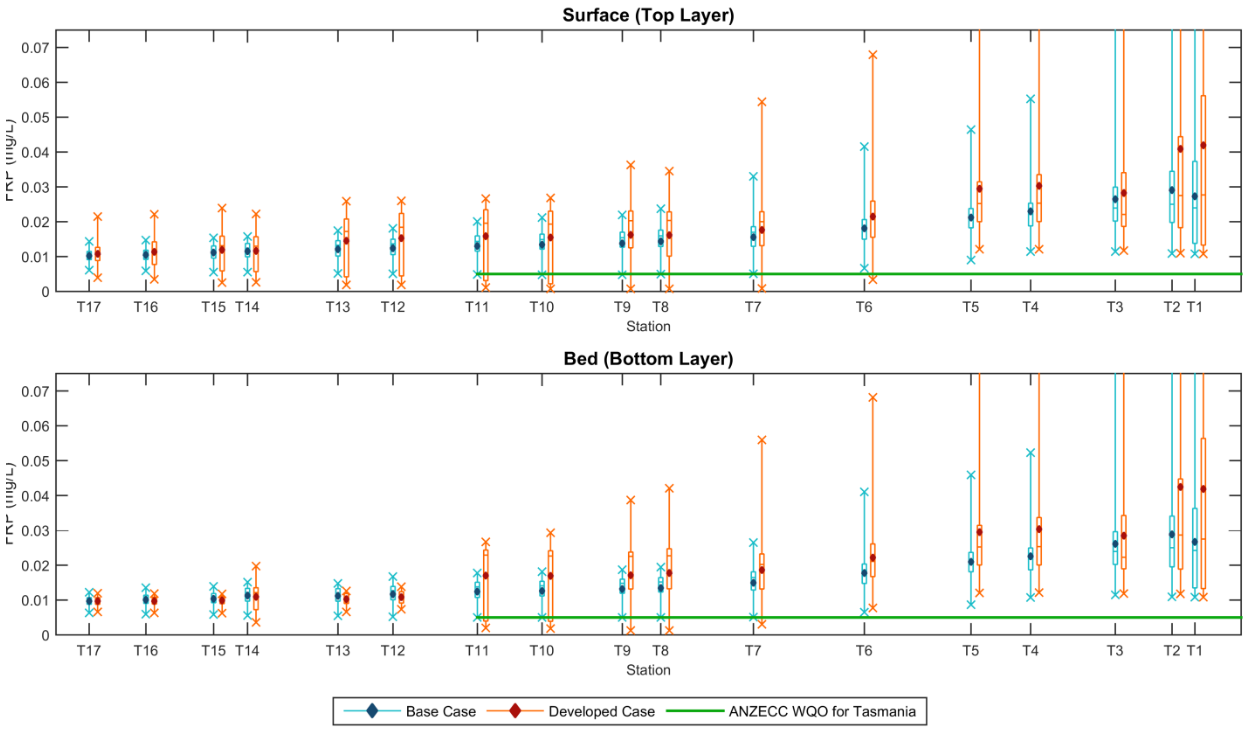


Figure 4-34 Scenario 1 – FRP – Winter (Wet)

4.6.8 Total Phosphorus

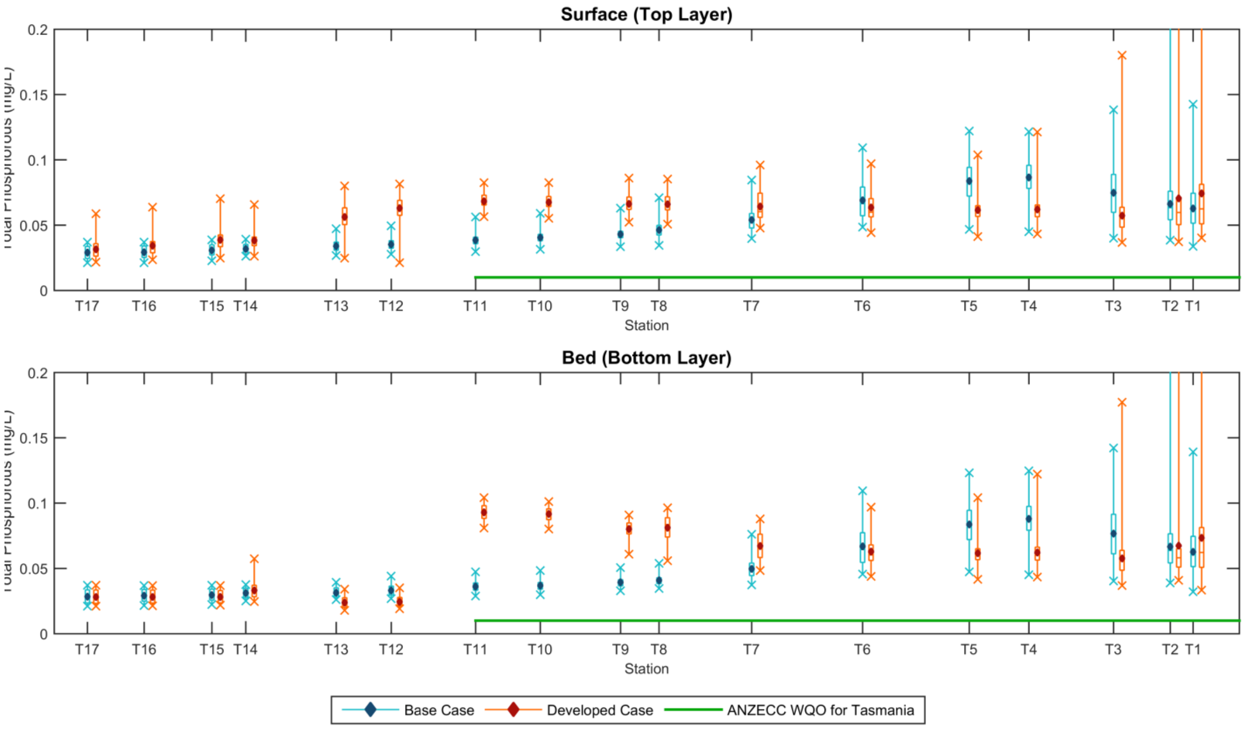


Figure 4-35 Scenario 1 – Total Phosphorus – Summer (Dry)

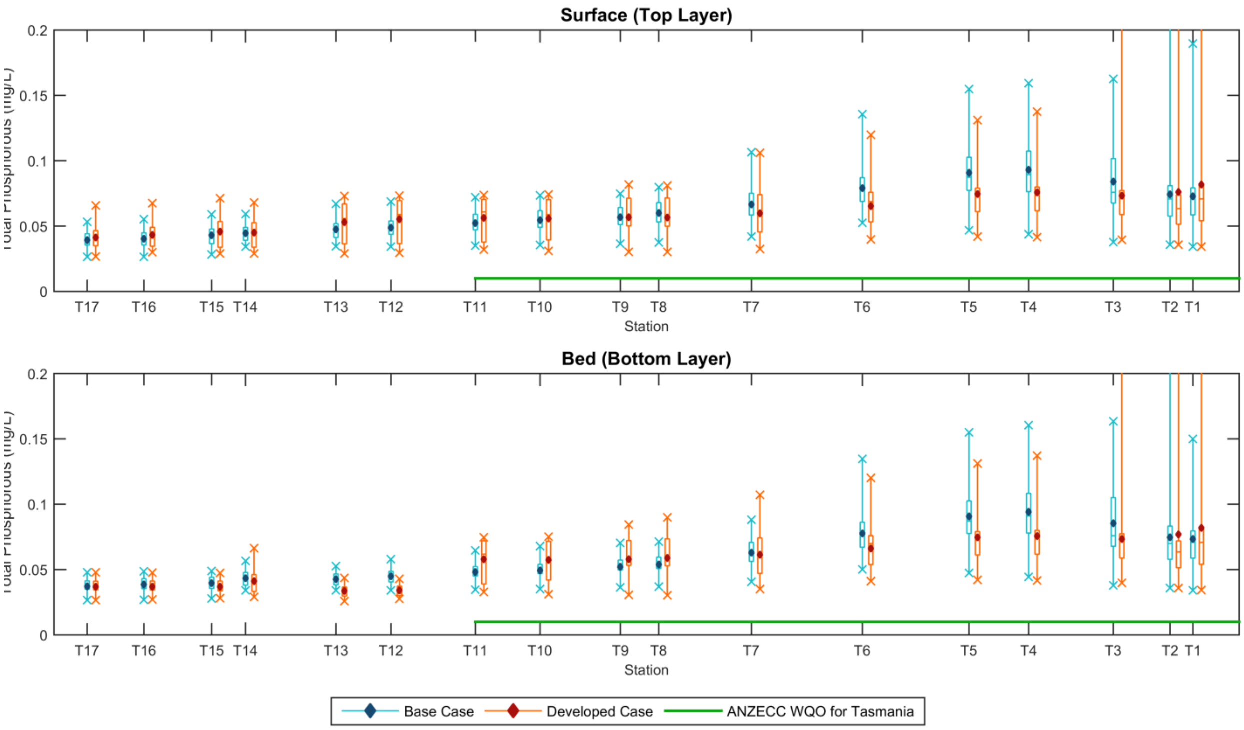


Figure 4-36 Scenario 1 – Total Phosphorus – Winter (Wet)

4.6.9 Chlorophyll-a

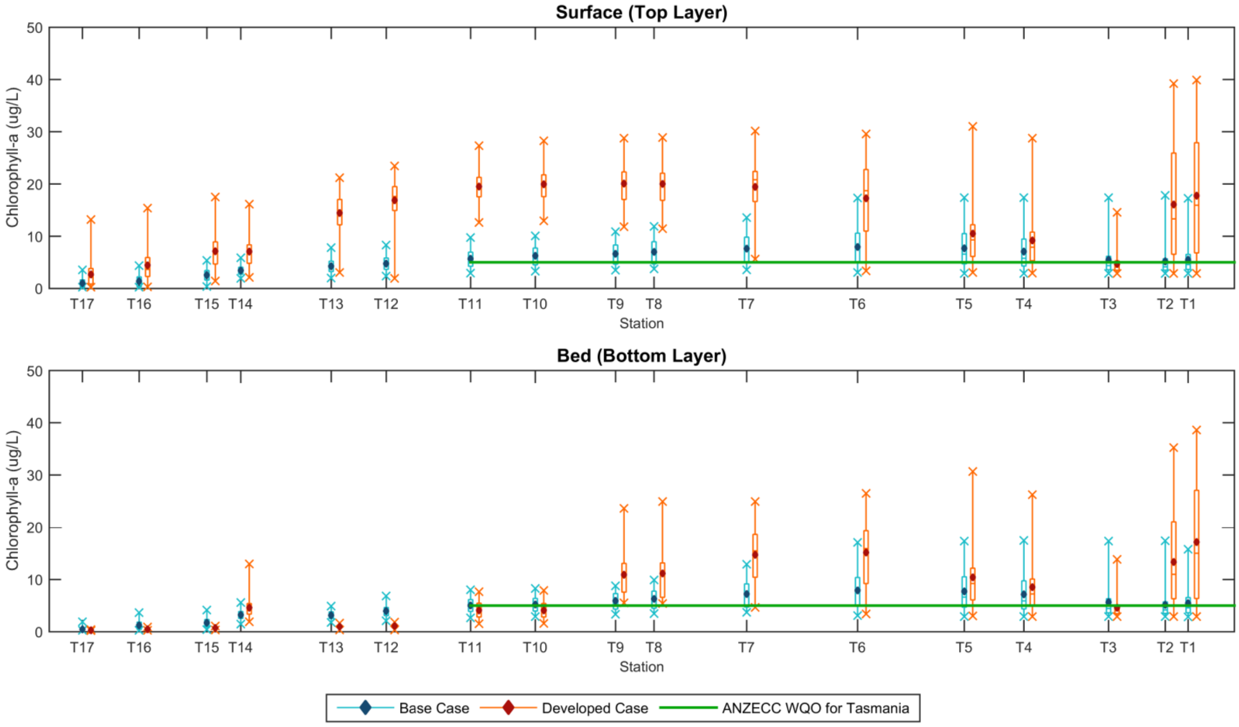


Figure 4-37 Scenario 1 – Chlorophyll-a – Summer (Dry)

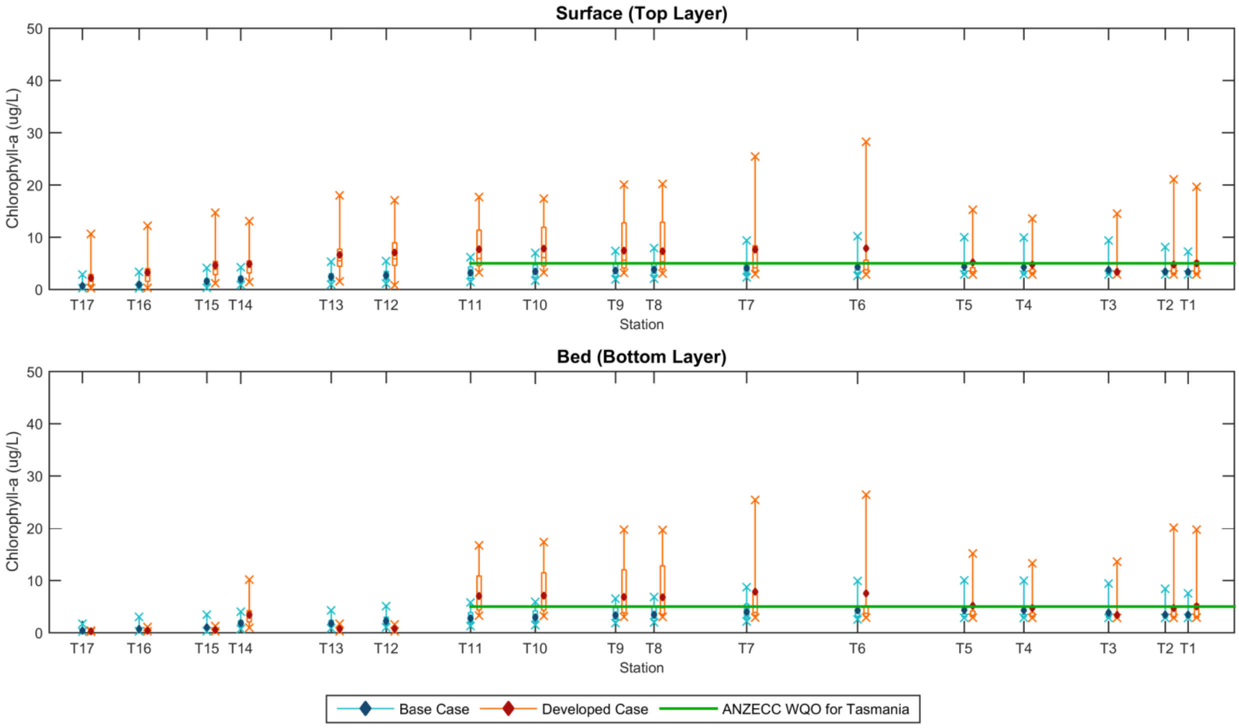


Figure 4-38 Scenario 1 – Chlorophyll-a – Winter (Wet)

4.6.10 Enterococci

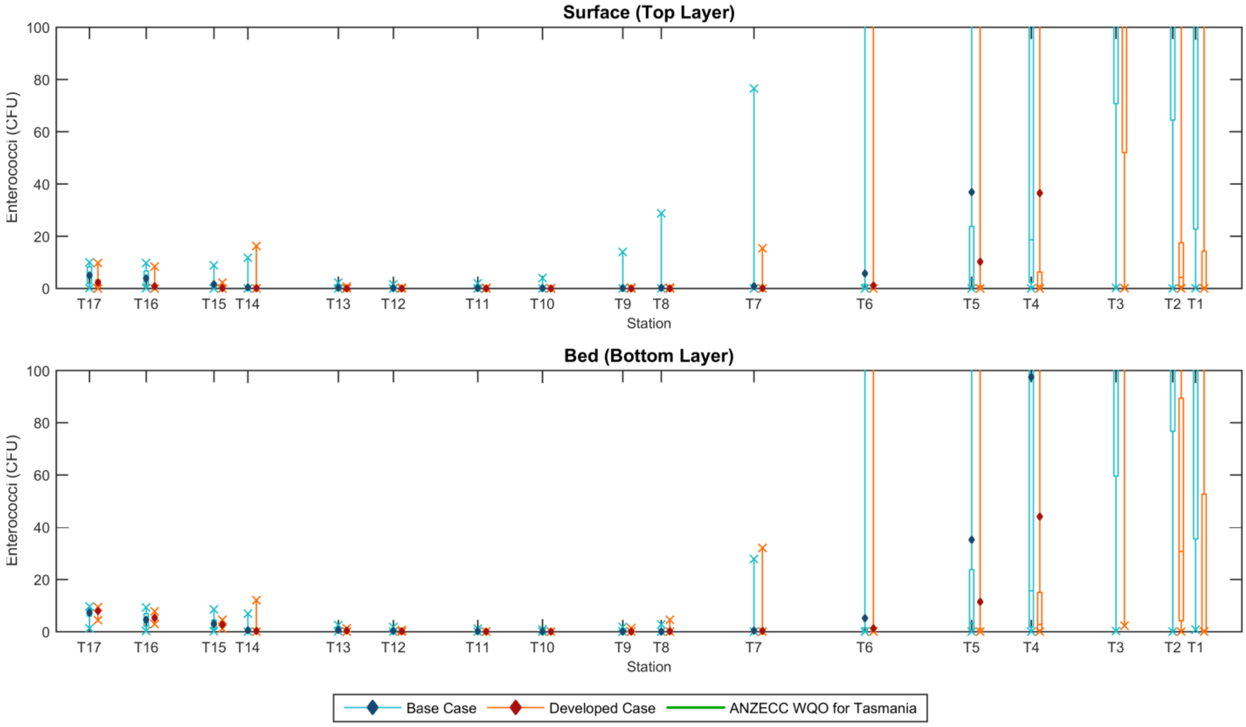


Figure 4-39 Scenario 1 – Enterococci – Summer (Dry)

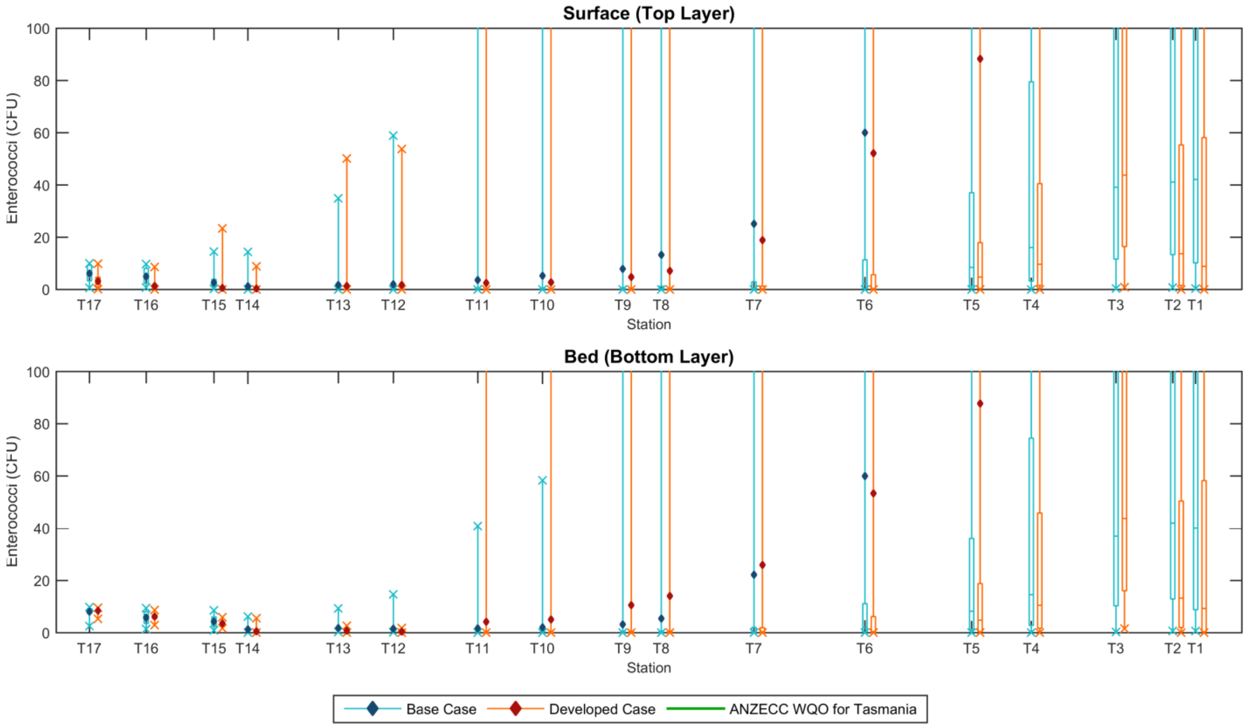


Figure 4-40 Scenario 1 – Enterococci – Winter (Wet)

4.7 Water Quality Scenario 2

Adaption of the barrage setup as described in Section 1 with flows applied to the top two meters with LSIP load reductions applied.

4.7.1 Temperature

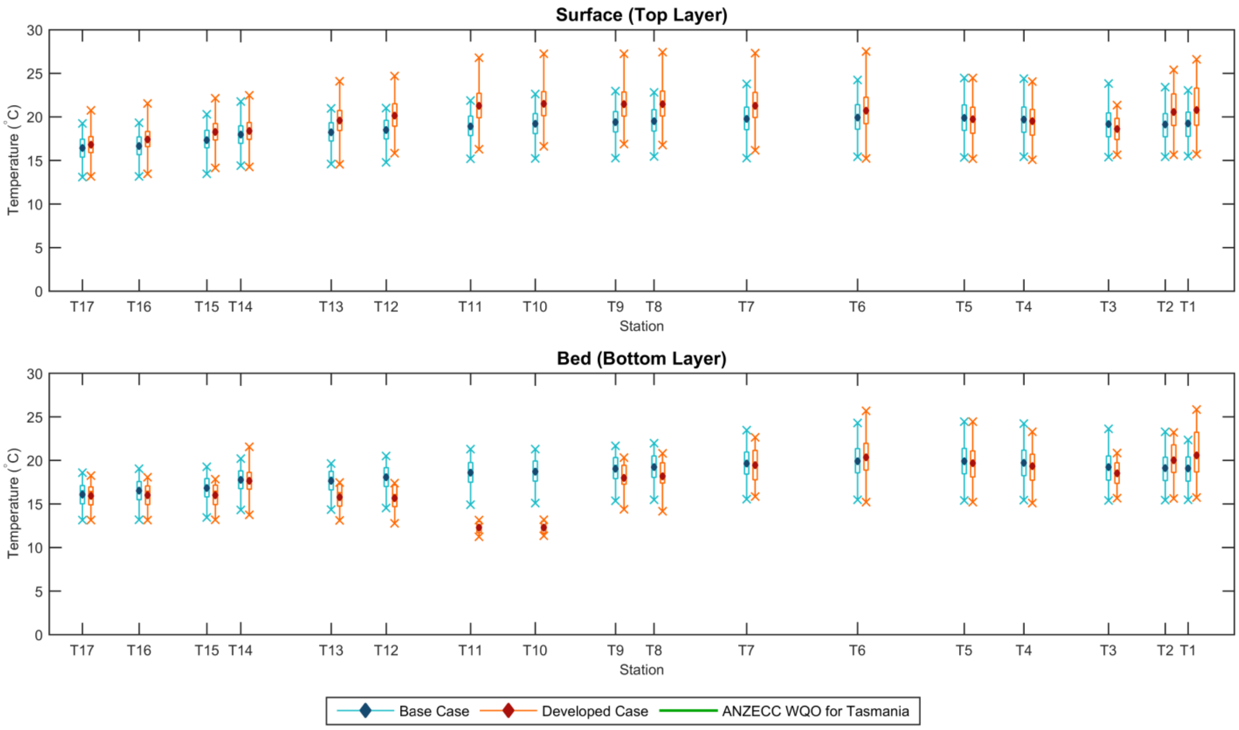


Figure 4-41 Scenario 2 – Temperature – Summer (Dry)

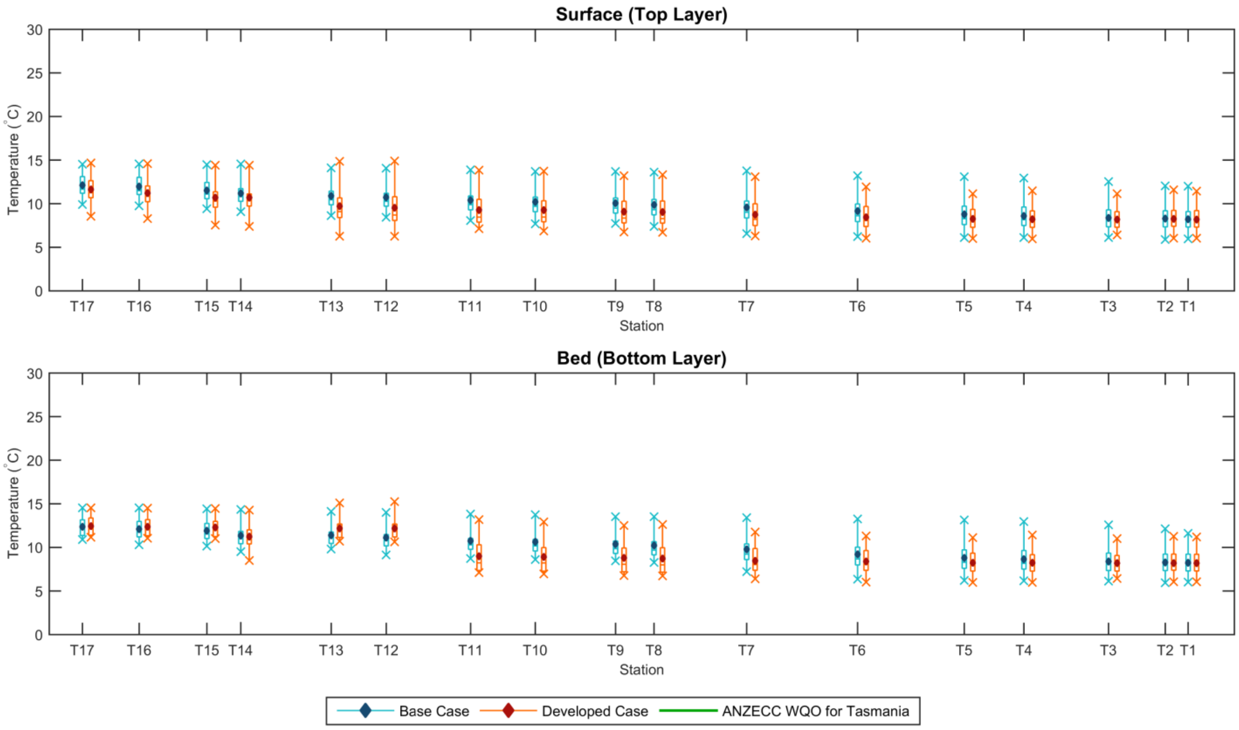


Figure 4-42 Scenario 2 – Temperature – Winter (Wet)

4.7.2 Dissolved Oxygen (mg/L)

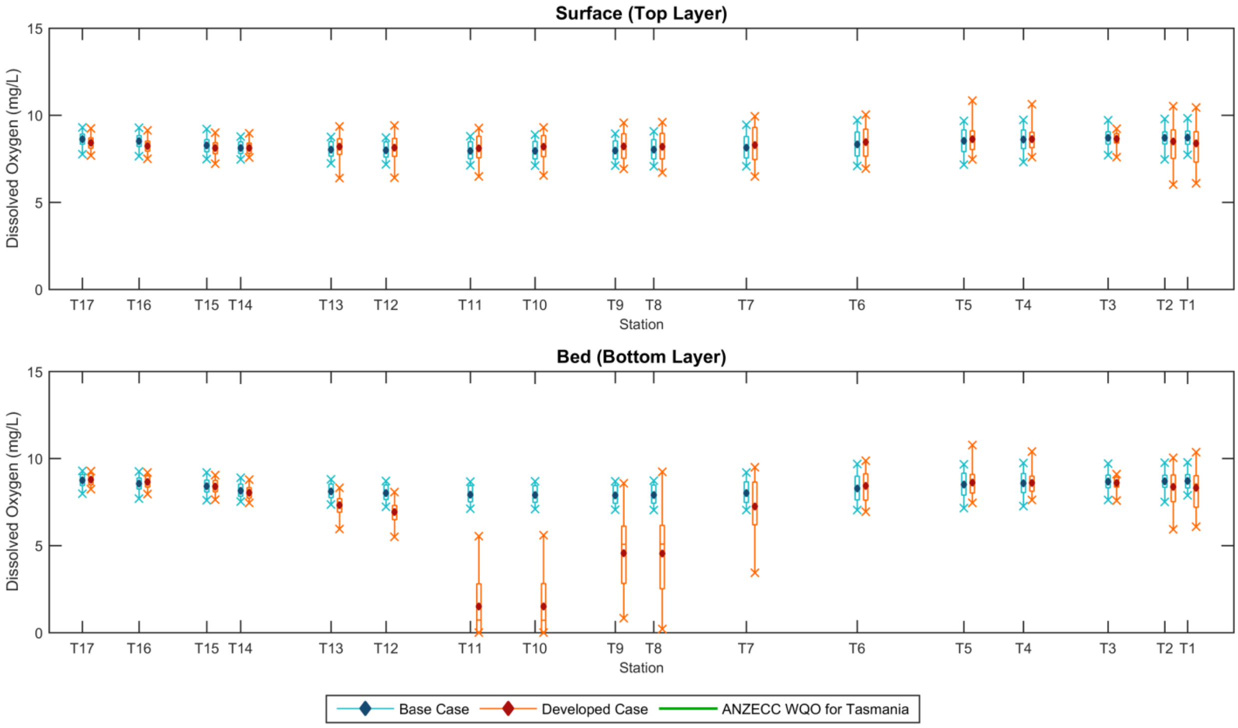


Figure 4-43 Scenario 2 – Dissolved Oxygen (mg/L) – Summer (Dry)

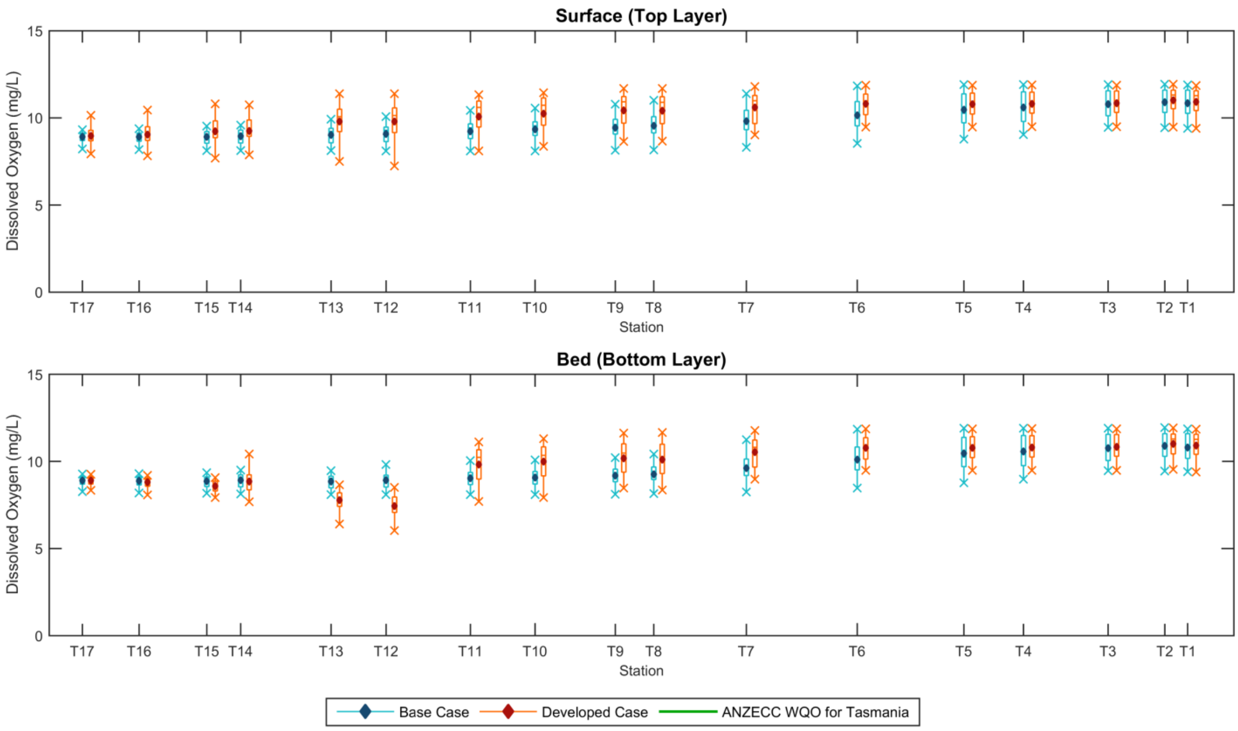


Figure 4-44 Scenario 2 – Dissolved Oxygen (mg/L) – Winter (Wet)

4.7.3 Dissolved Oxygen (% saturation)

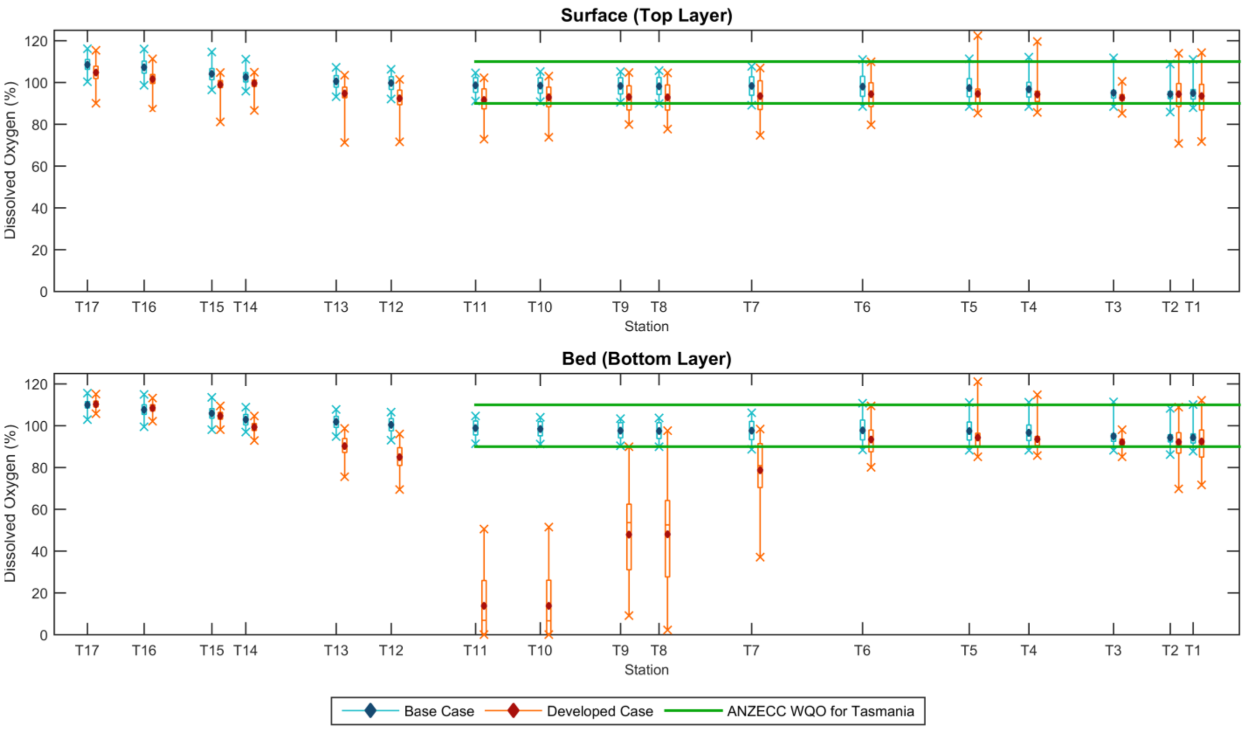


Figure 4-45 Scenario 2 – Dissolved Oxygen (% Saturated) – Summer (Dry)

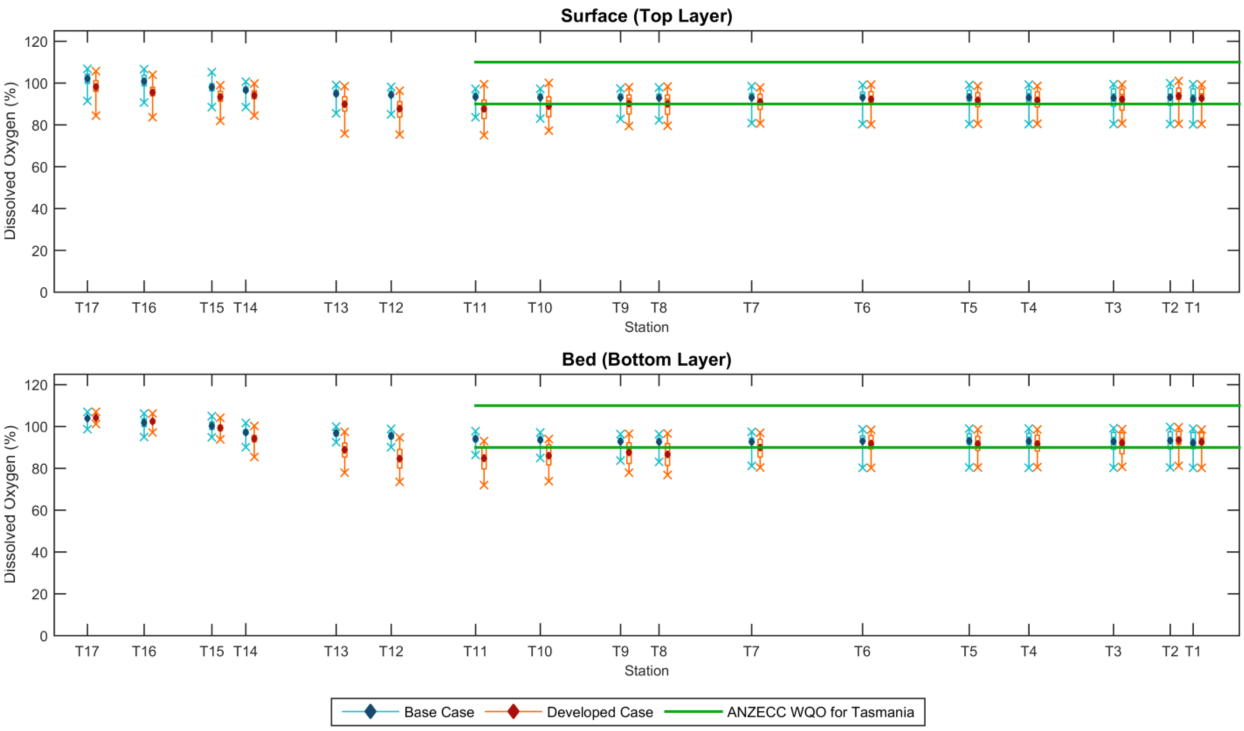


Figure 4-46 Scenario 2 – Dissolved Oxygen (% Saturated) – Winter (Wet)

4.7.4 Ammonia

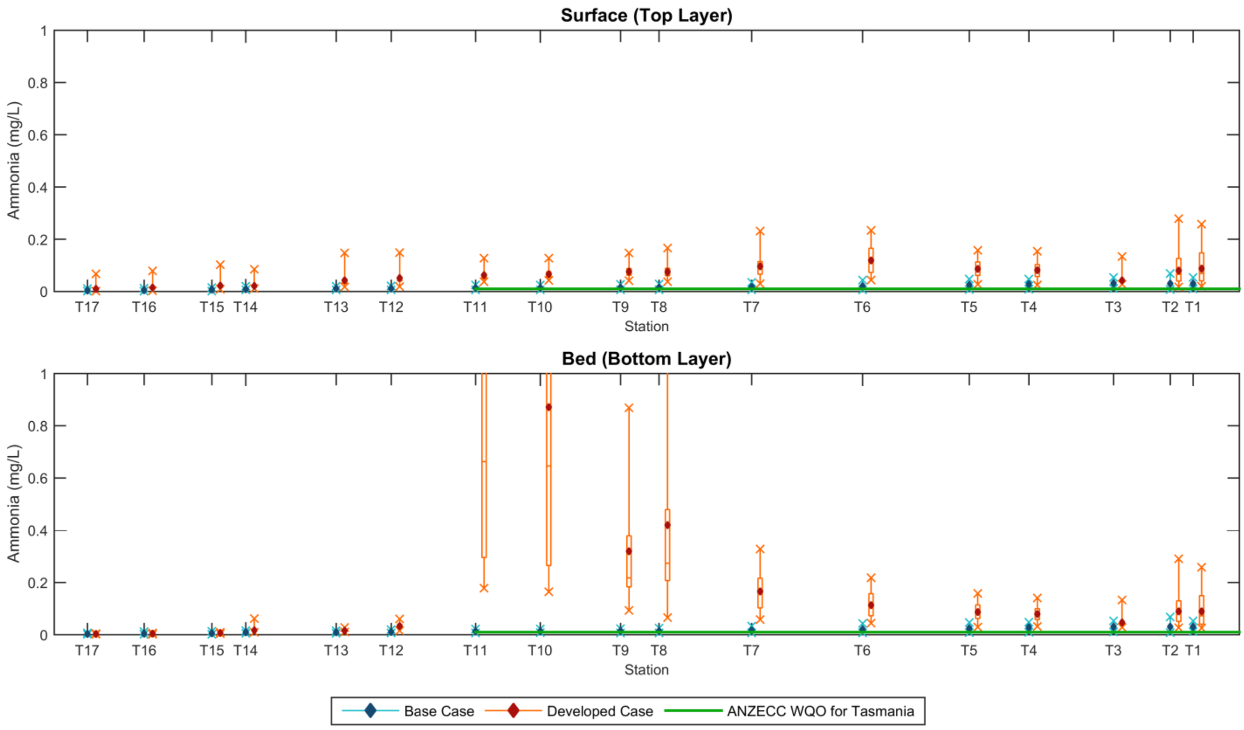


Figure 4-47 Scenario 2 – Ammonia – Summer (Dry)

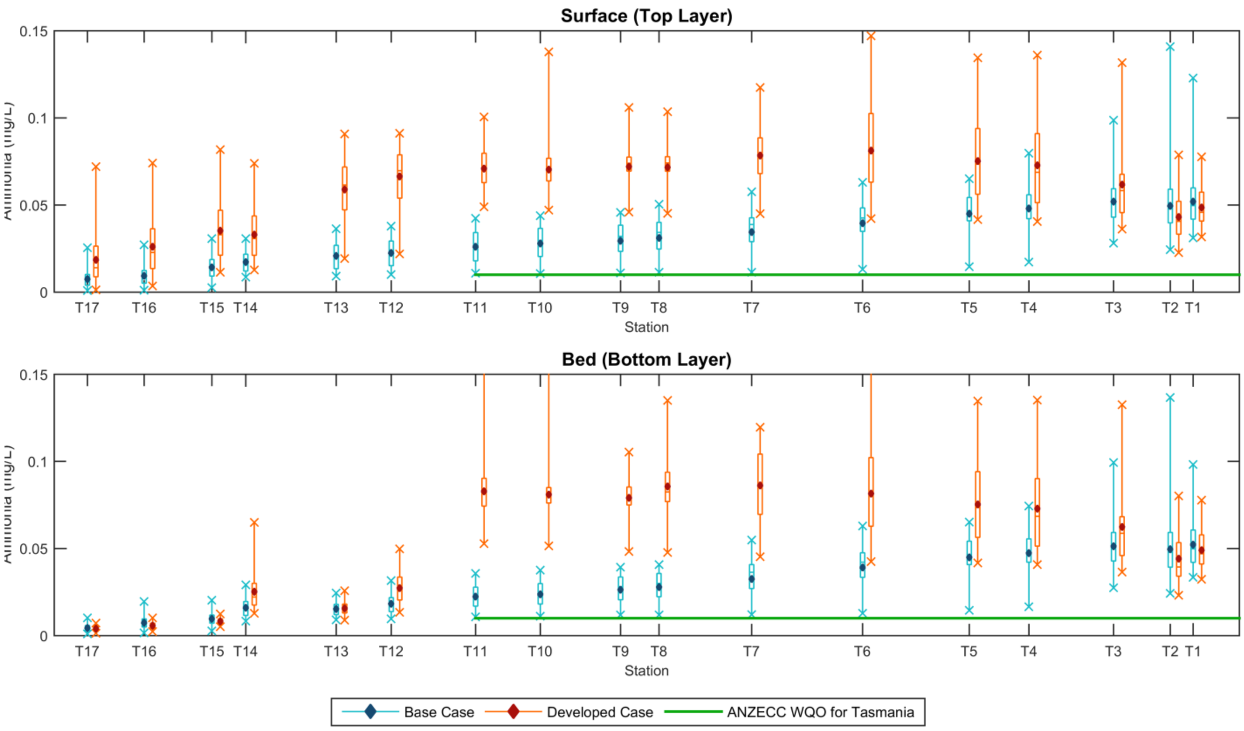


Figure 4-48 Scenario 2 – Ammonia – Winter (Wet)

4.7.5 Nitrate

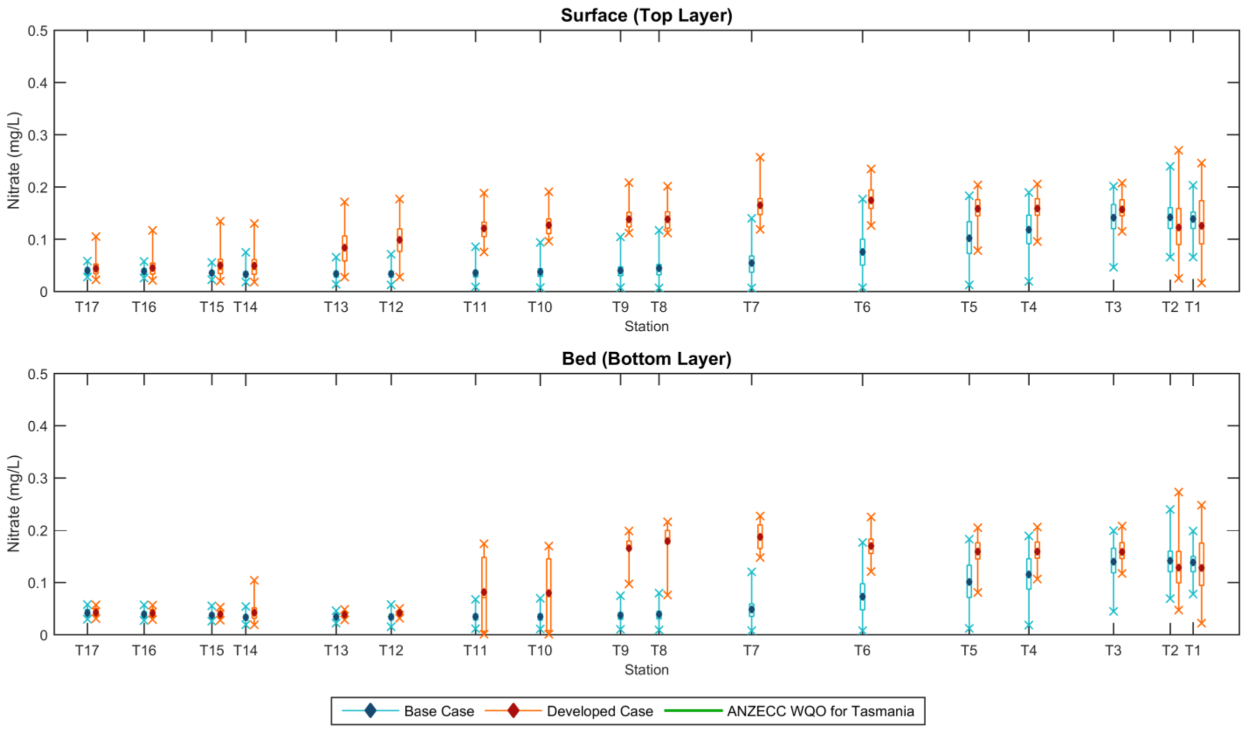


Figure 4-49 Scenario 2 – Nitrate – Summer (Dry)

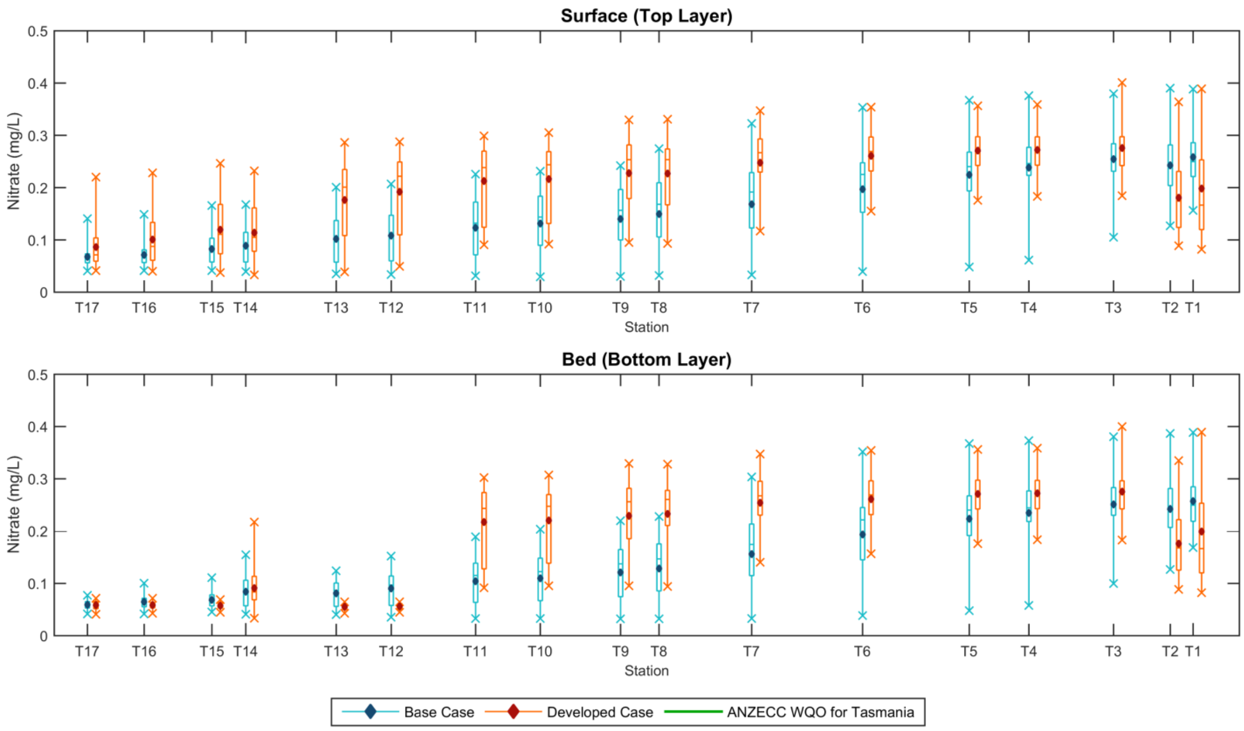


Figure 4-50 Scenario 2 – Nitrate – Winter (Wet)

4.7.6 Total Nitrogen

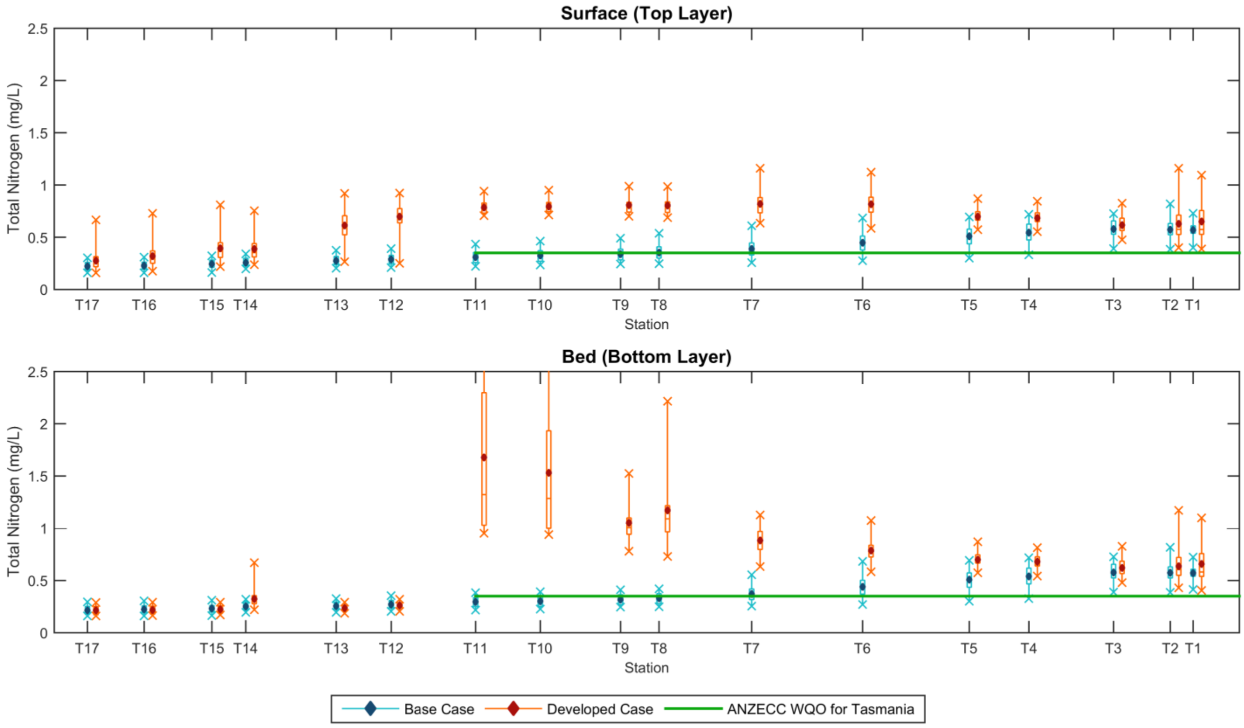


Figure 4-51 Scenario 2 – Total Nitrogen – Summer (Dry)

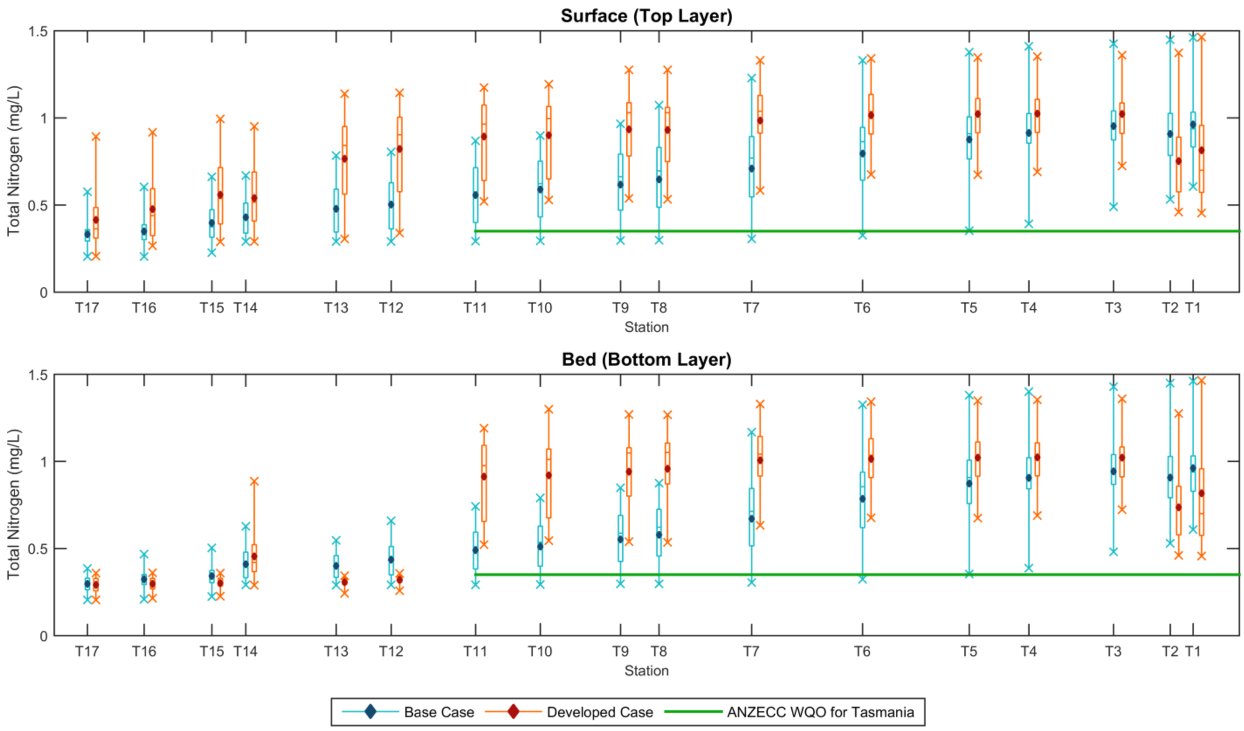


Figure 4-52 Scenario 2 – Total Nitrogen – Winter (Wet)

4.7.7 FRP

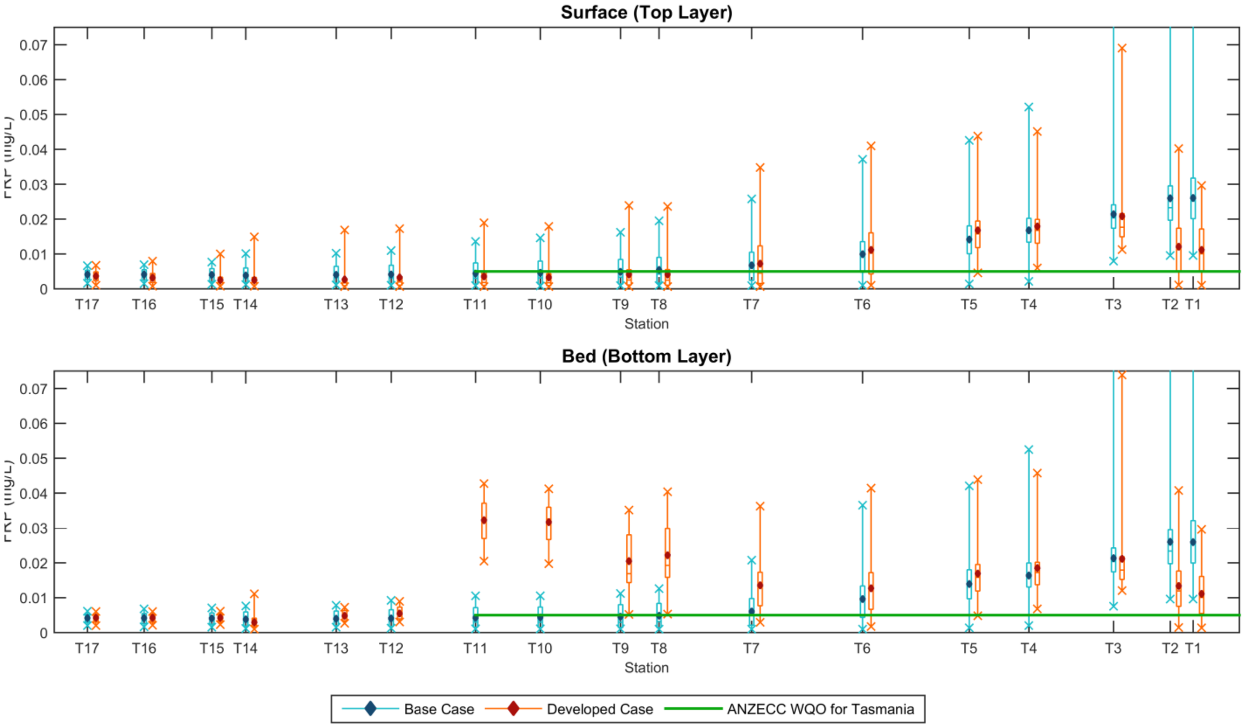


Figure 4-53 Scenario 2 – FRP – Summer (Dry)

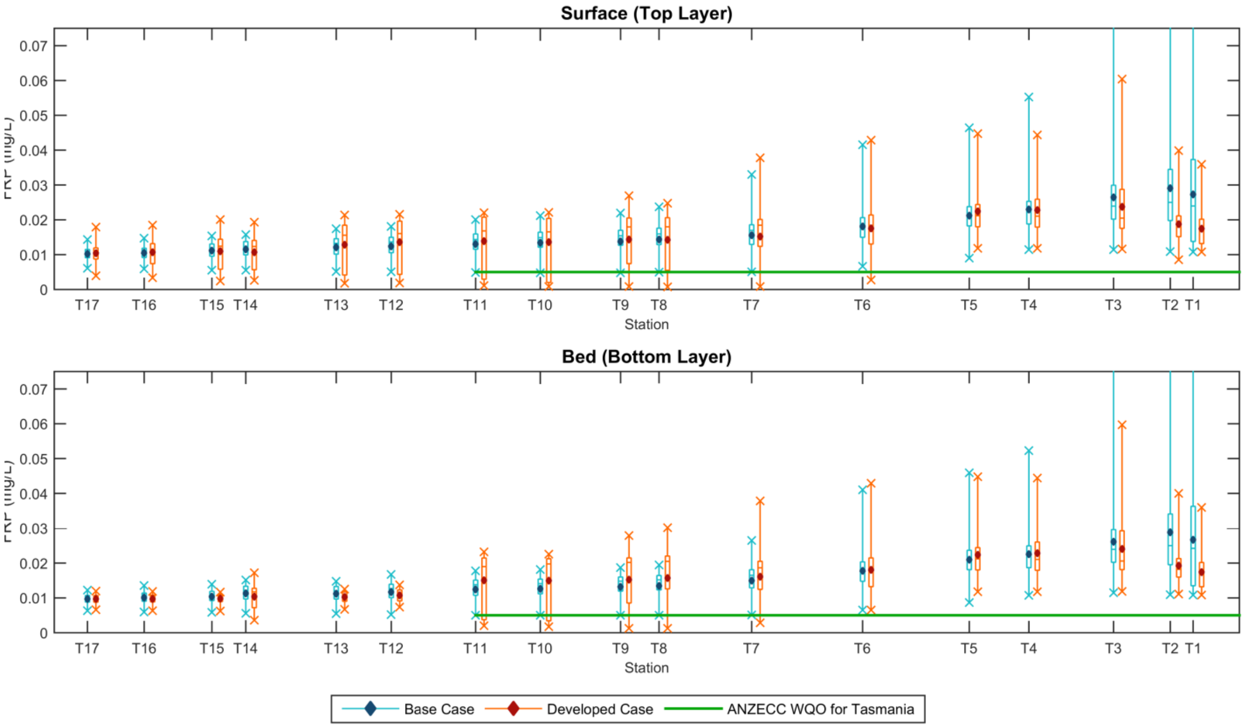


Figure 4-54 Scenario 2 – FRP – Winter (Wet)

4.7.8 Total Phosphorus

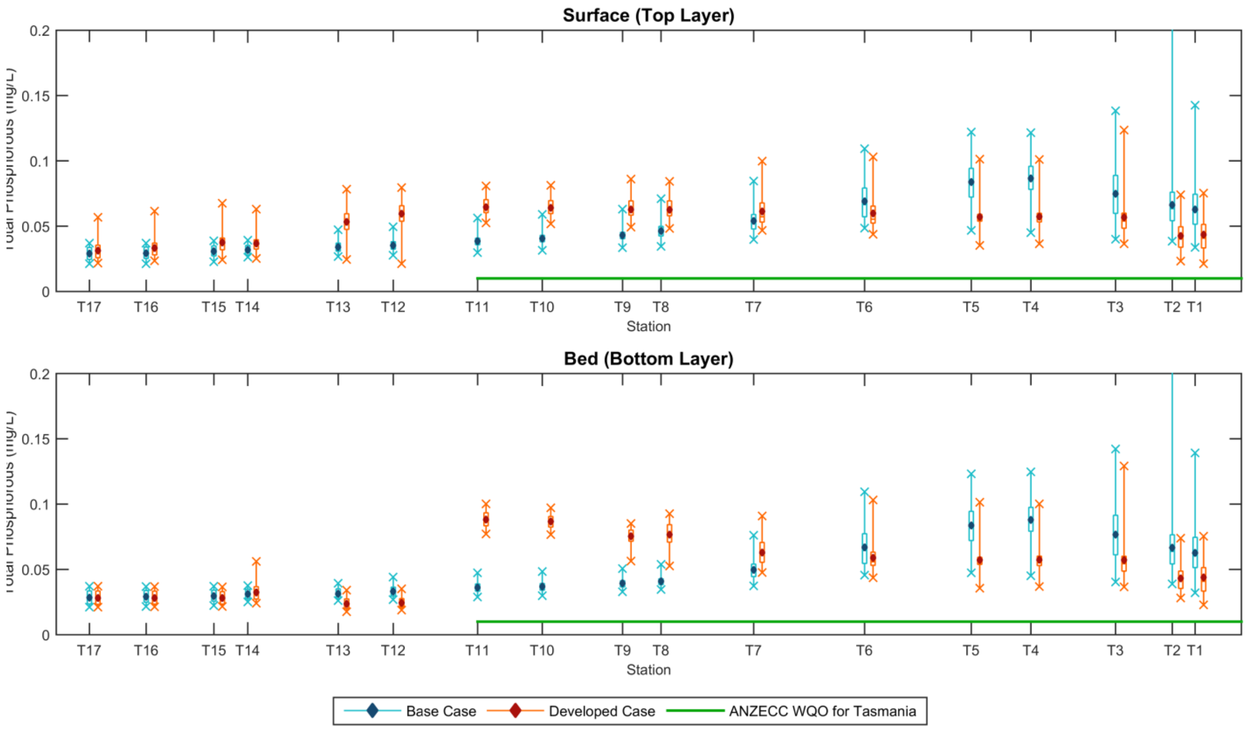


Figure 4-55 Scenario 2 – Total Phosphorus – Summer (Dry)

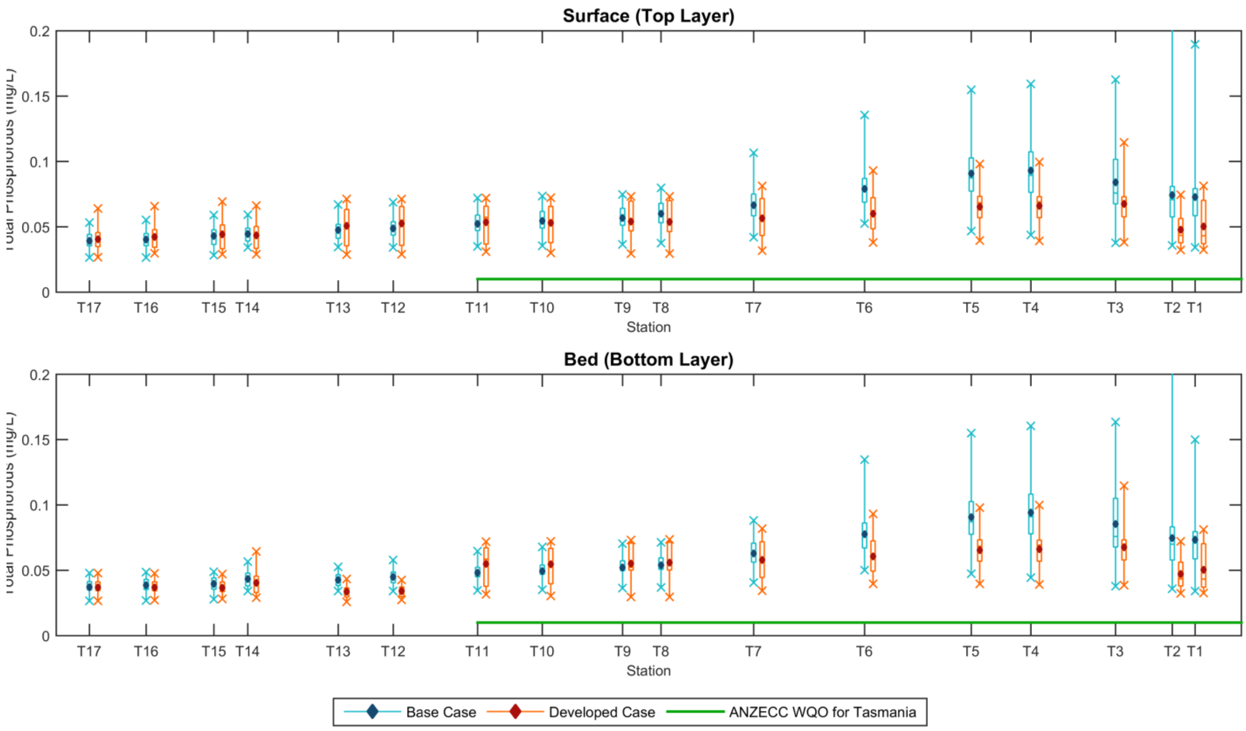


Figure 4-56 Scenario 2 – Total Phosphorus – Winter (Wet)

4.7.9 Chlorophyll-a

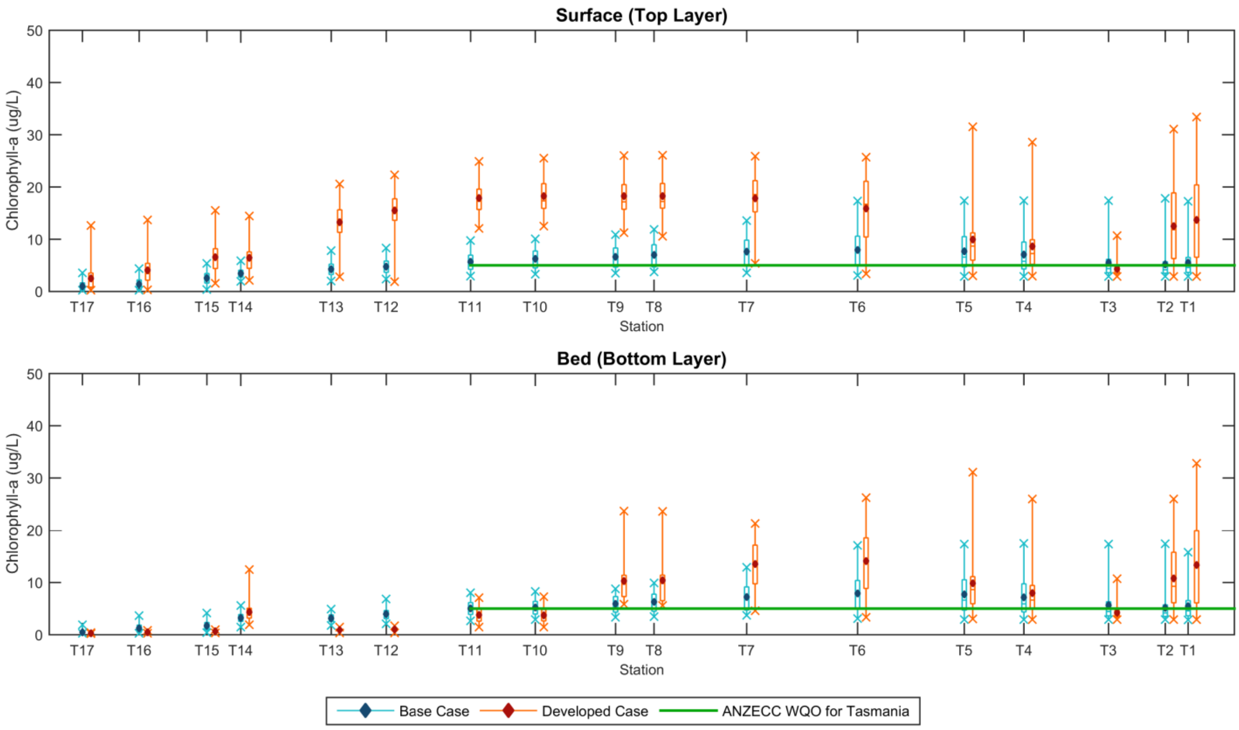


Figure 4-57 Scenario 2 – Chlorophyll-a – Summer (Dry)

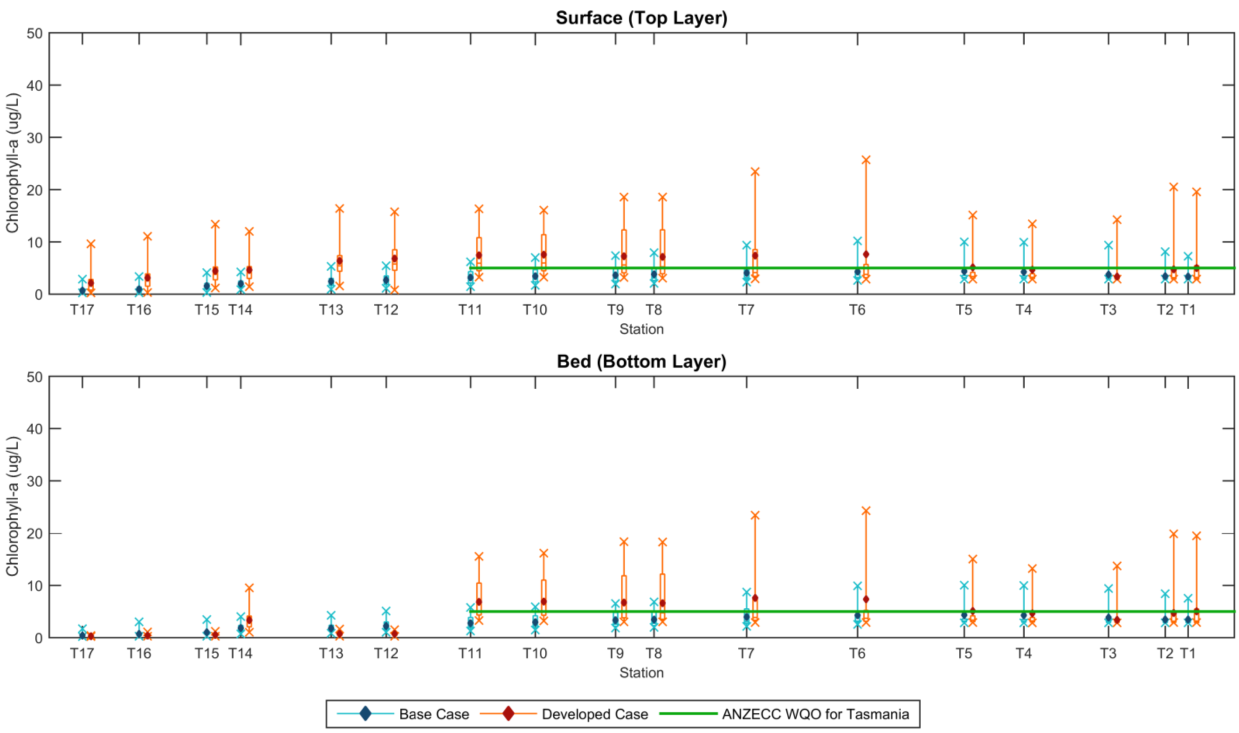


Figure 4-58 Scenario 2 – Chlorophyll-a – Winter (Wet)

4.7.10 Enterococci

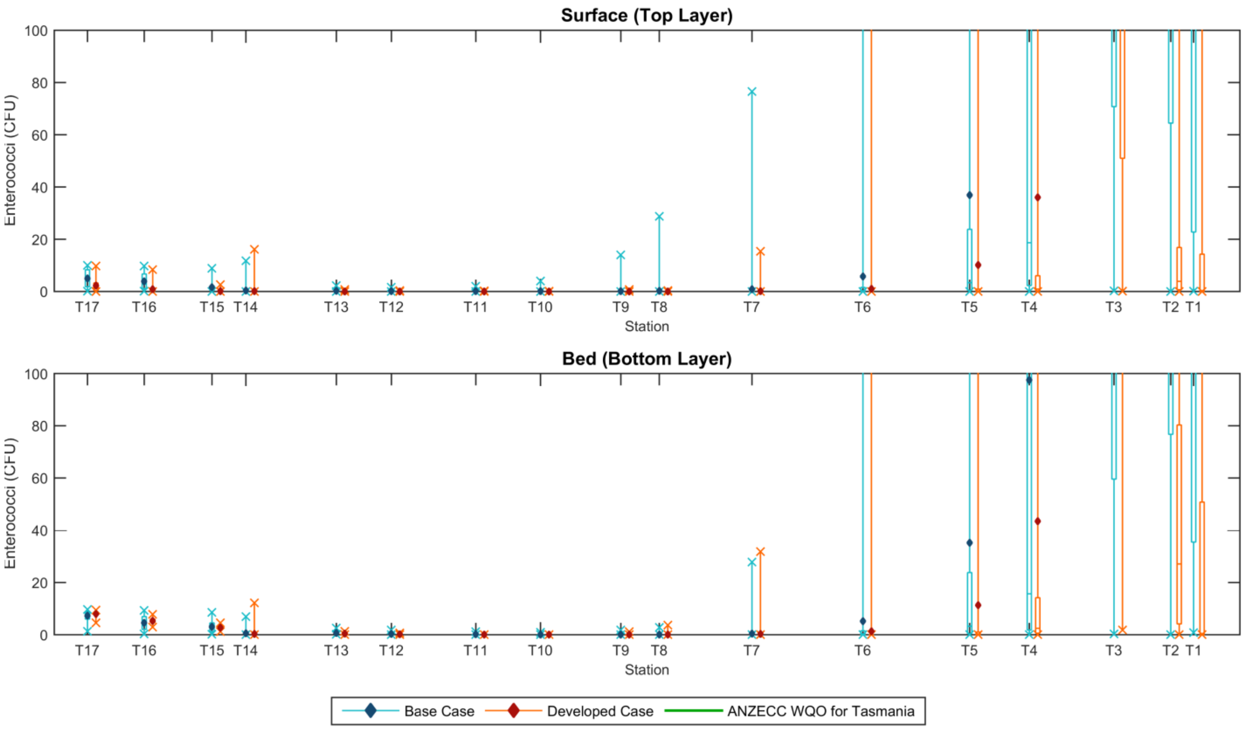


Figure 4-59 Scenario 2 – Enterococci – Summer (Dry)

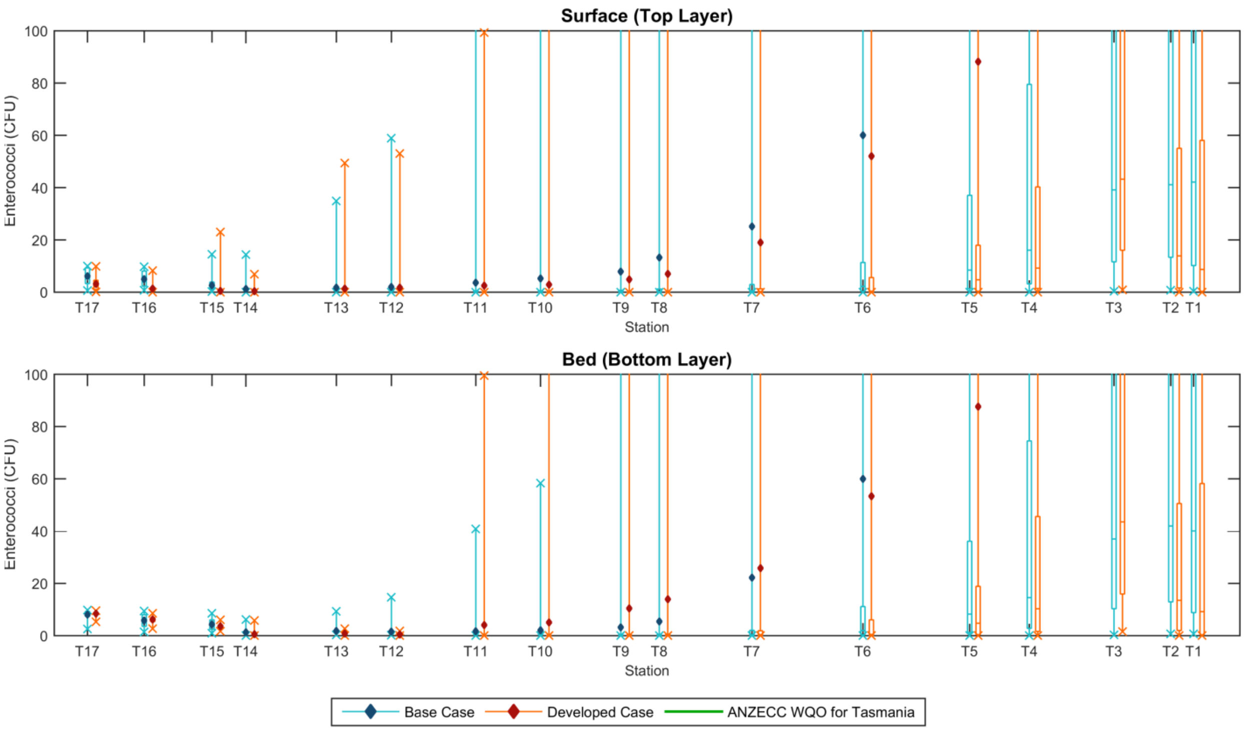


Figure 4-60 Scenario 2 – Enterococci – Winter (Wet)

4.8 Water Quality Scenario 3

Adaption of the barrage setup as described in Section 1 with flows applied to the bottom two meters.

4.8.1 Temperature

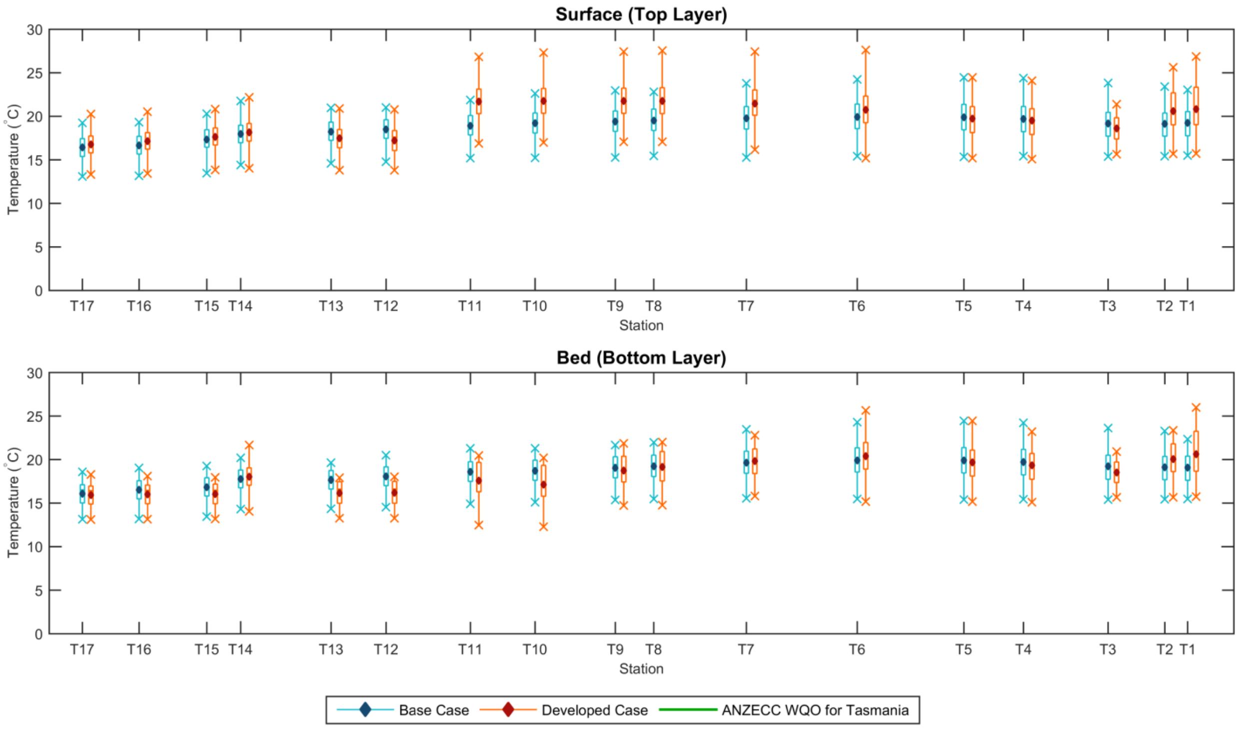


Figure 4-61 Scenario 3 – Temperature – Summer (Dry)

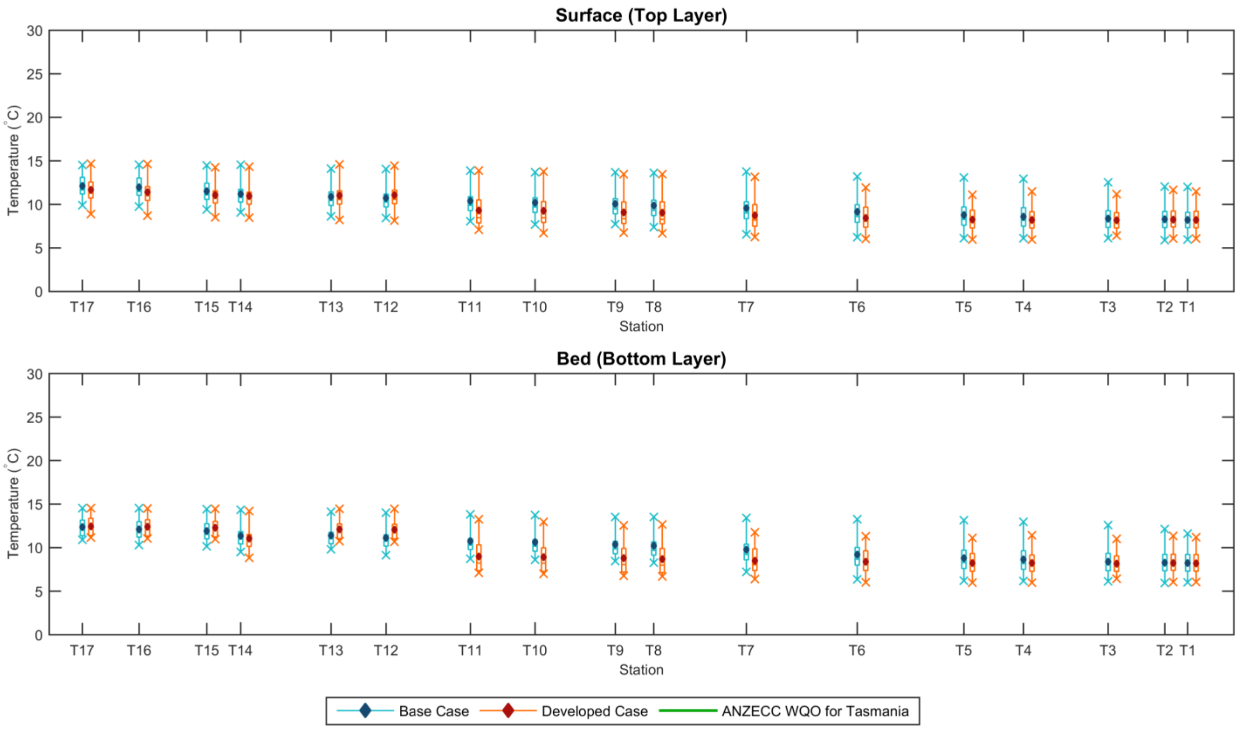


Figure 4-62 Scenario 3 – Temperature – Winter (Wet)

4.8.2 Dissolved Oxygen (mg/L)

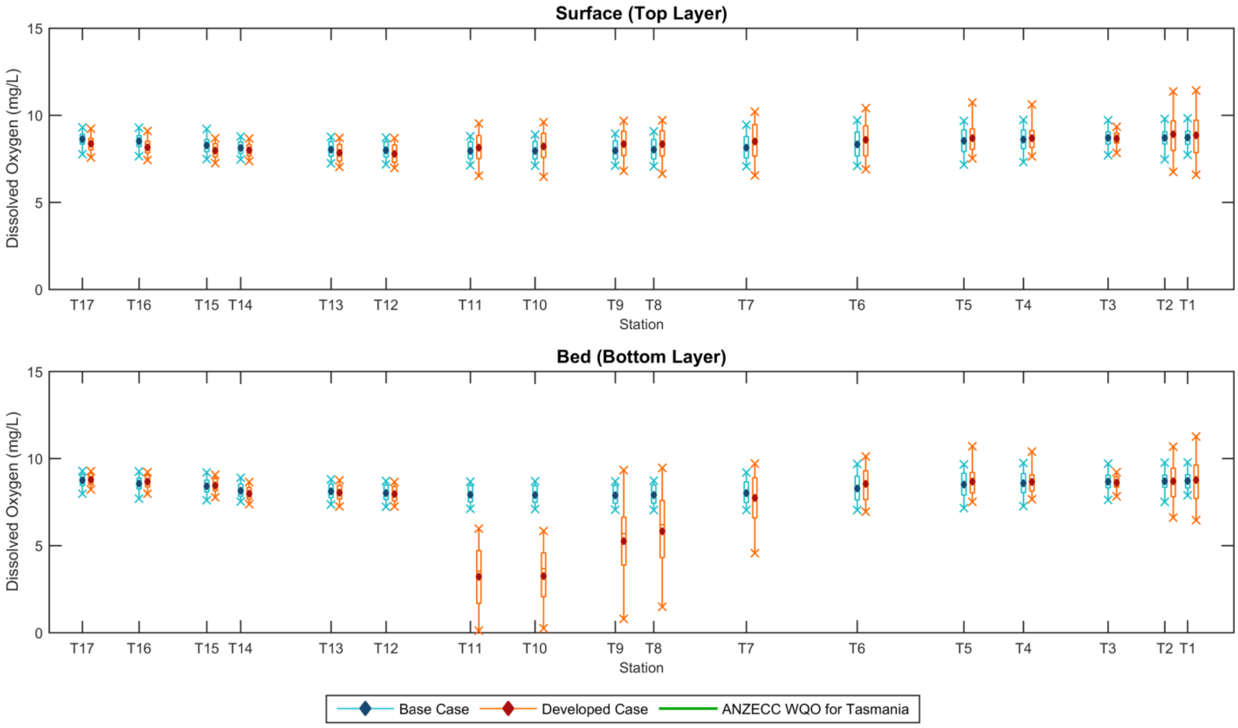


Figure 4-63 Scenario 3 – Dissolved Oxygen (mg/L) – Summer (Dry)

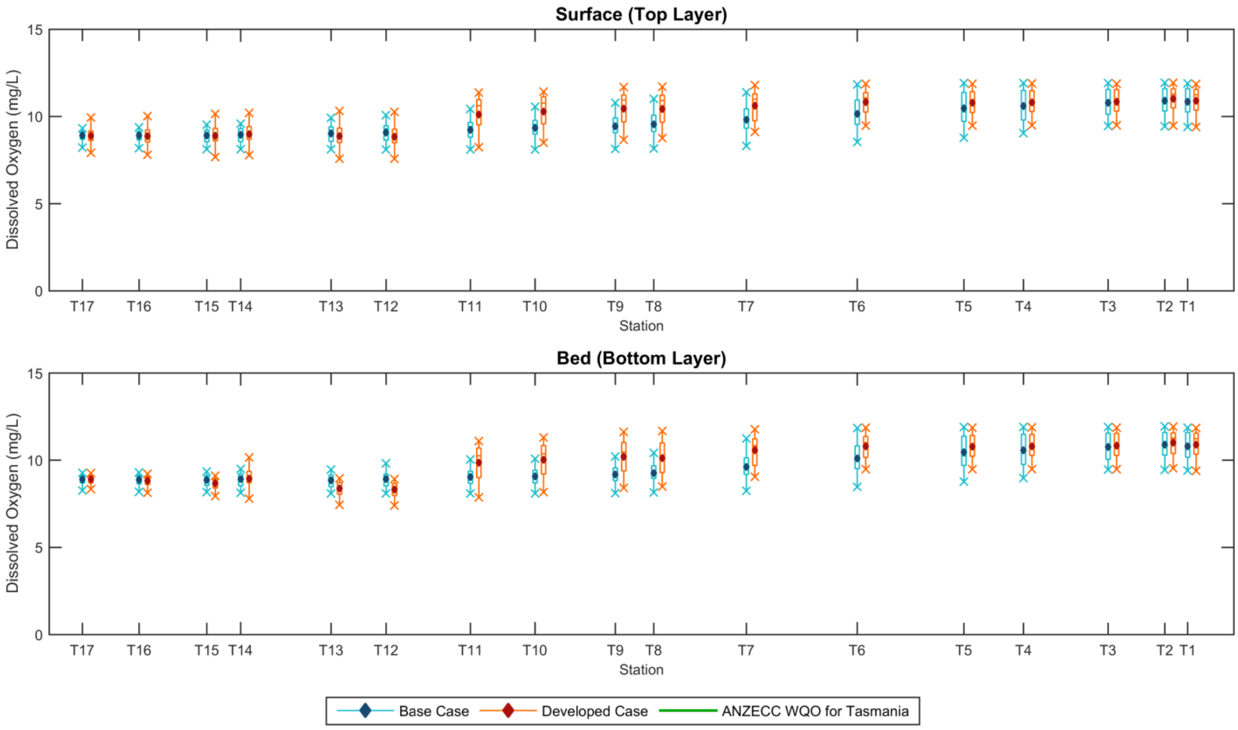


Figure 4-64 Scenario 3 – Dissolved Oxygen (mg/L) – Winter (Wet)

4.8.3 Dissolved Oxygen (% Saturation)

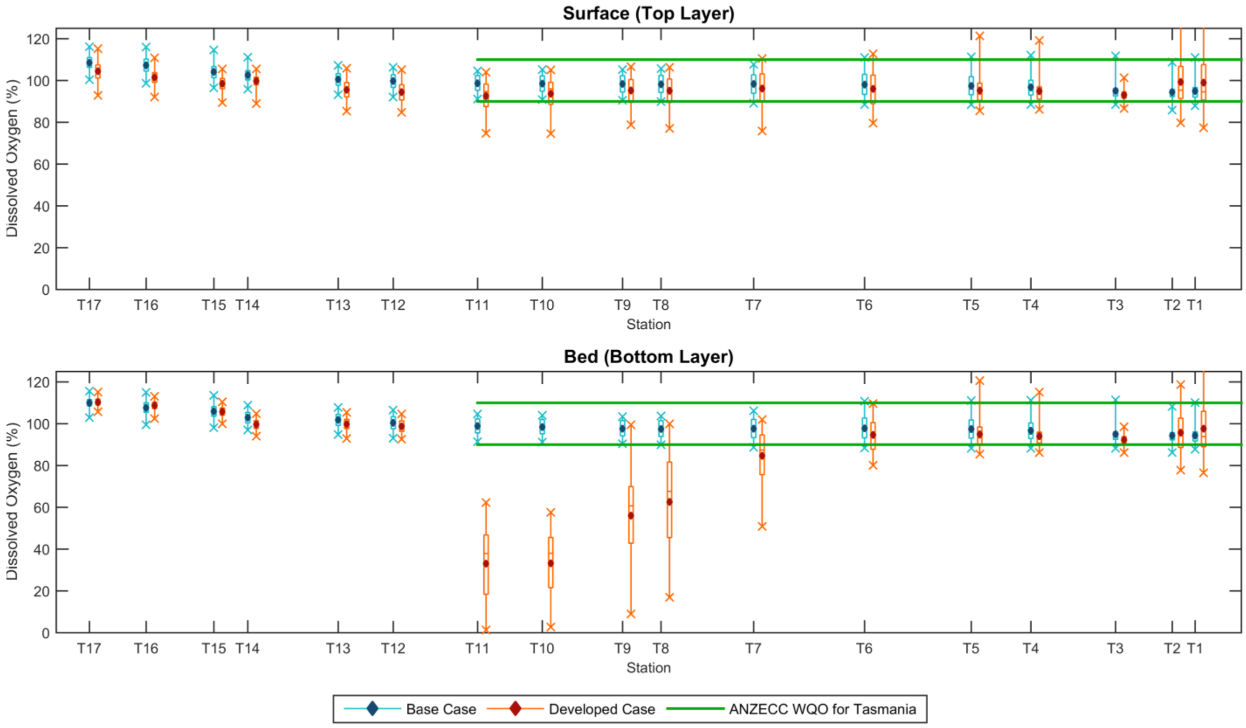


Figure 4-65 Scenario 3 – Dissolved Oxygen (% Saturated) – Summer (Dry)

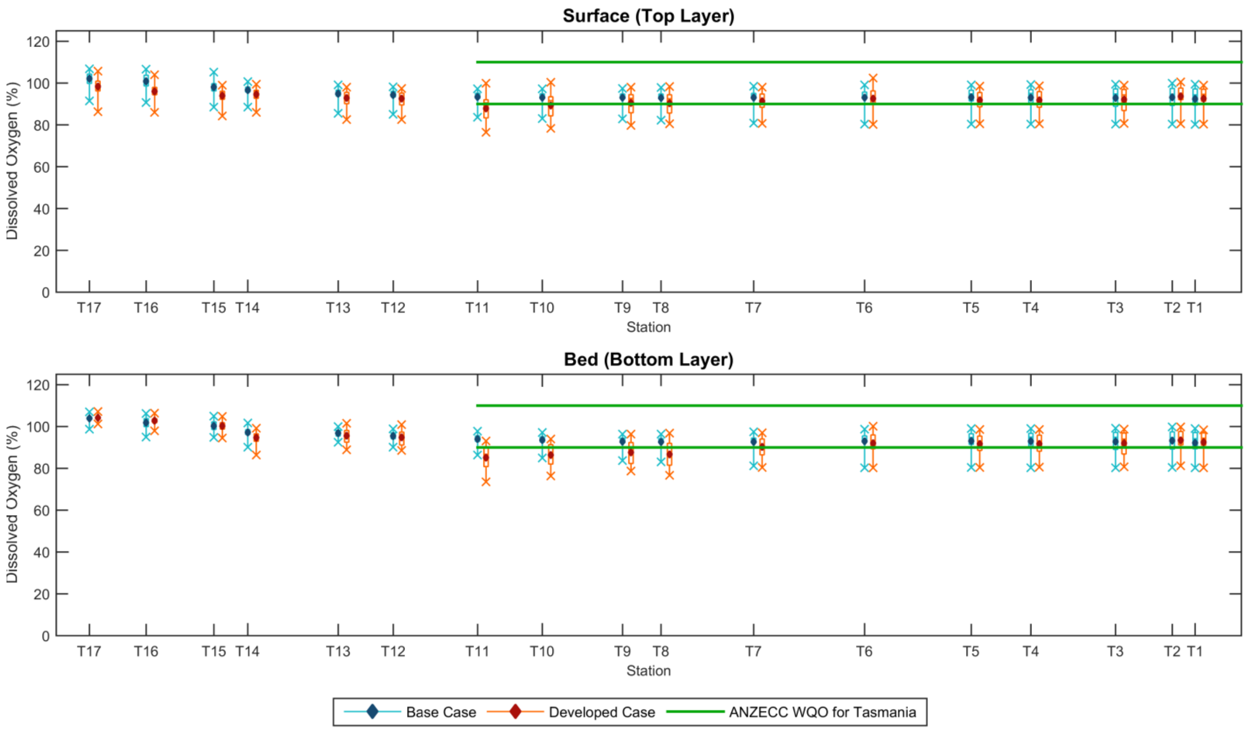


Figure 4-66 Scenario 3 – Dissolved Oxygen (% Saturated) – Winter (Wet)

4.8.4 Ammonia

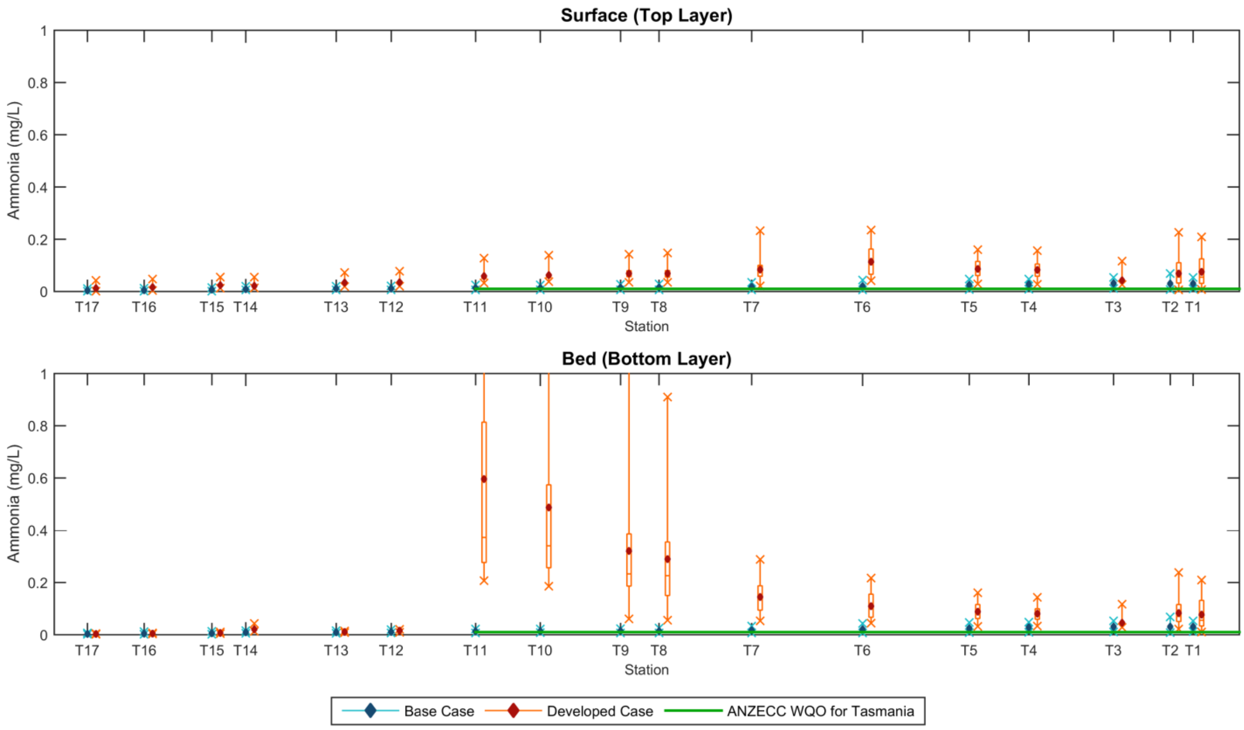


Figure 4-67 Scenario 3 – Ammonia – Summer (Dry)

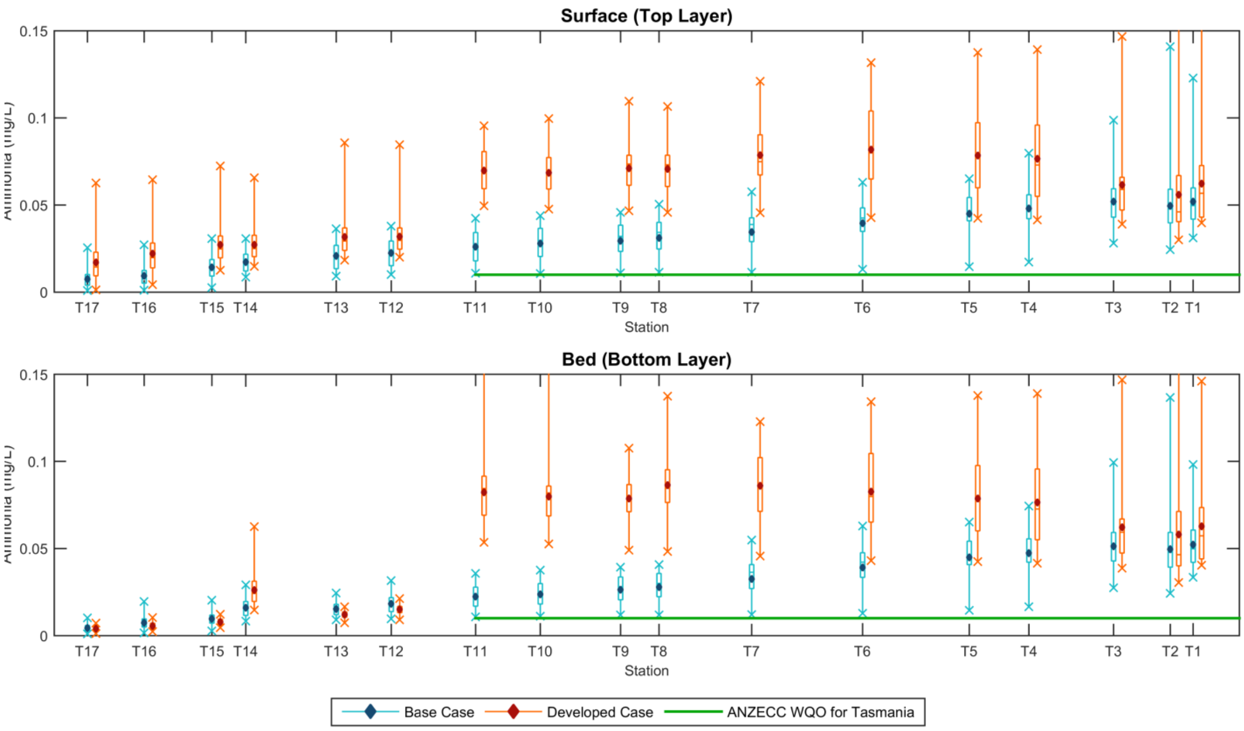


Figure 4-68 Scenario 3 – Ammonia – Winter (Wet)

4.8.5 Nitrate

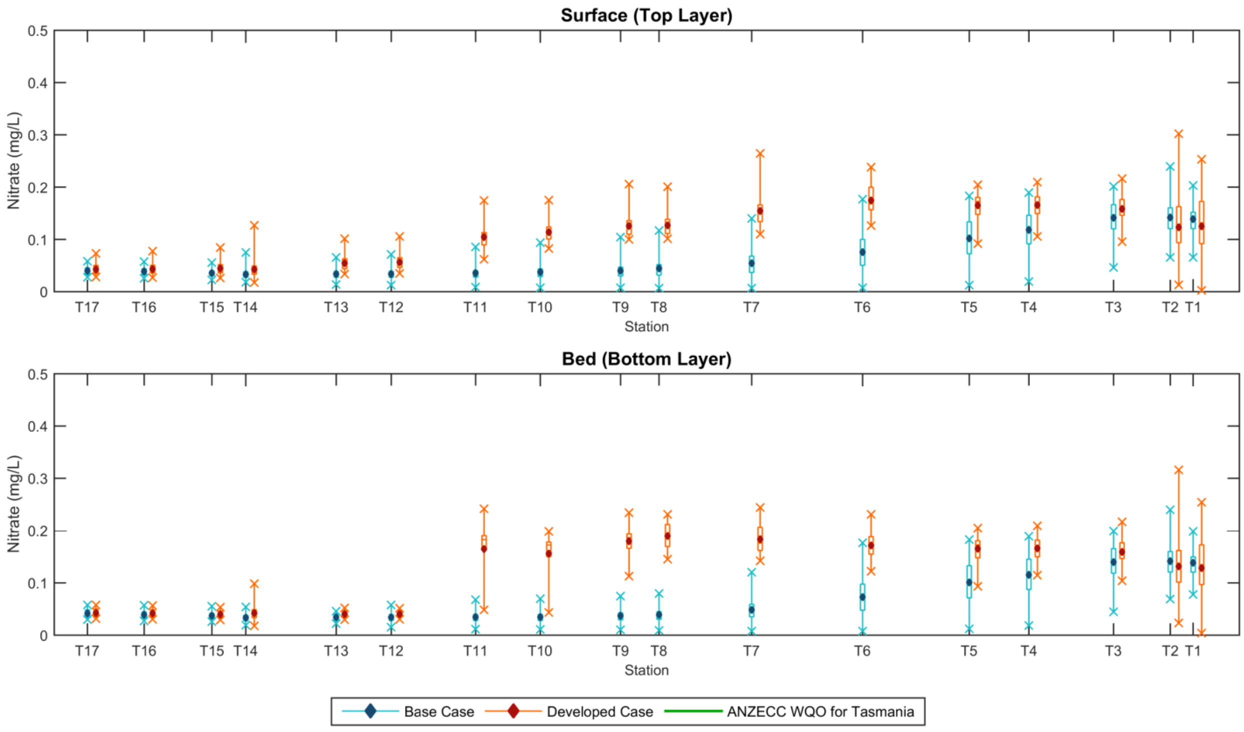


Figure 4-69 Scenario 3 – Nitrate – Summer (Dry)

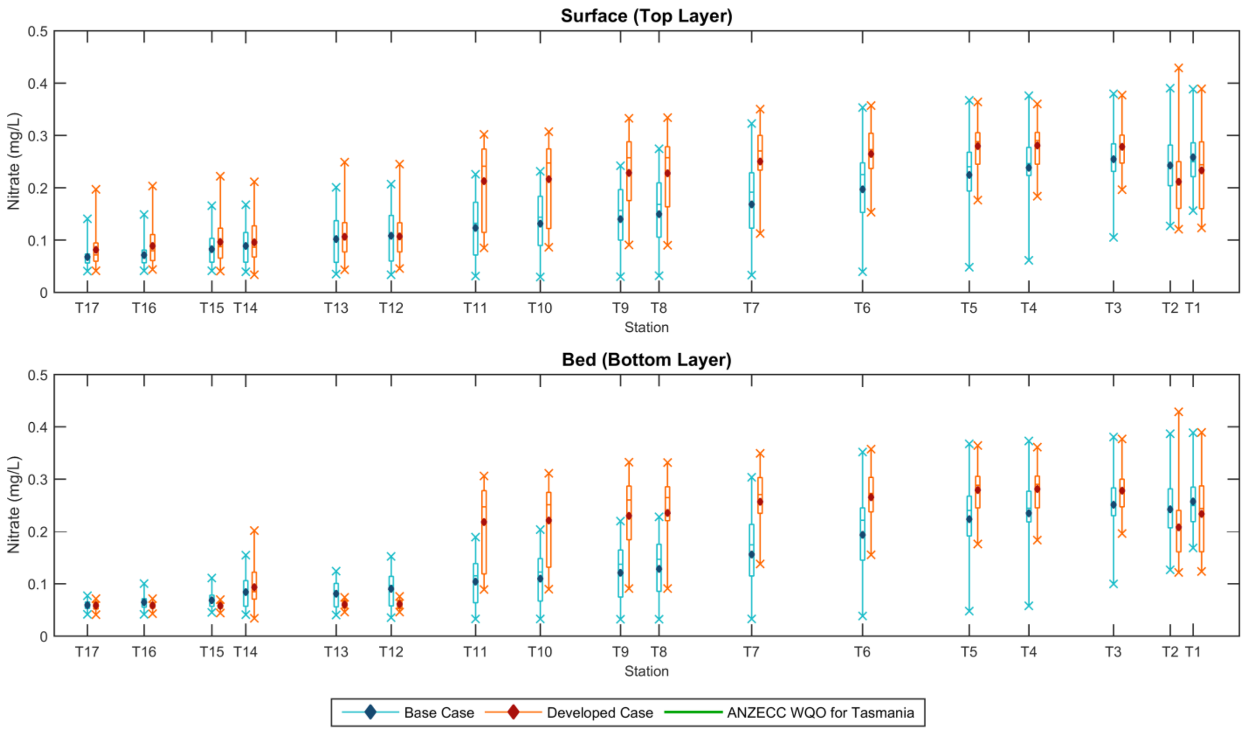


Figure 4-70 Scenario 3 – Nitrate – Winter (Wet)

4.8.6 Total Nitrogen

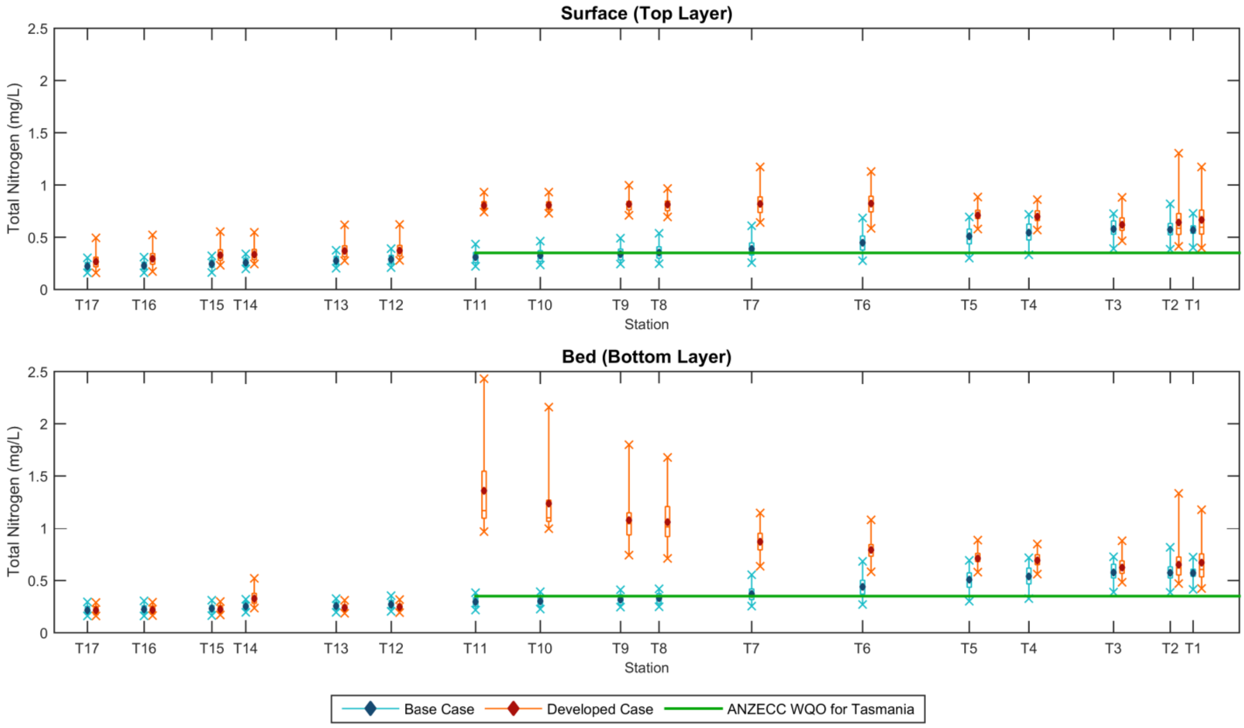


Figure 4-71 Scenario 3 – Total Nitrogen – Summer (Dry)

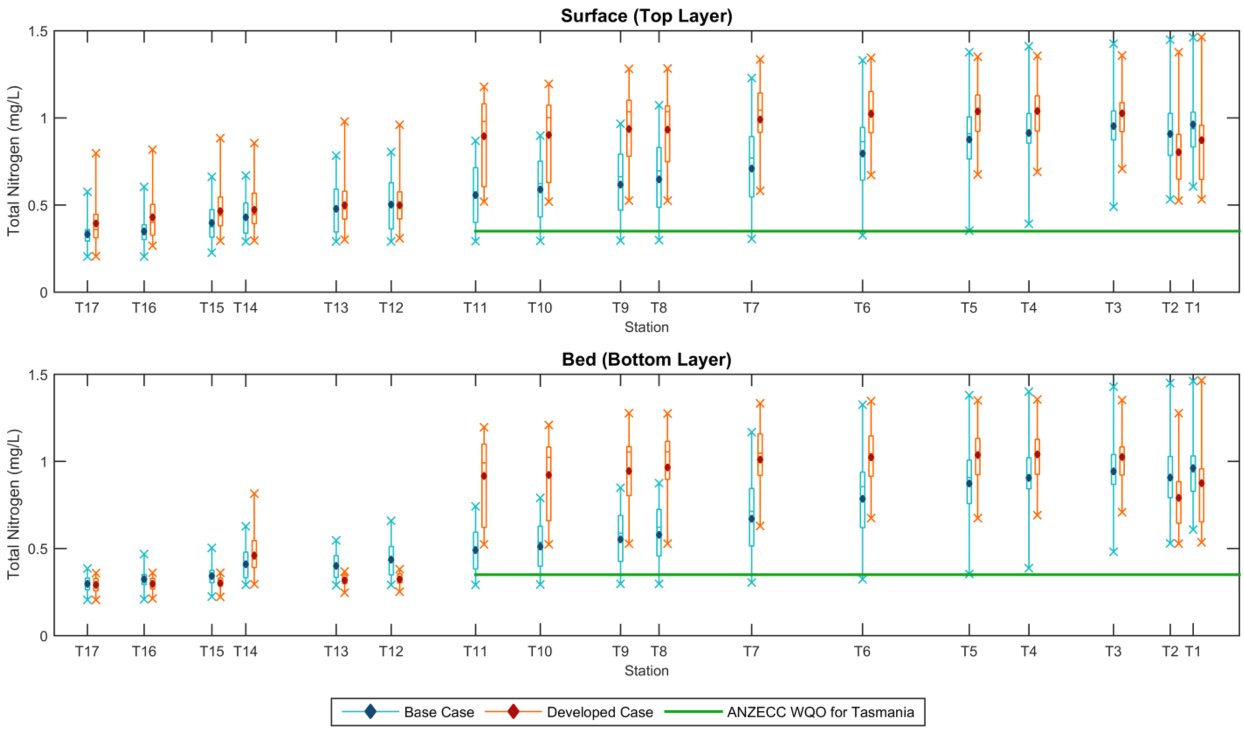


Figure 4-72 Scenario 3 – Total Nitrogen – Winter (Wet)

4.8.7 FRP

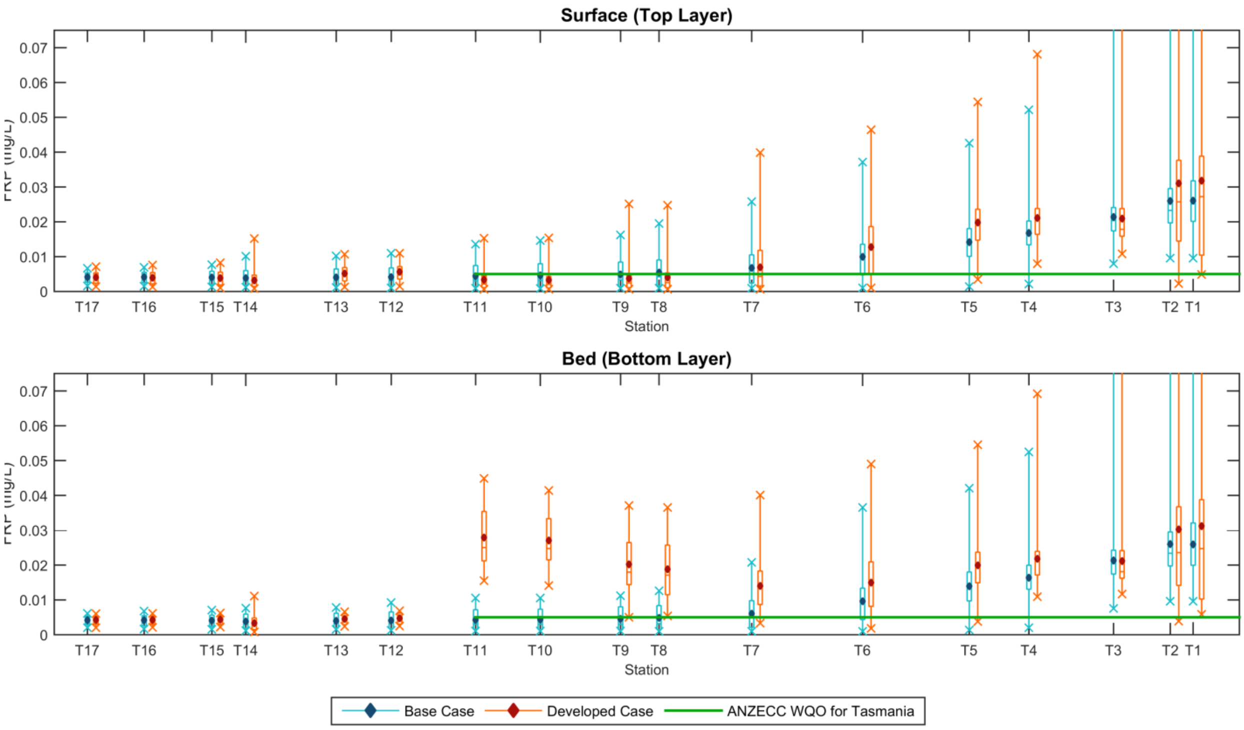


Figure 4-73 Scenario 3 – FRP – Summer (Dry)

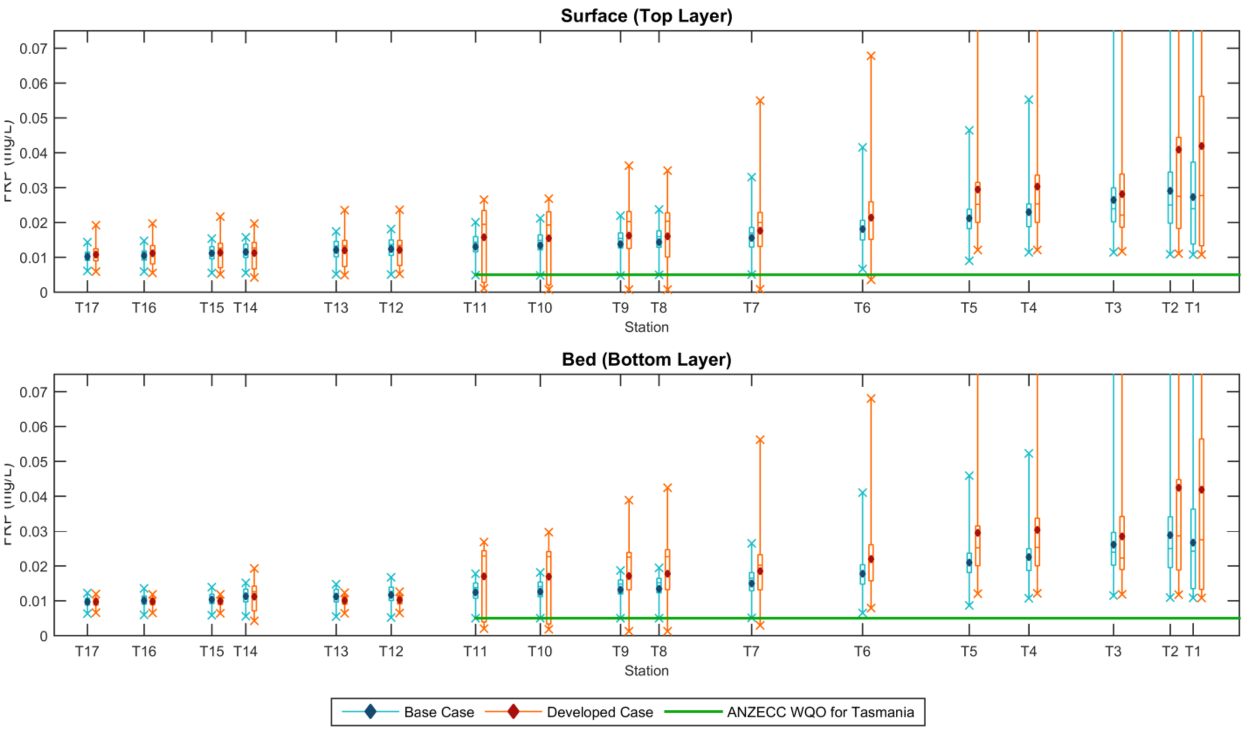


Figure 4-74 Scenario 3 – FRP – Winter (Wet)

4.8.8 Total Phosphorus

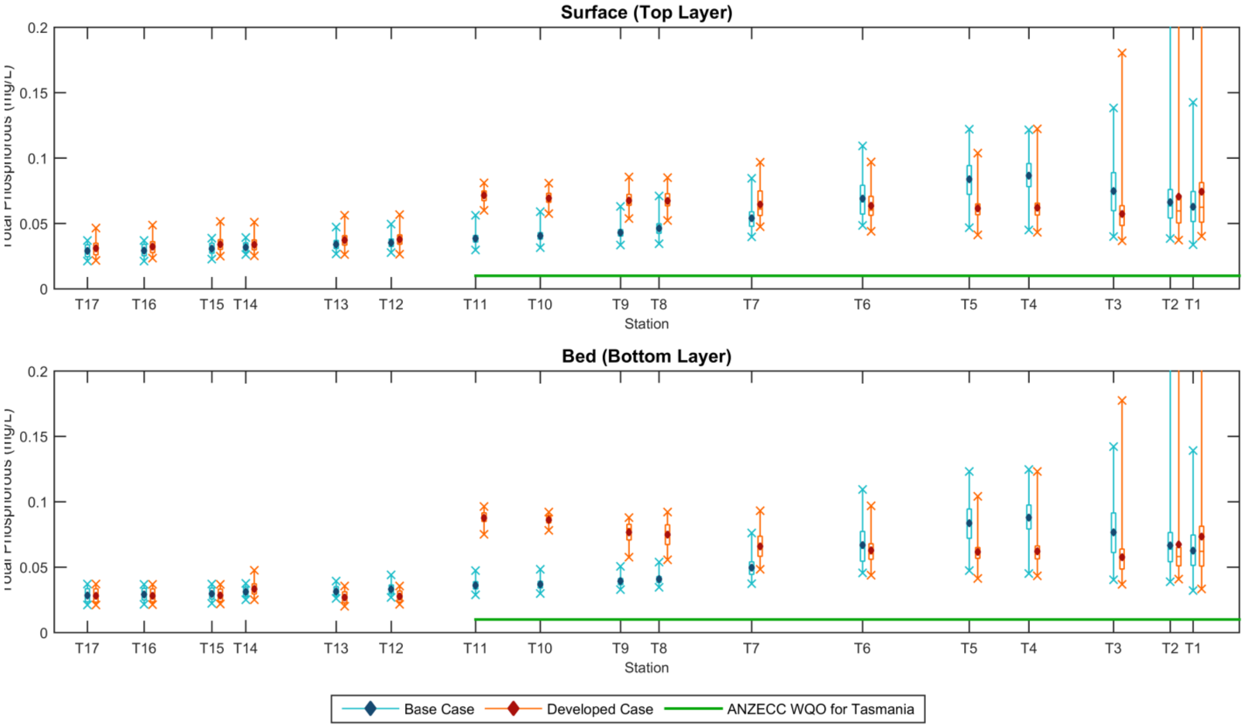


Figure 4-75 Scenario 3 – Total Phosphorus – Summer (Dry)

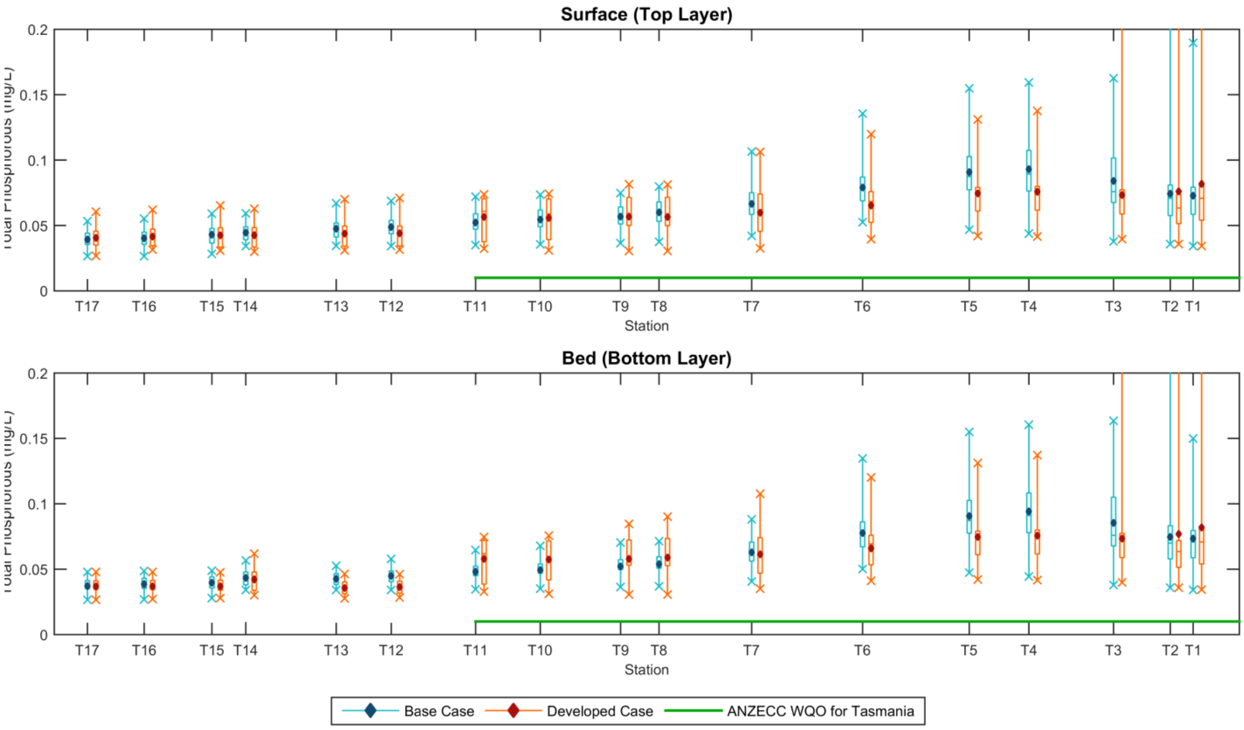


Figure 4-76 Scenario 3 – Total Phosphorus – Winter (Wet)

4.8.9 Chlorophyll-a

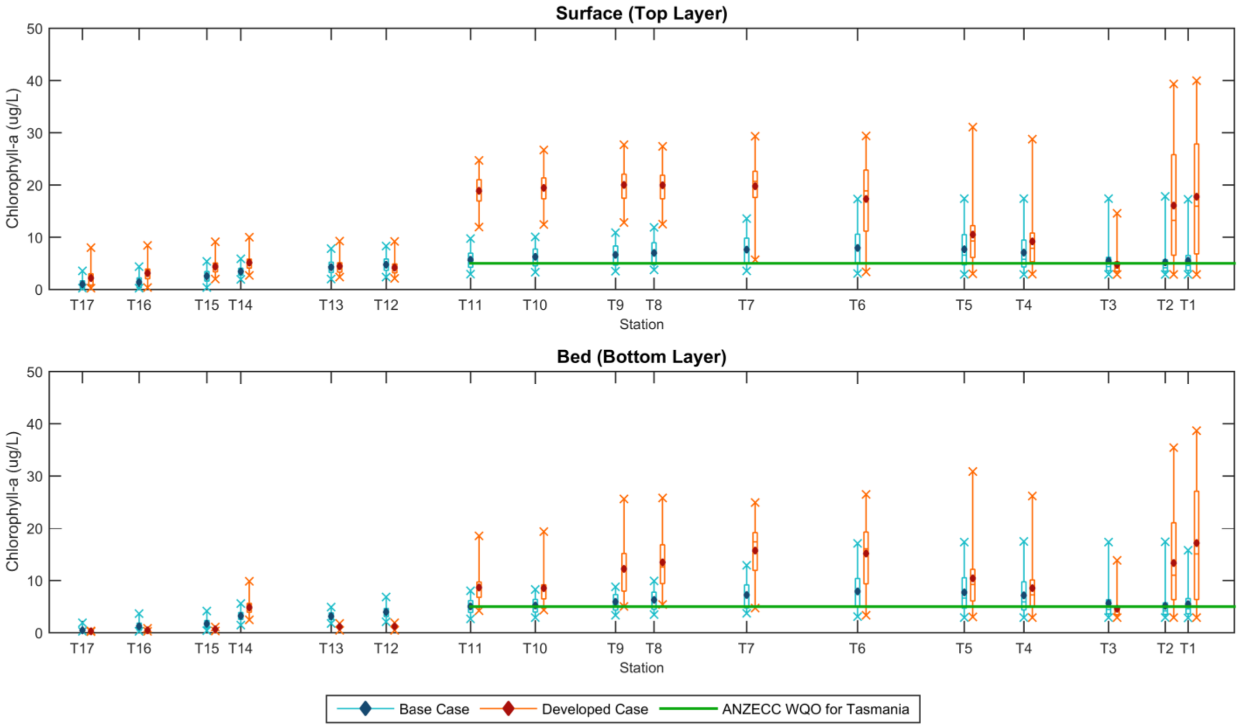


Figure 4-77 Scenario 3 – Chlorophyll-a – Summer (Dry)

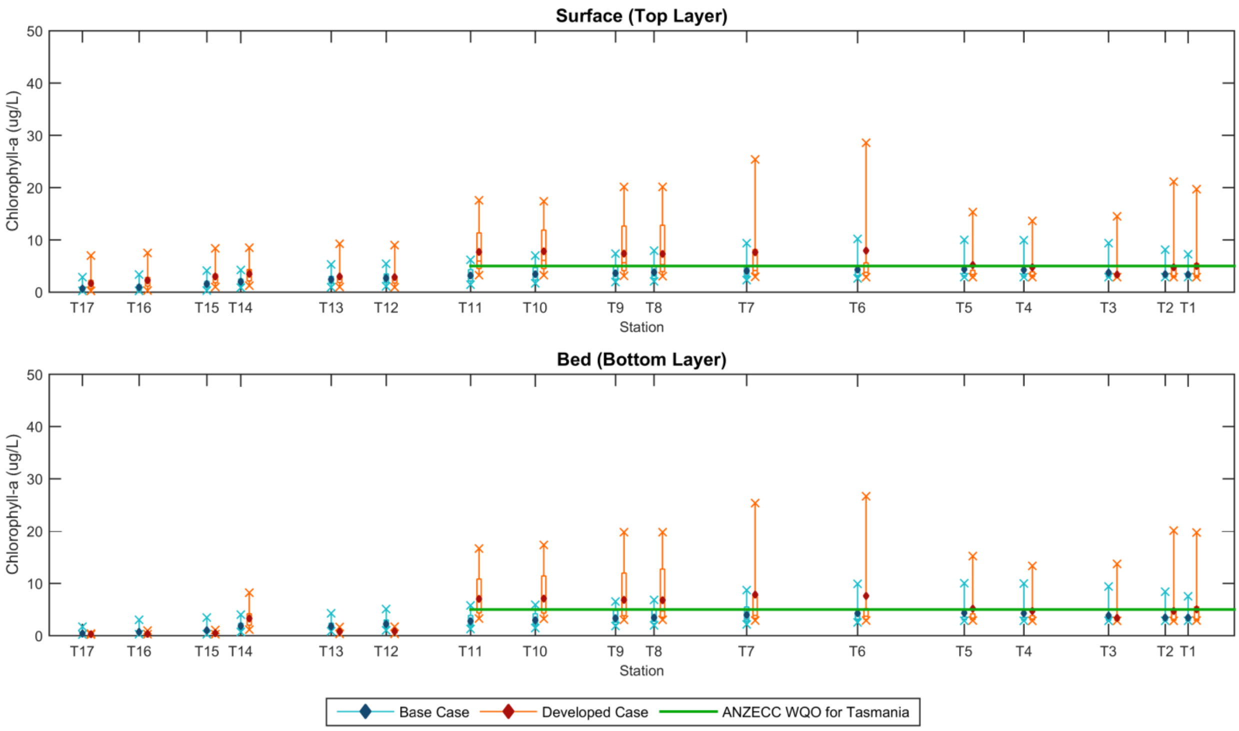


Figure 4-78 Scenario 3 – Chlorophyll-a – Winter (Wet)

4.8.10 Enterococci

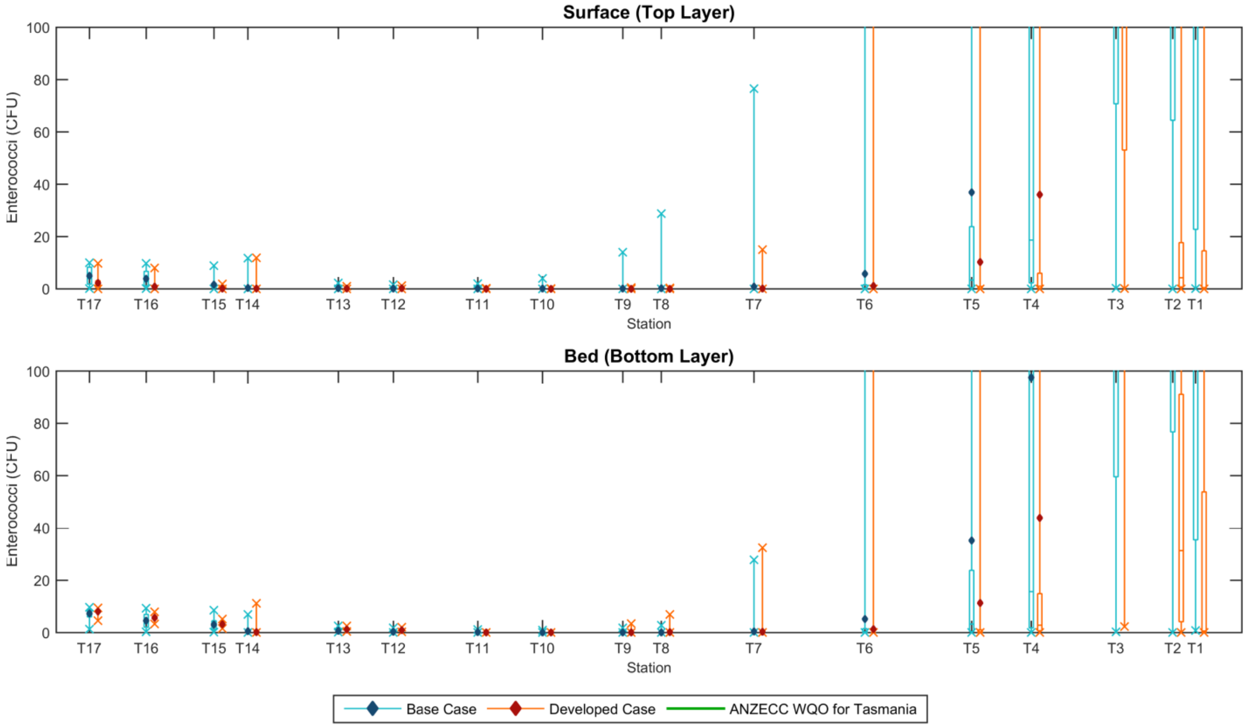


Figure 4-79 Scenario 3 – Enterococci – Summer (Dry)

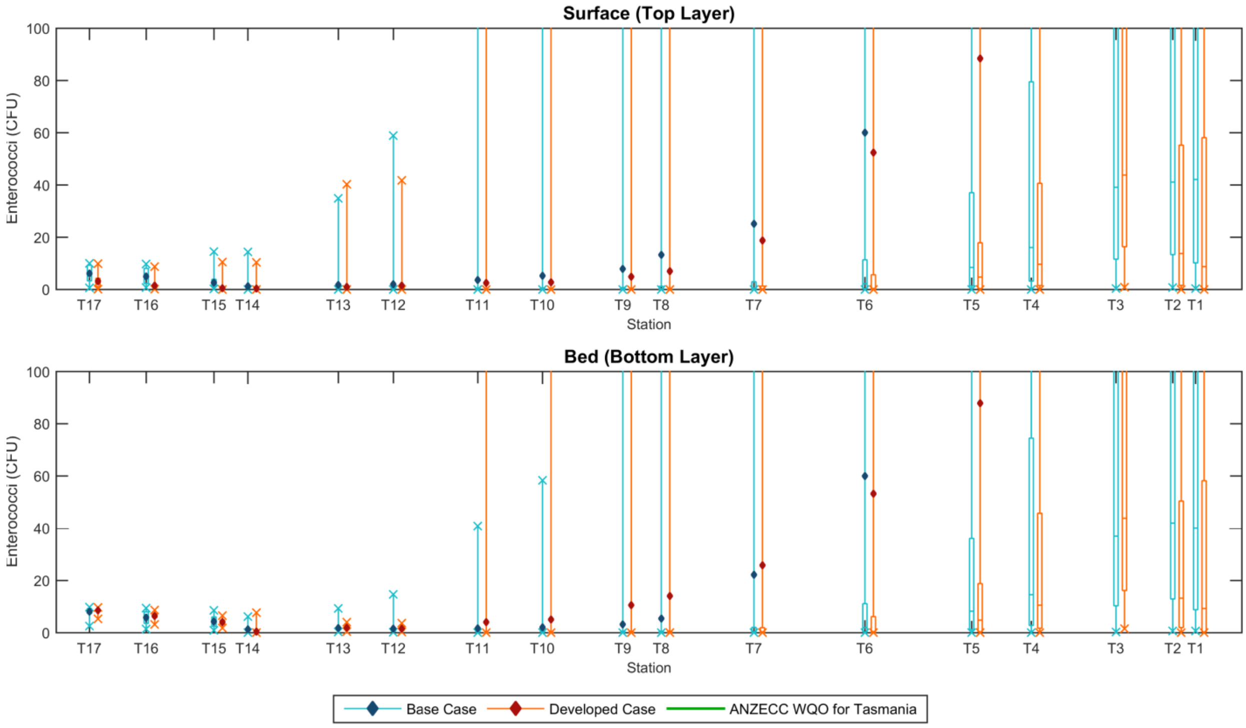


Figure 4-80 Scenario 3 – Enterococci – Winter (Wet)

4.9 Water Quality Scenario 4

Adaption of the barrage setup as described in Section 1 with flows applied to the bottom two meters with LSIP load reductions applied.

4.9.1 Temperature

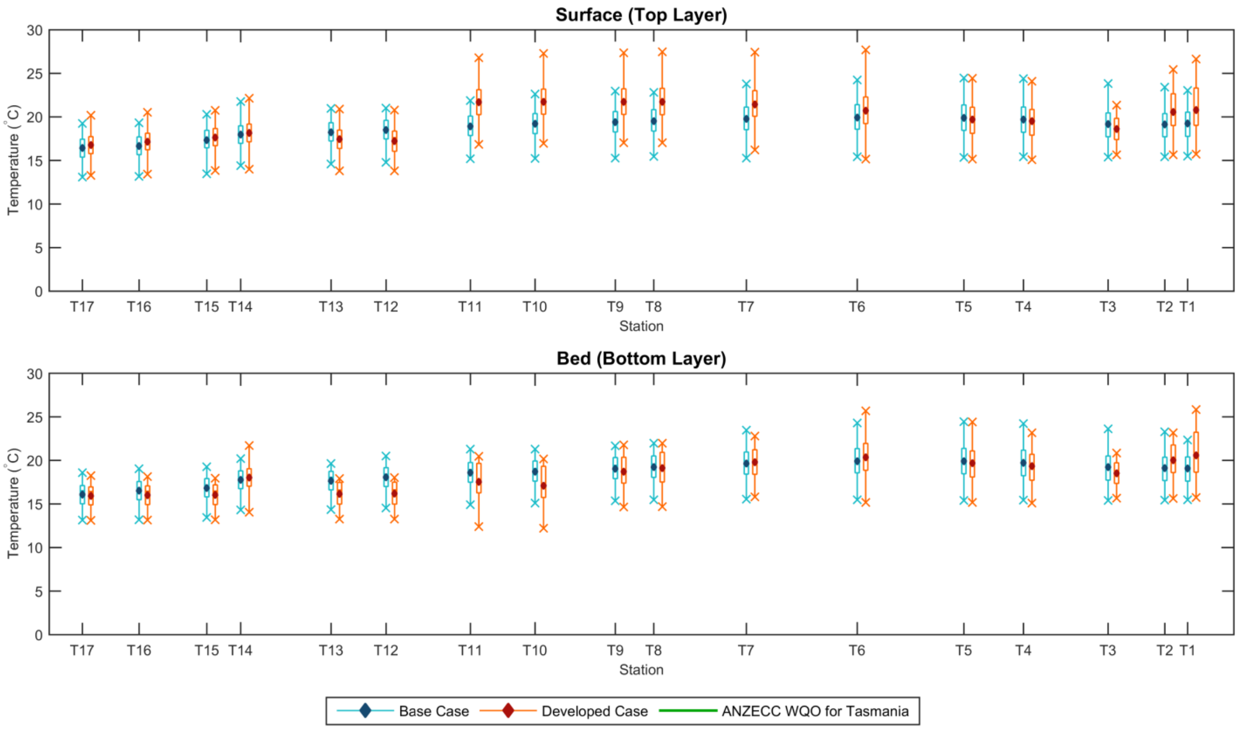


Figure 4-81 Scenario 4 – Temperature – Summer (Dry)

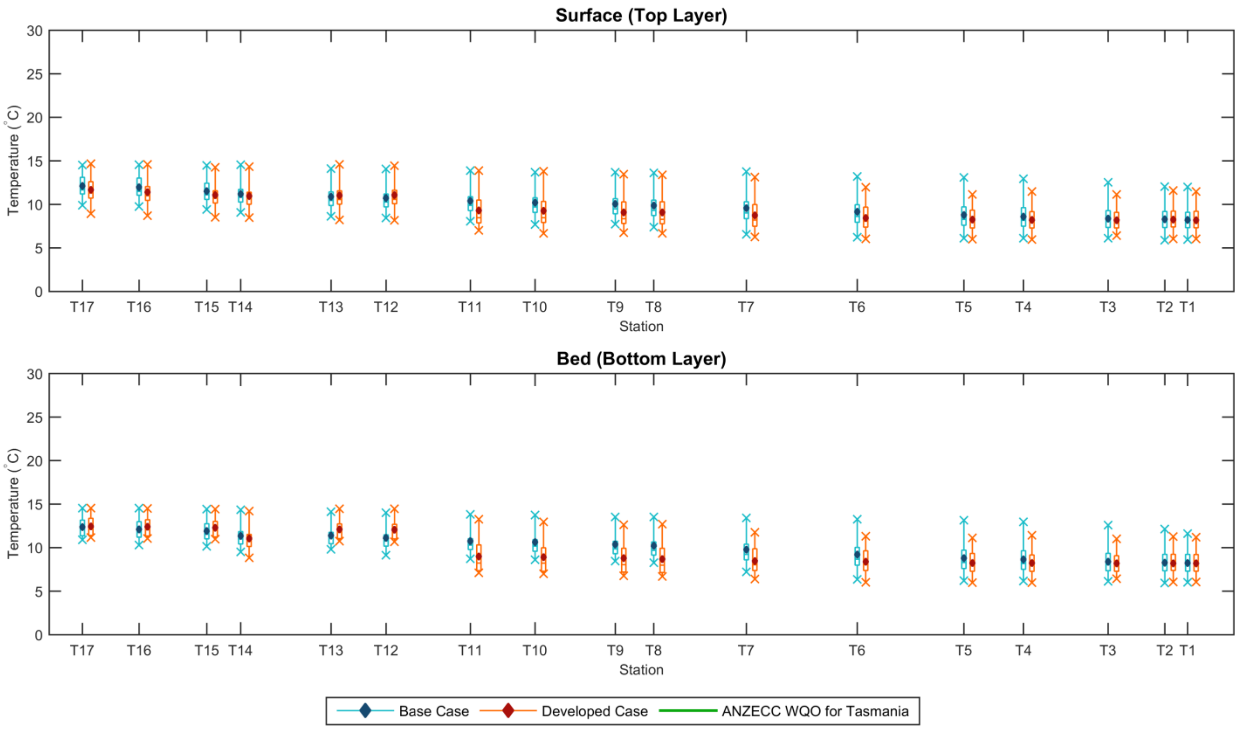


Figure 4-82 Scenario 4 – Temperature – Winter (Wet)

4.9.2 Dissolved Oxygen (mg/L)

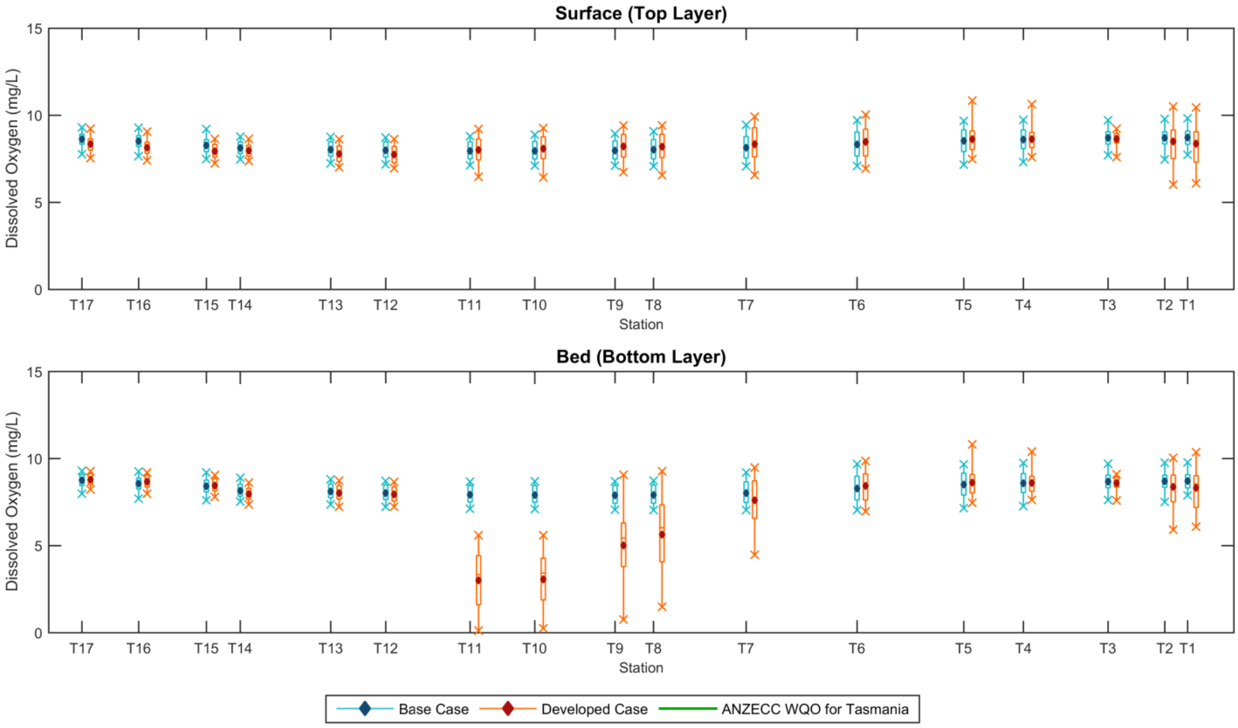


Figure 4-83 Scenario 4 – Dissolved Oxygen (mg/L) – Summer (Dry)

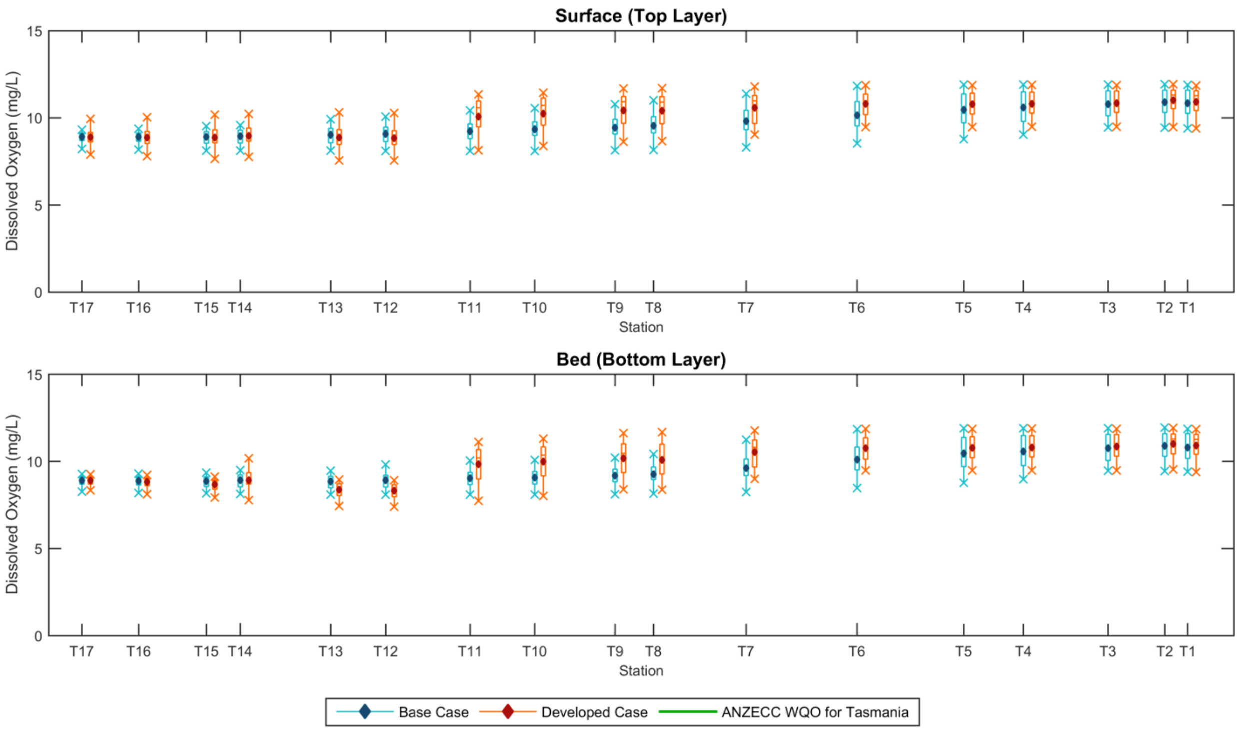


Figure 4-84 Scenario 4 – Dissolved Oxygen (mg/L) – Winter (Wet)

4.9.3 Dissolved Oxygen (% Saturation)

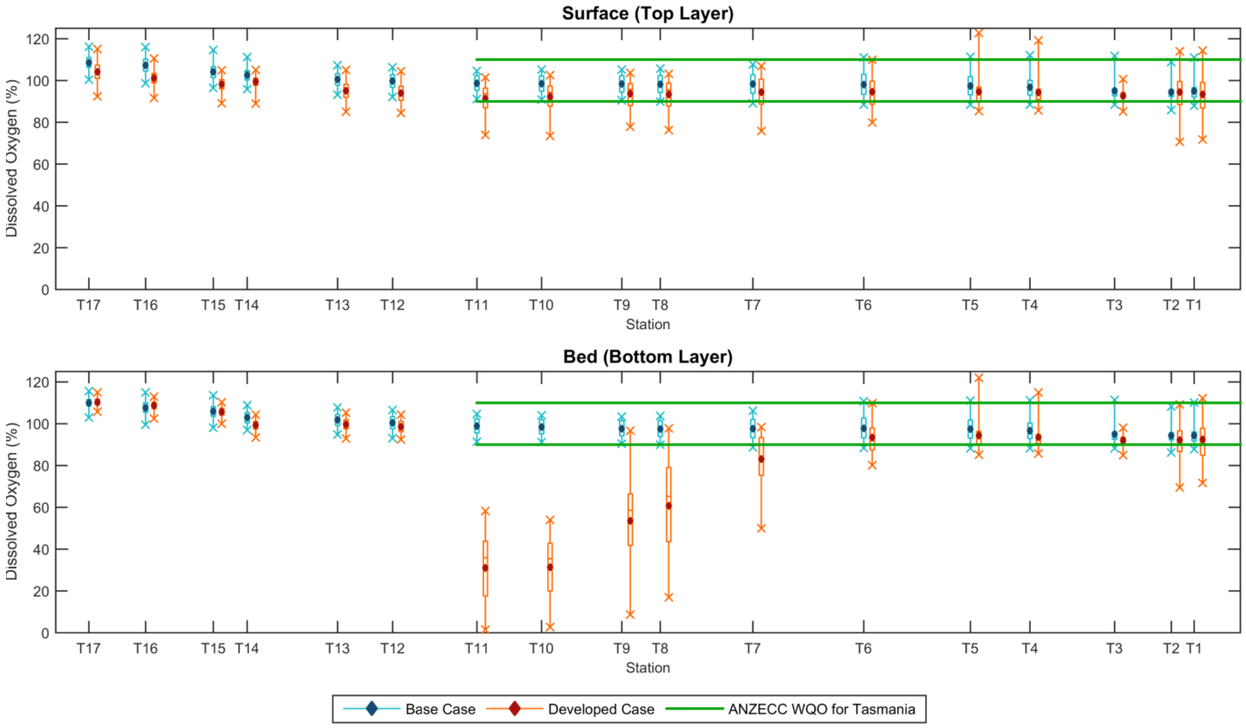


Figure 4-85 Scenario 4 – Dissolved Oxygen (% Saturated) – Summer (Dry)

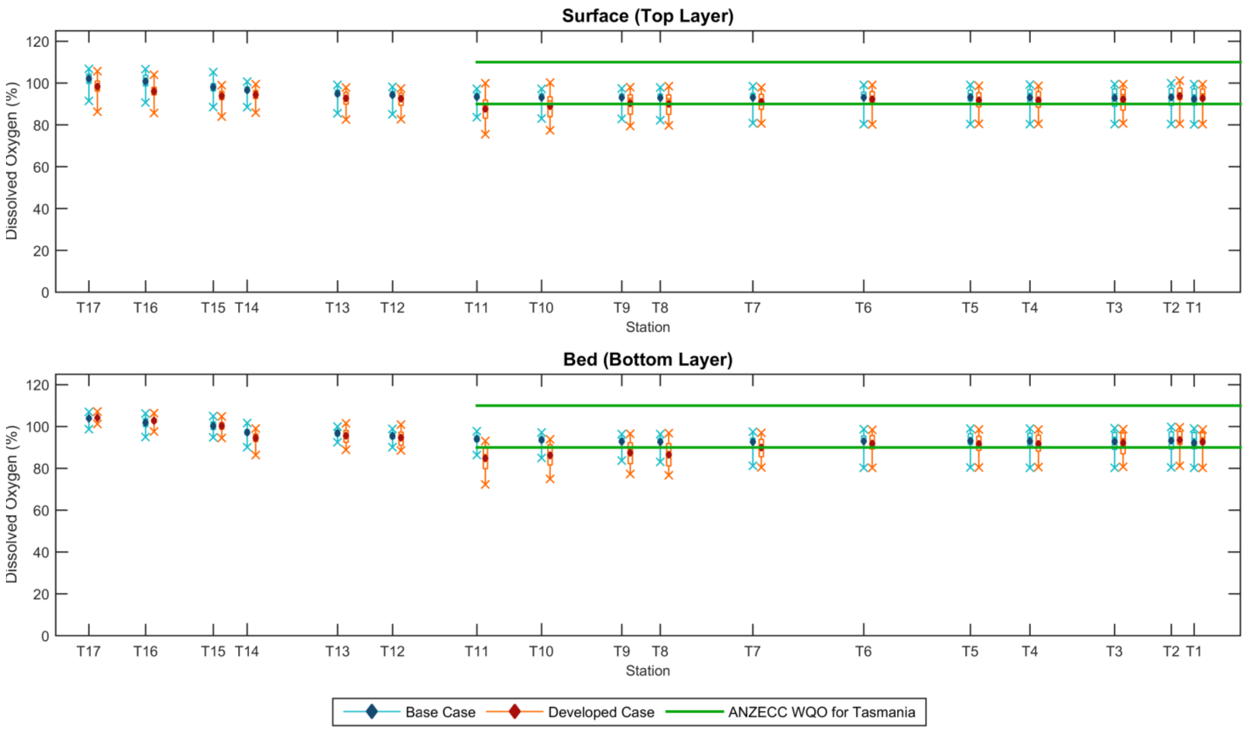


Figure 4-86 Scenario 4 – Dissolved Oxygen (% Saturated) – Winter (Wet)

4.9.4 Ammonia

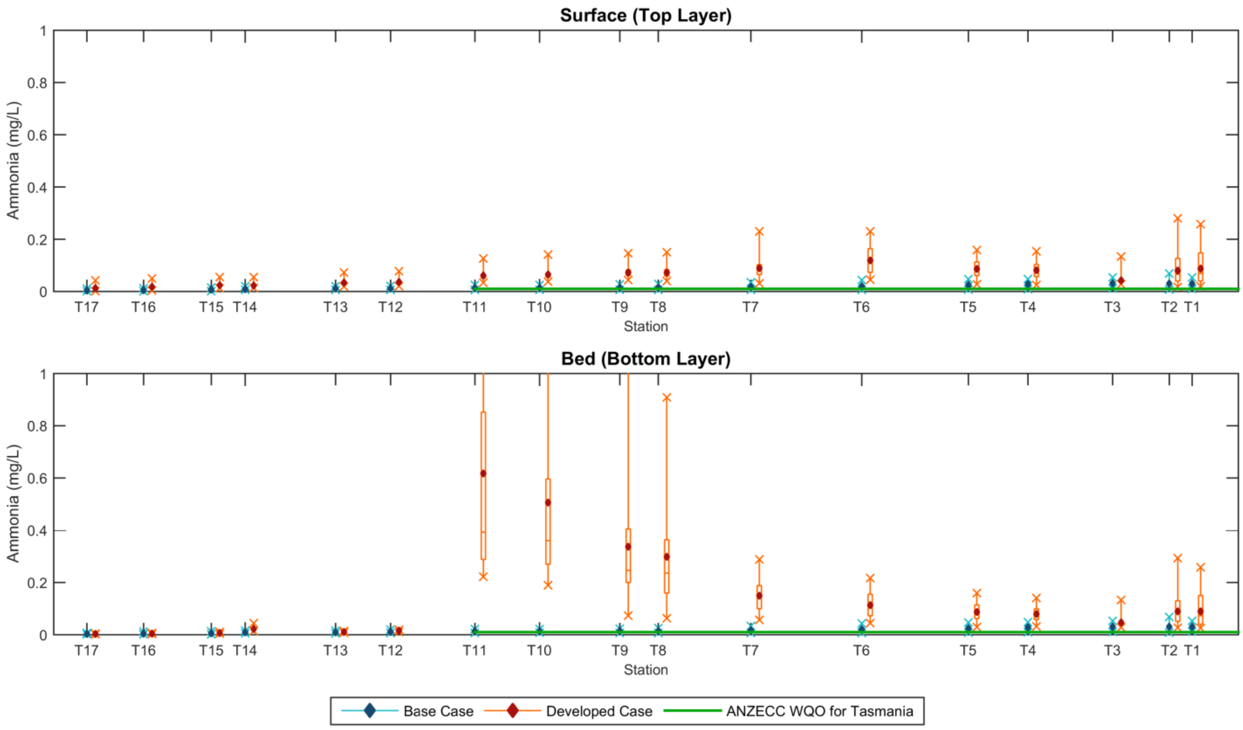


Figure 4-87 Scenario 4 – Ammonia – Summer (Dry)

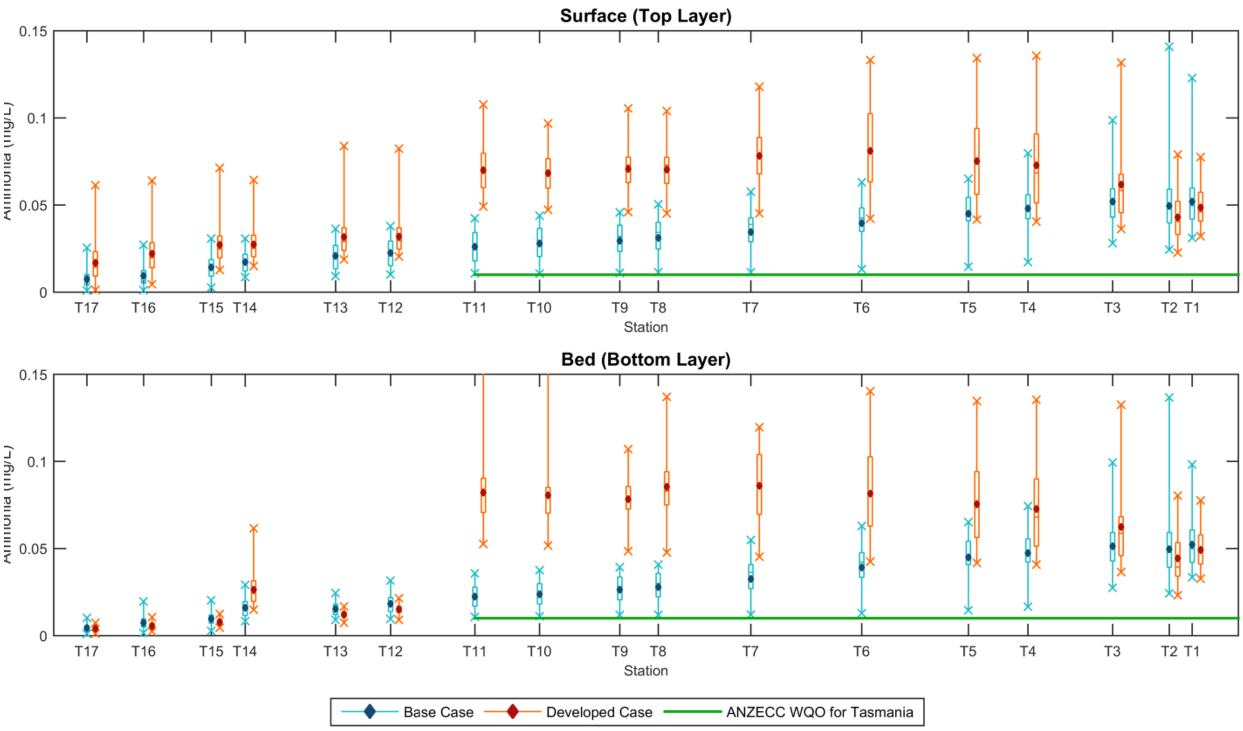


Figure 4-88 Scenario 4 – Ammonia – Winter (Wet)

4.9.5 Nitrate

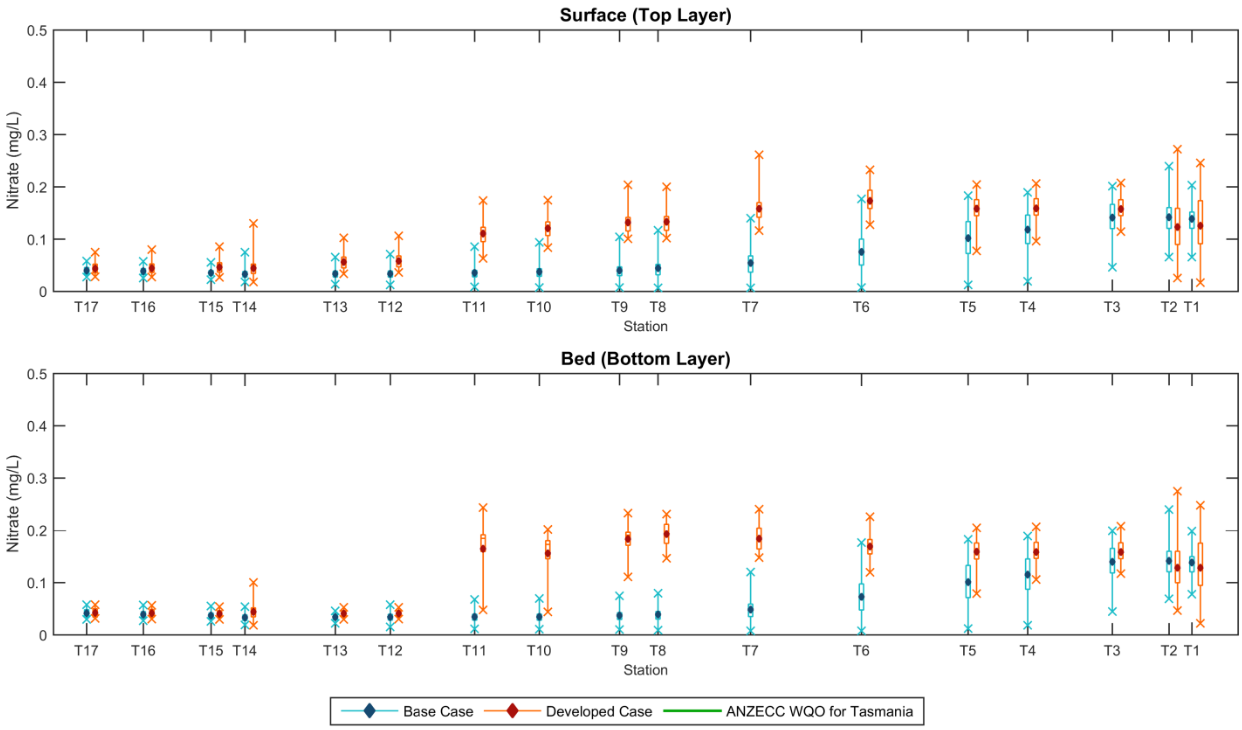


Figure 4-89 Scenario 4 – Nitrate – Summer (Dry)

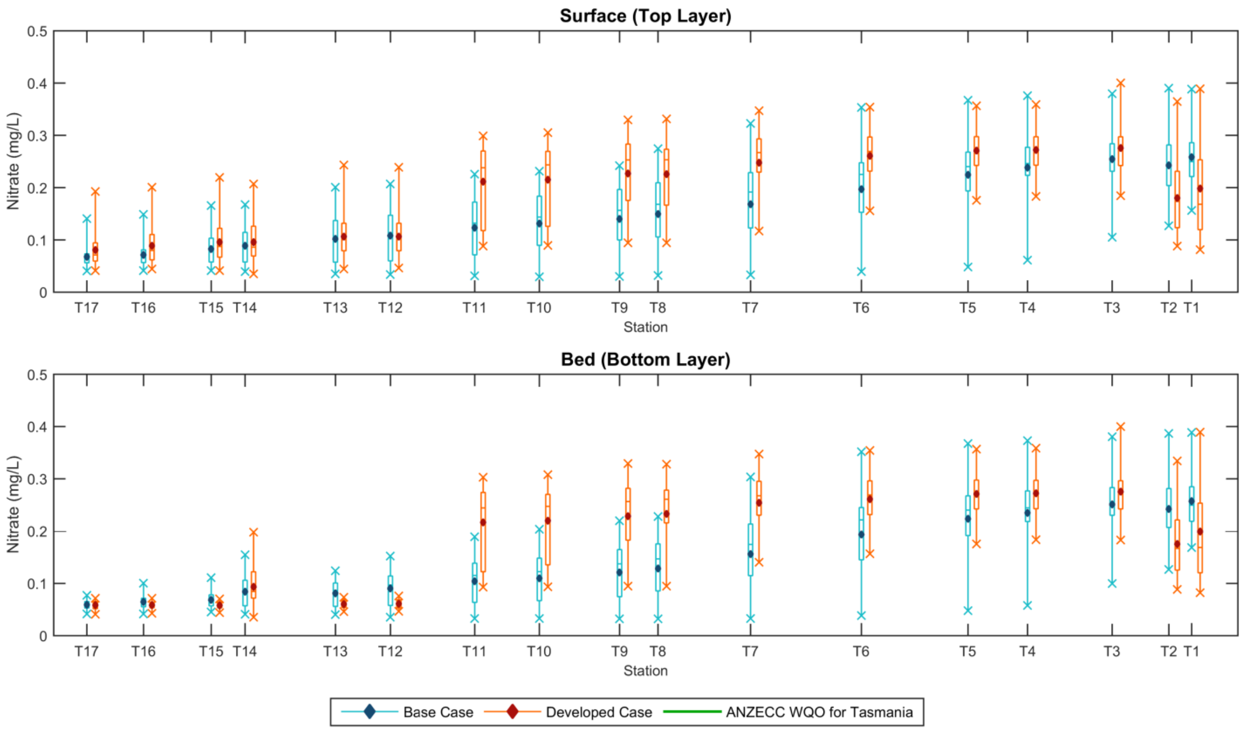


Figure 4-90 Scenario 4 – Nitrate – Winter (Wet)

4.9.6 Total Nitrogen

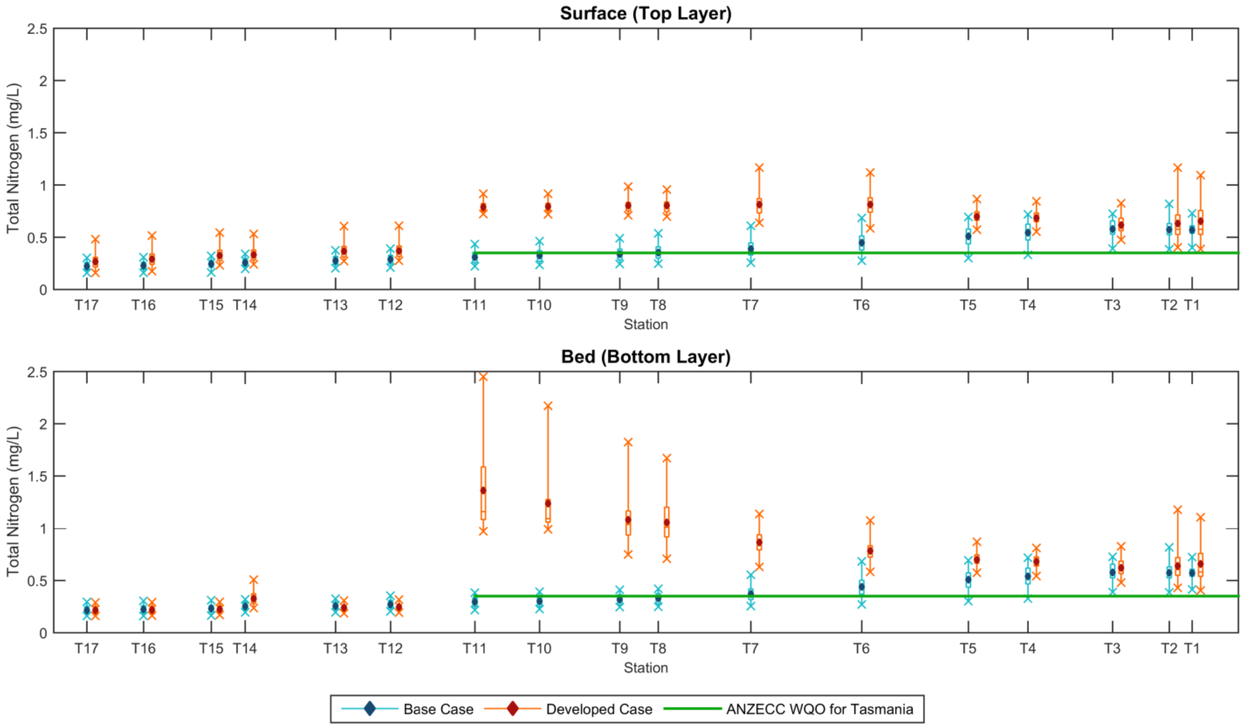


Figure 4-91 Scenario 4 – Total Nitrogen – Summer (Dry)

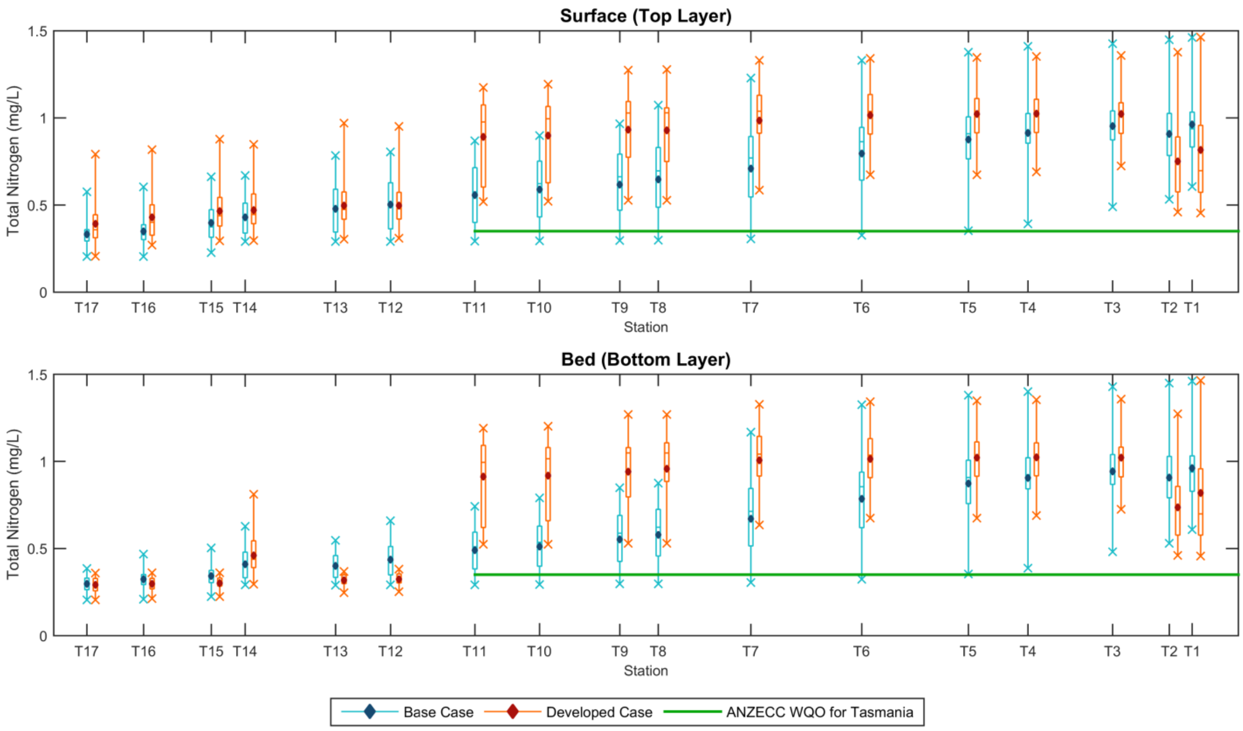


Figure 4-92 Scenario 4 – Total Nitrogen – Winter (Wet)

4.9.7 FRP

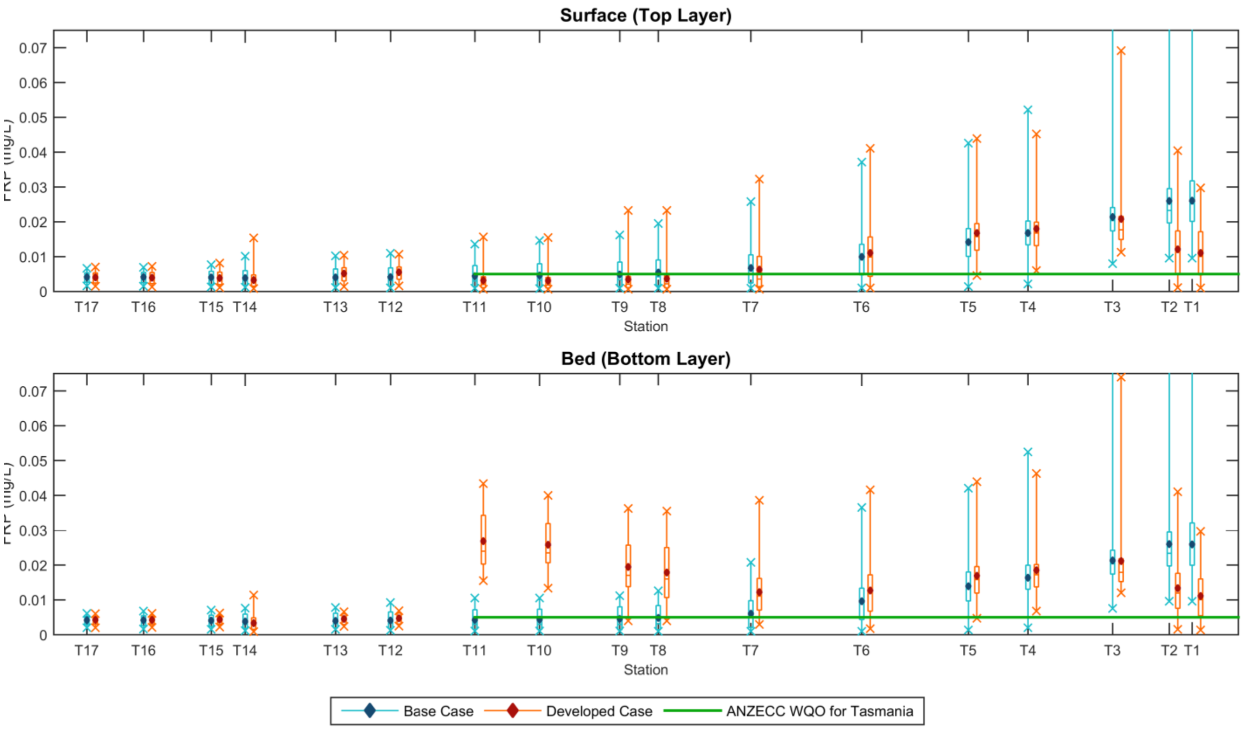


Figure 4-93 Scenario 4 – FRP – Summer (Dry)

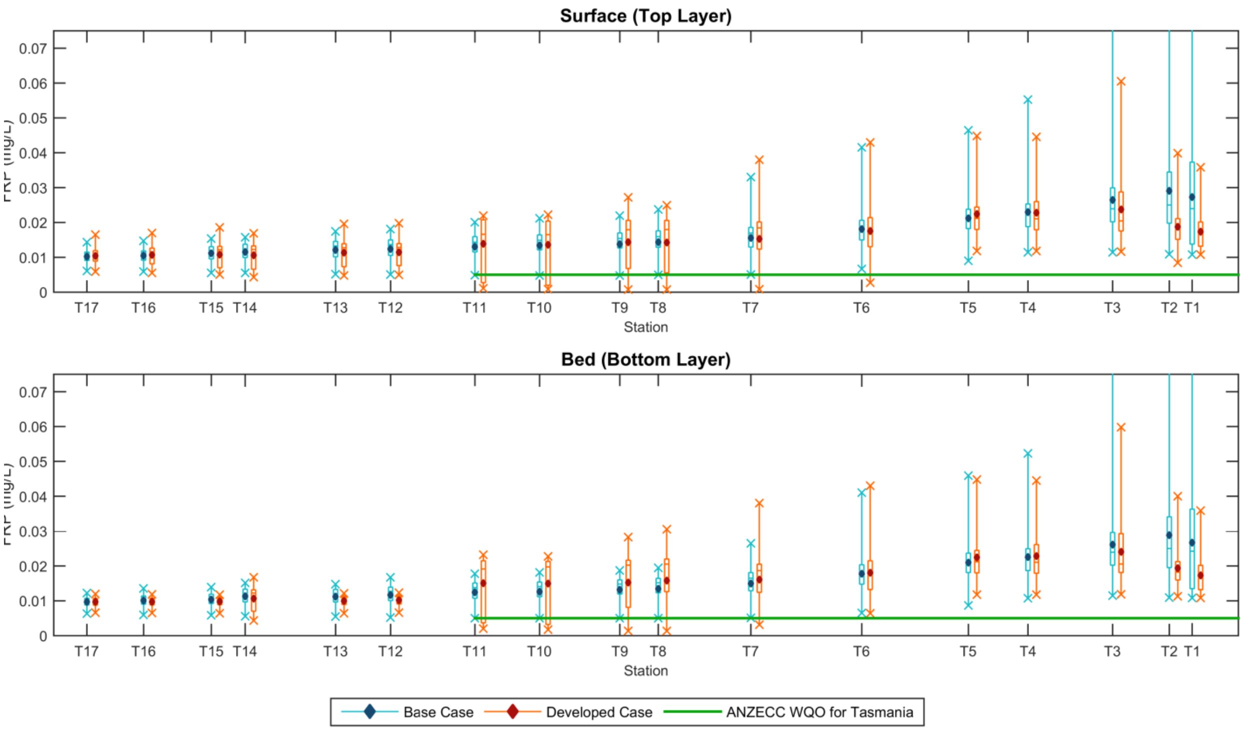


Figure 4-94 Scenario 4 – FRP – Winter (Wet)

4.9.8 Total Phosphorus

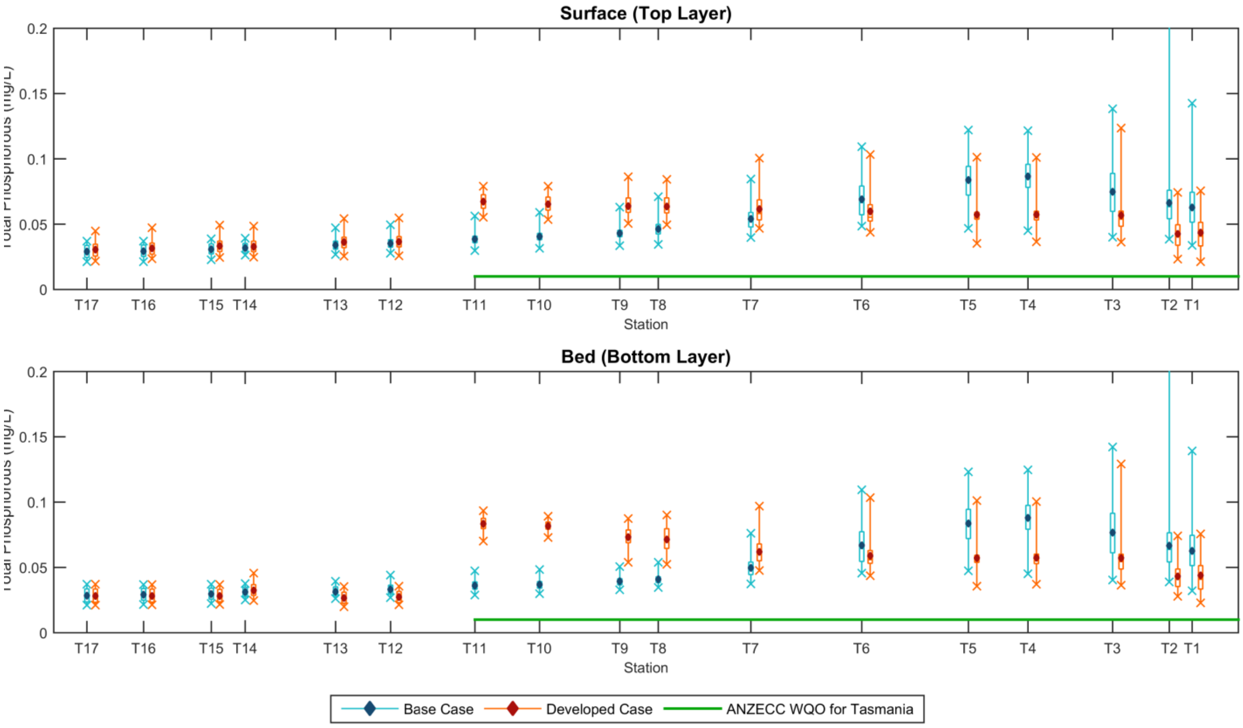


Figure 4-95 Scenario 4 – Total Phosphorus – Summer (Dry)

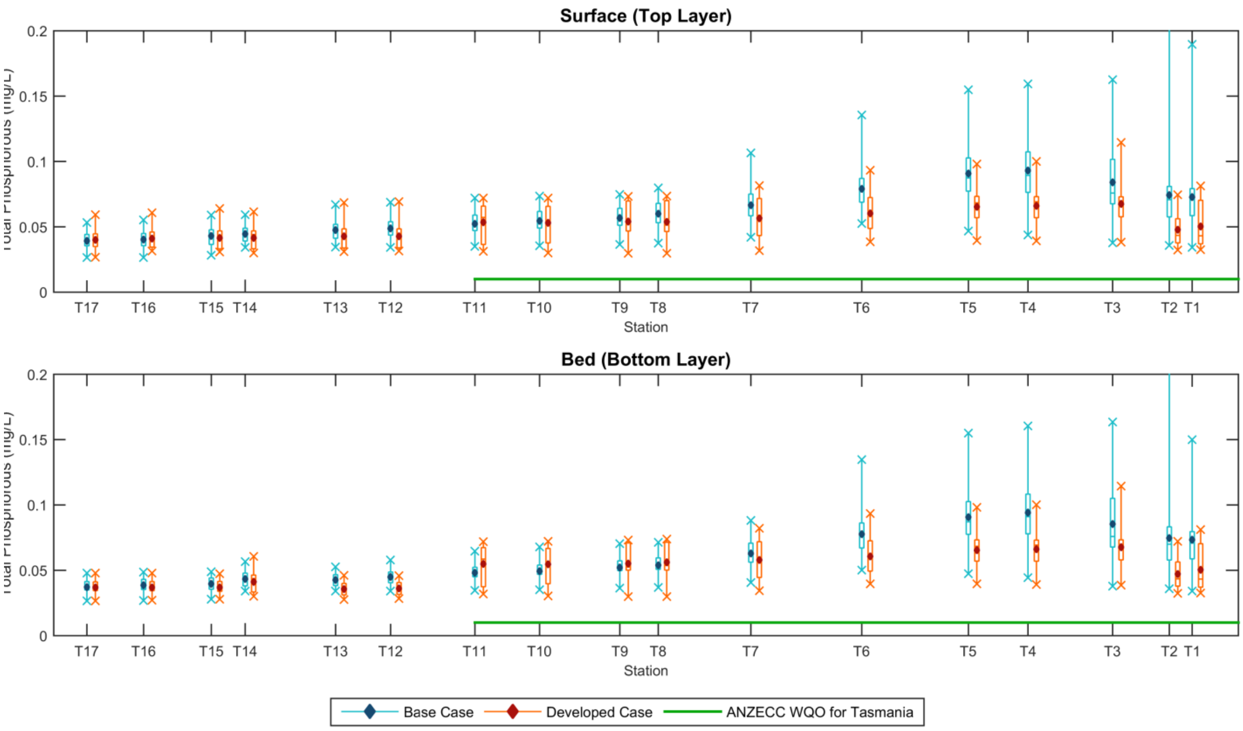


Figure 4-96 Scenario 4 – Total Phosphorus – Winter (Wet)

4.9.9 Chlorophyll-a

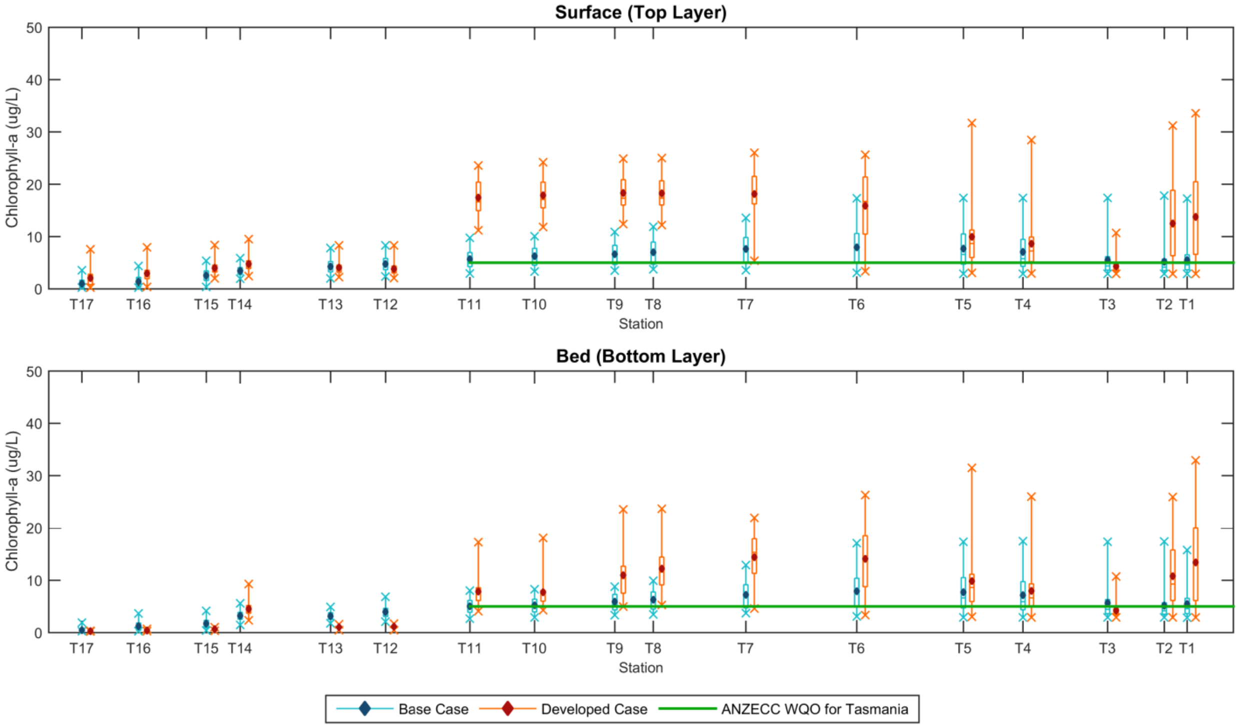


Figure 4-97 Scenario 4 – Chlorophyll-a – Summer (Dry)

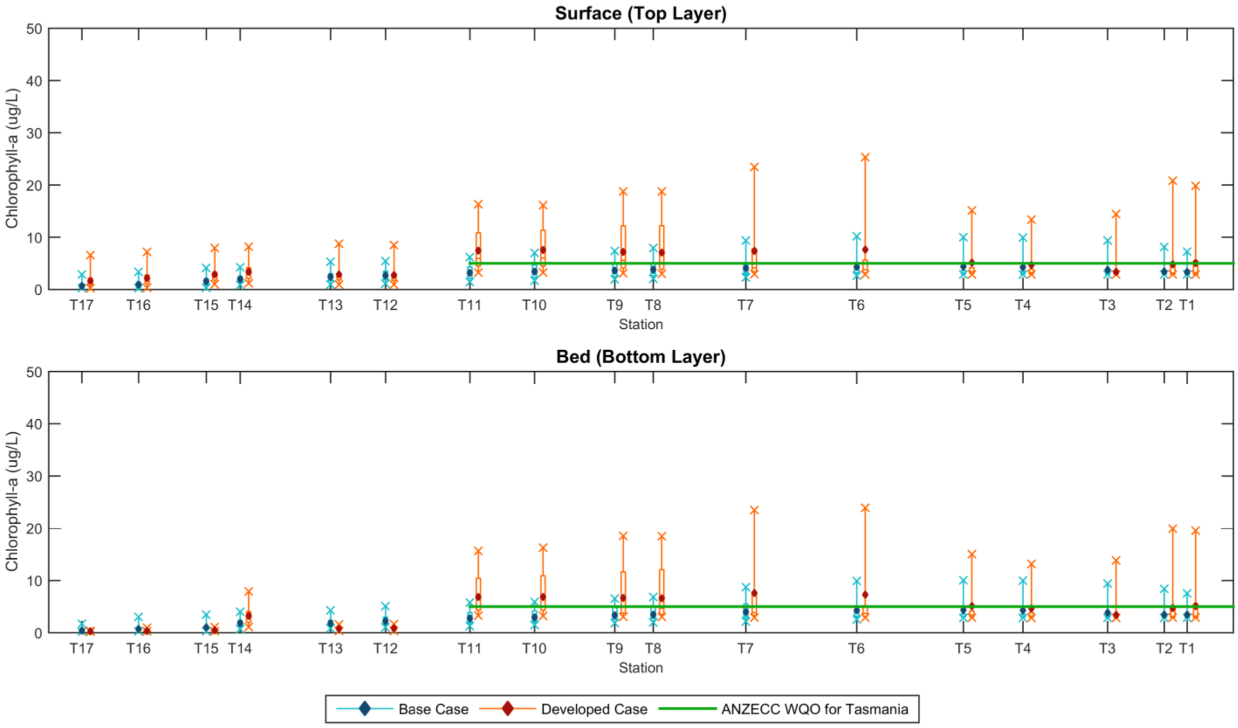


Figure 4-98 Scenario 4 – Chlorophyll-a – Winter (Wet)

4.9.10 Enterococci

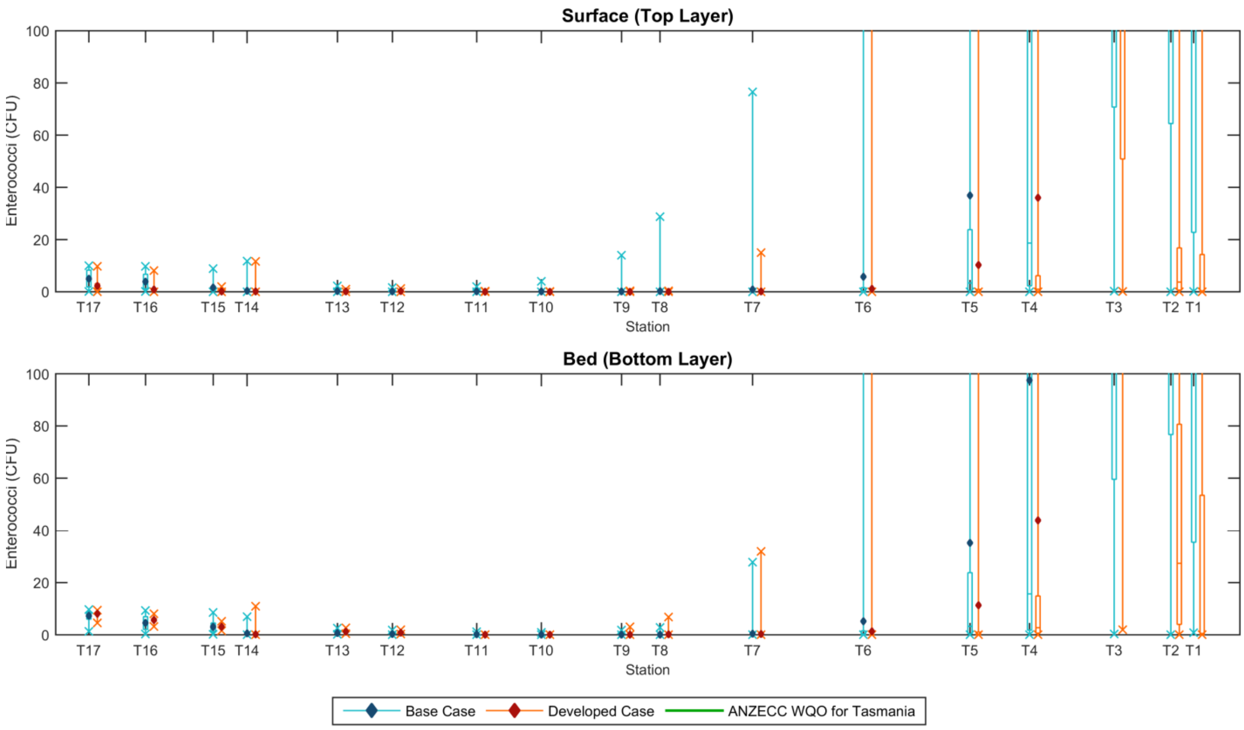


Figure 4-99 Scenario 4 – Enterococci – Summer (Dry)

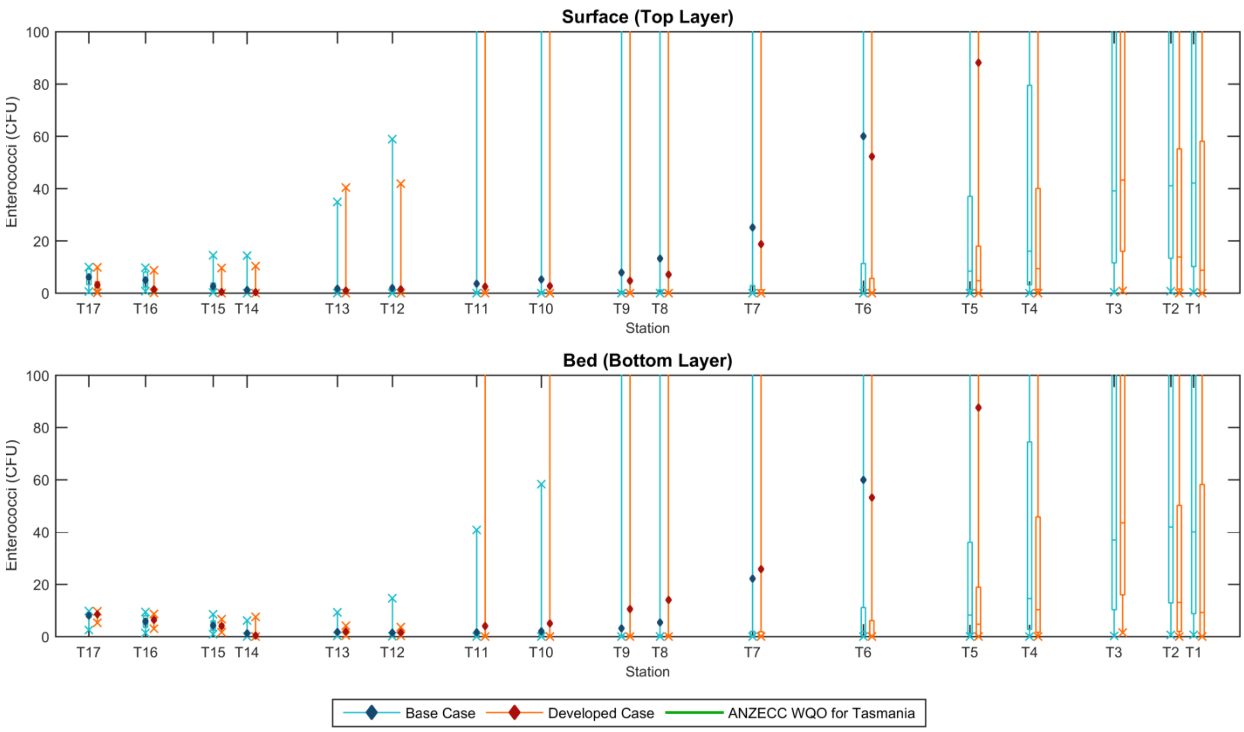
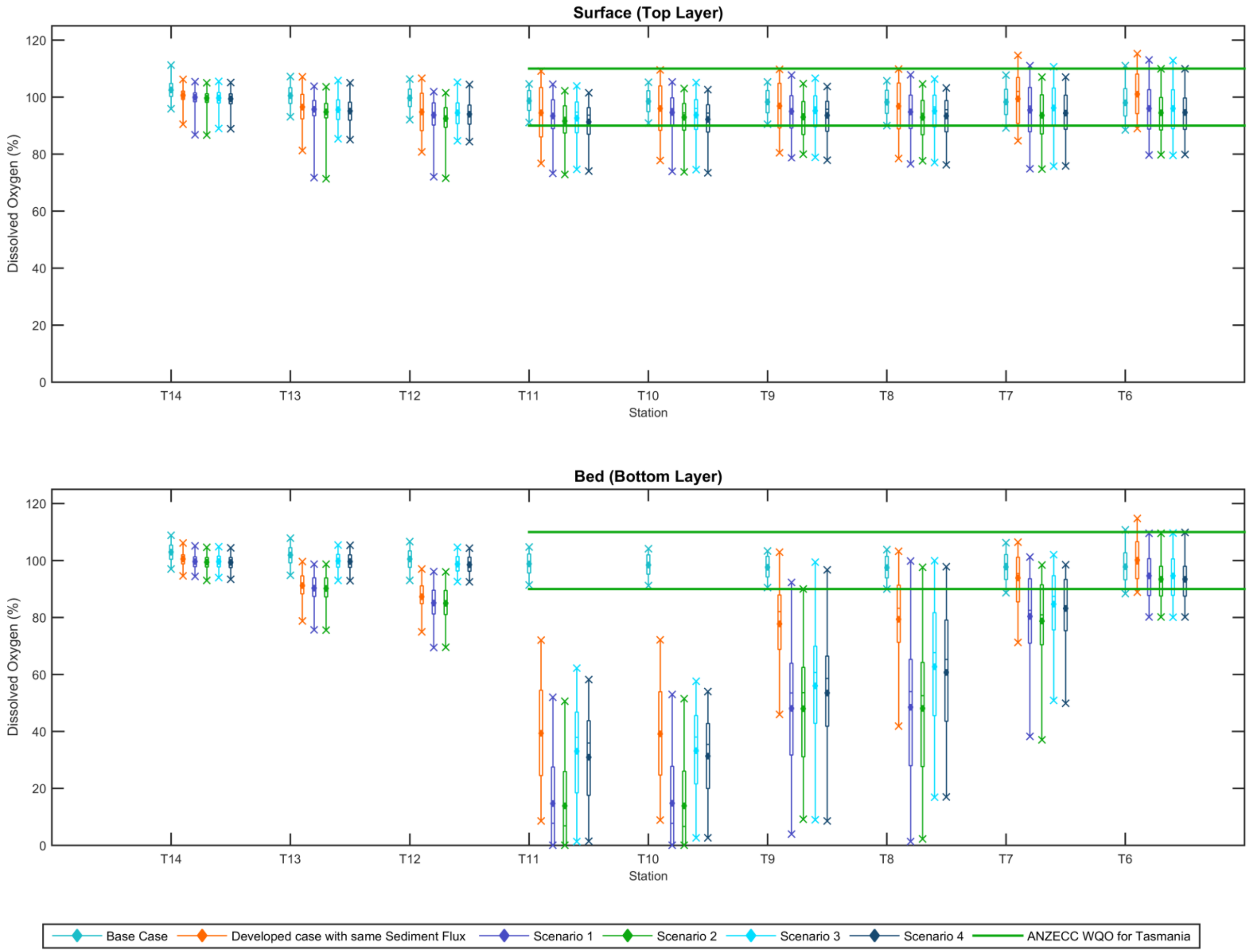


Figure 4-100 Scenario 4 – Enterococci – Winter (Wet)

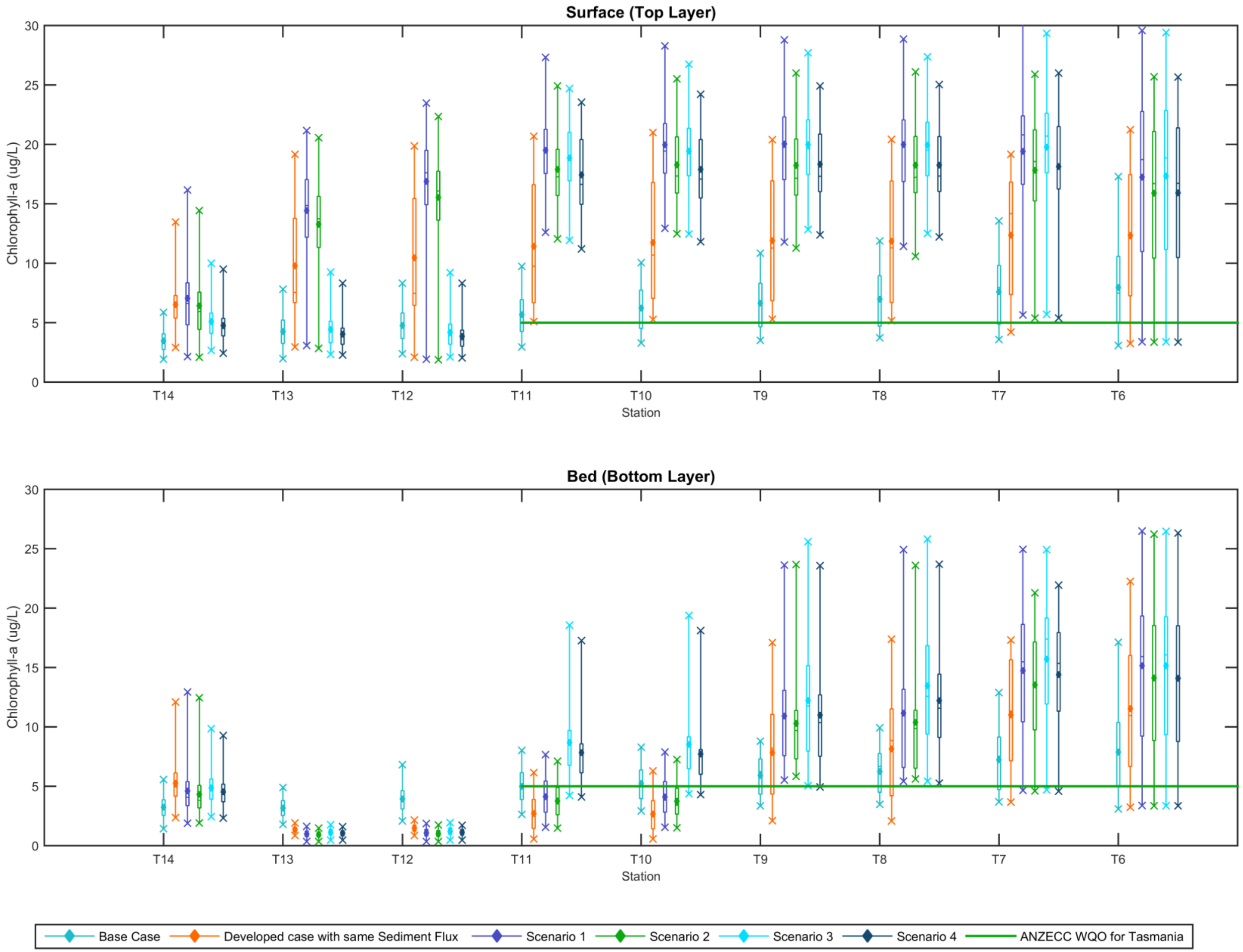
4.10 Scenario Comparison

A selection of model predictions is presented below that allows comparison across all scenarios.

4.10.1 Dissolved Oxygen

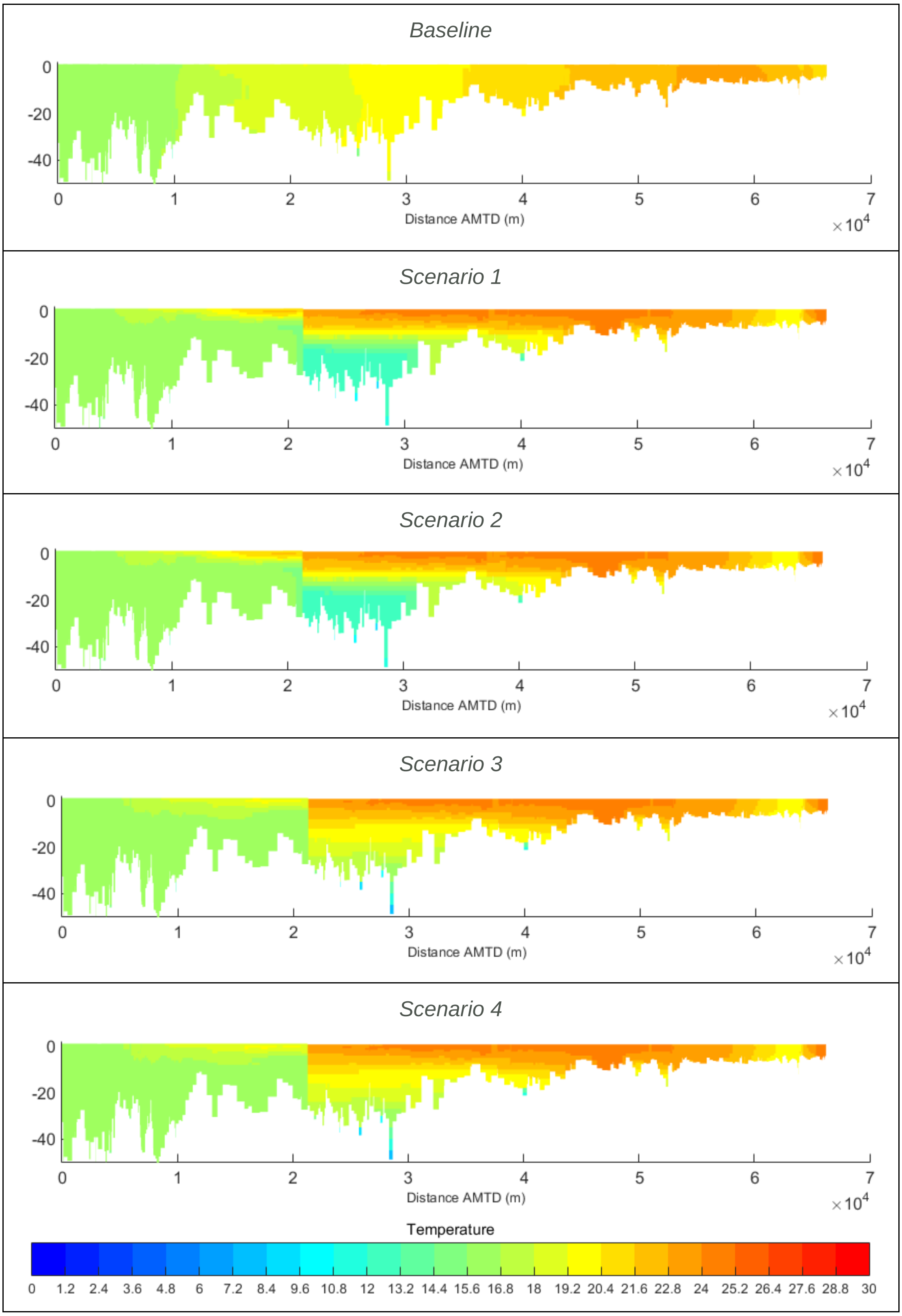


4.10.2 Chlorophyll-a

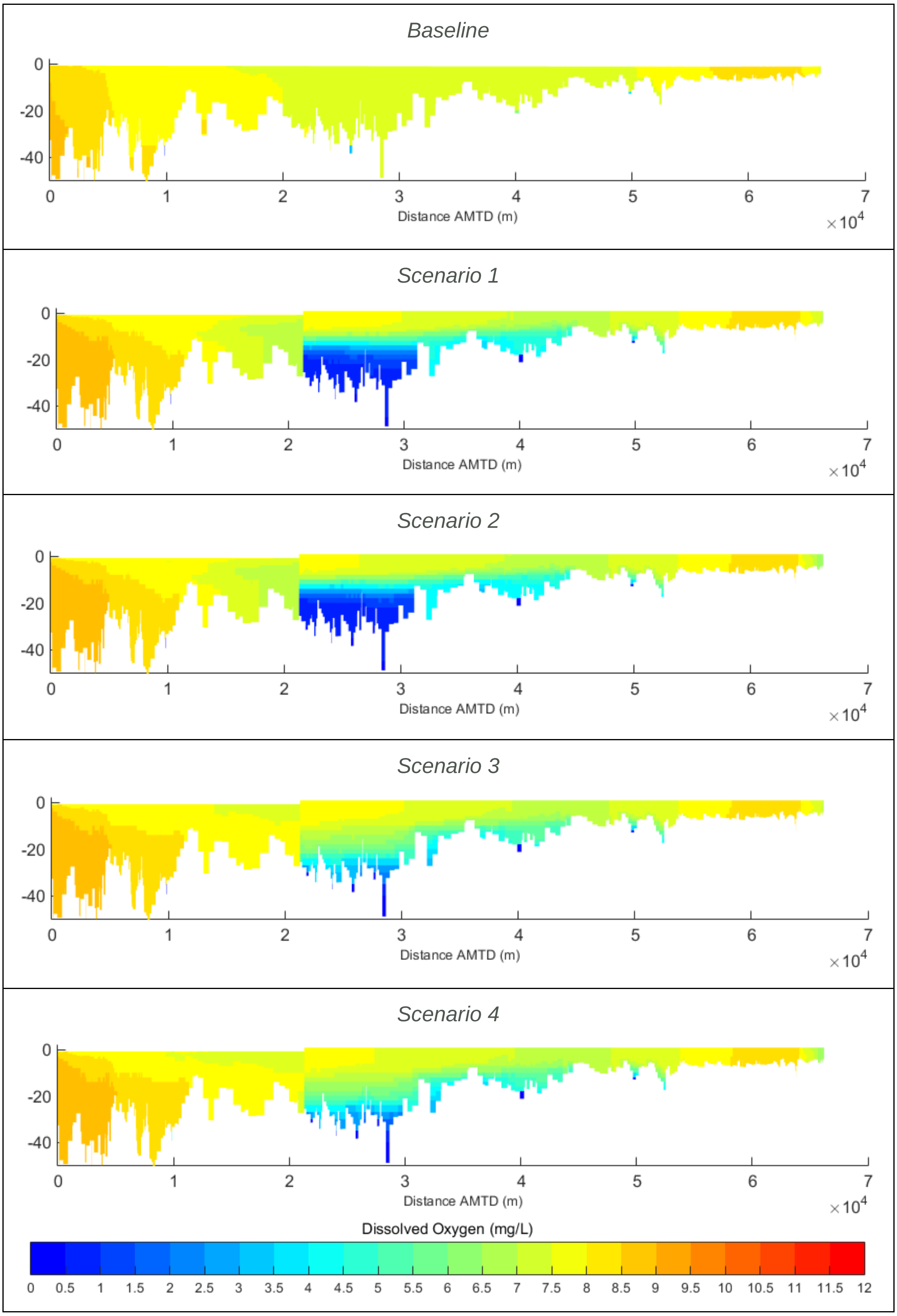


4.11 Profile view contour comparisons

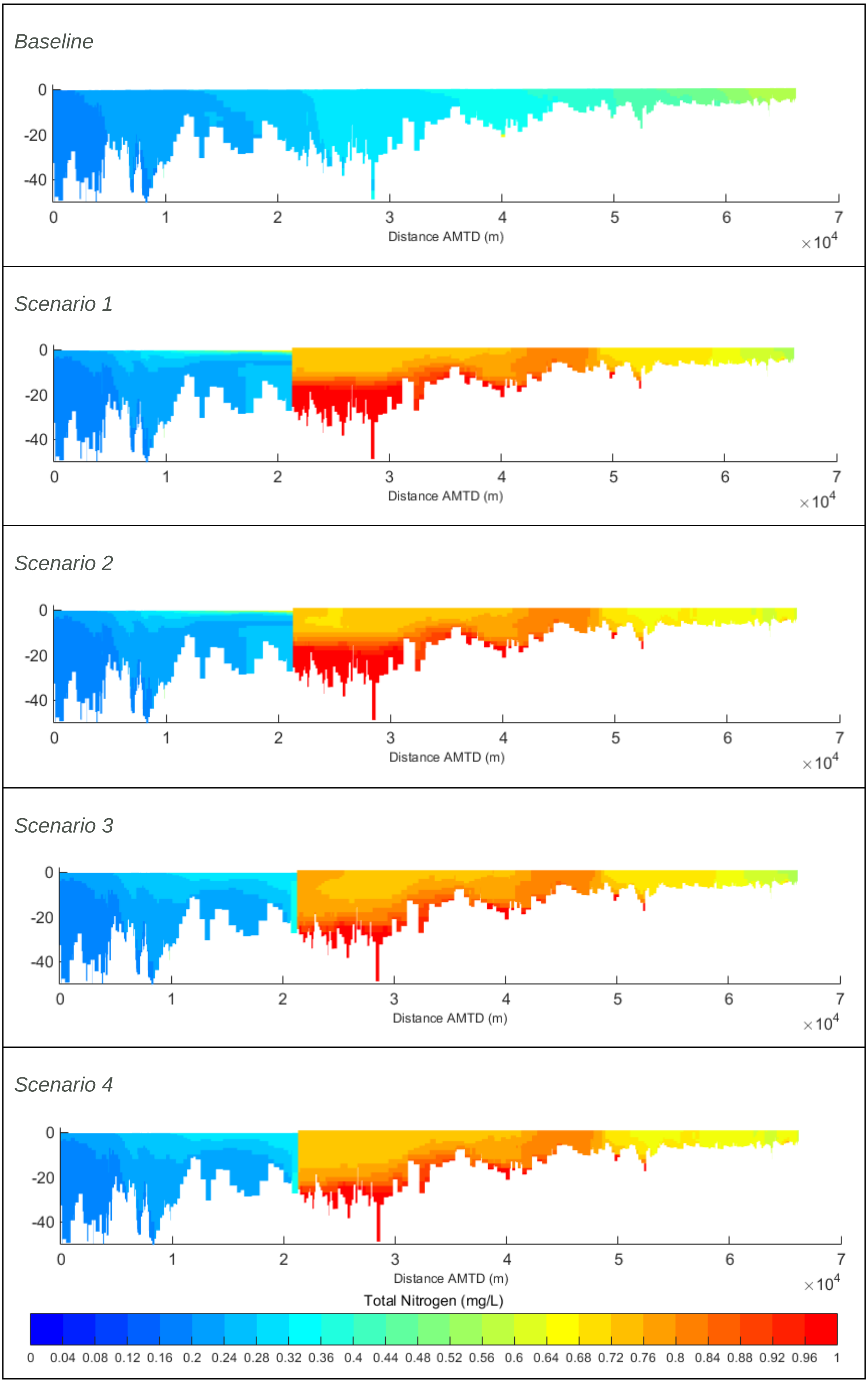
4.11.1 Temperature



4.11.2 Dissolved Oxygen

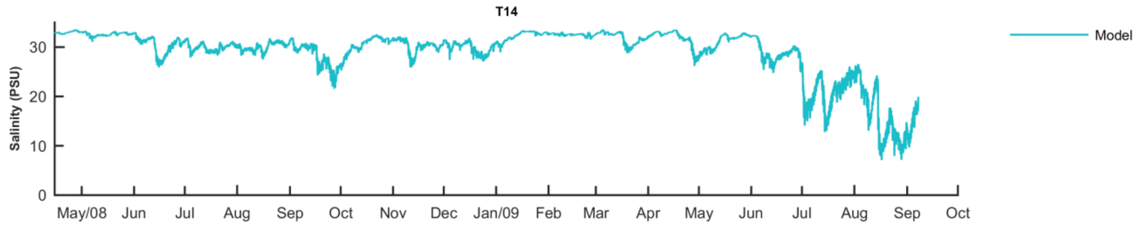


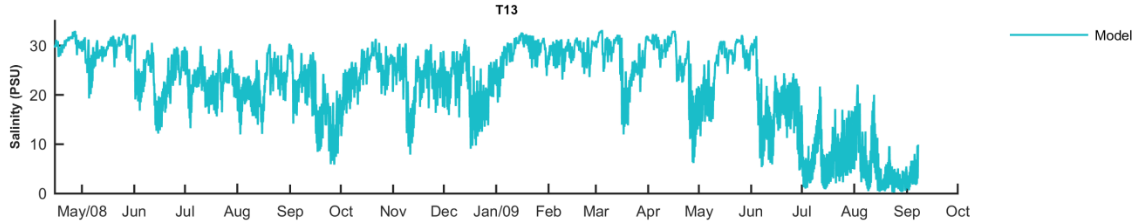
4.11.3 Total Nitrogen

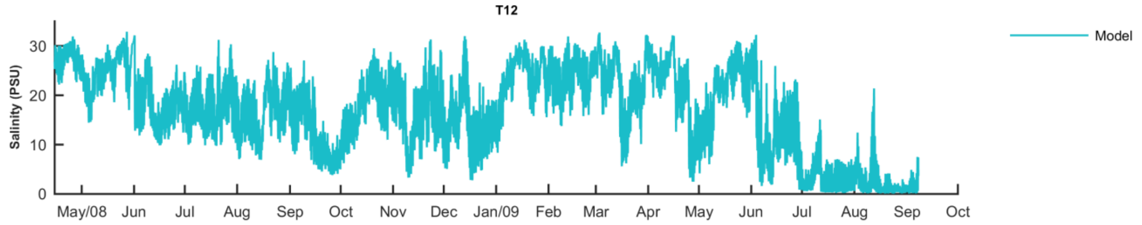


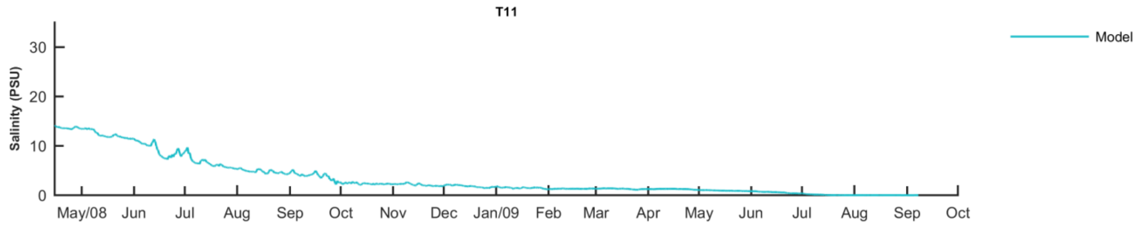
4.12 WQ Scenario 5

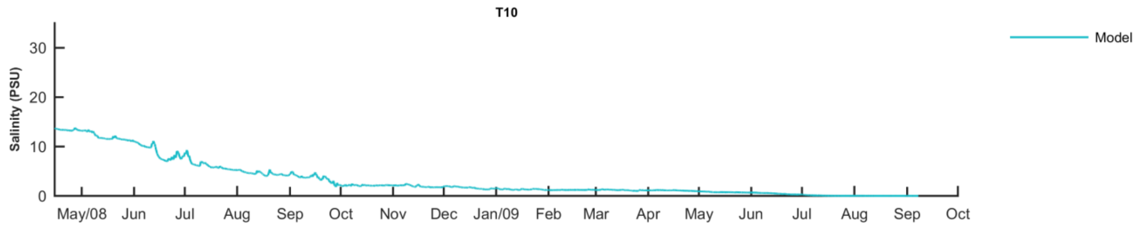
4.12.1 Dry

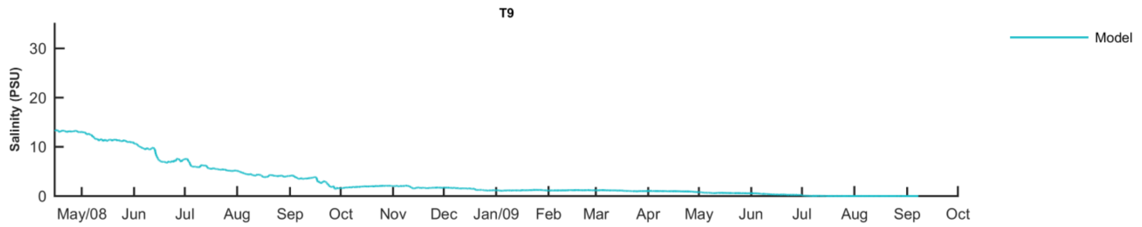




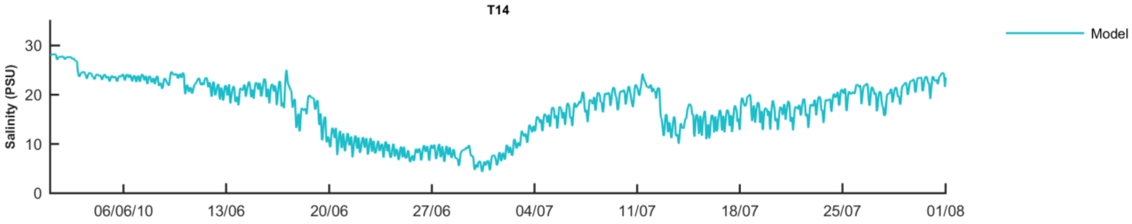


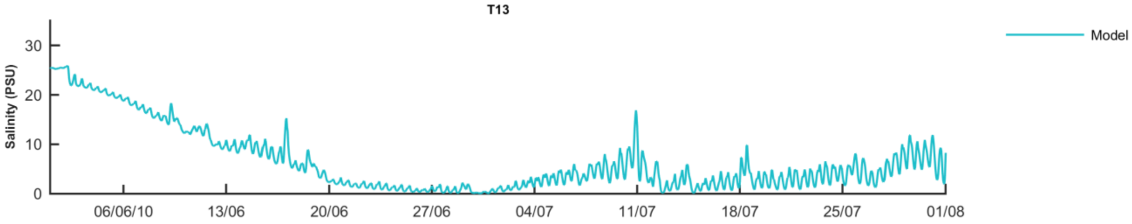


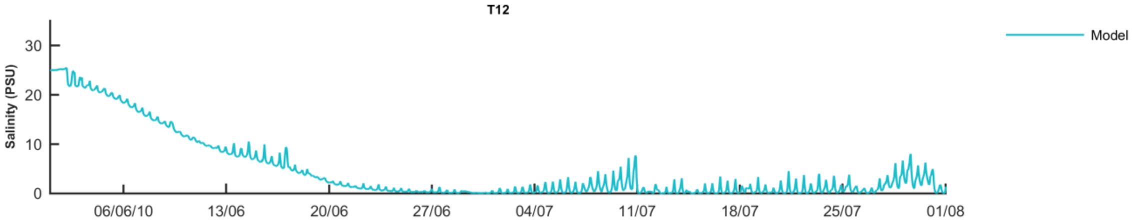


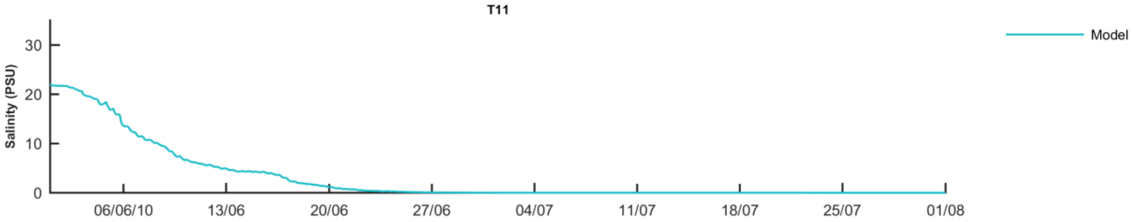


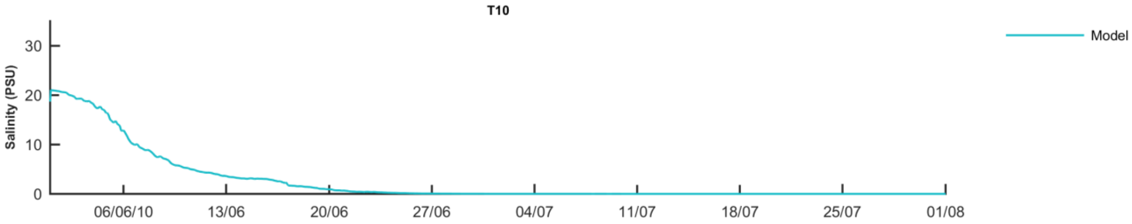
4.12.2 Wet

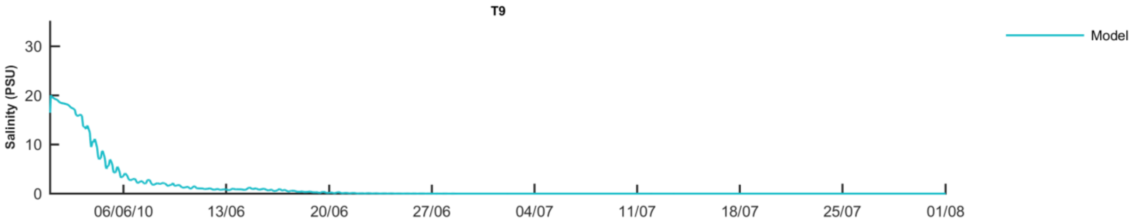

T14
Model
Salinity (PSU)
30
20
10
0
06/06/10
13/06
20/06
27/06
04/07
11/07
18/07
25/07
01/08


T13
Model
Salinity (PSU)
30
20
10
0
06/06/10
13/06
20/06
27/06
04/07
11/07
18/07
25/07
01/08


T12
Model
Salinity (PSU)
30
20
10
0
06/06/10
13/06
20/06
27/06
04/07
11/07
18/07
25/07
01/08


T11
Model
Salinity (PSU)
30
20
10
0
06/06/10
13/06
20/06
27/06
04/07
11/07
18/07
25/07
01/08


T10
Model
Salinity (PSU)
30
20
10
0
06/06/10
13/06
20/06
27/06
04/07
11/07
18/07
25/07
01/08


T9
Model
Salinity (PSU)
30
20
10
0
06/06/10
13/06
20/06
27/06
04/07
11/07
18/07
25/07
01/08

5 Discussion (Water Quality)

The results for scenarios 1 to 4 show a clear and significant change to water quality in the system, particularly with respect to the freshwater reaches behind the barrage. It appears that the water column dynamics in these areas support extensive and prolonged summertime bottom deoxygenation and sediment nutrient release to a distance of some 20km upstream of the barrage, and that this results in elevated nutrient concentrations and algal activity. For example, at station T11, the scenario 1 model predicts bottom DO to be as low as 0% saturation (i.e. completely anoxic) for extended periods. Although there is a slight improvement in DO for scenarios 3 and 4 (when the at-depth culvert is installed) results still fall well below the WQO for lake systems. The base case model at the same location predicts a minimum DO of no less than approximately 90% saturation. This represents a significant and detrimental shift in ambient environmental conditions.

More generally, we note that the proposed lake presents water quality behaviour that is consistent with that often observed and modelled in deep fresh (usually water supply) water bodies. This includes the following broad attributes:

- Strong summertime thermal stratification. This is the fundamental issue at the heart of the water quality dynamics predicted by the model
- Significant subsequent depletion of dissolved oxygen at depth, with the development of ecologically toxic anoxic waters
- Remineralisation of organic matter within and on top of bottom sediments – this occurs to distances of several kilometres upstream of the barrage (see Section 4.8 profile contours)
- Supply of nutrients to the water surface where their abundance, together with light and warm temperatures leads to significant primary production and algal activity.

The above attributes are obviously highly detrimental to ecosystem health and in our view will present a major threat to the environmental health of the area, even with the at-depth exchange process in place.

On this matter, and even though the at-depth pipe exchange system does provide for (very minor) alleviation of some water quality issues upstream of the barrage (albeit not to an extent that water quality approaches guideline values), the model predicts commensurate deterioration of water quality downstream under this arrangement. It is therefore our view that such an at-depth exchange system will not materially improve the overall water quality performance of the barrage system. This water quality performance will be very poor, and highly damaging to the receiving aquatic environment.

The additional simulation which applies base case (existing conditions) nutrient sediment flux parameters to the completed barrage scenario places a best case limit on the outcomes. Results still reflect the detrimental attributes as described earlier, and represent significant degradation of environmental conditions and indicate a very high likelihood of ongoing water quality issues.

Finally, the timeframe for which it takes the system to transition from salt water esturine to a fresh water lake varies considerably dependent on fresh water inflows from catchments. The simulation executed over the 2008/9 period required over 12 moths for the transition wheras the simulation executed over a period with high inflows had a transitional period of less than two months.