



## Sustainable Pollutant Loads for Target Setting

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# Sustainable Pollutant Loads for Catchment Target Setting

## Introduction to the report

This report provides supporting information for the development of pollutant load targets for south east Queensland (SEQ) catchments. The report was commissioned by the Queensland Government Department of Environment and Heritage Protection (now Department of Environment and Science). The report focusses on three main pollutants—nitrogen, phosphorus and sediment—which are the primary threats to the environmental, social and economic values that the SEQ community has for their waterways.

The project's objectives were to calibrate and execute Source catchment models and 3D hydrodynamic and estuarine water quality models to generate sediment and nutrient load predictions based on five distinct management scenarios that are relevant for catchment management in SEQ. The modelled predictions are presented catchment by catchment in the report to support the State's target setting process. The modelling data will assist councils, water utilities, the State Government and other organisations in decision making and prioritisation of management options.

The report has been reviewed and endorsed by the Healthy Land and Water Science Committee, led by Professor Stuart Bunn (Griffith University). In its review of the report, the Science Committee stressed the importance of considering the results presented in the report within the context of the objectives of the project and the assumptions of the modelled scenarios. Below we outline key considerations for interpreting the findings in the report.

## Consideration 1: The modelled predictions were determined at the catchment scale

The predicted loads have been presented at a whole of catchment scale (e.g. Maroochy, Lower Brisbane etc.) for the purpose of regional target setting. However, prioritization of on-ground investment is likely to set across a range of spatial scales. For example, target setting at a sub-catchment or reach scale requires finer scale predictions based on actions suitable for reducing pollutant loads at an individual sub-catchment scale, especially given we know that most of the sediment and nutrients come from specific parts of the landscape. This is an important consideration when using the results outlined in the report for developing action plans that are not at the catchment scale.

The load reduction targets and the subsequent water quality objectives for each catchment in SEQ will be set by the State Government. Prioritising actions for investment to achieve those targets and objectives will therefore need to be made within each catchment. As presented, the scenarios have not been considered at the scale of Moreton Bay.

Considering pollutant load reductions at the Moreton Bay scale rather than at a catchment scale would likely result in a different suite of management actions required to achieve those targets, most likely by focussing heavily on the catchments with the highest load generation and delivery to Moreton Bay (e.g. Brisbane/Bremer and Logan/Albert).

### **Consideration 2: The report only considers actions required to improve water quality and doesn't consider other environmental, social or economic values**

The actions applied to the model scenarios were selected to help the State Government set water quality objectives and pollutant load reduction targets for each catchment. There are many other environmental, social and economic values that the region's stakeholders consider important for catchment management. These include, 1) protection and maintenance of key habitats, (e.g. wetlands, riparian vegetation, seagrass, mangroves, corals and seagrass); 2) protection or maintenance of aquatic communities like fish and macroinvertebrates; 3) protection of key processes like nutrient cycling; 4) protection of the social and economic benefit generated by waterways-based recreation, and 5) enhancement of the communities' satisfaction and interaction with waterways.

Protection or maintenance of Moreton Bay's key habitats like seagrass, for example, would require the model scenarios to consider the full range of threats to the regions seagrasses that are not solely related to nutrient and sediment loads. In order to prioritise actions to restore or protect the region's seagrass might therefore require different management actions than those included for this project. This is also true for other environmental, social and economic values that are required by the region.

### **Consideration 3: "The "Full Investment" model scenario underestimates what is likely to be technically feasible with targeted investment**

Five modelled scenarios were executed as outlined in the report, including four future scenarios: Full Investment (FI), Partial Investment Sub-Catchment Focus (PI-SCF), Partial Investment Land Use Focus (PI-LUF) and Business As Usual (BAU). The catchment actions applied to the FI scenario were those that are currently known to have an impact on nutrient

and sediment loads. However, in the time since the initiation of this project, there has already been progress in engineering technology that can further improve the nutrient and sediment export from new urban developments and it is anticipated that in the coming decade more progress will be made. Furthermore, we know that targeted (and large-scale) investment in the upper catchments is likely to significantly alter run-off in rain events. If we undertake investments in the upper catchments to slow water down and increase infiltration, then the run-off response to rainfall must change in the full investment scenario. In turn, this should have a measurable effect on N-loads. The future scenario, however has not included consideration this process, nor does it account for any technical advances or new actions that may arise in the future to reduce pollutant loads.

As such, the name of this scenario is misleading. We recommend that readers of the report consider that the load reduction predictions under the "full investment" scenario as presented may not truly reflect the full suite of actions available to managers to reduce pollutant loads. The solutions that have been chosen are only one option suite– they may not be the answer to reducing pressures for all catchments.

#### **Consideration 4: The impact of actions to reduce nitrogen are not well known and are likely to be underestimated**

Different land use types generate different nutrient loads. In this project, the loads predicted to be generated from each land use are estimated from experimental data or are derived from literature values. However, the experimental information available for nitrogen generation from different land uses in SEQ is poor. As a result, there is low confidence in the magnitude of nitrogen reductions predicted under each scenario. This is particularly notable under the full investment scenario (FI), where in some cases full investment appears to show no improvement in nitrogen loads. This is an artefact of our poor understanding of nitrogen behaviour and an underestimate of the effect of on-ground investment on catchment hydrology (see consideration 3). It is a limitation of the current modelling and should not be interpreted as the investment being ineffective.

For example, the total nitrogen loads generated by natural forested land parcels are often higher than those generated by intensively grazed parcels. However, it is likely that the nitrogen loads from forested land uses are not in the form of bioavailable nitrogen, and therefore not as damaging to aquatic communities as those coming from more intensive land uses. HLW, along with our research partners from Griffith University and the Department of Environment and Science are working on improving the nitrogen predictions from different land uses and what those loads mean for aquatic ecosystems.

This consideration is only relevant for nitrogen, there is a much better understanding of phosphorus dynamics from different land uses.

### **Consideration 5: The management actions included in the simulations do not account for costs of those actions**

The project does not consider the financial cost of the suite of actions used in the management scenarios. This was outside the scope of the project. As such, it is important to assess the financial feasibility of the actions required to achieve pollutant load reduction. Any catchment action planning that is developed on the basis of the results in this report should include a rigorous cost/benefit appraisal.

### **Consideration 6: The rainfall used to generate the pollutant loads in scenarios did not include a large flood event**

The catchment model used to generate pollutant loads for the five scenarios presented in the report includes a module that delivers rainfall and associated runoff from the land use types that make up a catchment. To drive that module, daily rainfall from the 2014-15 financial year was used. The HLW Model Advisory Panel considered this to be close to an average year of rainfall for the majority of sub-catchments in SEQ. However, there are ramifications of this decision. The 2014-15 rainfall data set did not include a larger flood event. The inclusion of such an event would have enabled an assessment of the management actions required to reduce large event pollutant loads, however the model is not calibrated for flows that exceed the height of the main channel. As such, it was decided that an average year would provide a suitable compromise.

The effects of the decision are most apparent in the load predictions for the Moreton Bay zones. This is because the majority of loads delivered to the bay occur during large events. As a result, the load reductions predicted for the bay zones are likely to be an underestimate given the lack of large event loads in the 2014-15 rainfall dataset.

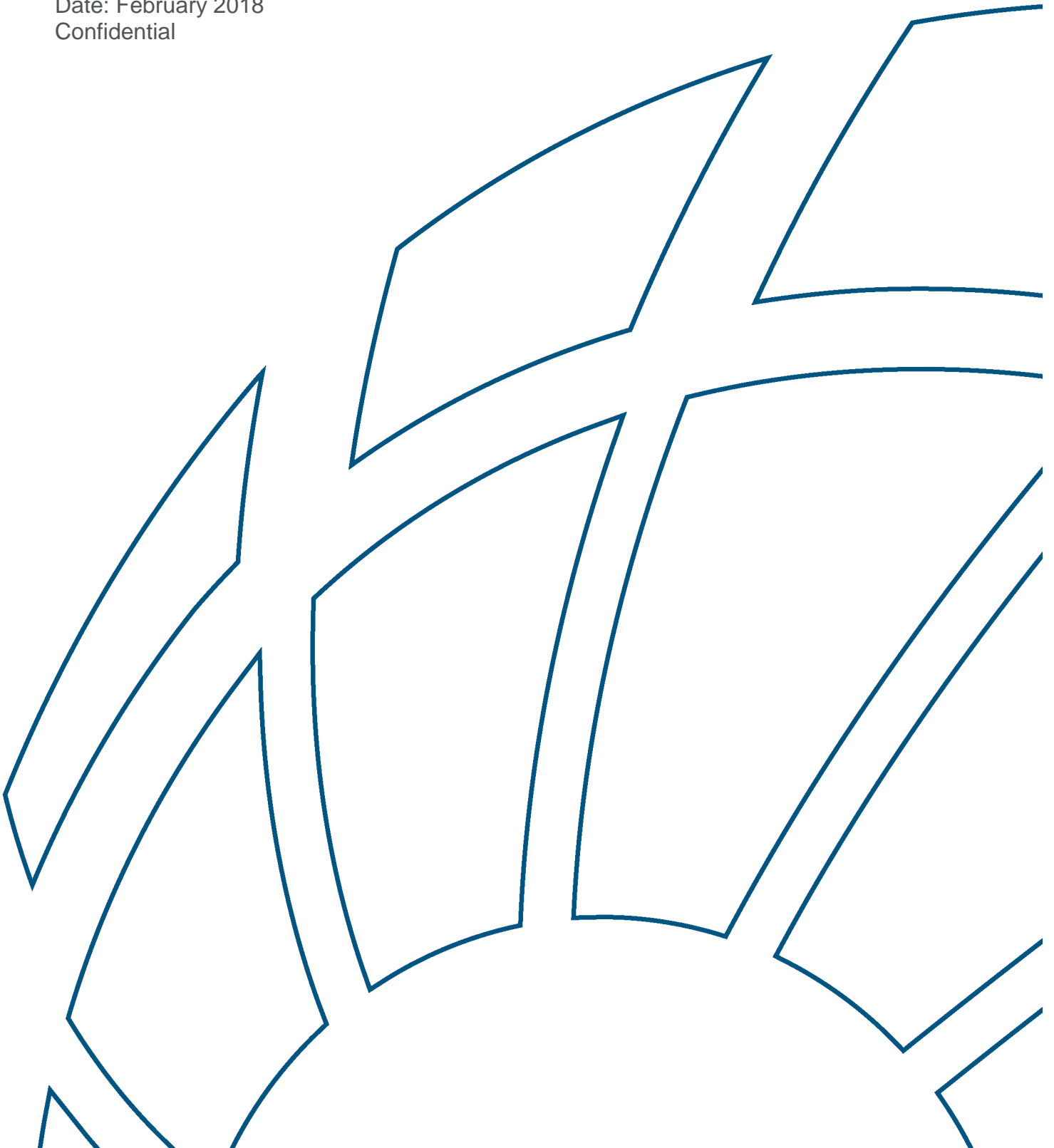


# EHP Target Loads Modelling

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## Document Control Sheet

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<p><b>Synopsis:</b> The Queensland Department of Environment and Heritage Protection commissioned Healthy Land and Water Ltd. to use the models developed by BMT WBM as part of the annual estuarine Report Cards process to examine target setting of pollutant loads for a selection of catchment/estuary systems. This report describes the methods used and modelled scenario thalweg median values for each estuary under a range of future management scenarios.</p>		

### REVISION/CHECKING HISTORY

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### DISTRIBUTION

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## Executive Summary

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- BMT WBM was commissioned by Healthy Land and Water Ltd (HLW) to build, calibrate and execute catchment and 3D hydrodynamic and receiving water quality models of estuaries in Southeast Queensland and Moreton Bay. These models have been peer reviewed and are being used to assist, to varying extents, in calculation of annual estuarine Report Cards.
- The Queensland Department of Environment and Heritage Protection (DEHP) invited HLW to submit a proposal of services to use these models to examine target setting of pollutant loads for a selection of catchment/estuary systems in Southeast Queensland.
- In order to support this target setting process, Source and TUFLOW FV AED<sup>2</sup> modelling was undertaken for a subset of the Report Card models including the Maroochy, Mooloolah, Pumicestone Passage, Caboolture, Pine, Brisbane/Bremer and Logan Albert estuaries, as well as Moreton Bay.
- A total of five catchment management scenarios were executed:
  - Current (baseline) 2015 - Current land management practices and existing land uses;
  - Business as Usual (BAU) 2030 - Current land management practices, but with increased population and expanded urban footprint;
  - Full Investment (FI) 2030 – BAU with every land use type/management theme is undertaken to the fullest extent possible;
  - Partial Investment Sub-catchment Focus (PI-SCF) – BAU but with full investment (as above) in selected catchments which are responsible for generating the greatest pollutant load on a per hectare basis, where this areal loading includes the impact of sewage treatment plant discharges.
  - Partial Investment Land Use Focus (PI-LUF) – BAU but with full investment (as above) in the land uses which deliver the greatest pollutant load on a tonnes/year basis, but across all catchments.
- The scenario outputs focussed on annual median thalweg (centreline) predictions for Total nitrogen (TN), Total phosphorus (TP), Total suspended solids (TSS), Dissolved oxygen (DO), Chlorophyll-a.
- Outputs from the catchment models predicted that loads across the three constituents – TSS, TN and TP were the highest for BAU and the lowest for FI, with BASE, LUF and SCF varying between the two extremes.
- Results from the thalweg medians replicated the pattern in application of catchment loads, with BASE, LUF and SCF generally varying between BAU and FI. Specifics of the response of each estuary are described in respective sections in this report.

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# 1 Introduction

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## 1.1 Background

Management of ecosystem health within Moreton Bay and Southeast Queensland's major estuaries has been at the forefront of environmental planning initiatives in the region since the mid- 1990s. Underpinning these initiatives has been the commissioning and completion of several numerical modelling studies, where study outcomes have been used, to various extents, to inform environmental policy and the direction of investment.

In response to a number of drivers, including the desire to plan for future urban development and catchment management including load reduction initiatives, BMT WBM on behalf of Healthy Land and Water Ltd. (HLW) were commissioned to develop a suite of numerical models of South East Queensland waterways. This undertaking involved building, calibrating and executing catchment and three-dimensional hydrodynamic receiving water quality models of Moreton Bay and its surrounding estuaries including:

- The Noosa, Maroochy, Mooloolah, Caboolture, Pine, Brisbane, Bremer, Logan and Albert Rivers;
- Cabbage Tree, Tingalpa, Erapah and Hilliards Creeks; and
- Pumicestone Passage.

These models have been peer reviewed and are being used to assist, to varying extents, in calculation of annual estuarine Report Cards.

The Queensland Department of Environment and Heritage Protection (DEHP) commissioned HLW to use these models to examine target setting of pollutant loads for a subselection of the catchment/estuary systems included in Report Card assessments. This report describes the methods used to do so, together with all predictions of estuarine response to various catchment management actions.

## 2 Methodology

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In order to support target setting in South East Queensland estuaries, a series of management Based scenarios were established by HLW and DEHP, then executed by BMT WBM using the models developed for HLW. This was achieved by linking flows and loads generated within Source catchment models of Southeast Queensland under the established scenarios, to the TUFLOW FV AED<sup>2</sup> receiving water quality models (RWQMs) developed for Report Card assessments. This approach was adopted for the following waterways:

- Maroochy
- Mooloolah
- Pumicestone passage
- Caboolture
- Pine
- Brisbane/Bremer
- Logan/Albert
- Moreton Bay

In the absence of RWQM's, Source predictions only were undertaken for the following waterways:

- Upper Brisbane
- Mid Brisbane
- Stanley
- Lockyer
- Oxley
- Noosa.

### 2.1 Scenarios

A total of 5 scenarios were executed as follows:

- (1) **Current (baseline) 2015** - Current land management practices and existing land uses.
- (2) **Business as Usual (BAU) 2030** - Current land management practices, with increased population and expanded urban footprint at 2030.
- (3) **Full Investment (FI) 2030** – BAU, but with every land use type/management initiative is undertaken to the fullest extent possible.
- (4) **Partial Investment Sub-catchment Focus (PI-SCF)** – BAU but with full investment (as above) in selected catchments which are responsible for generating the greatest pollutant load on a per hectare basis.

## Methodology

- (5) **Partial Investment Land Use Focus (PI-LUF)** – BAU but with full investment (as above) in selected land uses within all catchments which deliver the greatest pollutant load on a tonnes/year basis.

Annual catchment loads were computed for each of these scenarios using 2014/15 meteorological conditions. Regional rainfall for this year was approximately the long-term average (1137 mm at Lake Samsonvale BoM site, which has a mean of 1156 mm). The Source catchment models were used to estimate diffuse loads for all catchments, with the TUFLOW FV AED<sup>2</sup> models then being used to predict the water quality for waterways between the Logan River estuary to the Maroochy River estuary. Sewage treatment plant discharges were included in either Source or TUFLOW FV models, as required.

The scenario outputs focused on annual median thalweg (centreline) predictions for the following variables:

- Total nitrogen (TN);
- Total phosphorus (TP);
- Total suspended solids (TSS);
- Dissolved oxygen (DO); and
- Chlorophyll-a.

### 2.1.1 Baseline

The baseline results were computed using the Source models developed as part of the 2016 HLW Report Cards (HARC, 2017), but executed over the 2014/15 financial year period. Parameters used for the baseline scenario are presented in this section to provide context to changes in both BAU and FI scenarios.

#### 2.1.1.1 Catchments

Pollutant export was simulated using the event-mean concentration (EMC) and dry-weather concentration (DWC) approach, with values Based on those used in existing Source catchment models of the region (BMT WBM 2015). The EMC/DWC values used for the baseline simulation are presented below in .

Table 2-1.

**Table 2-1 Baseline EMC/DWC parameters**

Grouped Functional Units	Functional Unit	DWC (mg/l)			EMC (mg/l)		
		TSS	TN	TP	TSS	TN	TP
Green Space	Managed Forest	7	0.4	0.03	20	1.5	0.06
	Conservation	7	0.4	0.03	20	1.5	0.06
	Plantations	7	0.4	0.03	20	1.5	0.06
	Native vegetation	7	0.4	0.03	20	1.5	0.06

## Methodology

Grouped Functional Units	Functional Unit	DWC (mg/l)			EMC (mg/l)		
		TSS	TN	TP	TSS	TN	TP
Grazing	Grazing native vegetation	10	0.7	0.07	260	2.08	0.3
	Grazing modified pastures	10	0.7	0.07	260	2.08	0.3
Broadacre Agriculture	Broadacre Agriculture	10	0.7	0.07	300	1.95	0.321
	Horticulture	10	0.7	0.07	300	1.95	0.321
Intensive Agriculture	Irrigated Agriculture	10	0.7	0.07	550	5.2	0.449
Rural Residential	Rural Residential	10	0.7	0.07	130	1.6	0.28
	Peri-urban	10	0.7	0.07	130	1.6	0.28
Urban/Dense Urban	Urban residential	7	1.5	0.11	130	1.6	0.28
	Commercial	7	1.5	0.11	130	1.6	0.28
	Industrial	7	1.5	0.11	130	1.6	0.28
	Roads	7	1.5	0.11	130	1.6	0.28

### 2.1.2 Business as usual

#### 2.1.2.1 Catchments

The future land-use dataset was derived from the 2031 Regional Plan, which has three categories of land-use: Urban, Rural Residential and Rural Production. The existing Source land-use layer (derived from QLUMP 2012) (Figure 2-5) was then modified with the expanded urban or rural residential footprints (derived from QLUMP 2031) (Figure 2-6), as detailed .

Table 2-2.

**Table 2-2 BAU land use changes**

Functional Unit	Conversion Based on 2031 Regional Plan
Managed Forest	Unchanged
Conservation	Unchanged
Plantations	Unchanged unless classified as rural residential or urban in 2031
Native vegetation	Unchanged unless classified as rural residential or urban in 2031
Grazing native vegetation	Unchanged unless classified as rural residential or urban in 2031
Grazing modified pastures	Unchanged unless classified as rural residential or urban in 2031
Broadacre Agriculture	Unchanged unless classified as rural residential or urban in 2031
Horticulture	Unchanged unless classified as rural residential or urban in 2031
Irrigated Agriculture	Unchanged unless classified as rural residential or urban in 2031
Rural Residential	Unchanged unless classified as urban in 2031
Peri-urban	Unchanged unless classified as urban in 2031
Urban residential	Unchanged

## Methodology

Functional Unit	Conversion Based on 2031 Regional Plan
Commercial	Unchanged
Industrial	Unchanged
Roads	Unchanged

Note the 2031 expanded 'Urban' land-use was classified as Urban Residential in Source, rather than Commercial, Industrial or Roads (which have the same EMC/DWCs in any case). Furthermore, to reflect the construction associated with an expanded urban footprint, a portion of the additional urban land was classified as 'Construction' in Source, which was assigned the following EMC/DWC values (Table 2-3)(Brisbane City Council, 2000; BMT WBM *et al.* , 2014):.

**Table 2-3 Construction EMC/DWC parameters**

Functional Unit	DWC (mg/l)			EMC (mg/l)		
	TSS	TN	TP	TSS	TN	TP
Construction	12	2.8	0.06	5300	7.3	1.1

The proportion of future urban landuse was 6. 25% (1/16), which is equivalent to an assumption that construction will proceed linearly for 16 years and each site will be bare earth for a period of one year.

Catchment management actions within Source were simulated by applying a load reduction percentage to reduce the pollutant export from a given functional unit. Under the BAU scenario, the following load-reduction percentages were applied:

- 20% (TSS), 15% (TP) and 11. 25% (TN) applied for all newly developed areas, representing water-sensitive urban design for the expanded urban footprint with a 75% discount to planning policy (planning policy includes reductions of 80/60/45%). No retro-fitting of WSUD was assumed.
- In addition to the load reduction percentages, a pervious fraction of 0.3 was applied to new developments, reflecting a reduction in future lot sizes. The perviousness of existing urban developments decreased from 0.75 (baseline) to 0.5 (this is in keeping with MUSIC Guidelines suggesting 40 – 60% impervious for urban land with between 11 – 15 houses per ha.).
- No additional rural management practices were assumed to be in place (existing riparian vegetation is maintained).
- Sediment control practices on construction sites were assumed to result in a reduction of 10% (TSS). This was the upper limit of current compliance, estimated by HWL surveys and industry liaison. No literature supporting load reduction percentages for TN and TP was found for construction sites, so some indicative values were assumed. Following consultation with peer reviewers, BMT WBM applied a 10% reduction for TP and a 5% reduction for TN (as a substantial portion of TN may be in the dissolved form).

## Methodology

### 2.1.2.2 Wastewater treatment plant assumptions

Under both future scenarios, wastewater treatment plants (WWTPs) were assumed to have an increased flow Based on the additional population they serve (e. g. Brisbane's population will increase by 28% under the 2031 Regional Plan, therefore the flows at Brisbane plants will increase by 28% in the future BAU scenario). The concentrations of pollutants discharged under BAU remained the same as those applied for the baseline (i. e. reported values from the financial year 2014/2015).

### 2.1.2.3 Sediment nutrient release

In addition to catchment runoff and WWTP discharges, sediment release is a key source of nutrients to the receiving-environment models. Sediment nutrient release is a function of prior loads deposited within a waterway and it is expected that an increase in diffuse and point-source loads will lead to an increase in sediment flux, although the exact relationship is unclear. For the future scenarios, the baseline sediment nutrient fluxes were modified in line with the overall change in loads to the system, but with an additional reductive factor of 50% applied. For example, if combined catchment and WWTP loads increased by 70% over baseline, the sediment nutrient releases applied to the receiving-environment models were raised by 35% over baseline.

## 2.1.3 Full Investment

### 2.1.3.1 Catchments

The future land-use applied was the same as the BAU scenario, but improved management practices were incorporated through increased load-reduction percentages to the various land-use types as follows:

- Half of existing (2015) urban areas had retro-fitted WSUD and hence reductions applied of 40% (TSS), 30% (TP) and 22. 5% (TN) in keeping with Queensland state planning policy (Dept. of State Development, Infrastructure and Planning, 2014).
- All new urban development had WSUD applied leading to reductions of 80% (TSS), 60% (TP) and 45% (TN).
- It is noted that much of the assumed 80/60/45% pollution load reduction was likely to be achieved through an increase in effective perviousness. To prevent double counting of load reductions in Source, the perviousness for all urban (existing and new development) was set at 0.50, which was a decrease in perviousness from baseline. Although greater perviousness than this is achievable (best achievable in Healthy Waterways Living Waterways calculations is 0.80) it was felt that applying an 80/60/45% load reduction alongside high perviousness (>0. 7) would lead to an unrealistic representation of achievable outcomes.
- All rural areas (residential and production) had riparian re-vegetation applied, leading to reductions of up to 90% (TSS and TP) depending on the composition of the sub-catchment (Olley *et al.*, 2014). Note that although alternative management practices were not applied explicitly, it is envisaged that the reduction implied by the Olley *et al.* (2014) algorithms will be achieved through multiple means including riparian re-vegetation (e. g. improved agricultural practices, buffer zones, sediment traps).

## Methodology

- Rural areas with intensive fertiliser use (broadacre agriculture, irrigated agriculture and horticulture) had an 80% reduction in TN applied, representing a combination of management practices, including buffer zones (Croke *et al.*, 1999), modified fertiliser use (BMT WBM, 2008) and reduced stocking rates (BMT WBM, 2008).
- Construction sites had an 80% load-reduction percentage applied for TSS, representing appropriate execution of existing best-practice sediment control (BMT WBM *et al.* 2014). No literature supporting load-reduction percentages for TN and TP was found, so some indicative values were assumed. Following consultation with peer reviewers, BMT WBM applied an 80% reduction for TP and a 40% reduction for TN (as a substantial portion of TN may be in the dissolved form).

### 2.1.3.2 Wastewater treatment plant assumptions

For the FI scenario, WWTPs were simulated with increased discharge volumes in line with predicted population increases. Unlike the BAU scenario, however, 50% of the total volume was assumed to be re-used rather than discharged to the receiving environment. Hence, there was a 50% reduction in the volume of WWTP effluent per capita applied. In addition to flow changes, the nutrient concentration in discharges were assumed to be the lesser than those of the baseline discharge and 3 mg/L (TN) or the baseline discharge and 1 mg/L (TP).

### 2.1.3.3 Sediment nutrient release

The same methodology as BAU was applied, with modifications to sediment nutrient flux scaled to the overall catchment and sewage treatment plant loads entering the system.

## 2.1.4 Partial Investment – Sub-catchment Focus

### 2.1.4.1 Catchments

The purpose of this scenario was to identify those sub-catchments which generated the most pollutant load per hectare and focus management actions in those sub-catchments. Three key pollutants were considered (TSS, TN and TP). To identify those sub-catchments to which management actions were applied, the following steps were taken:

- All sub-catchments were ranked in order of load per hectare of TSS, TN and TP (i. e. each sub-catchment was given 3 ranks, one for each pollutant)
- A single rank was determined for each sub-catchment by weighting the ranks as follows:
  - A 50% weighting applied to the TSS rank
  - A 25% weighting applied to the TN rank
  - A 25% weighting applied to the TP rank
- The percentiles of total catchment load using the same weighting as above were computed
- In order of weighted rank, the highest load-producing sub-catchments were selected until the sum of weighted percentiles exceeded the 75<sup>th</sup> percentile (i. e. the most polluting sub-catchments)

## Methodology

which make up 75% of total load were selected). Figure 2-3 shows the areas of application of FI methodology in the catchment model.

FI measures were applied to the selected sub-catchments while the others are set to BAU. A map of the selected areas have been shown in Figure 2-3.

### 2.1.4.2 Sediment nutrient release

The same methodology as other future scenarios was applied, with modifications to sediment nutrient flux again scaled to the overall loads entering the system.

## 2.1.5 Partial Investment – Land Use Focus

### 2.1.5.1 Catchments

The purpose of this scenario was to identify those land uses which generate the most pollutant load across all catchments and focus management actions on those. The top 2 pollutant load generating land uses were selected and FI scenario applied to areas with the selected landuse. As per the PI-SCF scenario above, WWTP loads were incorporated in the assessment alongside diffuse loads.

Total TSS, TP and TN loads were calculated on a per catchment and per land-use basis for the period 1/7/2014 to 1/7/2015. For each catchment, the land uses and WWTPs were ranked by total TSS, TP and TN load using the weighting as described in the PI-SCF scenario above. The top two ranked land uses (or WWTPs) were assigned the FI methodology to them, and the rest had the BAU methodology applied. A map of the selected areas have been shown in Figure 2-4.

**Table 2-4 List of land uses selected for application of FI for each catchment in the PI-LUF scenario**

Catchment	Land Use - Rank 1	Land Use - Rank 2
Maroochy	Grazing Natural Veg	Rural Residential
Mooloolah	Future Urban	Urban Residential
Noosa	Grazing Natural Veg	Conservation
Bribie Island	Urban Residential	Future Urban
Caboolture	Grazing Natural Veg	Future Urban
Pine	Grazing Natural Veg	Future Urban
Pumicestone	Horticulture	Future Urban
Albert	Grazing Natural Veg	Future Urban
Bremer	Grazing Natural Veg	Future Urban
Lockyer	Grazing Natural Veg	Future Urban
Logan	Grazing Natural Veg	Future Urban
Lower Brisbane	Urban Residential	Future Urban
Mid Brisbane	Grazing Natural Veg	Future Urban
Redland	Urban Residential	Future Urban
Stanley	Grazing Natural Veg	Rural Residential

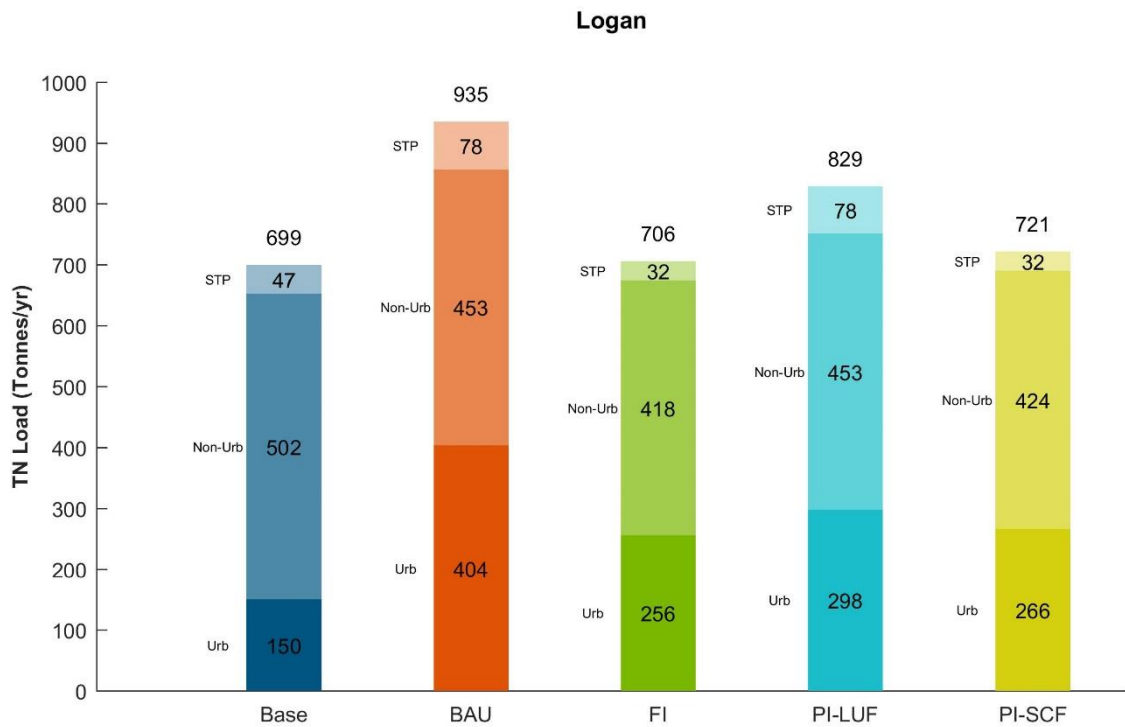
Catchment	Land Use - Rank 1	Land Use - Rank 2
Upper Brisbane	Grazing Natural Veg	Broadscale Cropping

### 2.1.5.2 Sediment nutrient release

The same methodology as other future scenarios were applied, with modifications to sediment nutrient flux again scaled to the overall load entering the system.

### 2.1.6 Catchment loads

The catchment loads for TSS, TN and TP delivered to each receiving water model were calculated separately for urban, non urban and STP sources. An example catchment load is presented in Figure 2-1, all catchment load plots are configured in this way.



**Figure 2-1 Example catchment loads**

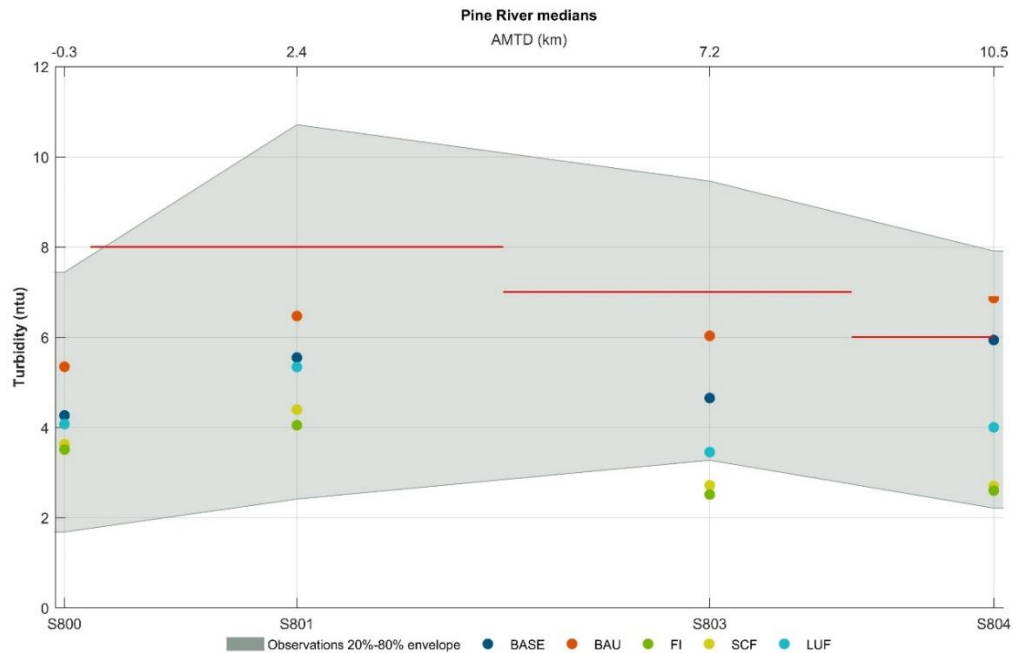
The figure presents the catchment loads for each of 5 scenarios with the darkest shading representing urban loads, medium shading representing non-urban loads and lightest shading loads from STPs. The numbers presented on the plot show aggregated loads from all subcatchments flowing into the designated system.

### 2.1.7 Receiving Water Models

The receiving water models were adapted Based in the most recent build from the 2016 HLW Report Cards and run over FY 2014-15 (BMT WBM, 2016). The model performance was calibrated against EHMP data and the calibration results of all the estuaries are provided in Appendix 1.

### 2.1.8 Thalweg medians

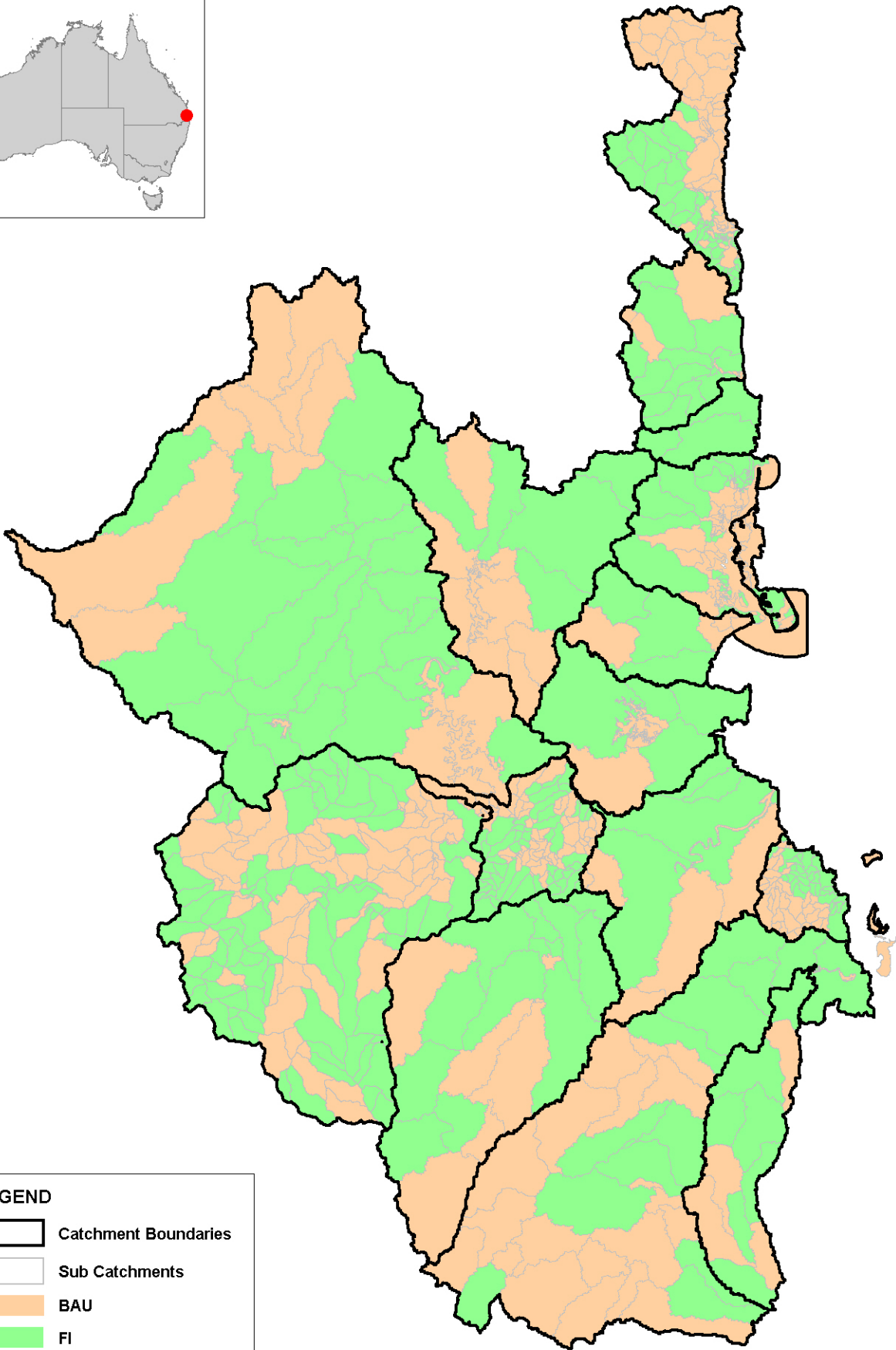
In order to provide a linkage between historical assessments of river health that use annual medians computed at each EHMP location, model predictions have been recast as annual medians at the EHMP sampling sites, again using model outputs that are simple point to point EHMP data comparisons. An example thalweg comparison is presented in Figure 2-2, and all thalweg plots are configured in this way.



**Figure 2-2 Example thalweg comparison**

The figure presents:

- BASE (blue dots), BAU (orange dots), FI (green dots), SCF (yellow dots) and LUF (turquoise dots) annual medians of a particular quantity
- The value of this quantity is presented on the ordinate (y-axis)
- Water quality objectives (WQOs) specified by DEHP have been included as red lines in the median plots, where appropriate
- The abscissa (x-axis) presents increasing distance from the river mouth from left to right, labelled as EHMP data site names (lower abscissa) and AMTDs (upper abscissa)
- The greyed area on the figure is the range in spot EHMP data points measured over the 12 month period (Jul 2014 - Jul 2015) at each location, represented by the 20<sup>th</sup> (lower edge of greyed area) to 80<sup>th</sup> (upper edge of greyed area) percentile range
- The values for each scenario are plotted in the order - BASE, PI-SCF, PI-LUF, BAU and FI. In some cases the values for all the five scenarios may overlap and multiple dots may not be visible.



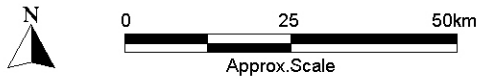
**LEGEND**

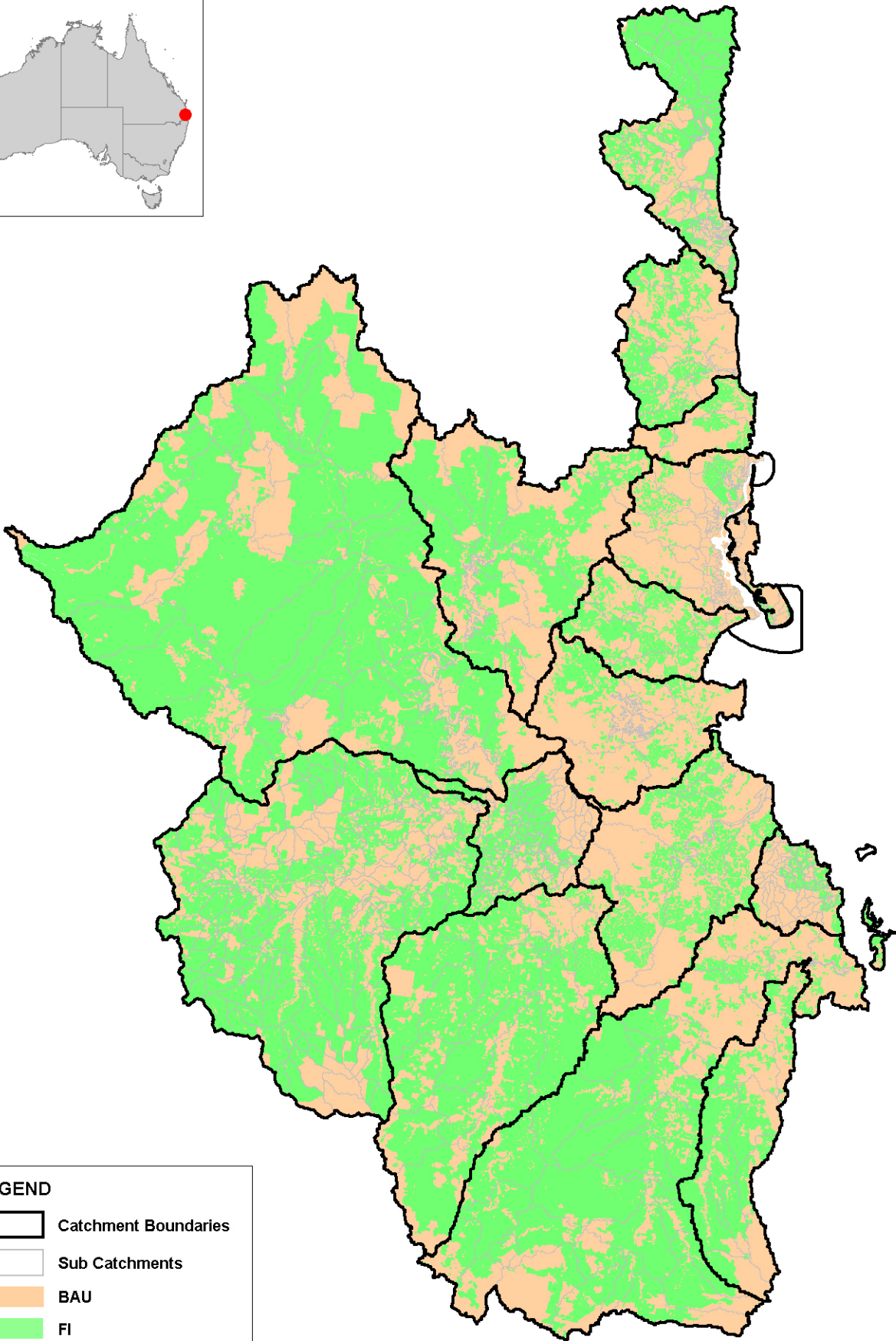
- Catchment Boundaries
- Sub Catchments
- BAU
- FI

Title: **Areas showing areas of application of Full Investment scenario for PI-SCF scenario**





Figure: **2-3** Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.





**LEGEND**

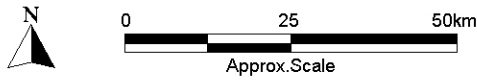
-  Catchment Boundaries
-  Sub Catchments
-  BAU
-  FI

Title: **Areas showing areas of application of Full Investment scenario for PI-LUF scenario**

Figure: **2-4**

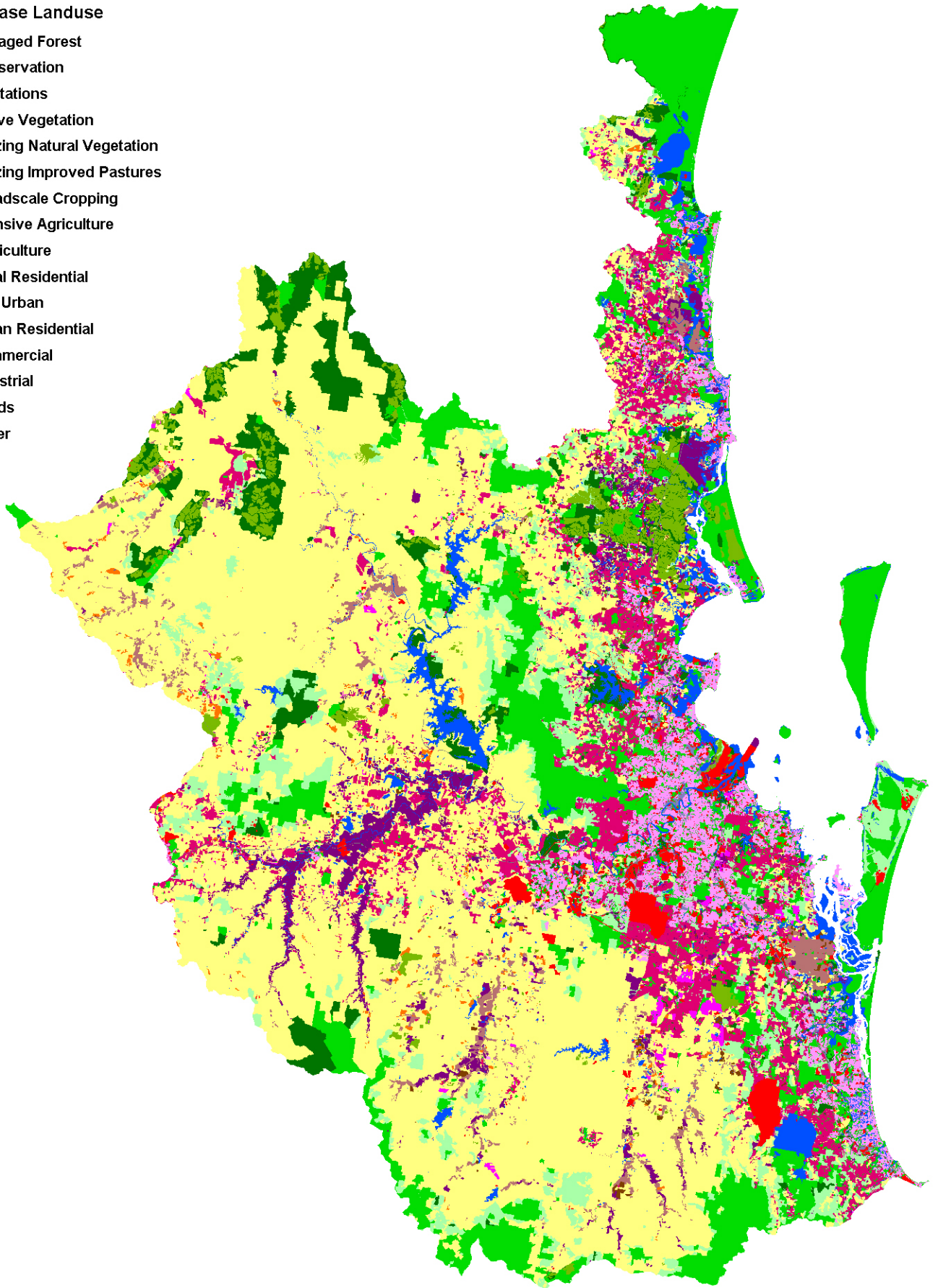
Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



**QLUMP Base Landuse**

- Managed Forest
- Conservation
- Plantations
- Native Vegetation
- Grazing Natural Vegetation
- Grazing Improved Pastures
- Broadscale Cropping
- Intensive Agriculture
- Horticulture
- Rural Residential
- Peri Urban
- Urban Residential
- Commercial
- Industrial
- Roads
- Water



Title:  
**QLUMP Base Land Use**

Figure:  
**2-5**

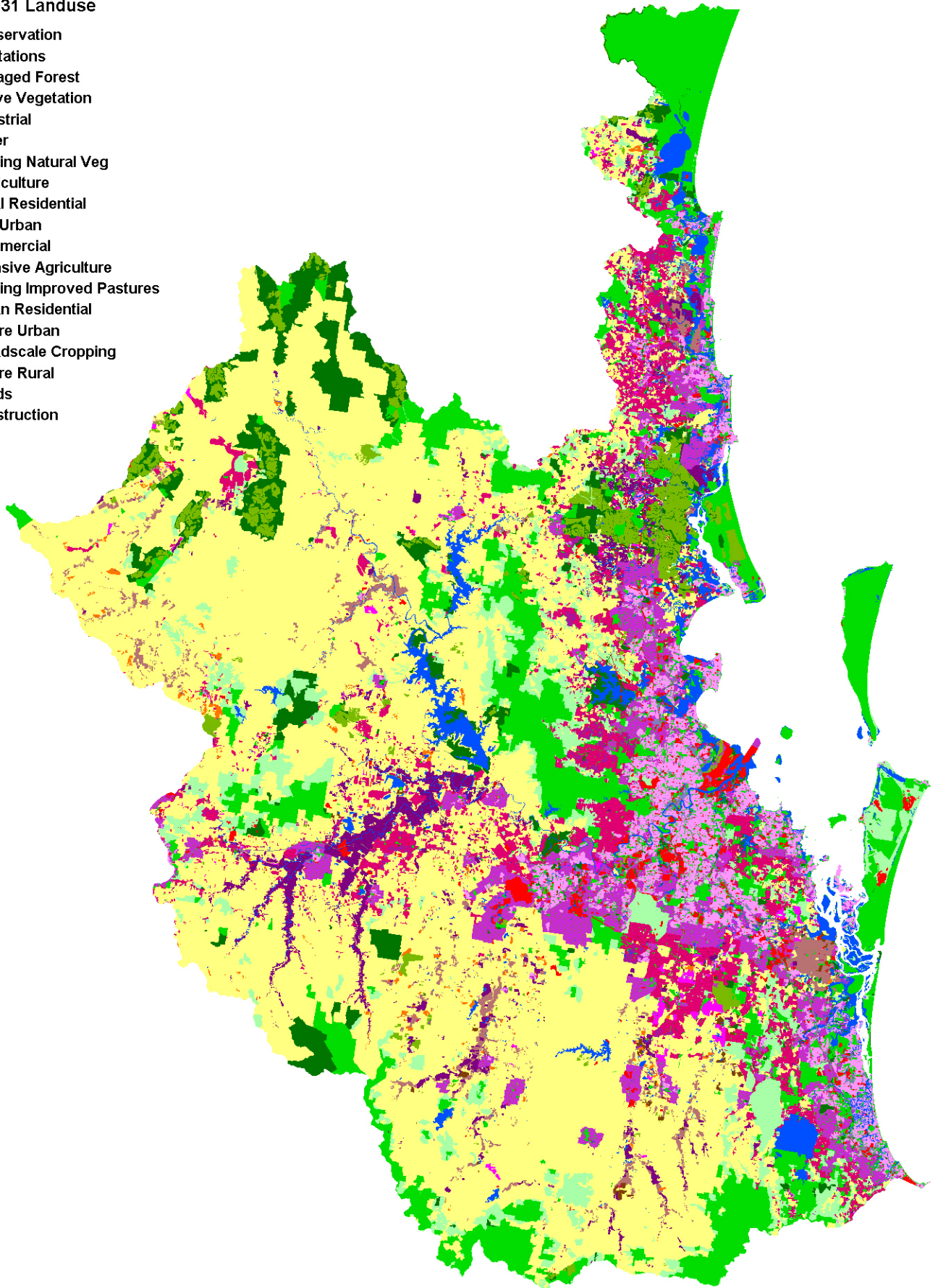
Rev:  
**A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



**QLUMP 2031 Landuse**

- Conservation
- Plantations
- Managed Forest
- Native Vegetation
- Industrial
- Water
- Grazing Natural Veg
- Horticulture
- Rural Residential
- Peri Urban
- Commercial
- Intensive Agriculture
- Grazing Improved Pastures
- Urban Residential
- Future Urban
- Broadscale Cropping
- Future Rural
- Roads
- Construction



Title:  
**QLUMP 2031 Land Use**

Figure:  
**2-6**

Rev:  
**A**

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## 3 Results and Discussion

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The results of the study are presented below. These include catchment loads delivered to each receiving model and thalweg pollutant median plots for each estuary. It must be noted that catchment loads are presented to the nearest tonne, which is beyond the model uncertainty bounds. As such, results should not be interpreted to be accurate to this level.

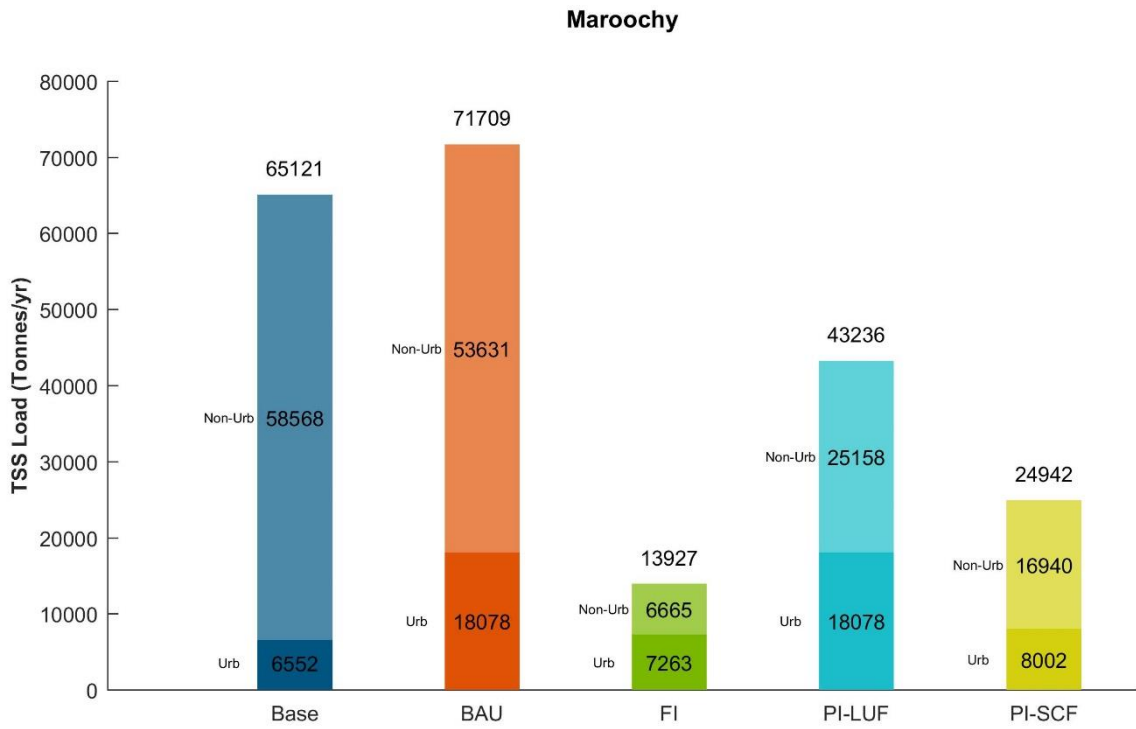
### 3.1 Maroochy

#### 3.1.1 Catchment Loads

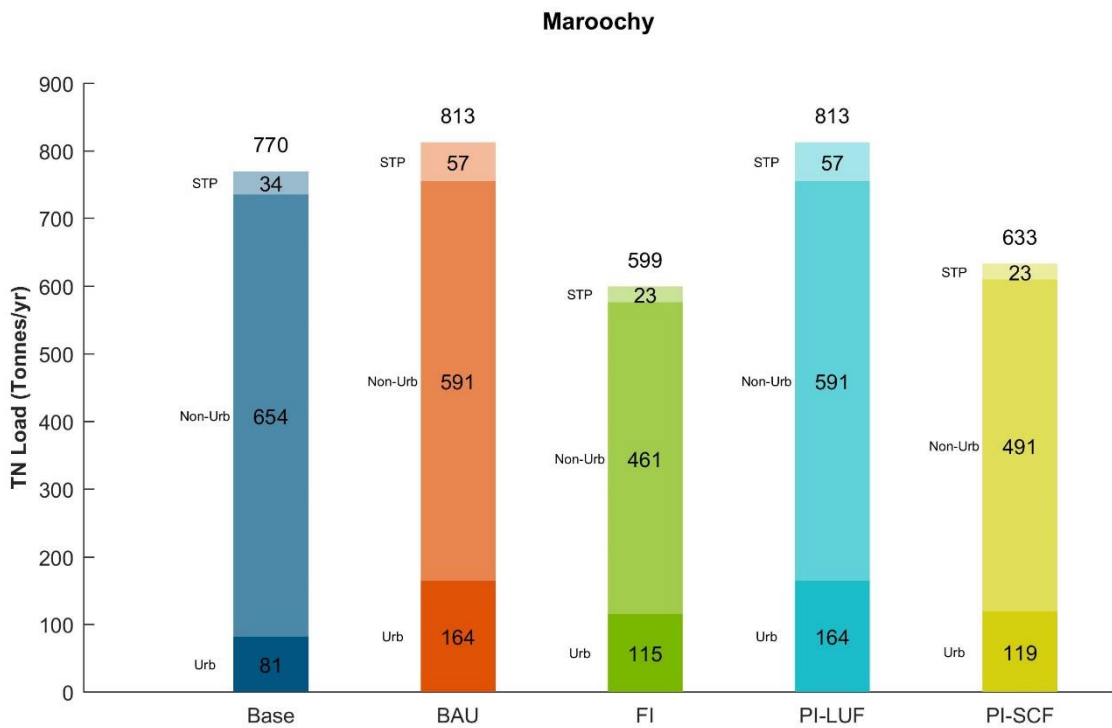
In the FI scenario, the TSS exports from the catchment were reduced by about 80% compared to the BAU scenario (Figure 3-1). Investing in minimising the pollutants on a land use basis (LUF scenario), reduced the TSS exports by 40% compared to the BAU scenario, whereas investing in minimising the pollutants on a per hectare basis (SCF scenario) reduced the TSS exports by 65% compared to BAU.

Overall, the TN loads from the Maroochy catchment were not greatly impacted by the investment strategies considered (Figure 3-2). Compared to the BAU scenario, the FI scenario decreased the exports by 26%, which represents a 19% decrease compared to the BASE. The LUF scenario reduced the TN exports by less than 1% compared to the BAU scenario, whereas the SCF scenario reduced the TN exports by 22% compared to the BAU. As such, investing in minimising the pollutants on a per sub-catchment basis (SCF scenario) reduced the TN exports by 22% more than investing in minimising the pollutants on a land use basis (LUF scenario).

The FI scenario led to a decrease in TP exports from the catchment by 72% (Figure 3-3), which represents a 68% decrease compared to the BASE. The LUF scenario decreased TP exports by 41% compared to BAU, whereas SCF decreased a further 18% (i. e., a 59% reduction from the BAU scenario).



**Figure 3-1 TSS catchment loads from Maroochy**



**Figure 3-2 TN catchment loads from Maroochy**

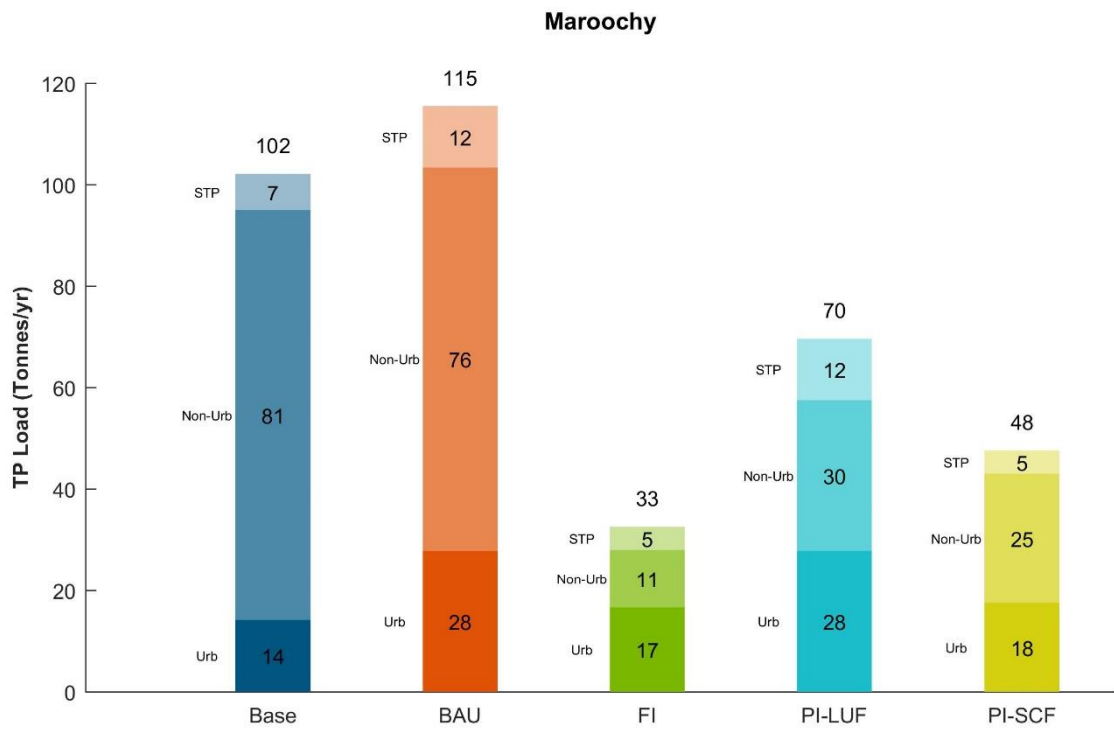


Figure 3-3 TP catchment loads from Maroochy

### 3.1.2 Turbidity

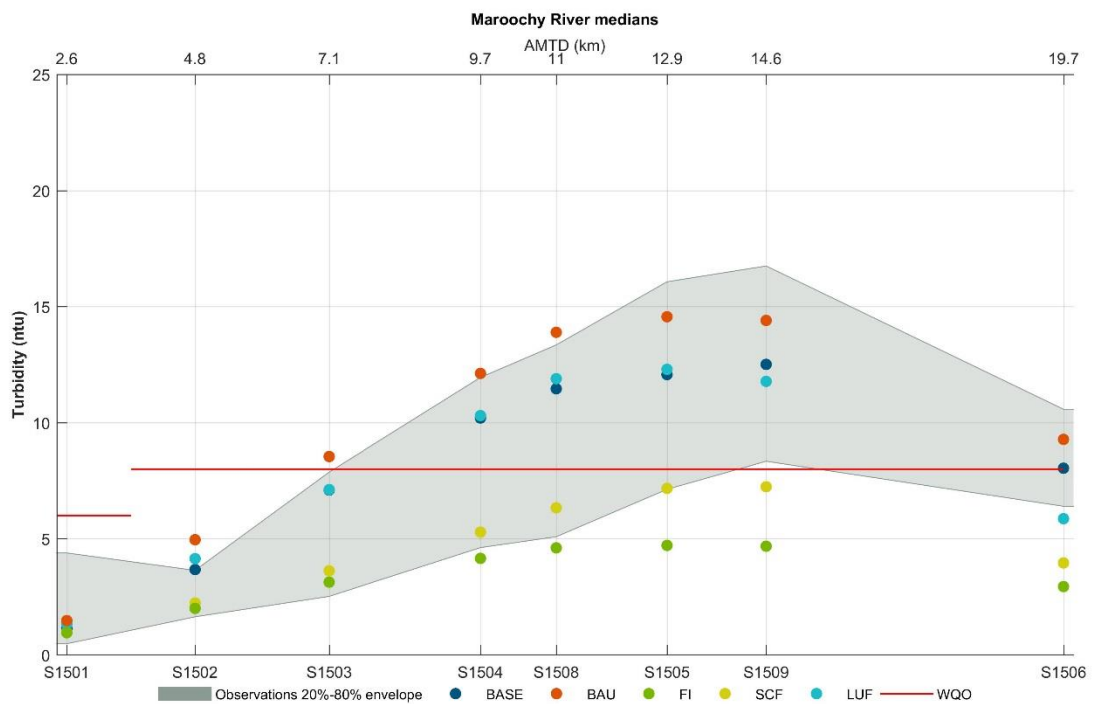
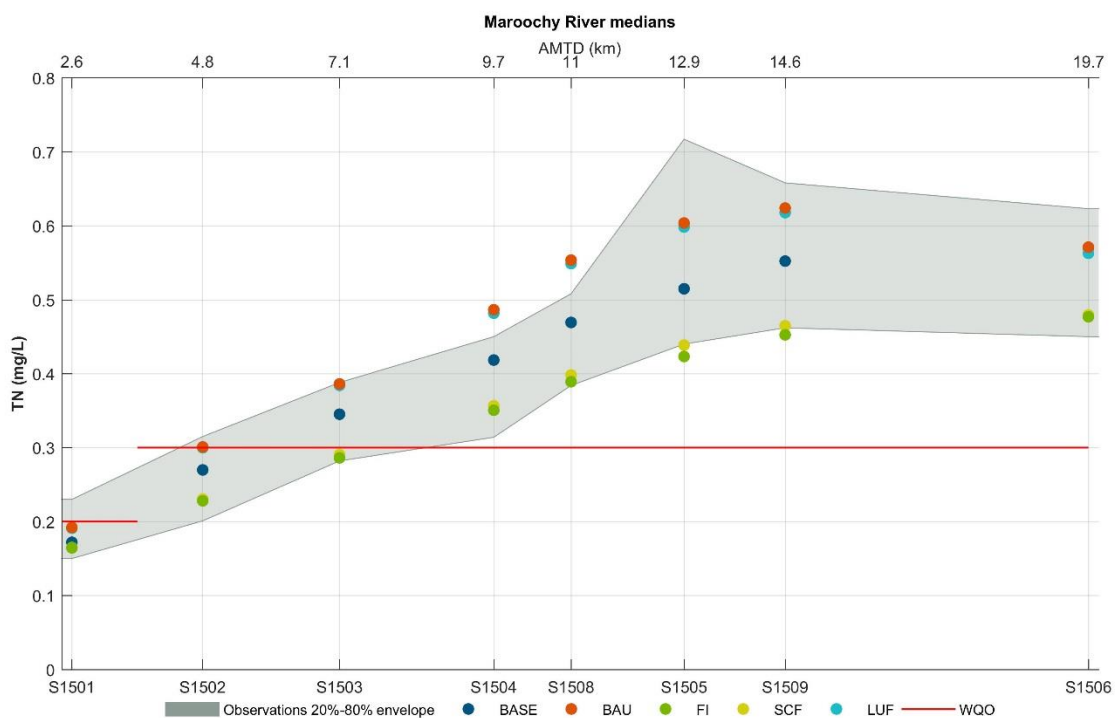


Figure 3-4 Comparison of Turbidity medians across scenarios for Maroochy

For the Maroochy estuary, the difference in turbidity between the BASE and LUF scenarios was relatively small, compared to the catchment loads (see Figure 3-4). The BAU scenario, however, increased the median turbidity by approximately 19% in the middle reaches, compared to the BASE scenario. Conversely, the FI scenario predicted a considerable decrease in turbidity (approximately 58% lower than the BASE scenario). The PI-SCF scenario has similar albeit slightly higher values. As a result, the turbidity in the Maroochy estuary could possibly meet water quality objectives (WQOs) if the FI or PI-SCF scenario was adopted, under the conditions considered in this study. The predicted turbidity medians in the lower reaches of the estuary complied with WQO limits for all five scenarios.

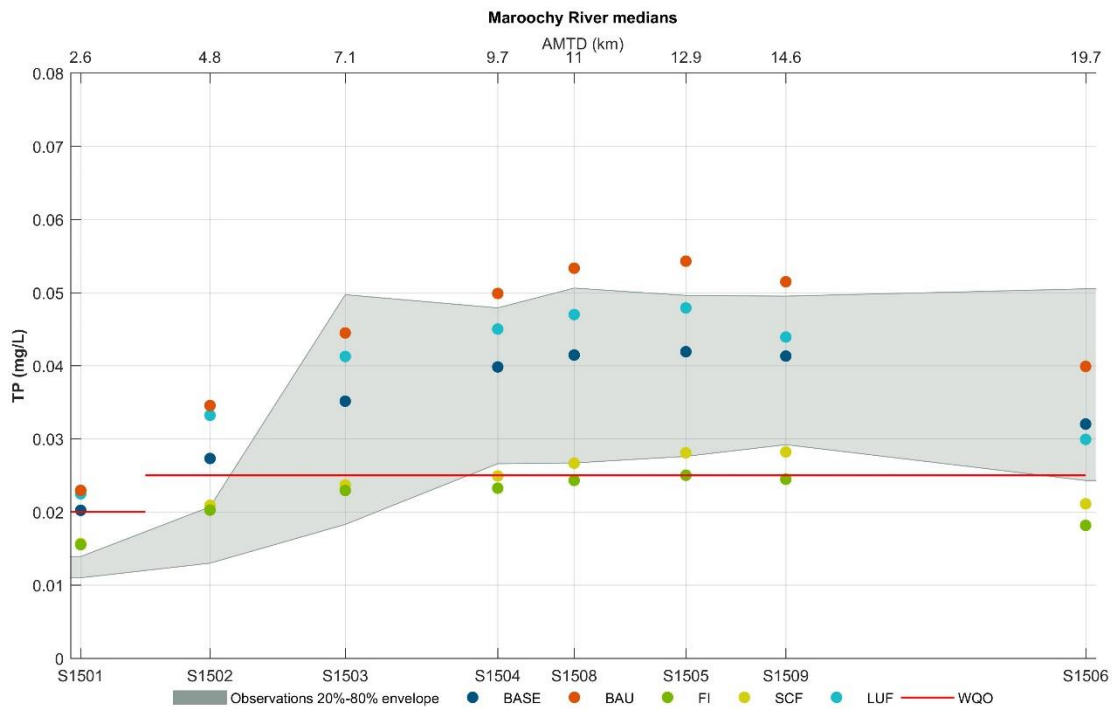
### 3.1.3 Total nitrogen



**Figure 3-5 Comparison of TN medians across scenarios for Maroochy**

The median values in the middle reaches of the Maroochy estuary predicted a TN concentration for the BAU and LUF scenarios up to 15% higher than for the BASE scenario (Figure 3-5). The SCF and FI scenarios predicted a TN concentration approximately 14% lower than the BASE scenario. The FI scenario predicted a TN median concentration at station S1503 that complied with WQOs. The predicted mean TN concentrations in the middle reaches and at the head of the estuary, however, failed to comply with WQOs for all scenarios. The model also predicted that the TN concentrations at the lower reaches of the estuary (stations S1501 and S1502) quite close to the WQO values for the BAU scenario.

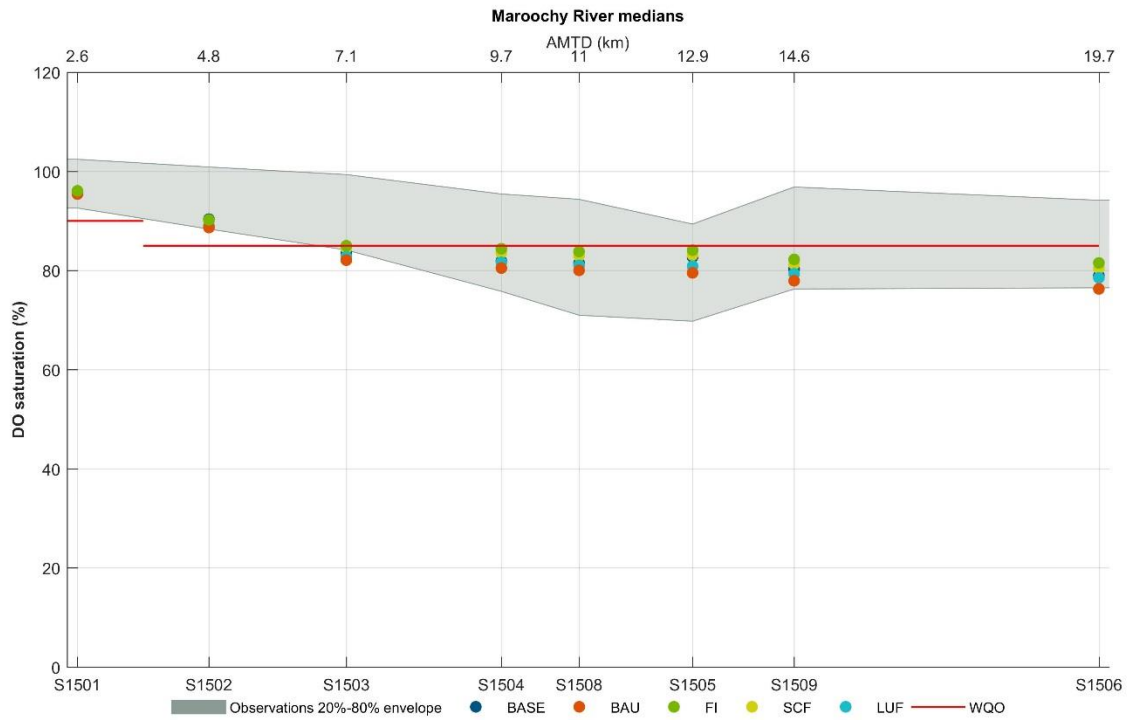
### 3.1.4 Total phosphorus



**Figure 3-6 Comparison of TP medians across scenarios for Maroochy**

The predicted median TP concentration in the middle reaches of the Maroochy estuary for the BAU scenario was 31.7% higher than the BASE (Figure 3-6), whereas the LUF scenario was predicted as 14.6% higher than the BASE. The SCF scenario predicted a TP concentration of approximately 32% lower than the BASE scenario, whereas the FI scenario predicted a TP concentration approximately 39% lower than the BASE scenario. The water quality model predicted that median TP concentrations in the middle and lower reaches of the Maroochy estuary would comply with WQOs in the FI scenario while the PI-SCF scenario comes close to the WQO guidelines. Currently (BASE), only the lower reaches of the estuary comply with the WQOs.

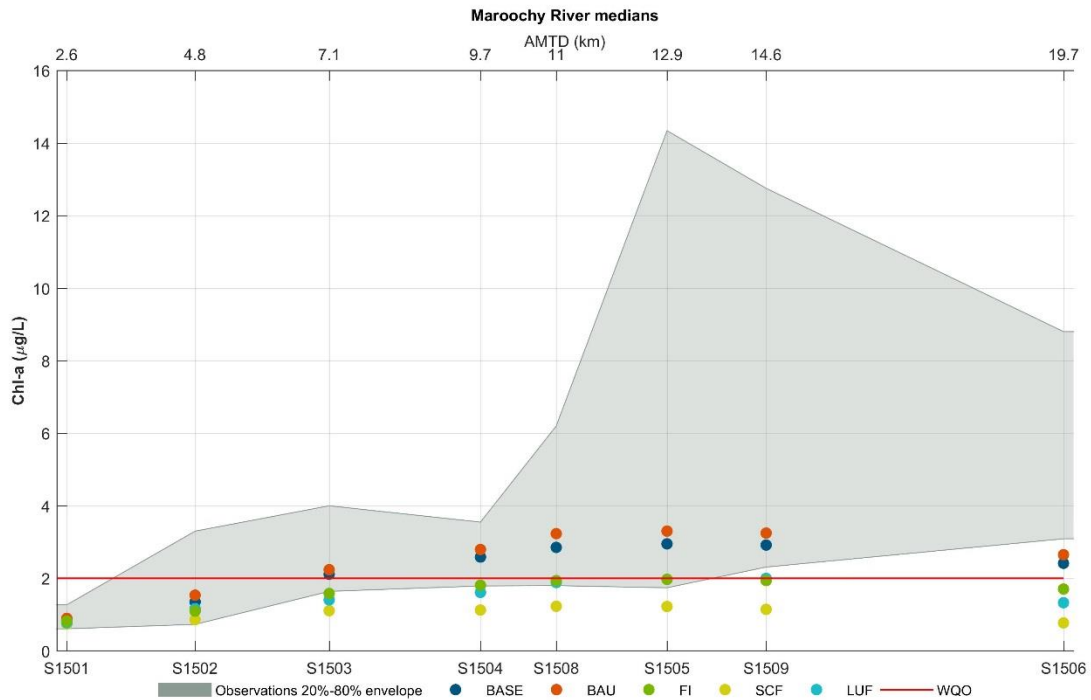
### 3.1.5 Dissolved Oxygen Saturation



**Figure 3-7 Comparison of DO saturation medians across scenarios for Maroochy**

The predicted median DO concentrations in the Maroochy estuary were similar in all five scenarios (Figure 3-7). Similarly to the BASE scenario (current state), only the lower reaches of the estuary complied to the DO concentration limits set by the WQOs for all scenarios.

### 3.1.6 Chlorophyll-a



**Figure 3-8 Comparison of Chlorophyll-a medians across scenarios for Maroochy**

In its current state (BASE scenario), the Maroochy estuary exhibits low Chlorophyll-a concentrations. The BASE and BAU scenarios exceed WQOs in the middle and lower estuary. All other scenarios comply with WQO guidelines (Figure 3-8).

### 3.1.7 Conclusions

- The catchment model predicted significant reductions in TSS for FI compared to BAU. SCF predicted a better outcome in TSS loads than LUF. Overall, TN loads from the Maroochy catchment were not greatly impacted by the investments aiming to reduce catchment exports. For TP, scenarios FI, SCF and LUF decreased exports by approximately 68%, 41% and 18% compared to the BASE, respectively, whereas BAU increased loads by approximately 17%.
- The turbidity in the Maroochy estuary complied with WQOs only in the FI scenario.
- The TN concentrations at the middle reaches and at the head of the estuary failed to comply with WQOs in all scenarios tested.
- Except two sites in the lower estuary, the predicted DO medians for the Maroochy estuary did not comply with concentration limits set by WQOs in all scenarios tested. FI and PI-SCF were the closest to the WQOs.
- The predicted chlorophyll-a medians for the FI, PI-SCF and PI-LUF scenarios complied with WQOs at all sites.

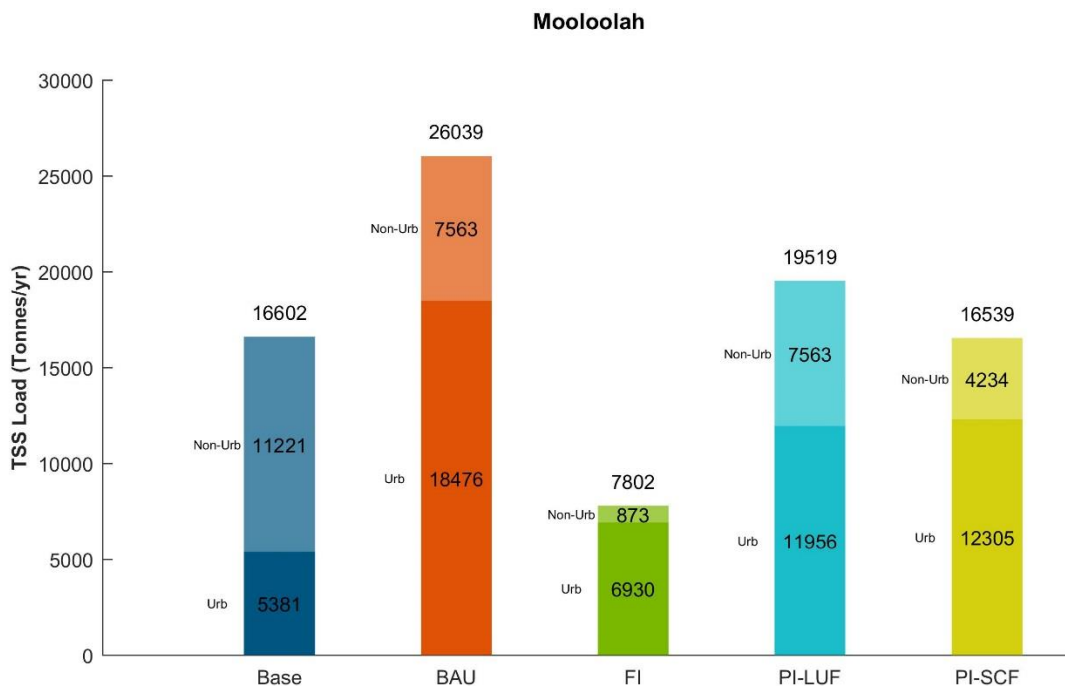
## 3.2 Mooloolah

### 3.2.1 Catchment Loads

The Mooloolah river catchment currently exports relatively low TSS loads when compared to other systems. Compared to the BASE scenario, the BAU scenario predicted an approximately 36% increase in TSS load whereas the FI scenario yielded a reduction of 55% (Figure 3-9). Investing in minimising the pollutants on a land use basis (LUF scenario) would reduce the TSS exports by 25% compared to the BAU scenario. Investing in minimising the pollutants on a per hectare basis (SCF scenario) would reduce the TSS exports by 35% compared to the BAU. The LUF scenario has higher TSS load compared to the BASE scenario, while SCF was lower than the BASE scenario.

Overall, the TN load was not greatly impacted by investments aimed at reducing catchment exports (Figure 3-10). For TN, the catchment loads are expected to rise by 35% in the BAU scenario in comparison to the BASE. The FI scenario showed comparable TN load to the BASE, whereas the increase in TN loads predicted for SCF and LUF were 17 and 7%, respectively.

The BAU scenario predicted almost 30% increase in TP exports compared to current conditions in the Mooloolah river (Figure 3-11). Both SCF and LUF scenarios presented TP exports similar to the BASE. The FI scenario decreased loads by 39% compared to the BASE, this represents a 57% decrease compared to the BAU scenario.



**Figure 3-9 TSS catchment loads from Mooloolah**

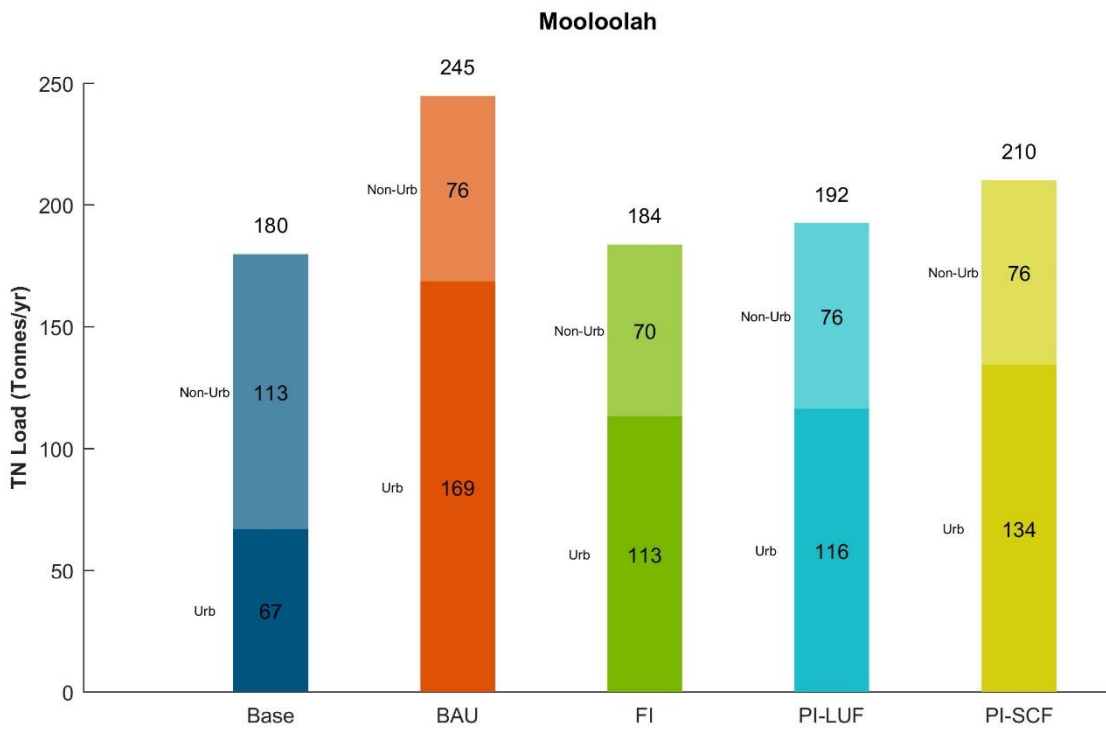


Figure 3-10 TN catchment loads from Mooloolah

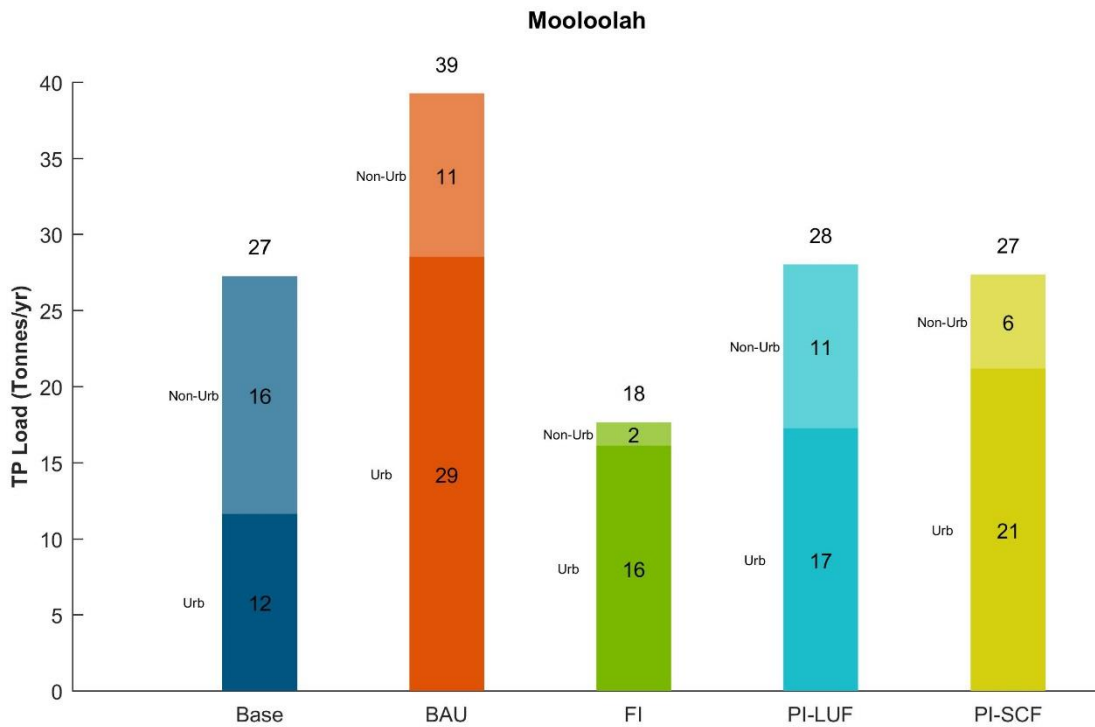
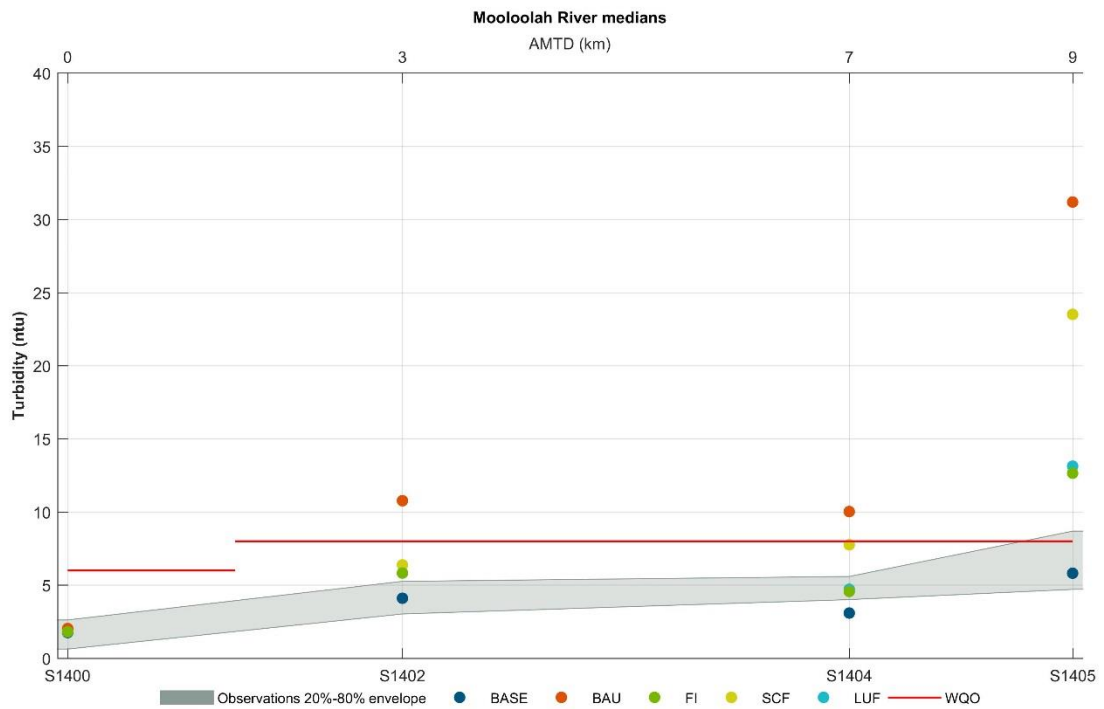


Figure 3-11 TP catchment loads from Mooloolah

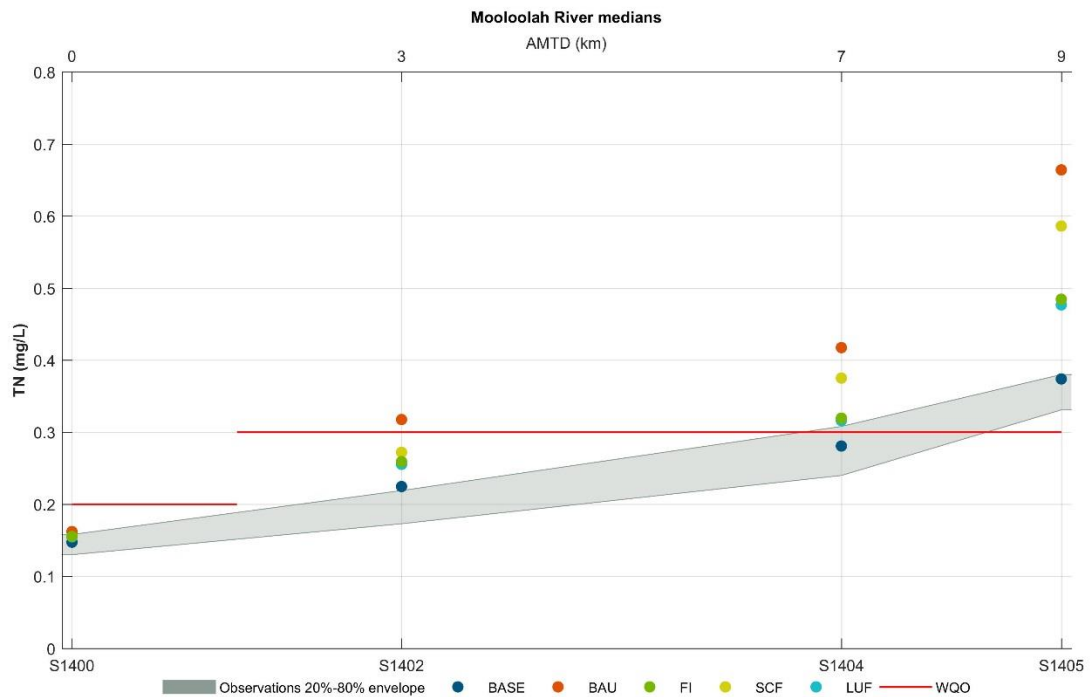
### 3.2.2 Turbidity



**Figure 3-12 Comparison of Turbidity medians across scenarios for Mooloolah**

The results of the water quality model suggest that the Mooloolah estuary would effectively settle the excess suspended solids added at the estuary head in each of the scenarios tested (Figure 3-12). The reason for the high spread in incoming turbidities from the scenarios can be attributed to increased flow for future scenarios and a smaller cross-section at head of estuary and the impact of volume is greater, becoming less pronounced at next station as river widens out. Due to the higher loads added at the estuary head, all scenarios failed to comply with WQOs. In the middle and downstream reaches, all scenarios comply with WQOs. The exception was the BAU scenario, which failed to comply to the turbidity limits set by the WQOs, except at station S1400, located at the estuary mouth.

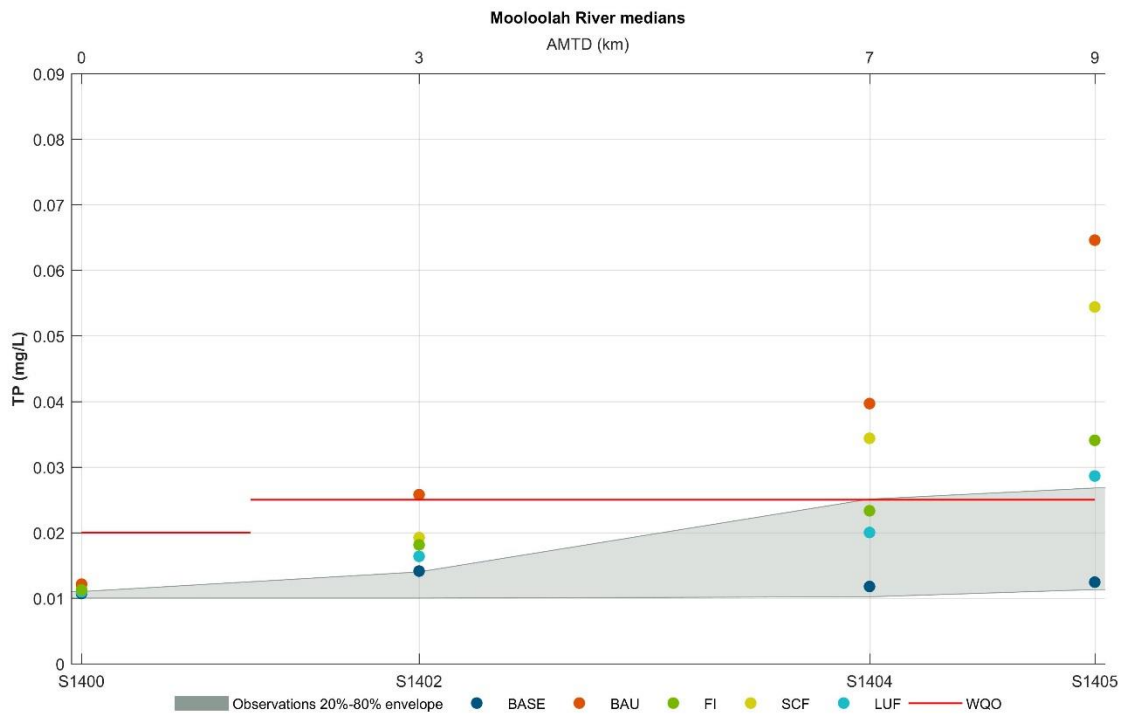
### 3.2.3 Total nitrogen



**Figure 3-13 Comparison of TN medians across scenarios for Mooloolah**

The median values in the middle reaches of the Mooloolah estuary predicted median TN concentrations for the BAU scenario up to 32% higher than for the BASE scenario (Figure 3-13). In station S1404, none of the scenarios except BASE complied with WQOs, whereas in station S1402, all but the BAU scenario complied. At the head of the estuary, none of the scenarios complied whereas at the estuary mouth predicted TN medians for all scenarios complied with WQOs.

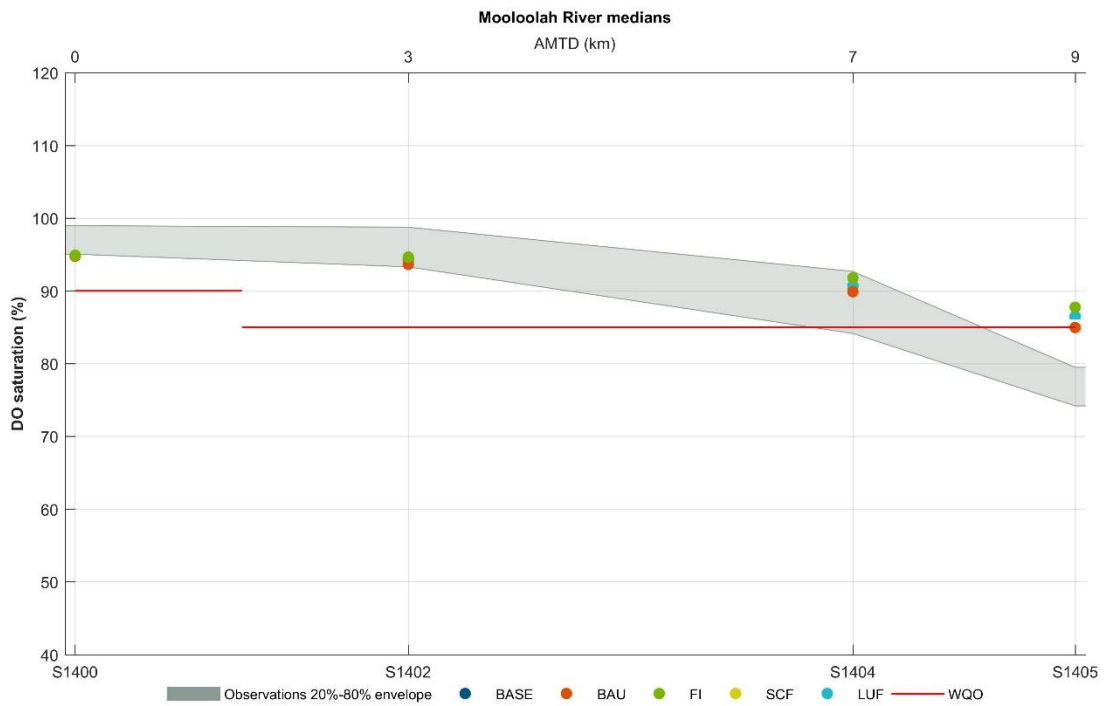
### 3.2.4 Total phosphorus



**Figure 3-14 Comparison of TP medians across scenarios for Mooloolah**

The median TP concentration in the middle reaches of the Mooloolah estuary for the BAU scenario was predicted to be between 46% and 70% higher than the BASE (Figure 3-14). The water quality model predicted that the BAU scenario would fail to comply with WQOs, except at the estuary mouth. Compared to the SCF, the LUF scenario showed a better TP concentration outcome. LUF failed to comply to the WQOs only at the estuary head.

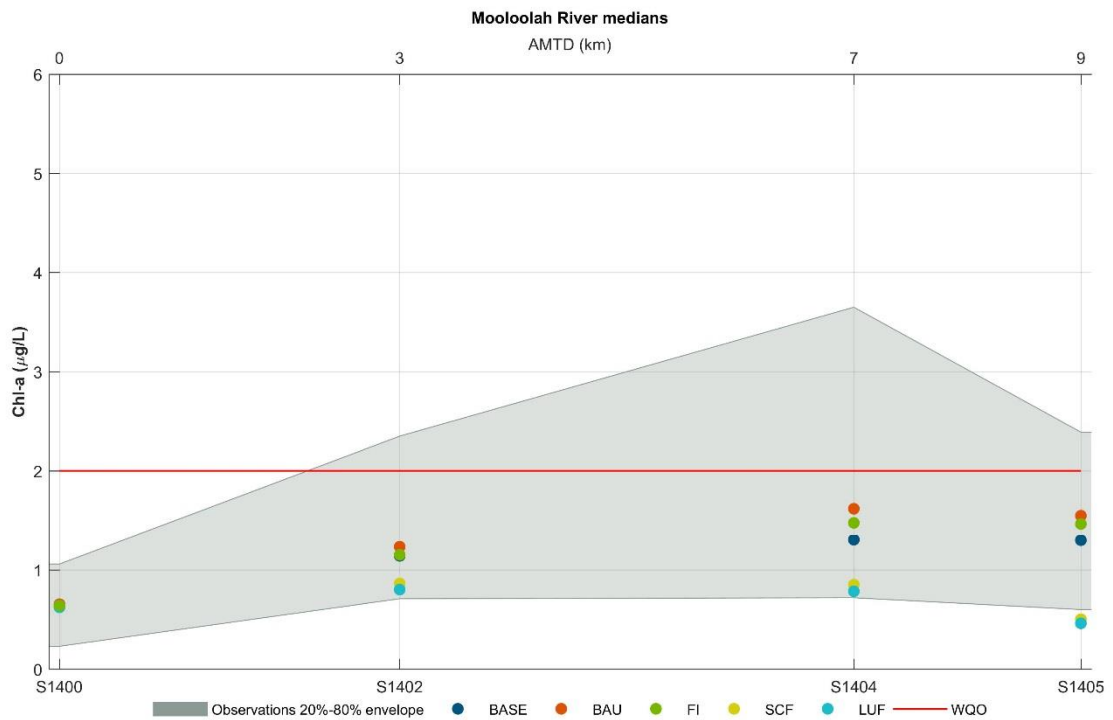
### 3.2.5 Dissolved Oxygen Saturation



**Figure 3-15 Comparison of DO saturation medians across scenarios for Moolooloolah**

The predicted DO concentrations in the Moolooloolah estuary were similar in all scenarios tested (Figure 3-15). Similarly to the current status (BASE), all scenarios complied to the DO concentration limits set by WQOs at all stations.

### 3.2.6 Chlorophyll-a



**Figure 3-16 Comparison of Chlorophyll-a medians across scenarios for Mooloolah**

At its current state (BASE scenario), the Mooloolah estuary exhibits low chlorophyll-a concentrations. Similarly, to the BASE, all scenarios tested complied to the chlorophyll-a concentration limits set by the WQOs for the whole estuary (Figure 3-16).

### 3.2.7 Conclusions

- Both SCF and LUF scenarios presented a TSS load greater than the current condition (BASE scenario). Compared to the BASE scenario, BAU predicted 36% increase in TSS load and the FI a reduction of 55%. Overall, TN loads from the Mooloolah catchment were not greatly impacted by the investments aiming to reduce catchmen pollutant export. Both SCF and LUF scenarios presented TP exports similar to the BASE, whereas the FI scenario decreased TP exports by 39%.
- The turbidity and TN at the lower reaches of the Mooloolah estuary complied with WQOs in all scenarios but failed to comply at the estuary head.
- The TP concentration at the upper reaches of the Mooloolah estuary failed to comply with WQOs in all but the BASE scenario.
- The Mooloolah estuary complied to the DO and Chlorophyll-a concentration limits set by WQOs in all scenarios tested.

### 3.3 Pumicestone Passage

#### 3.3.1 Catchment Loads

In the FI scenario, the TSS exports from the Pumicestone catchment reduced by 75% when compared to the BAU scenario (Figure 3-17), which represents a 66% decrease compared to the BASE. Investing in minimising the pollutants on a land use basis (LUF scenario), reduced the TSS exports by 31% compared to the BAU scenario, whereas investing in minimising the pollutants on a per hectare basis (SCF scenario) reduced the TSS exports by 64% compared to the BAU.

Compared to the BAU scenario, the TN loads from the Pumicestone catchment decreased exports by 38% in the FI scenario, which represents a 34% decrease compared to the BASE (Figure 3-18). Investing in minimising pollutants on a per hectare basis (SCF scenario) and investing in minimising pollutants on a land use basis (LUF scenario) both reduced the TN exports by approximately 31% compared to the BAU and by 26% compared to the BASE scenario.

Compared to the current status of Pumicestone catchment (BASE scenario), the BAU scenario increased TP exports by 41%, whereas the FI scenario decreased TP exports by 10% compared to the BASE (Figure 3-19). Investing in minimising the pollutants on a per hectare basis (SCF scenario) decreased the TP exports by approximately 5%, whereas investing in minimising the pollutants on a land use basis (LUF scenario) increased the TP exports by approximately 20% compared to the BASE scenario.

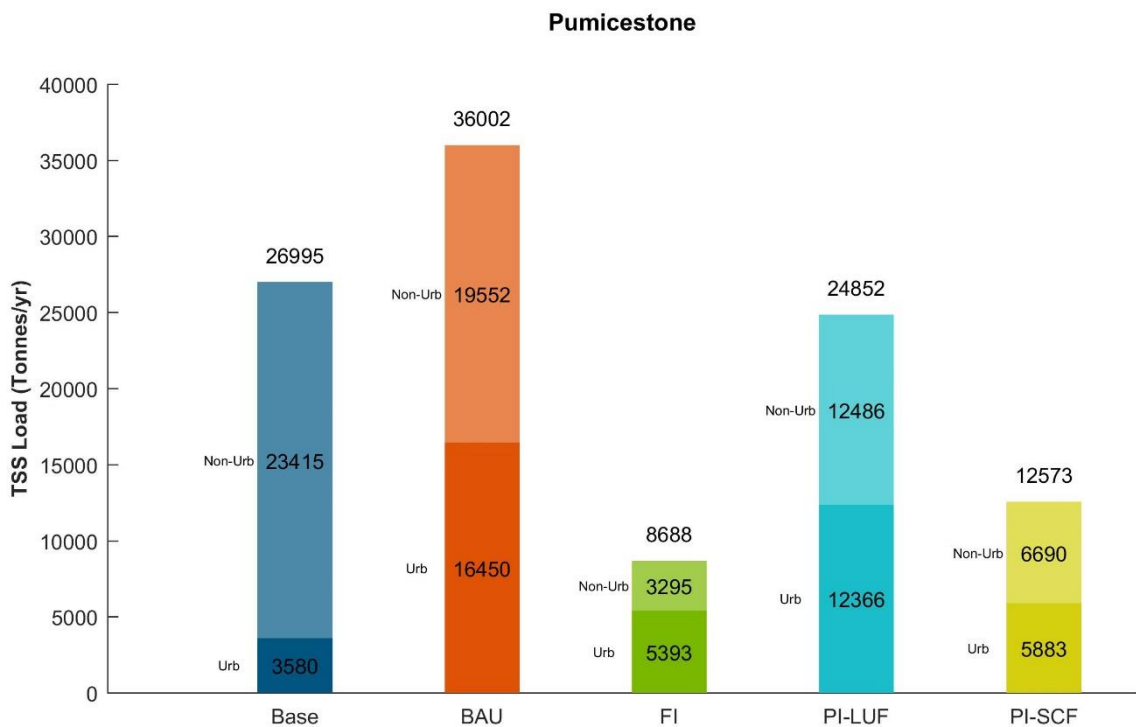


Figure 3-17 TSS catchment loads from Pumicestone

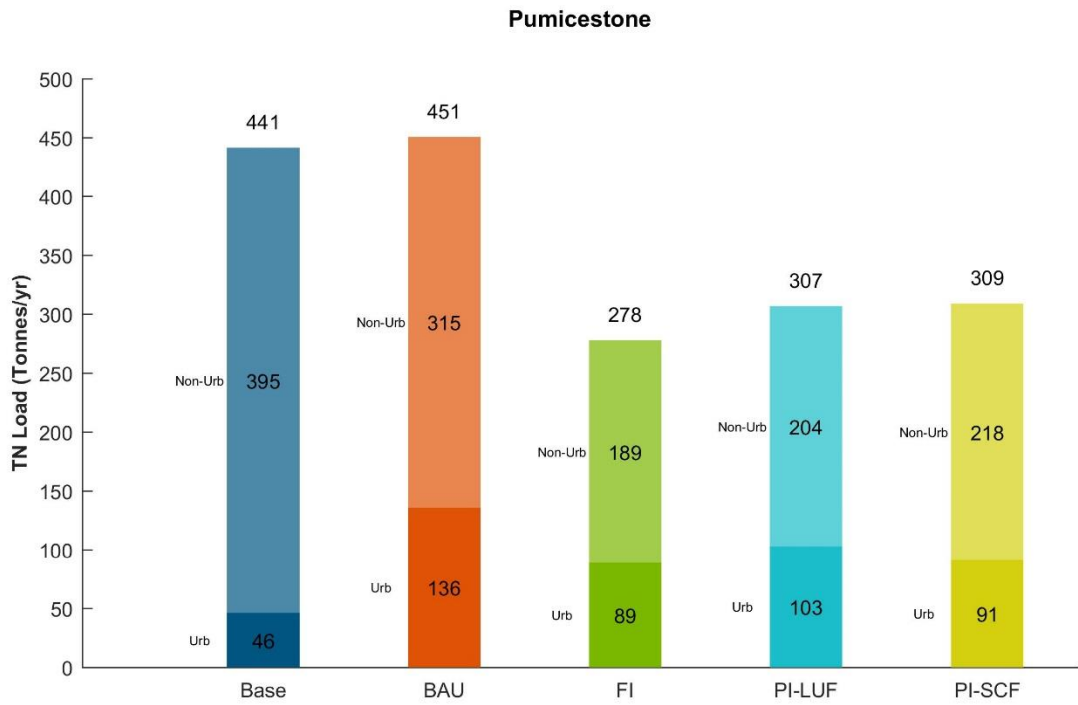


Figure 3-18 TN catchment loads from Pumicestone

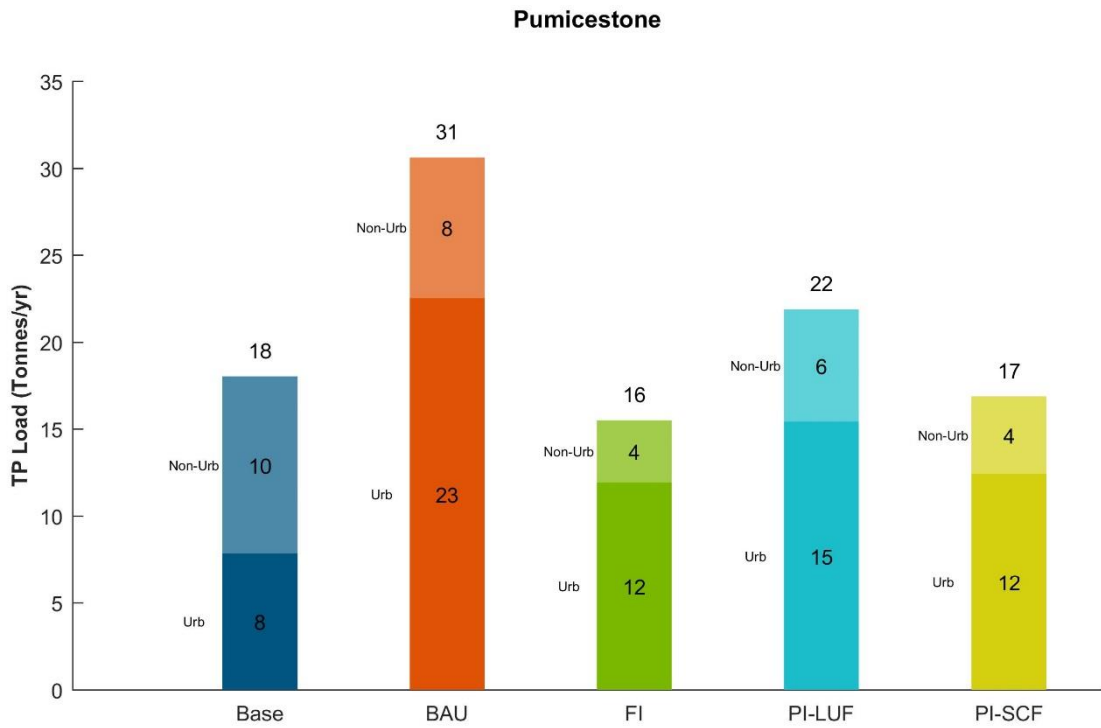


Figure 3-19 TP catchment loads from Pumicestone

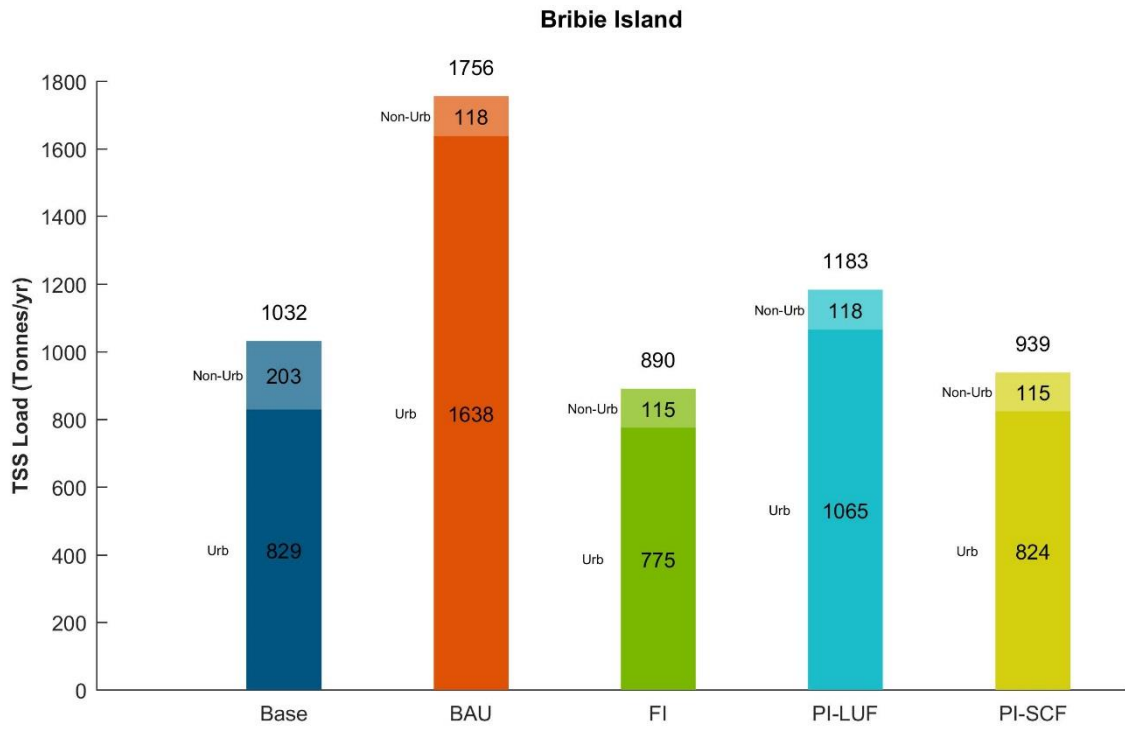


Figure 3-20 TSS catchment loads from Bribie Island

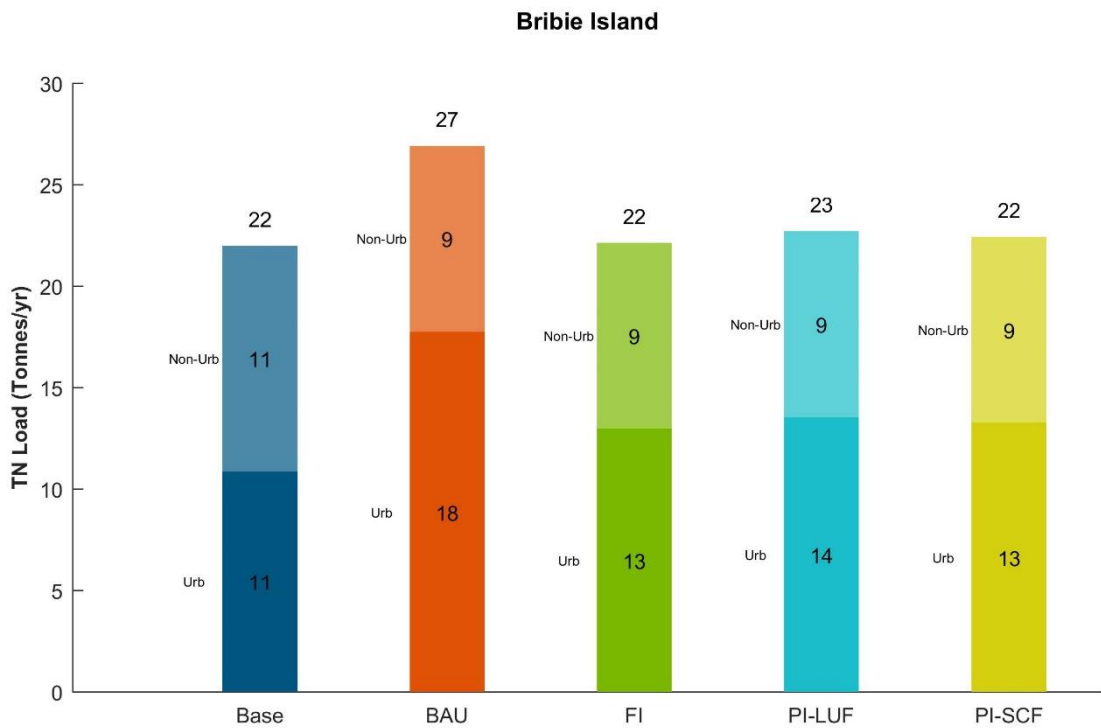


Figure 3-21 TN catchment loads from Bribie Island

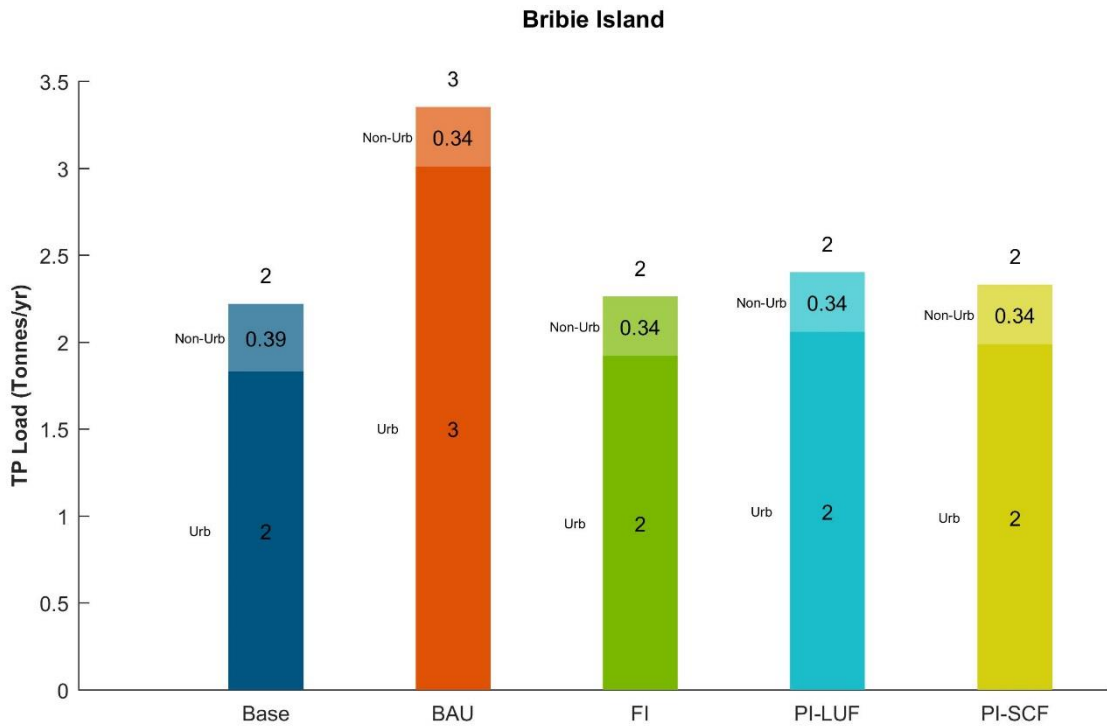


Figure 3-22 TP catchment loads from Bribie Island Turbidity

### 3.3.2 Turbidity

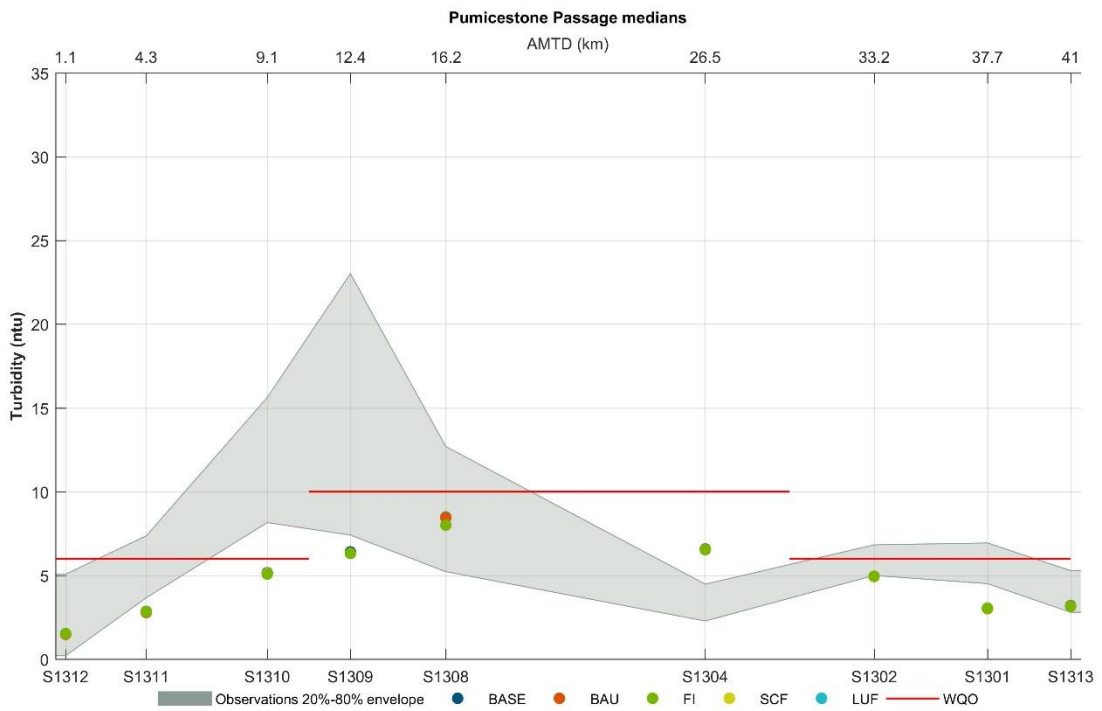
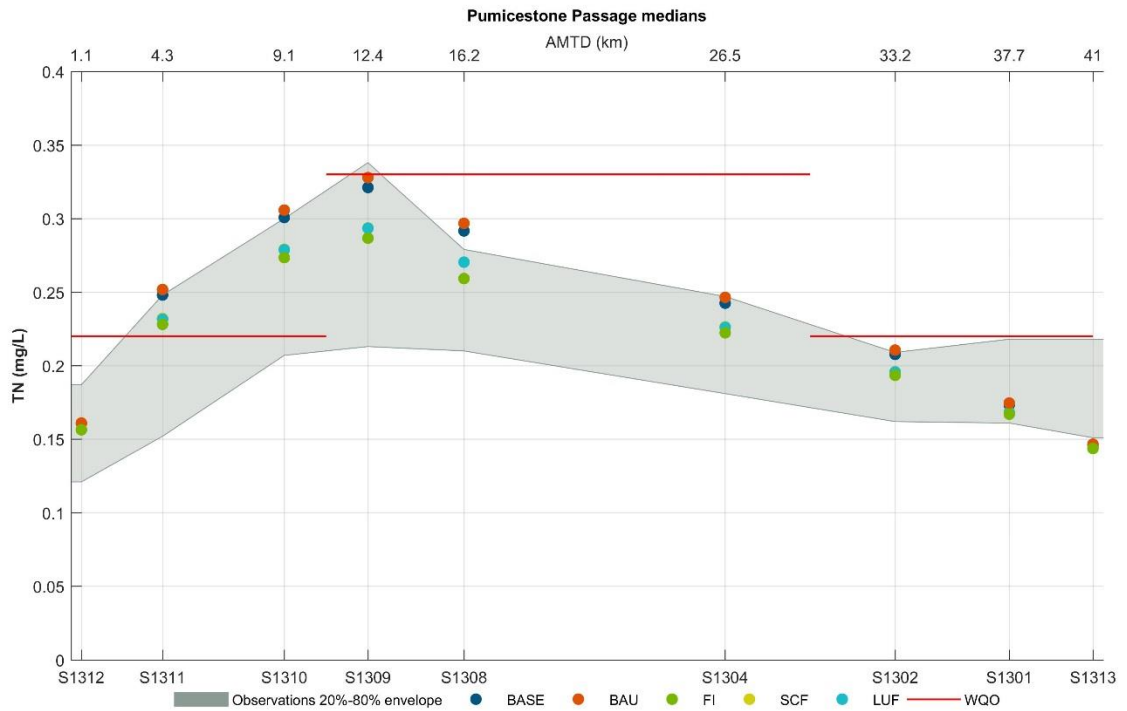


Figure 3-23 Comparison of Turbidity medians across scenarios for Pumicestone Passage

The results of the water quality model suggest that the Pumicestone Passage would effectively settle the excess suspended solids added at the estuary head in each of the scenarios tested. All scenarios complied with the turbidity limits set by the WQOs in all but S1308 station (Figure 3-23).

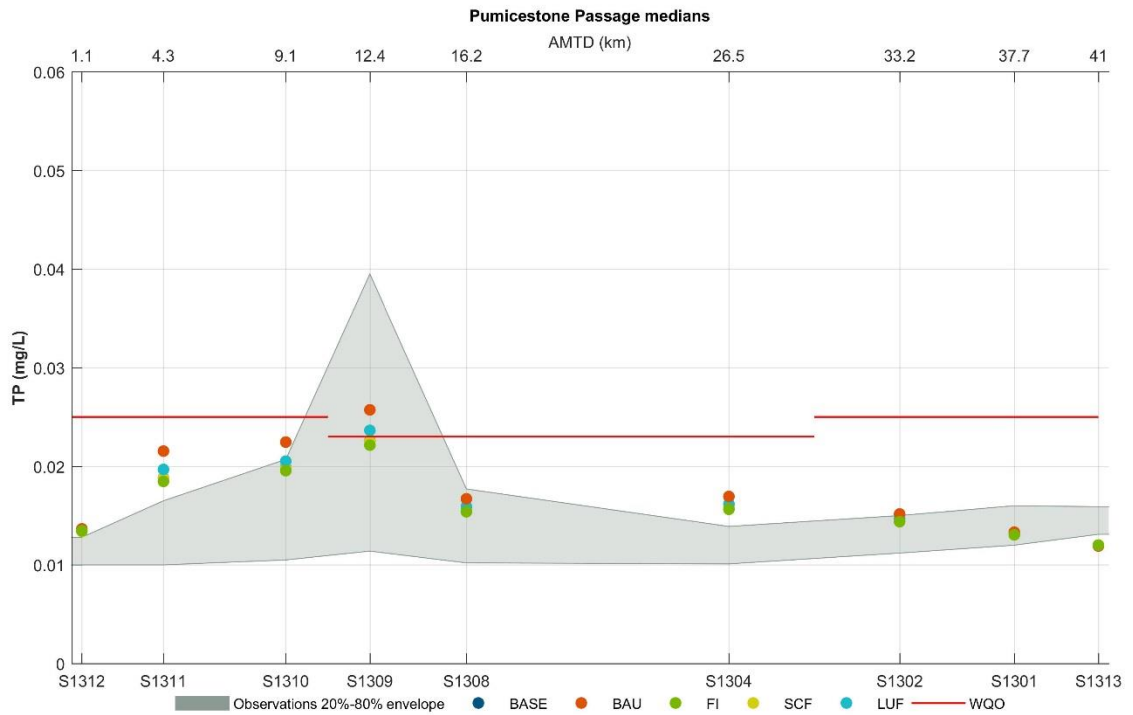
### 3.3.3 Total nitrogen



**Figure 3-24 Comparison of TN medians across scenarios for Pumicestone Passage**

The median values in the middle reaches of Pumicestone Passage showed a TN concentration for the FI, SCF and LUF up to 15% lower than for the BASE scenario, whereas the BAU scenario predicted concentrations very similar to the BASE along the entire passage (Figure 3-24). At station S1309, scenarios FI, SCF and LUF complied with the TN concentrations set by WQOs, whereas BAU and BASE failed to comply. Overall, the scenarios tested were unable to change the status of Pumicestone passage in terms of meeting WQOs.

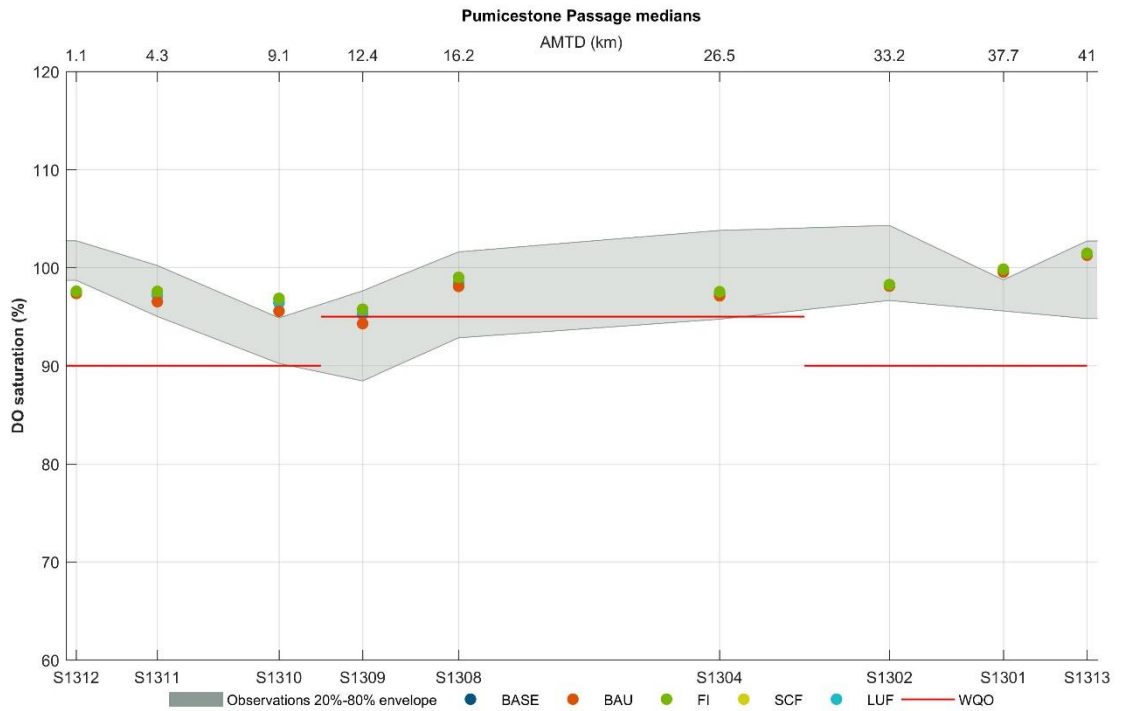
### 3.3.4 Total phosphorus



**Figure 3-25 Comparison of TP medians across scenarios for Pumicestone Passage**

At its current state (BASE scenario), TP concentrations in Pumicestone Passage are relatively low, with values similar to the LUF, SCF and FI scenarios. The water quality model predicted that only the BAU scenario would fail to comply to WQOs at stations S1310 and S1309 (Figure 3-25).

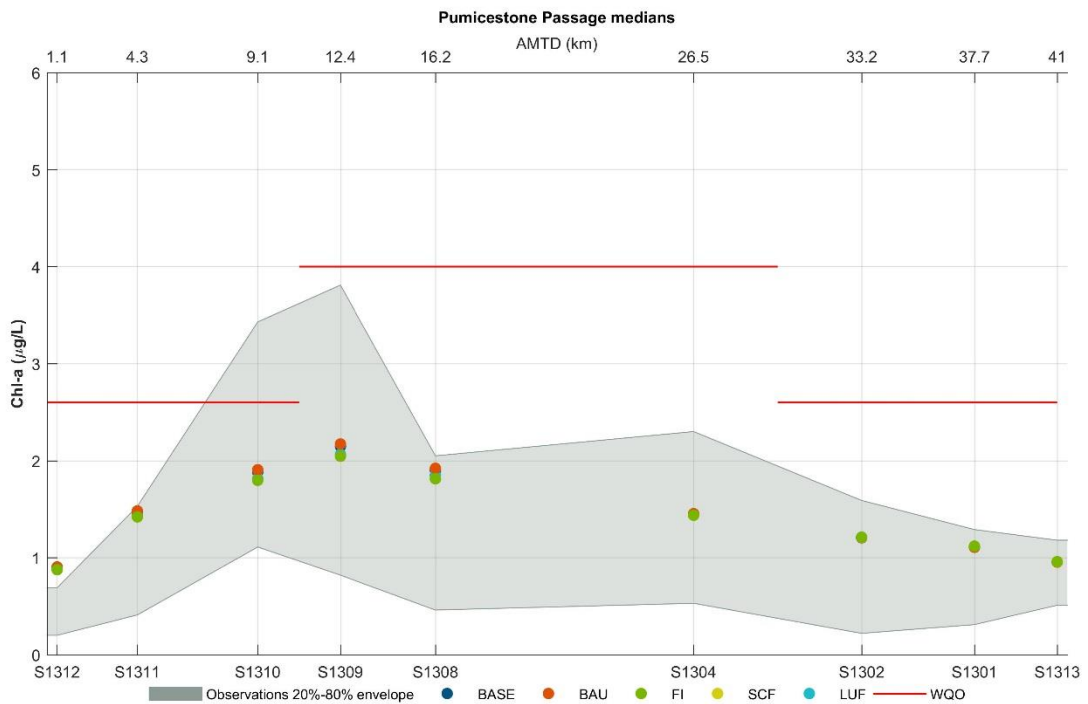
### 3.3.5 Dissolved Oxygen Saturation



**Figure 3-26 Comparison of DO saturation medians across scenarios for Pumicestone Passage**

The predicted DO concentrations in Pumicestone Passage were similar in all scenarios tested (Figure 3-26). All scenarios complied to the DO concentration limits set by the WQOs at all stations.

### 3.3.6 Chlorophyll-a



**Figure 3-27 Comparison of Chlorophyll-a medians across scenarios for Pumicestone Passage**

At its current state (BASE scenario), the Pumicestone Passage exhibits low Chlorophyll-a concentrations, never exceeding 4µg/L (Figure 3-27). Similarly to the BASE, all scenarios tested complied to the Chlorophyll-a concentration limits set by the WQOs for the whole estuary.

### 3.3.7 Conclusions

- The FI scenario decreased the catchment TSS load by approximately 75% compared to BAU and by approximately 66% compared to BASE. SCF was 47% more efficient than LUF in decreasing TSS loads. Both LUF and SCF decreased the TN loads by approximately 31% compared to BAU. FI decreased the TN loads by 38% compared to BAU. SCF, LUF and FI scenarios predicted TP loads similar to the BASE, whereas the BAU scenario increased TP exports by 41% compared to the BASE.
- The predicted median turbidity in the middle reaches of Pumicestone Passage failed to comply with WQOs in all scenarios.
- The TP and TN concentrations in the middle reaches failed to comply with WQOs in the BASE and BAU scenarios.
- Pumicestone Passage complied with the DO and Chlorophyll-a concentration limits set by WQOs in all scenarios.

### 3.4 Caboolture

#### 3.4.1 Catchment Loads

For the Caboolture River catchment, the BAU scenario predicted a 60% increase in TSS load compared to current conditions. The catchment model predicted that FI will yield a reduction in TSS load of 76% of BAU with the SCF and LUF scenarios predicting a catchment load reduction of 64% and 30% of BAU respectively (Figure 3-28).

For TN, the catchment loads are expected to rise by 33% in the BAU scenario, where by applying FI the resultant TN load was predicted as 75% of BAU. SCF yielded a similar load to FI and LUF 89% of BAU (Figure 3-29).

For TP, the catchment scenarios predict that BAU will yield a higher increase in load (46%) to TN, and FI will yield a greater reduction in load compared to BAU (59%). SCF and LUF scenarios predicted a catchment load reduction of 49% and 33% of BAU respectively (Figure 3-30).

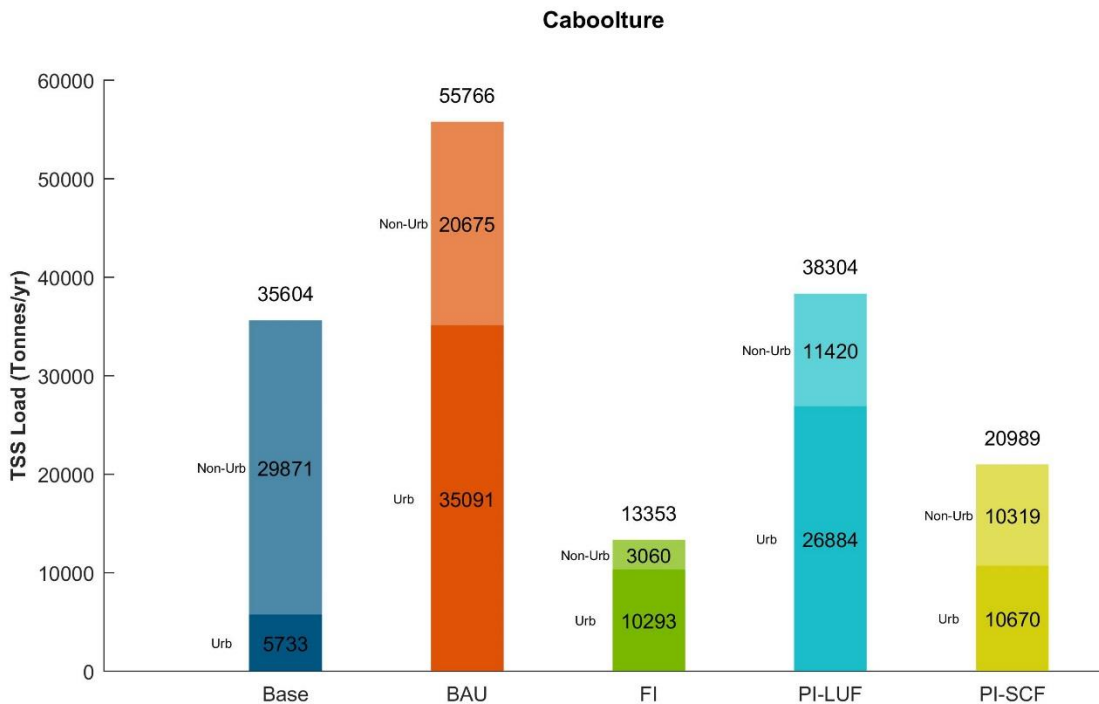


Figure 3-28 TSS catchment loads from Caboolture

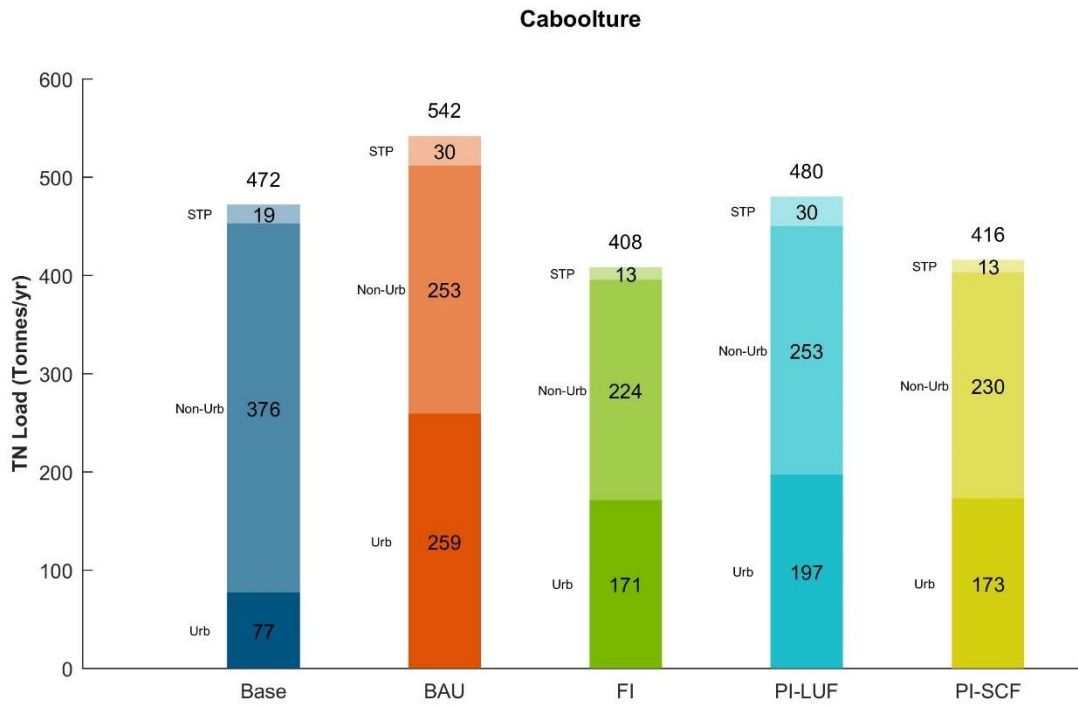


Figure 3-29 TN catchment loads from Cabootture

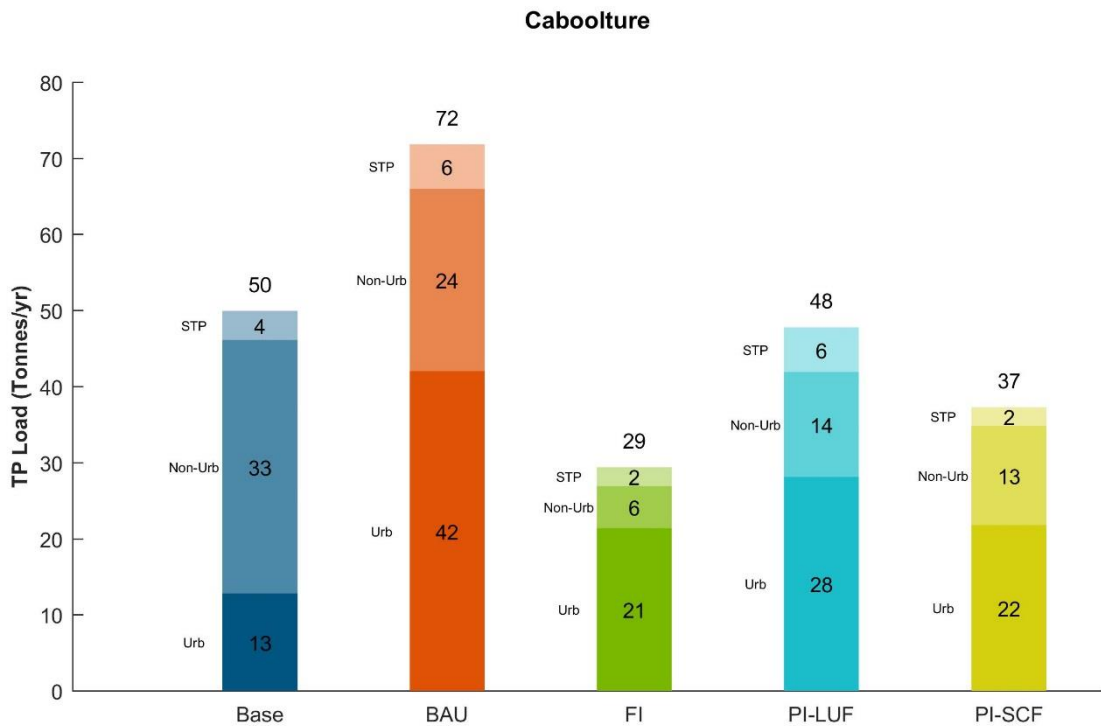
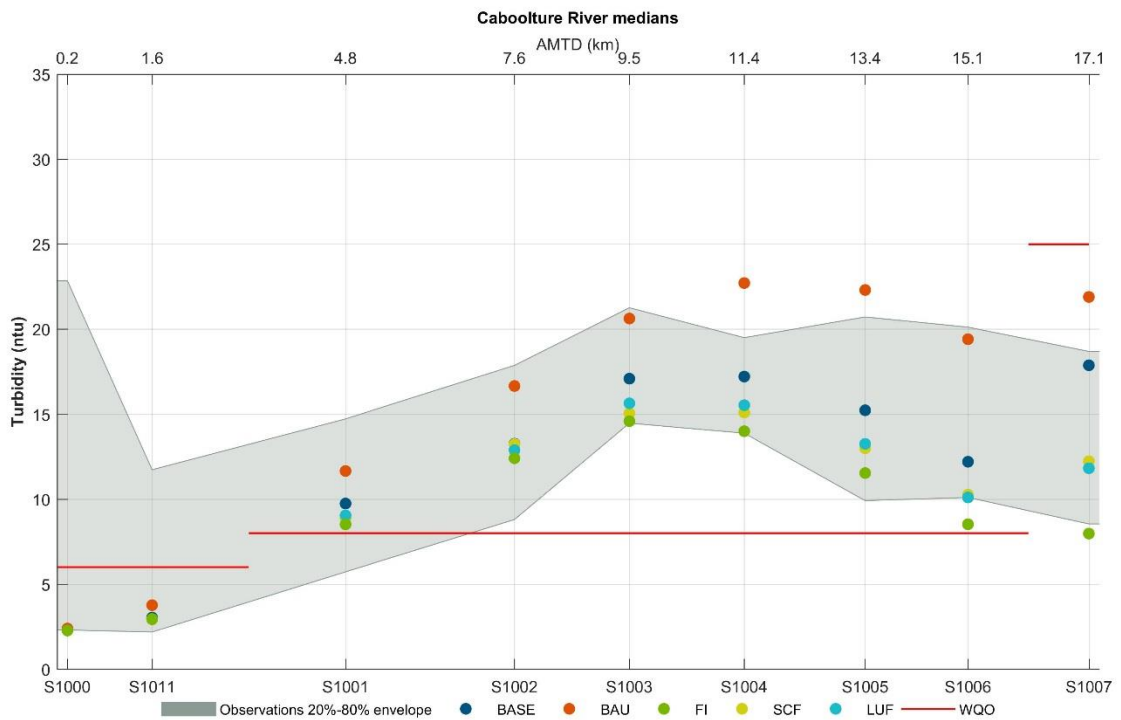


Figure 3-30 TP catchment loads from Cabootture

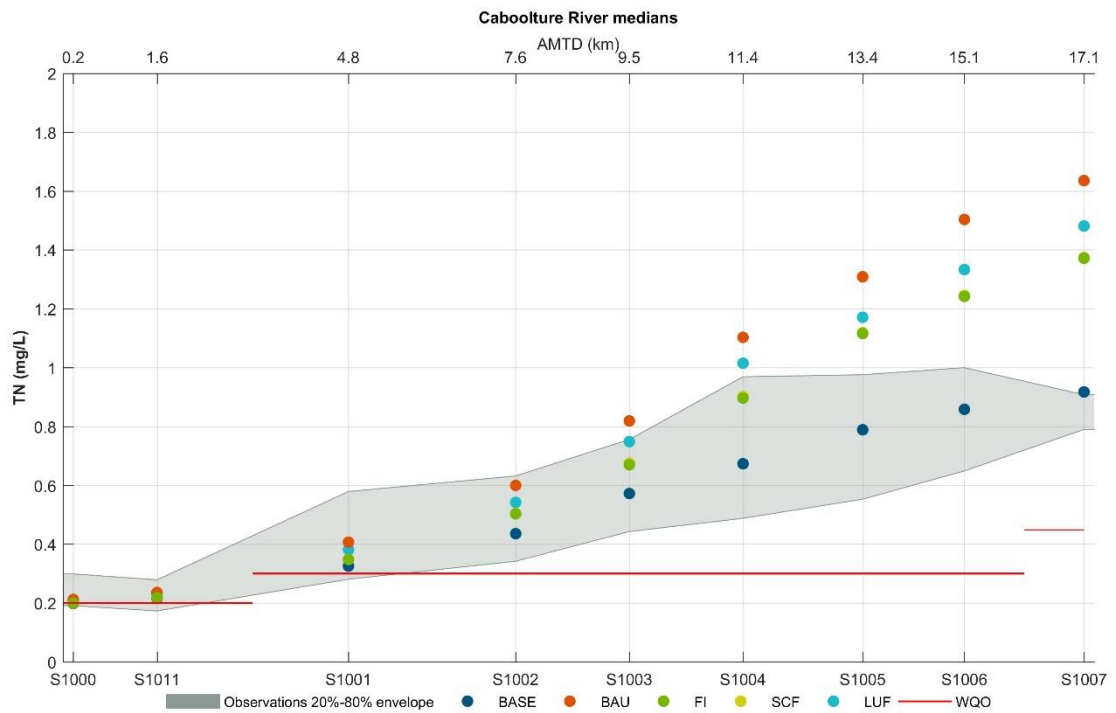
### 3.4.2 Turbidity



**Figure 3-31 Comparison of Turbidity medians across scenarios for Caboolture**

For the Caboolture River estuary, the difference in predicted turbidity between BAU and FI is large, with the difference being most pronounced in the upstream reaches of the estuary. With FI, the turbidity upstream is expected to reach close to the WQO where the BAU scenario is predicted to exceed the WQO by almost three times (Figure 3-31).

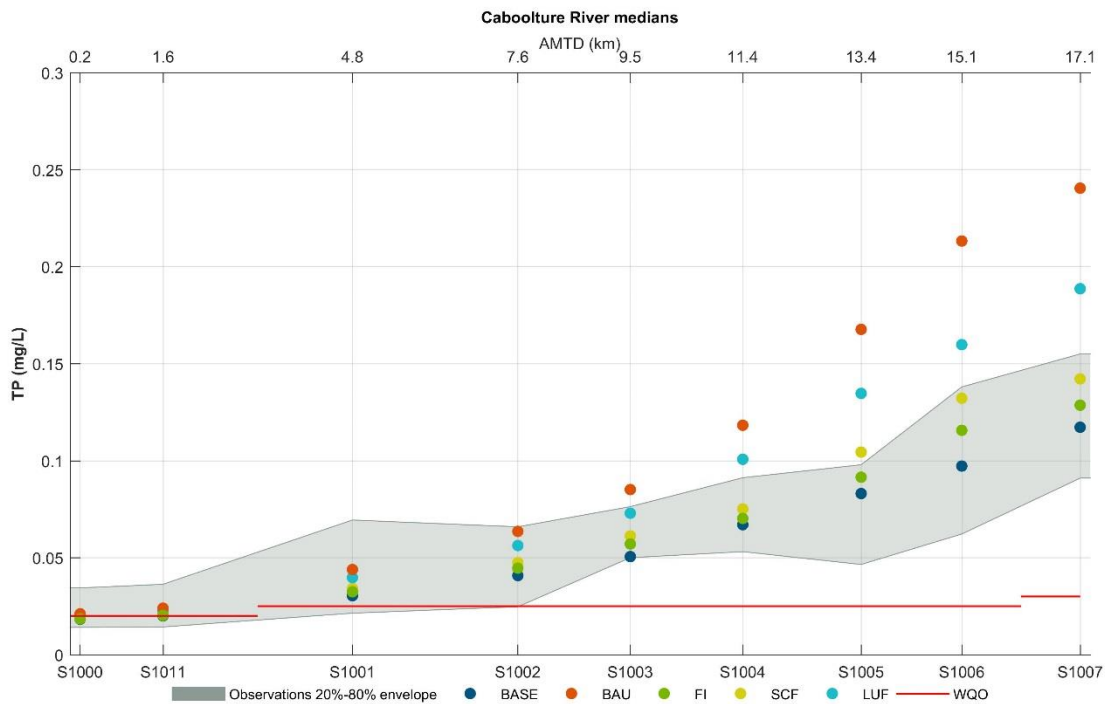
### 3.4.3 Total nitrogen



**Figure 3-32 Comparison of TN medians across scenarios for Caboolture**

Predicted TN in the Caboolture River FI scenario was approximately 15% less than the BAU concentration, with the difference between scenarios less downstream. The SCF scenario predicted similar reductions to the FI scenario although the predicted concentrations were slightly higher. The LUF predicted TN was approximately half way between the BAU and FI scenarios (Figure 3-32).

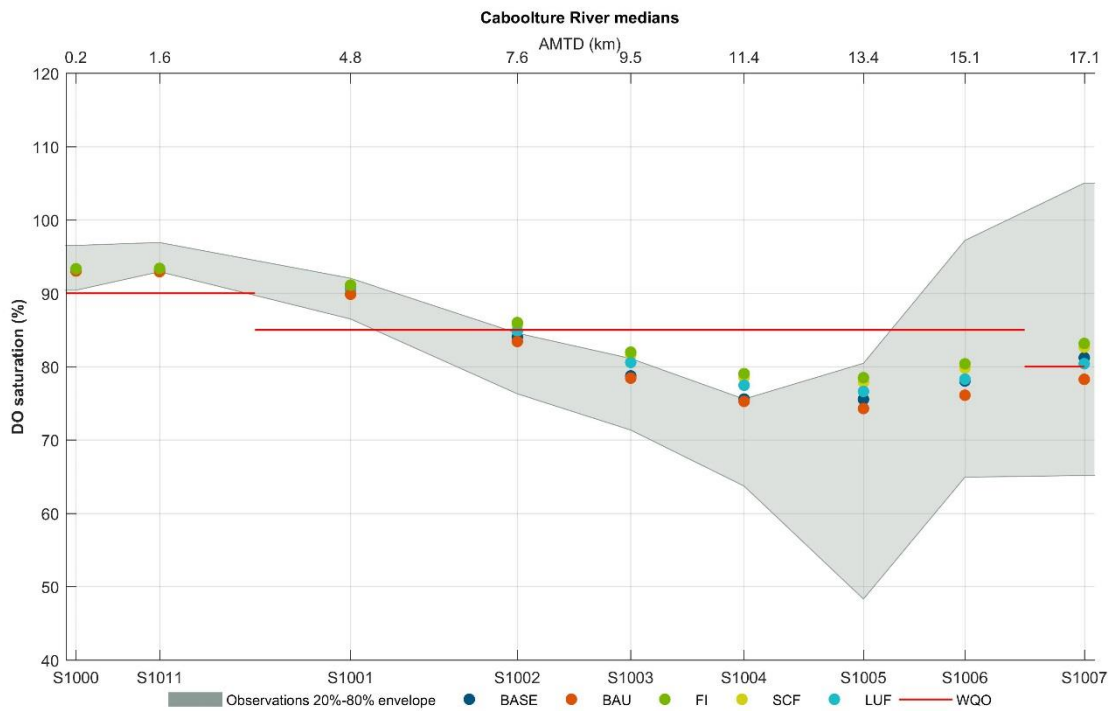
### 3.4.4 Total phosphorus



**Figure 3-33 Comparison of TP medians across scenarios for Caboolture**

For the Caboolture River, the BAU predicted concentrations for TP were significantly greater than the BASE scenario. The greatest concentrations predicted in the BAU scenario were in the upper reaches of the estuary where observed concentrations of TP are greatest close to the South Caboolture WWTP. The FI scenario predicted almost half of the TP predicted for the BAU scenario. The SCF scenario predicted a similar reduction in TP to the FI scenario and the LUF TP predictions were closer to the BAU scenario (Figure 3-33).

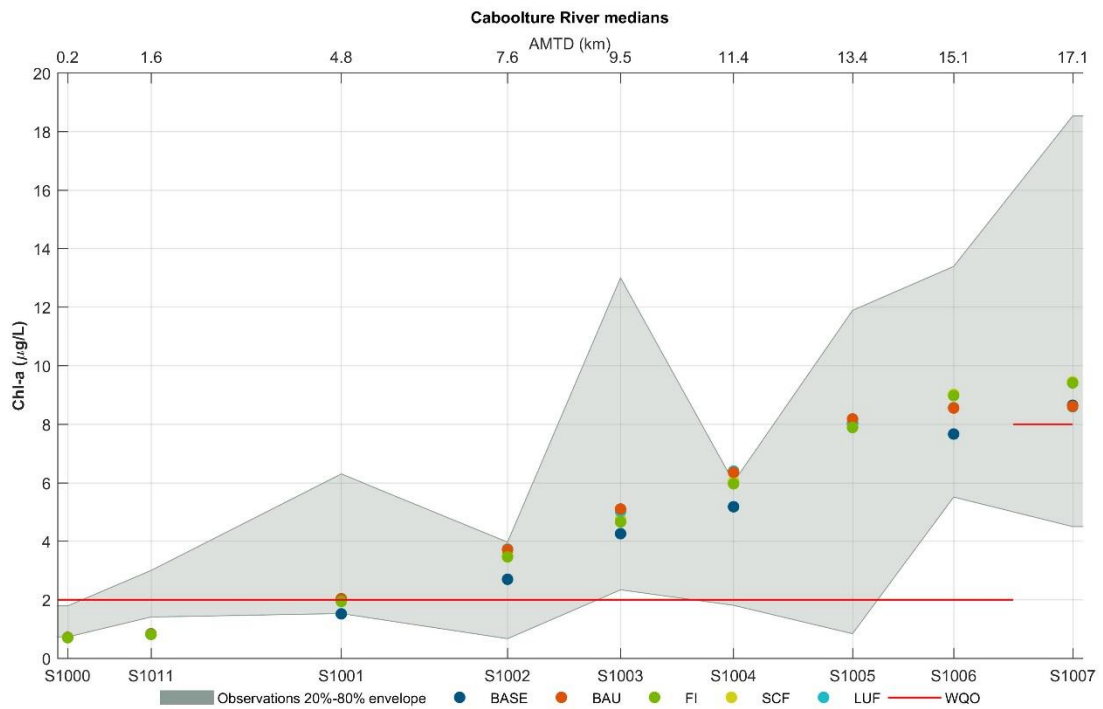
### 3.4.5 Dissolved Oxygen Saturation



**Figure 3-34 Comparison of DO saturation medians across scenarios for Caboolture**

The difference between predicted DO saturation for the BAU and FI scenarios was approximately 7% with the greatest difference occurring in the upper reaches of the estuary including the location of the South Caboolture WWTP. The SCF scenario predicted similar DO to FI where the predicted increase in DO for the LUF scenario was approximately half way between the BAU and FI scenarios (Figure 3-34).

### 3.4.6 Chlorophyll-a



**Figure 3-35 Comparison of Chlorophyll-a medians across scenarios for Caboolture**

No significant difference between scenario results were observed in predicted median Chl-a concentrations for the Caboolture river.

### 3.4.7 Conclusions

- Catchment model predicted significant reductions in TSS and TP for FI and SCF compared to BAU with smaller reductions in LUF. For TN the FI load reduction was smaller compared to BAU with SCF of similar magnitude to FI and LUF achieving approximately half the reduction in loads.
- The Caboolture estuary model predicted a significant reduction in turbidity with FI compared to BAU with SCF of similar magnitude to FI.
- Smaller differences in predicted TN concentrations between BAU and FI scenarios were observed, with the greatest differences being in the upper reaches of the estuary where the WWTP discharges. LUF scenario predicted a small decrease in TN compared to BAU and SCF almost as much as FI.
- Significant differences in predicted TP concentrations between BAU and FI scenarios were observed with the greatest differences occurring in the upper reaches of the estuary where the WWTP discharges. The LUF scenario predicted a smaller decrease in TP compared to BAU and SCF almost as much as FI.

- Small but significant differences in predicted DO concentrations were observed between BAU and FI scenarios with the greatest differences seen in the upper reaches of the estuary where the WWTP discharges. The LUF scenario predicted a small increase in DO compared to BAU and SCF almost as much as FI.
- There was no significant difference in prediction of Chl-a concentrations in the Caboolture River estuary.

### 3.5 Pine

#### 3.5.1 Catchment Loads

For the Pine River catchment, the BAU scenario predicted a 35% increase in TSS load compared to current conditions (Figure 3-36). The catchment model predicted that FI would yield a reduction in TSS load of 70% of BAU with the SCF and LUF scenarios predicting a catchment load reduction of 60% and 31% of BAU respectively.

For TN, the catchment loads were expected to rise by 15% in the BAU scenario, where by applying FI the resultant TN load was predicted as 75% of BAU (Figure 3-37). SCF yielded a similar load to FI and LUF 83% of BAU.

For TP, the catchment scenarios predicted that BAU would yield a higher increase in load (36%) to TN, and FI will yield a greater reduction in load compared to BAU (59%) (Figure 3-38). SCF and LUF scenarios predicted a catchment load reduction of 53% and 44% of BAU respectively.

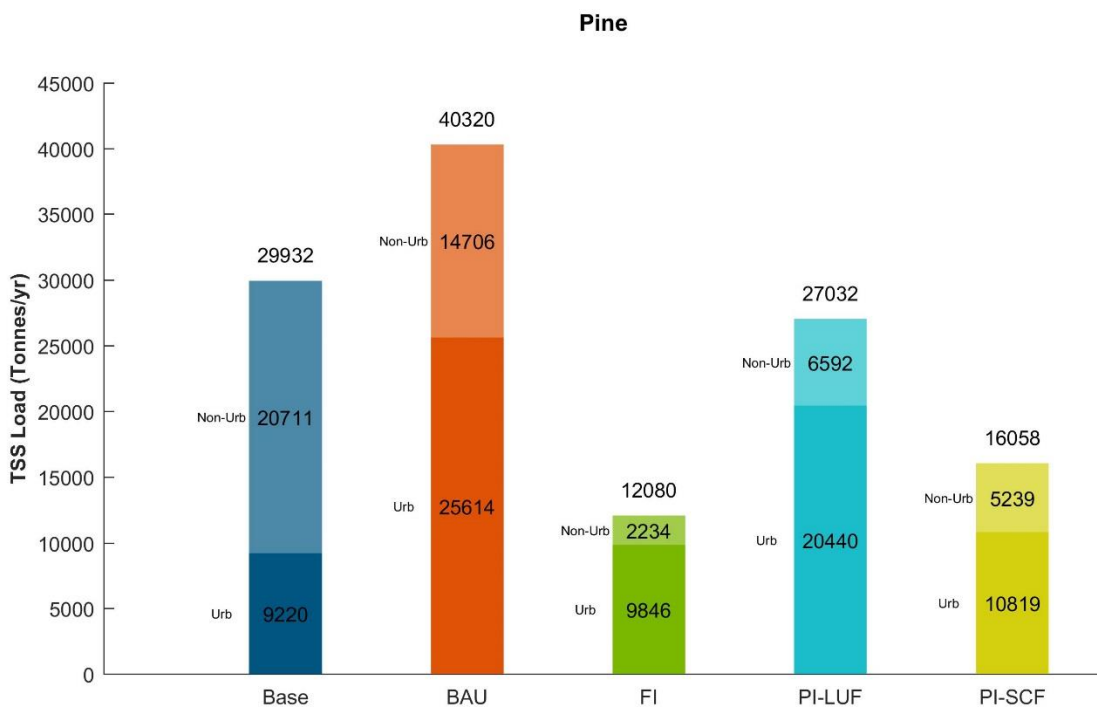


Figure 3-36 TSS catchment loads from Pine

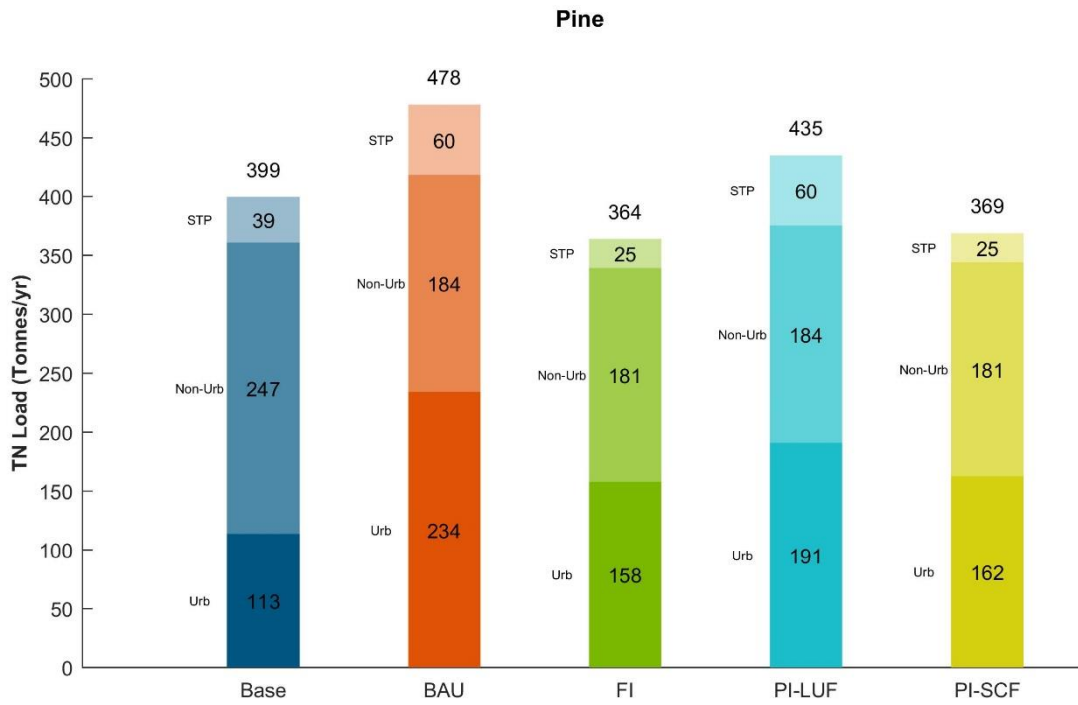


Figure 3-37 TN catchment loads from Pine

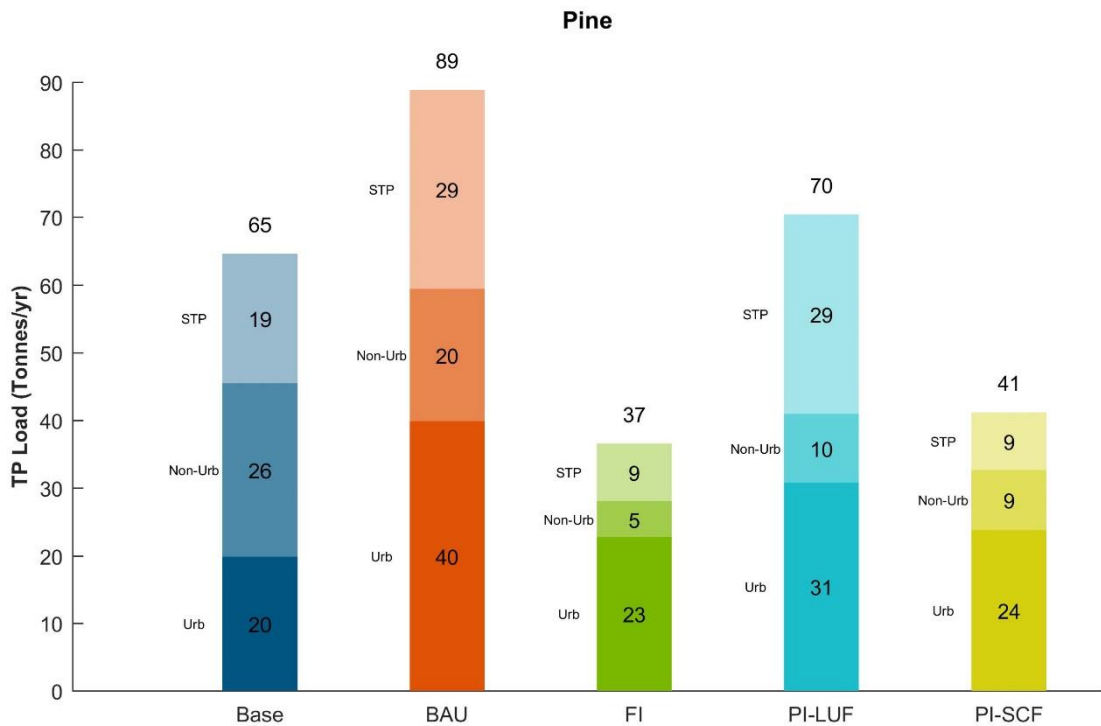
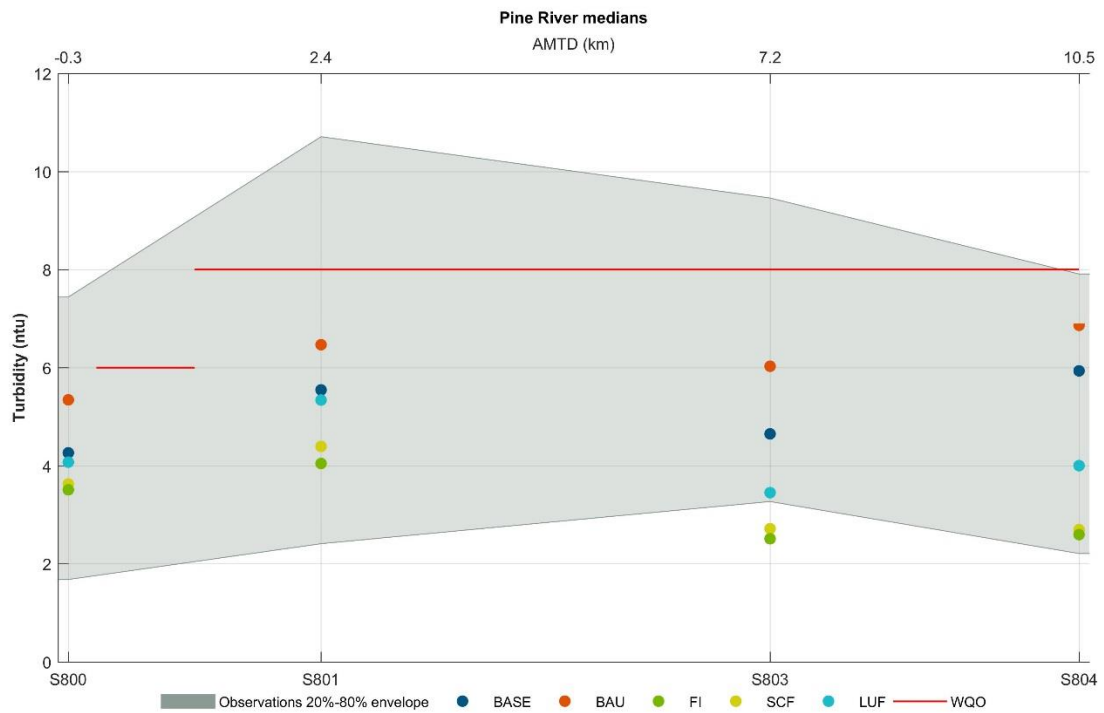


Figure 3-38 TP catchment loads from Pine

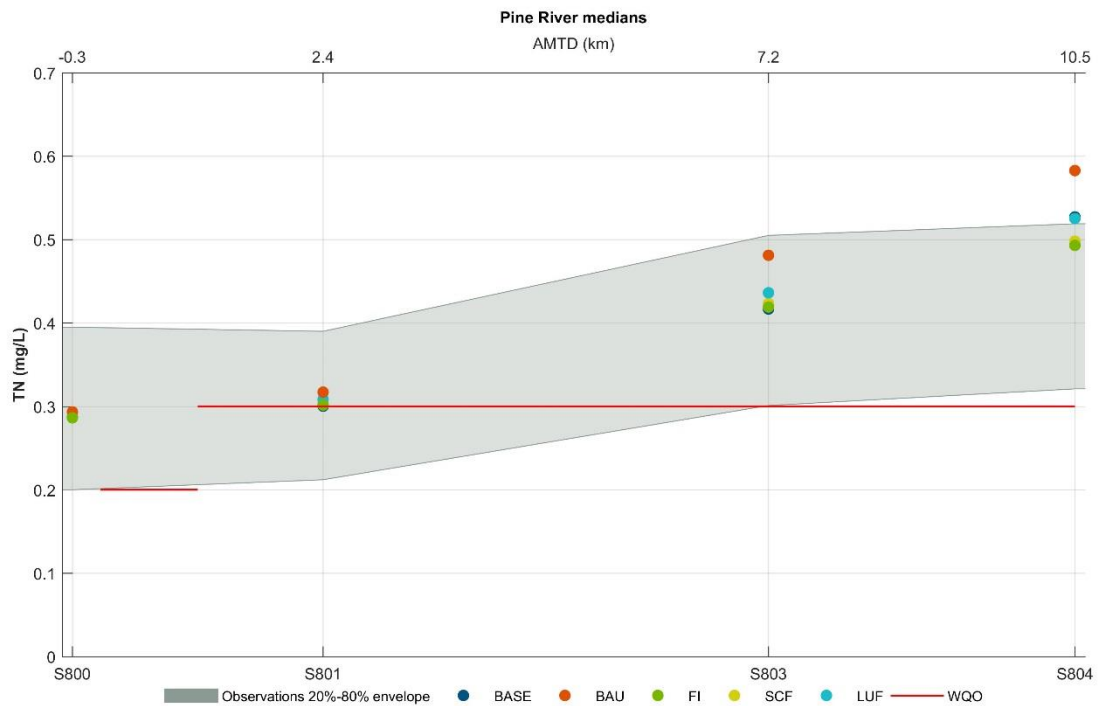
### 3.5.2 Turbidity



**Figure 3-39 Comparison of Turbidity medians across scenarios for Pine**

For the Pine River estuary, the difference in predicted turbidity between BAU and FI was relatively large, with the difference being most pronounced in the upper estuary (Figure 3-39). For the FI, SCF, LUF and BASE scenarios the median turbidity for all reaches of the estuary fell below WQOs, the exception being BAU which exceeded the WQO in the upper reaches of the estuary. SCF yielded a similar reduction in turbidity as FI and LUF at approximately half the reduction from BAU as FI.

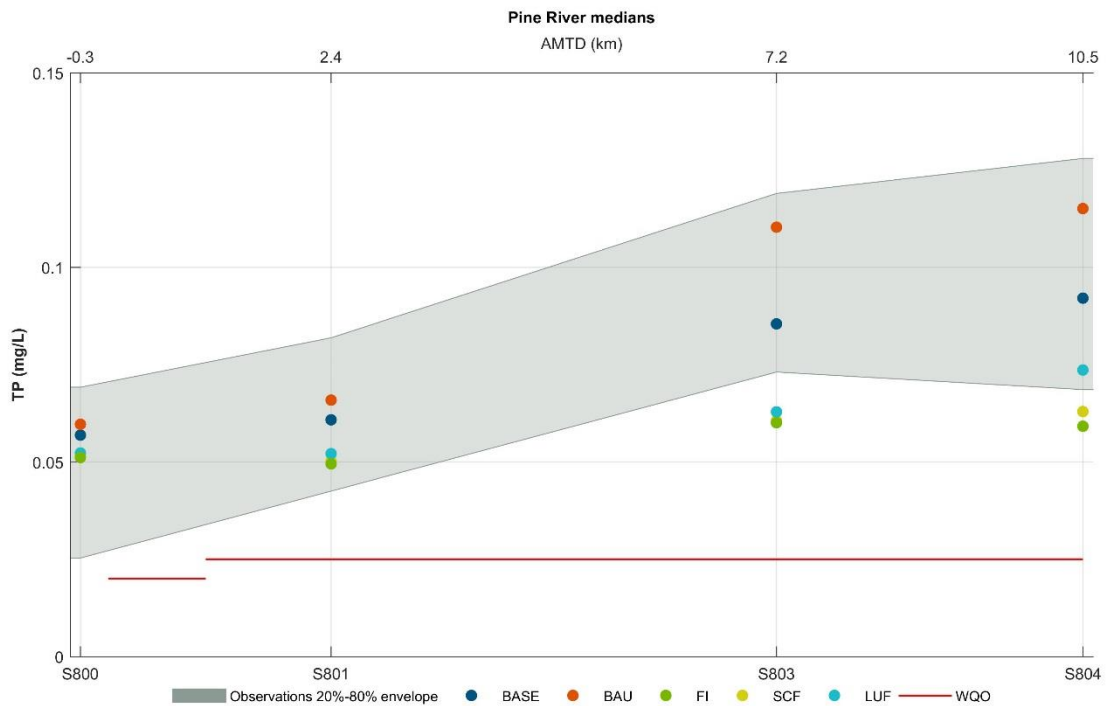
### 3.5.3 Total nitrogen



**Figure 3-40 Comparison of TN medians across scenarios for Pine**

Predicted TN in the Pine River FI scenario was approximately 16% less than the BAU concentration in the upstream regions, with the difference between scenarios negligible in the downstream regions (Figure 3-40). The SCF scenario predicted similar reductions to the FI scenario although the predicted concentrations were slightly higher. The LUF predicted TN was approximately half way between the BAU and FI scenarios.

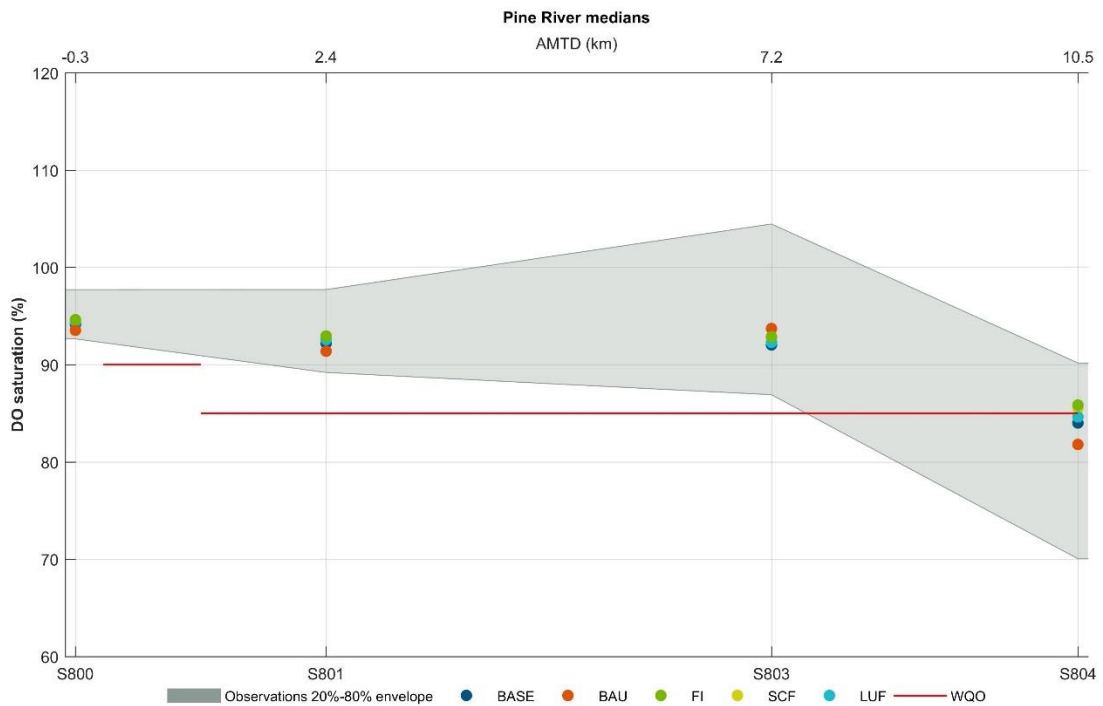
### 3.5.4 Total phosphorus



**Figure 3-41 Comparison of TP medians across scenarios for Pine**

The predicted BAU concentrations for TP were significantly greater than the BASE scenario (Figure 3-41). The greatest concentrations predicted in the BAU scenario were in the upper reaches of the estuary where observed concentrations of TP are greatest close to the South Pine River entrance. The FI scenario predicted less than half of the TP predicted for the BAU scenario. The SCF scenario predicted a similar reduction in TP to the FI scenario and the LUF TP predictions were slightly higher but also similar to the FI scenario.

### 3.5.5 Dissolved Oxygen Saturation



**Figure 3-42 Comparison of DO saturation medians across scenarios for Pine**

In the Pine River, the difference between predicted DO saturation for the BAU and FI scenarios was less than 5% in the upstream reaches of the estuary with almost no discernible difference downstream. For most of the estuary the median values of all scenarios fell within the WQO limits except for the predicted DO in the BAU scenario which fell below the WQO for the upper reaches of the estuary. The SCF and LUF scenarios predicted similar DO to FI (Figure 3-42).

### 3.5.6 Chlorophyll-a

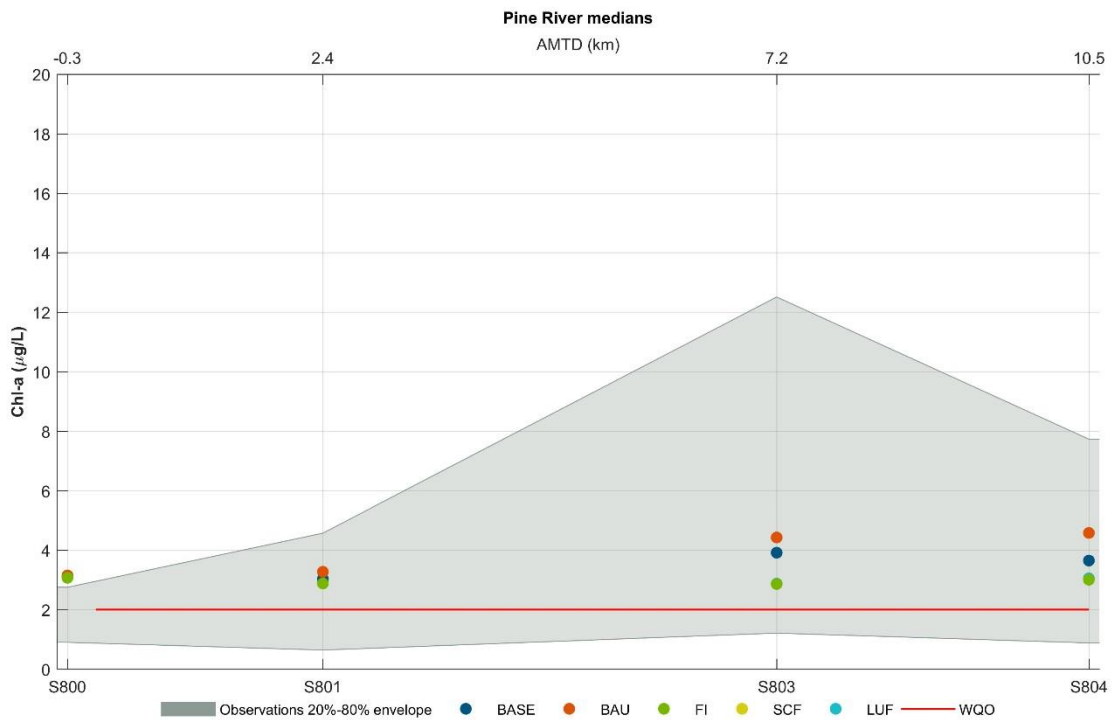


Figure 3-43 Comparison of chlorophyll-a medians across scenarios for Pine

No significant difference between scenario results were observed in predicted Chl-a concentrations for down stream reaches of the Pine River estuary (Figure 3-43). For the upstream reaches, FI predicted approximately half the Chl-a concentrations as BAU with the Chl-a concentration for BAU exceeding the WQO in the upstream station, S804. Both SCF and LUF were of similar magnitude to FI.

### 3.5.7 Conclusions

- The catchment model predicted significant reductions in TSS and TP for FI and SCF compared to BAU with a smaller reduction in LUF. For TN, the FI load reduction was smaller compared to BAU with SCF of similar magnitude to FI and LUF achieving approximately half the reduction in loads.
- The Pine estuary model predicted a significant reduction in turbidity with FI compared to BAU with SCF of similar magnitude to FI.
- Smaller differences were observed in predicted TN concentrations between BAU and FI scenarios, with the greatest differences in upper reaches of the estuary close to the South Pine River entrance. SCF predicted a similar reduction to FI and LUF around half the reduction in TN.

- Significant differences were seen in predicted TP concentrations between BAU and FI scenarios, with the greatest differences occurring in the upper reaches of the estuary. Both SCF and LUF scenarios predicted a similar decrease in TP to FI.
- An almost negligible difference in predicted DO concentrations between BAU, FI, SCF and LUF scenarios was observed, with the greatest differences being in the upper reaches of the estuary. The BAU scenario predicted that DO would fall below WQO in the upper estuary.
- There was no significant difference in prediction of Chl-a concentrations downstream with upstream with FI predicting approximately half the Chl-a concentrations as BAU.

### 3.6 Brisbane

#### 3.6.1 Catchment Loads

For the Brisbane River catchments, the BAU scenario predicted over 32% increase in TSS load from current conditions with full investment yielding a reduction of 59%. The SCF and LUF scenarios predicted a catchment load reduction of 35% and 38% respectively comparable to the BASE load.

For TN, the catchment loads are expected to rise by 27% in the BAU scenario, and by applying FI the resultant TN load is 5% more than the BASE load. Similarly, LUF yields a 11% increase to current conditions while SCF yields a smaller increase of around 9%.

For TP the catchment scenarios predict that while BAU will yield an increase in load of 36% compared to current conditions, while the FI will yield a 35% reduction in load. Both LUF and SCF yield similar load reductions of 21% and 18% respectively compared to BASE case.

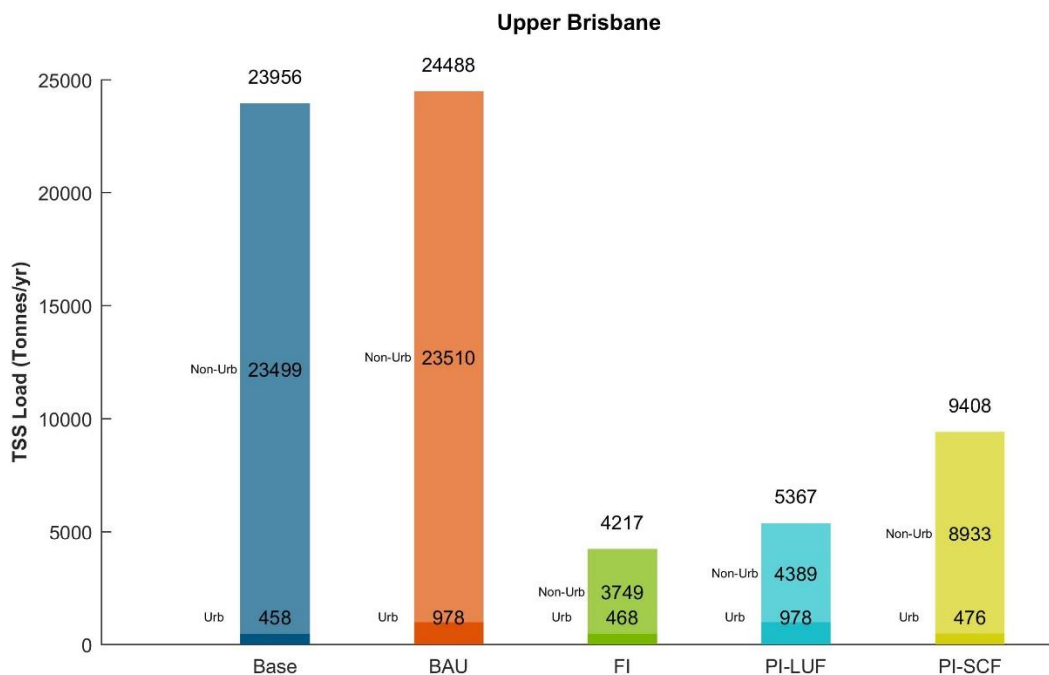


Figure 3-44 TSS catchment loads from Upper Brisbane

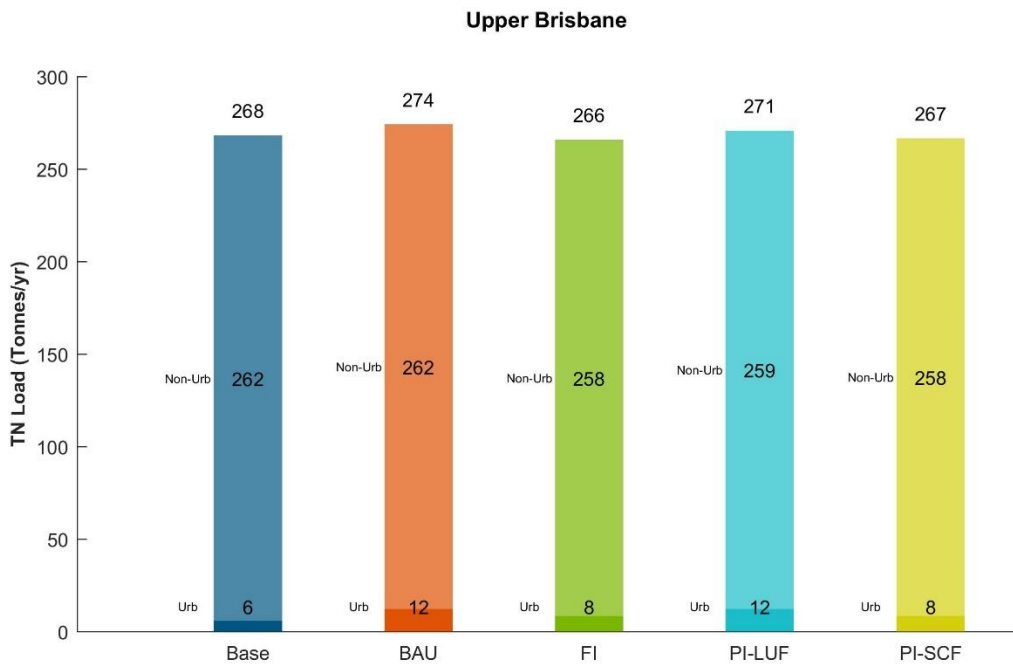


Figure 3-45 TN catchment loads from Upper Brisbane

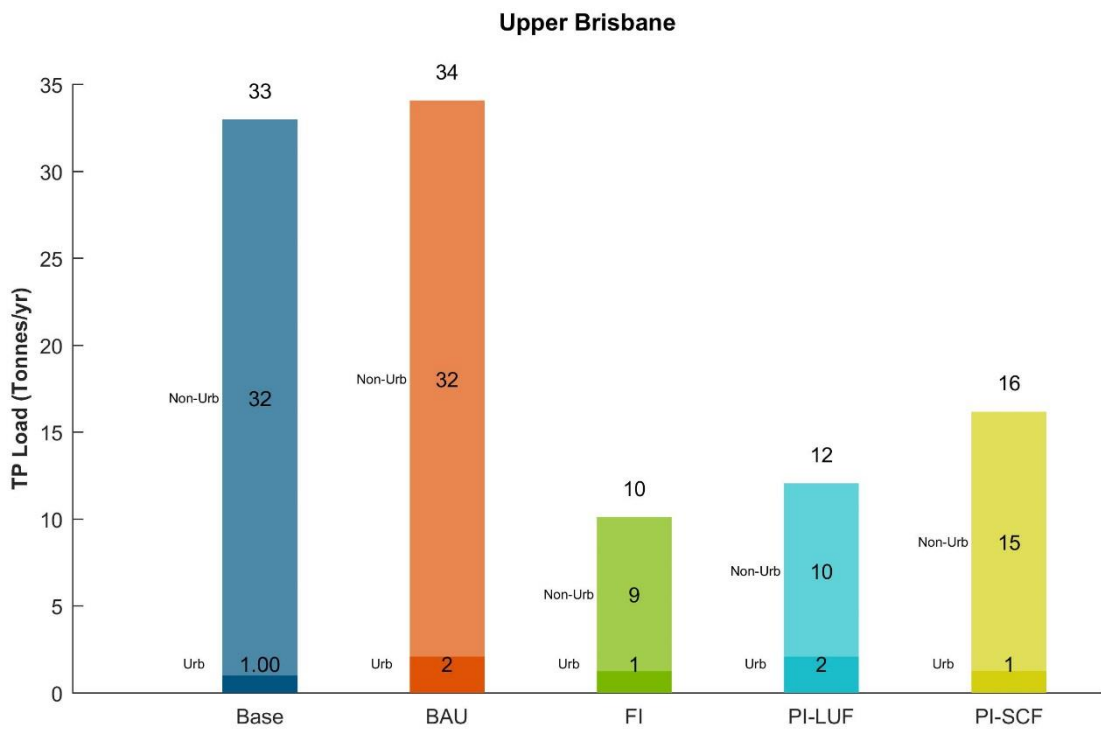


Figure 3-46 TP catchment loads from Upper Brisbane

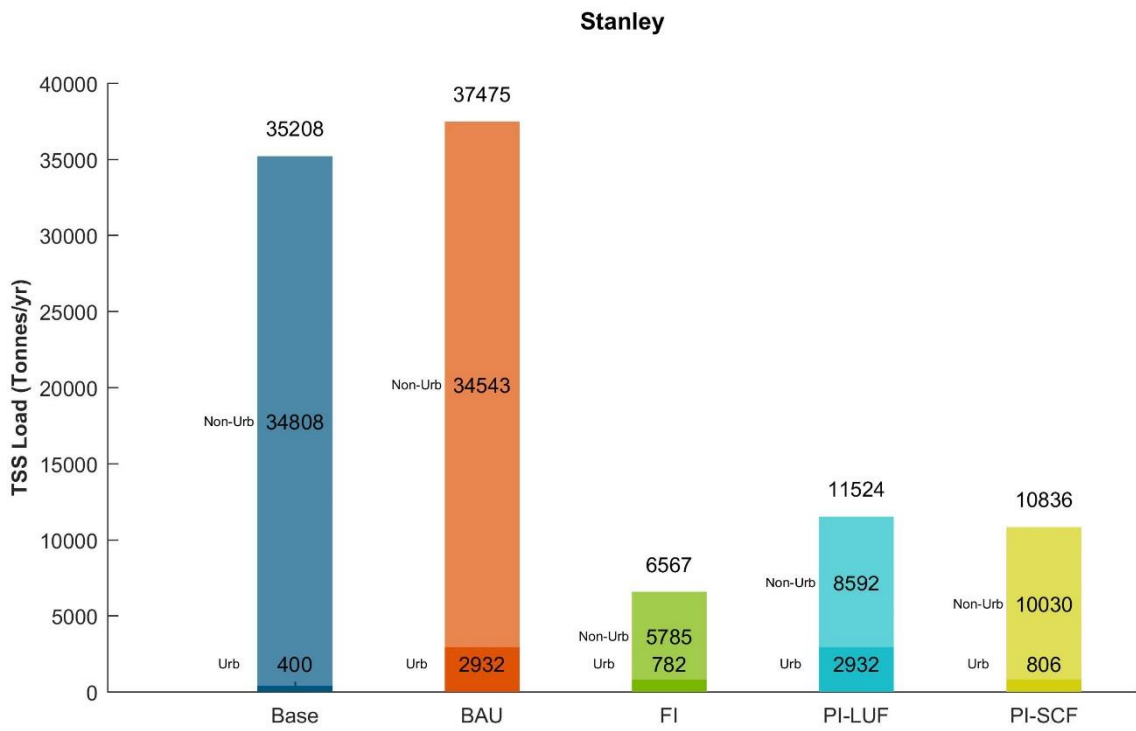


Figure 3-47 TP catchment loads from Stanley

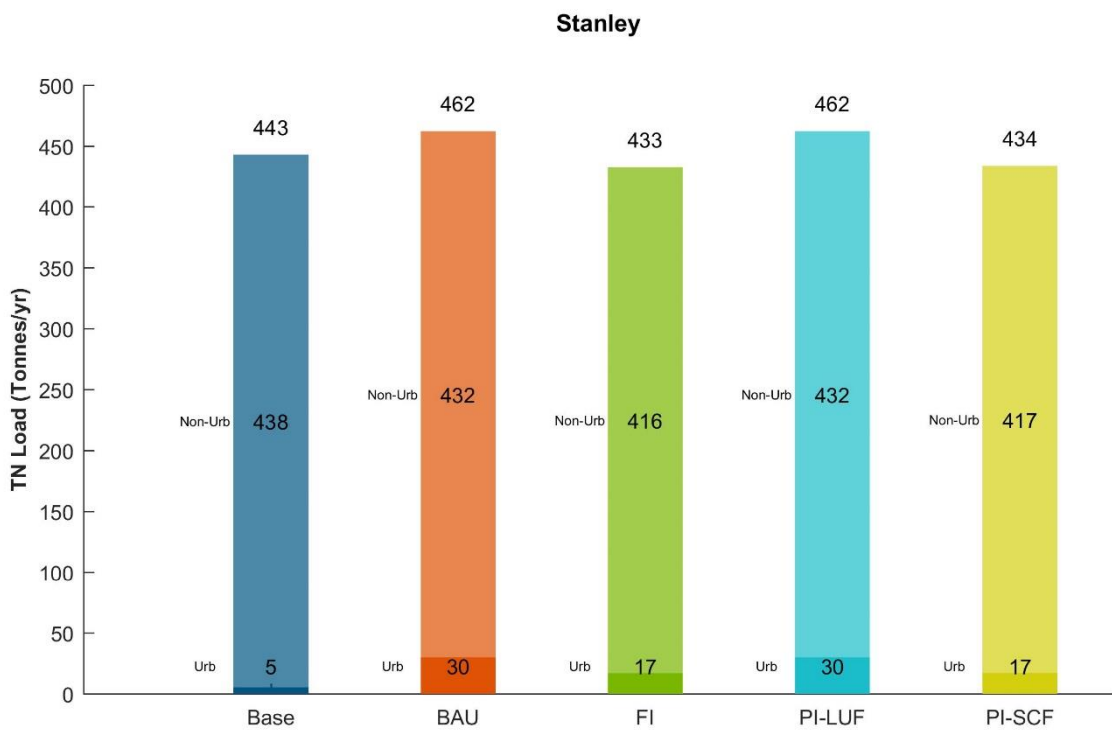


Figure 3-48 TN catchment loads from Stanley

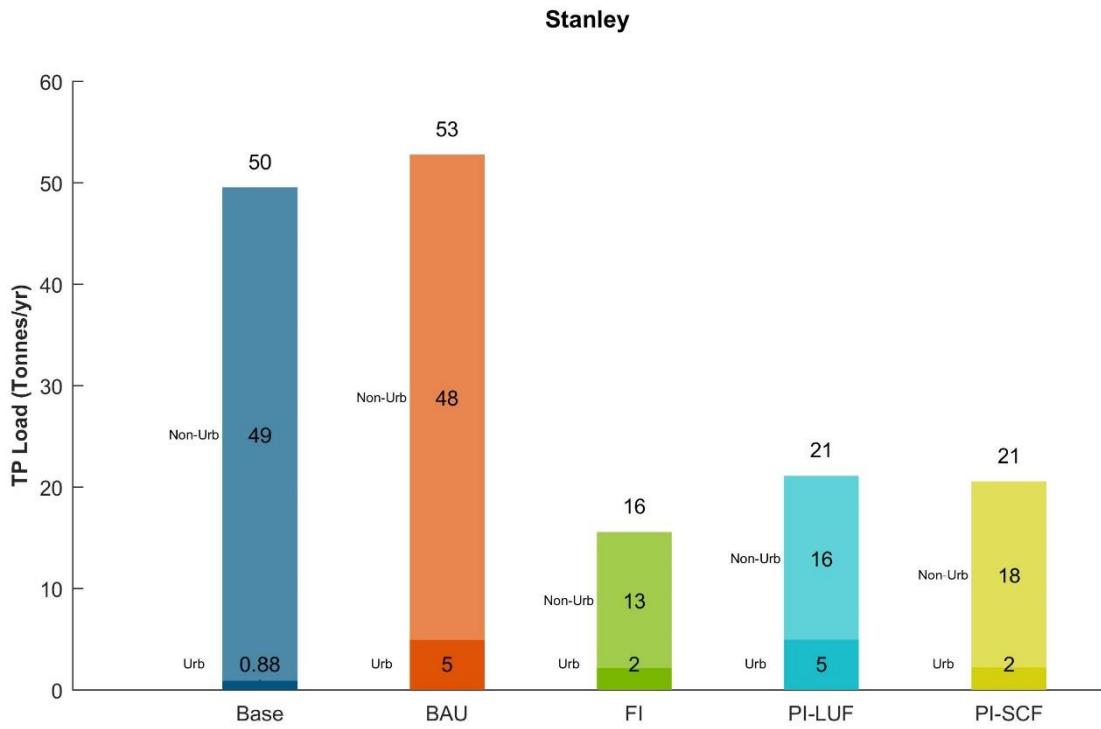


Figure 3-49 TP catchment loads from Stanley

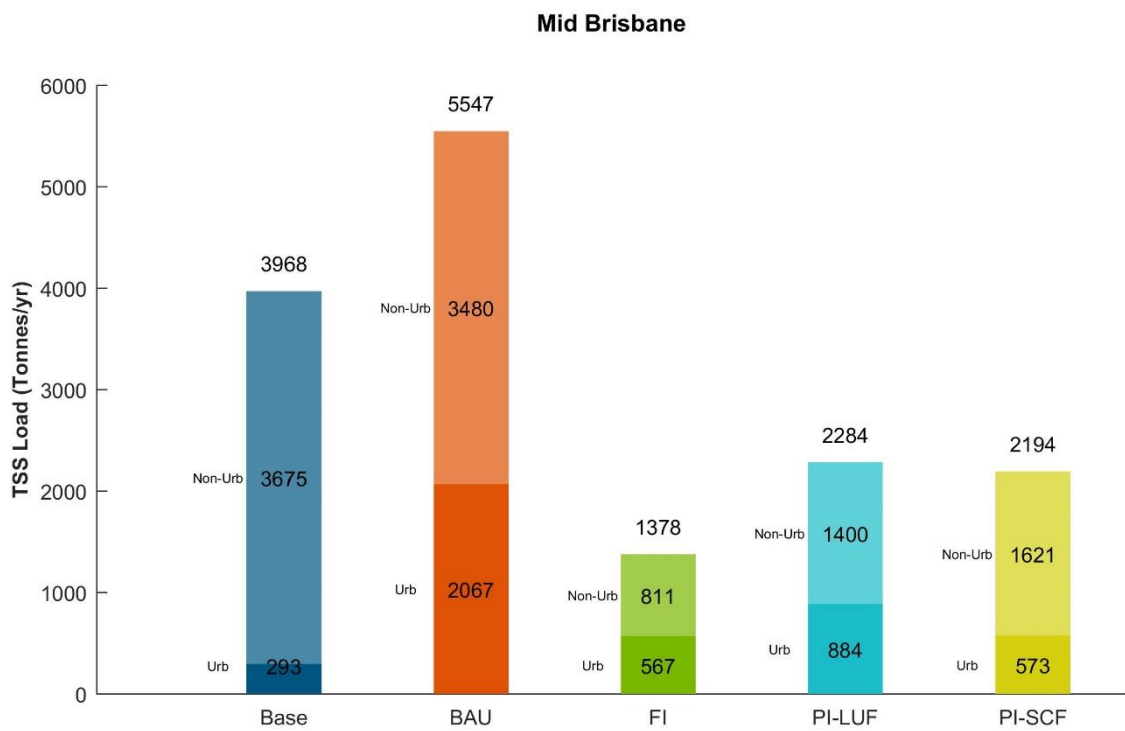


Figure 3-50 TSS catchment loads from Mid Brisbane

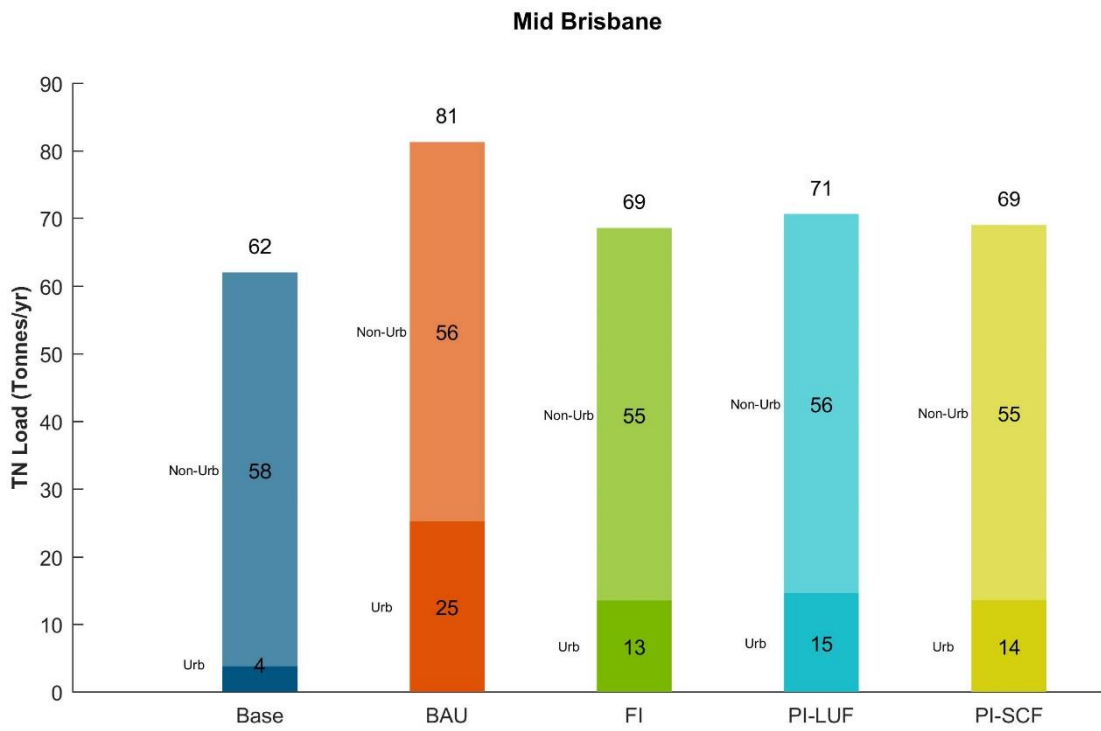


Figure 3-51 TN catchment loads from Mid Brisbane

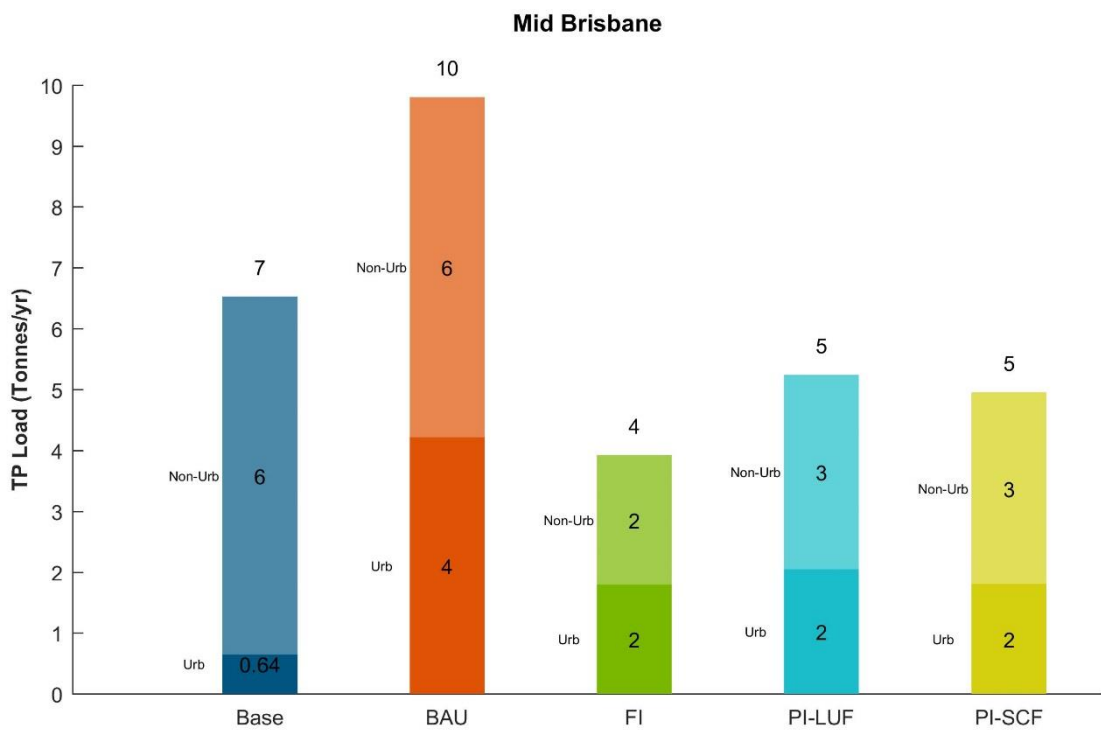


Figure 3-52 TP catchment loads from Mid Brisbane

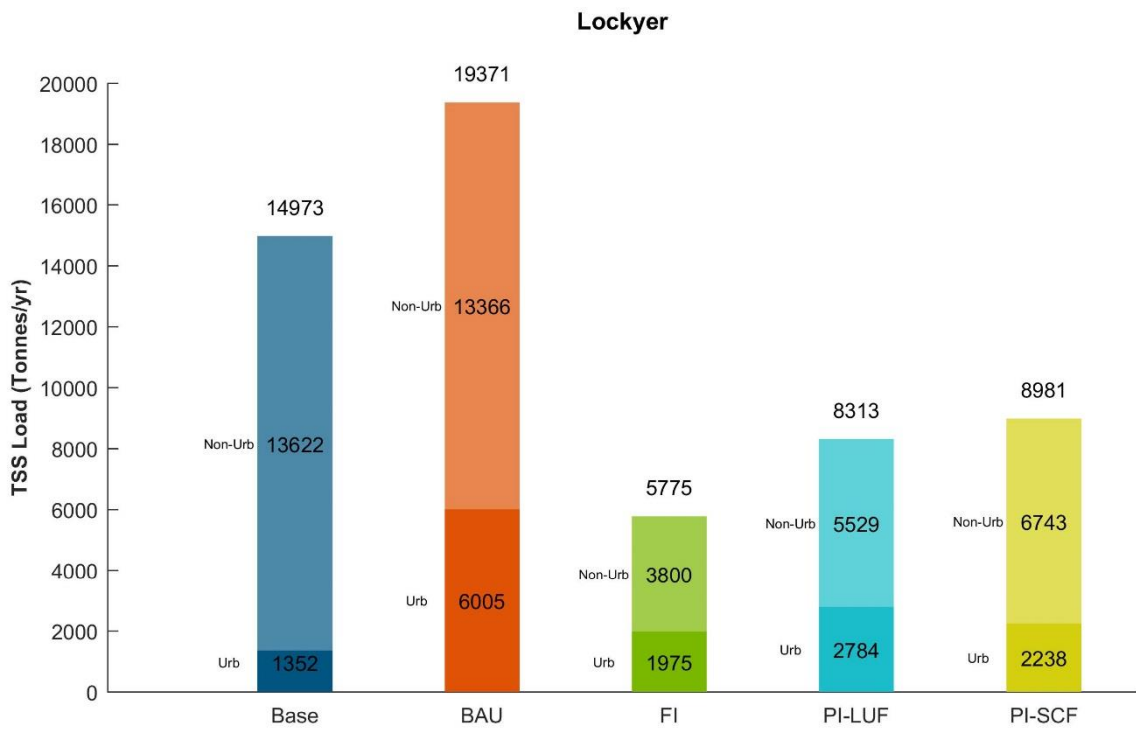


Figure 3-53 TSS catchment loads from Lockyer

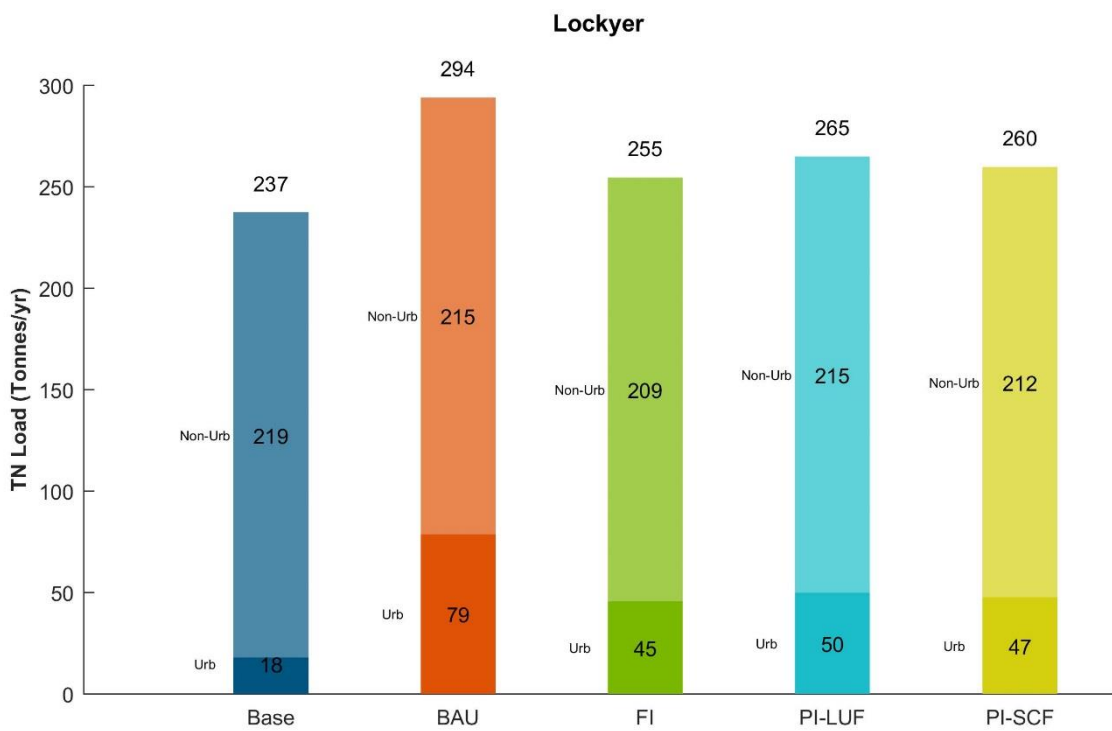


Figure 3-54 TN catchment loads from Lockyer

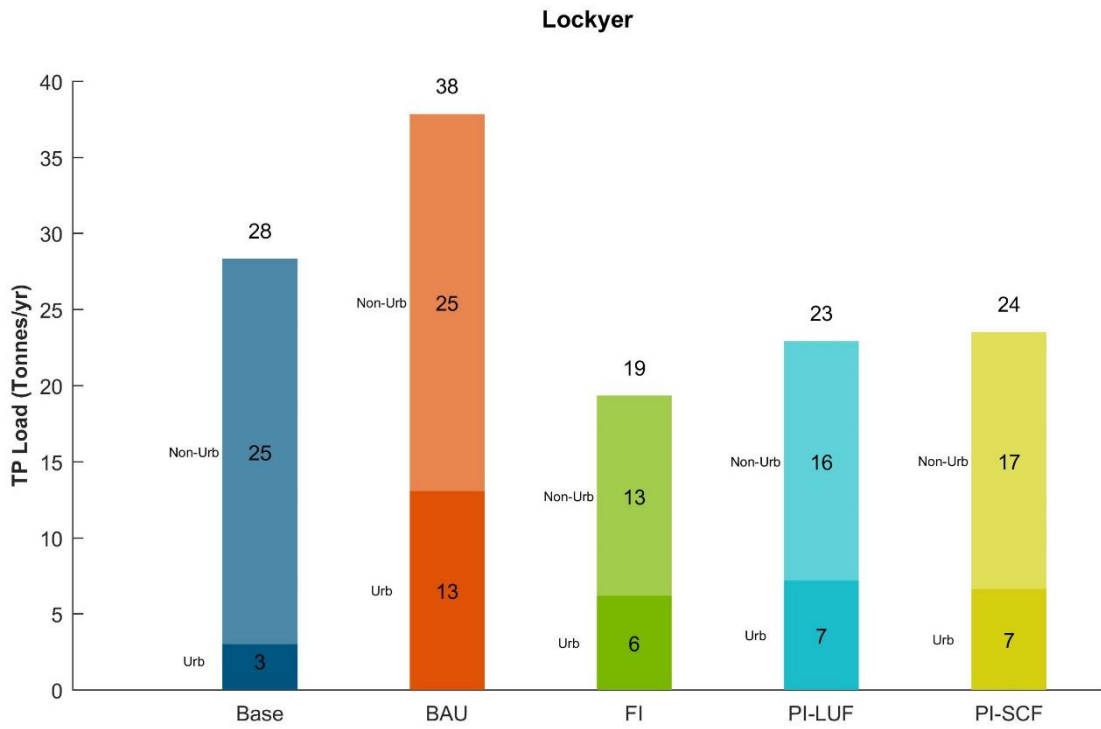


Figure 3-55 TP catchment loads from Lockyer

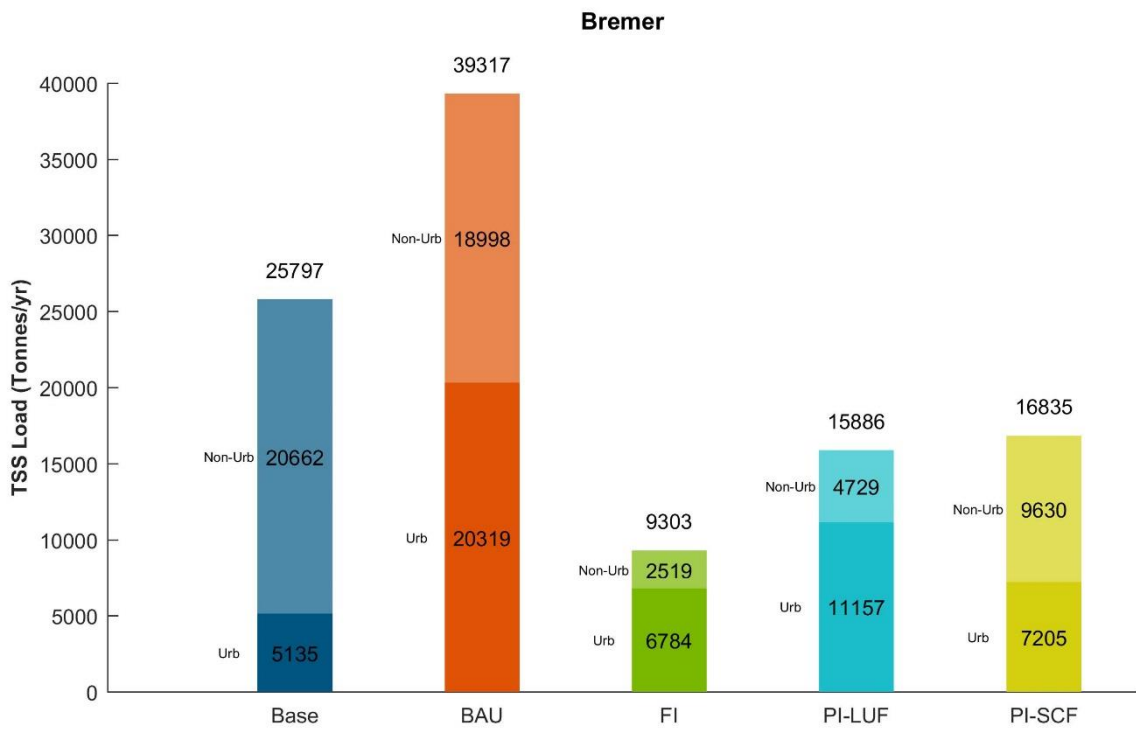


Figure 3-56 TSS catchment loads from Bremer

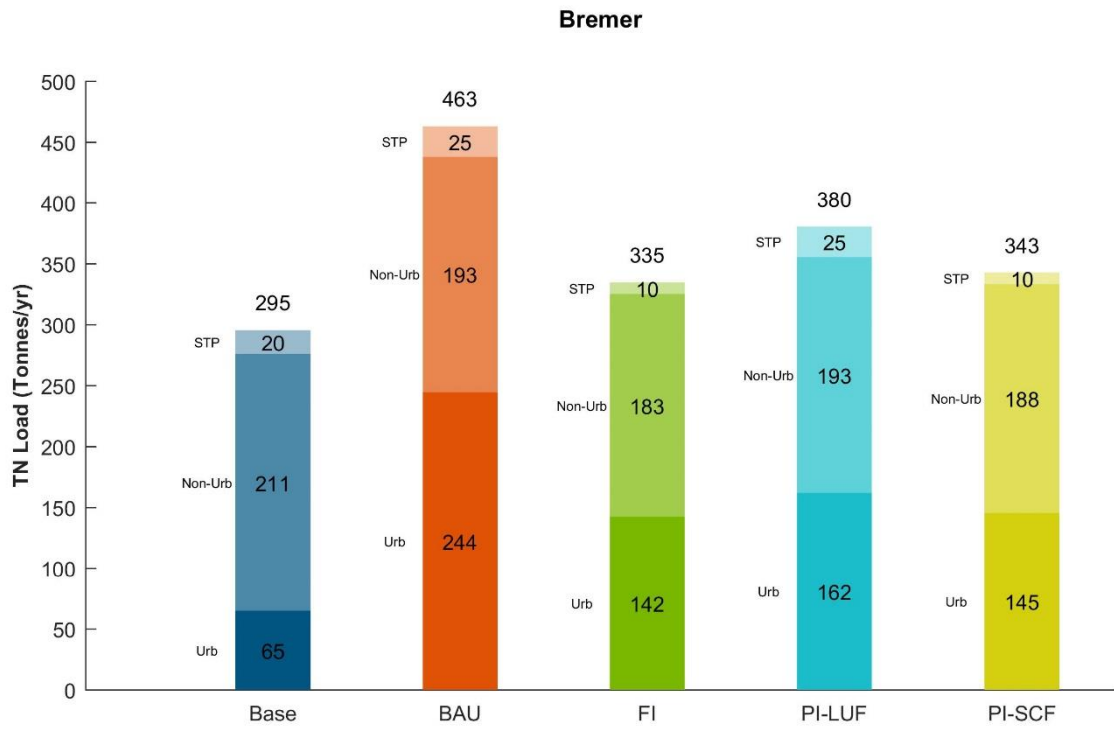


Figure 3-57 TN catchment loads from Bremer

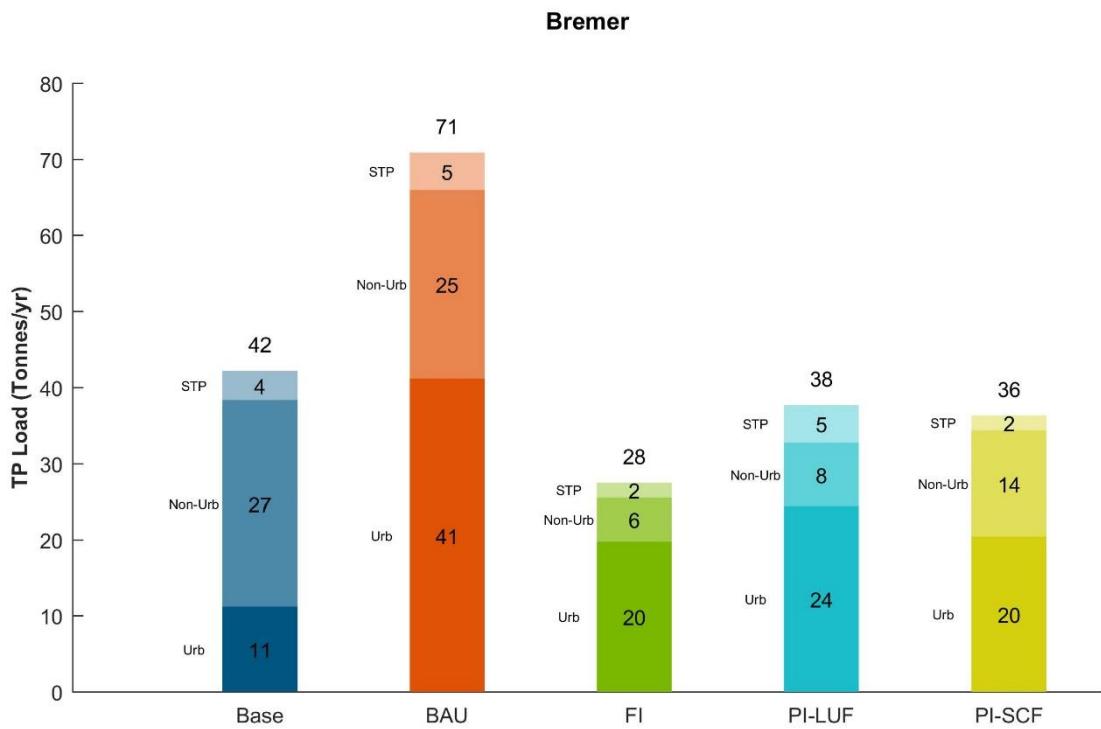


Figure 3-58 TP catchment loads from Bremer

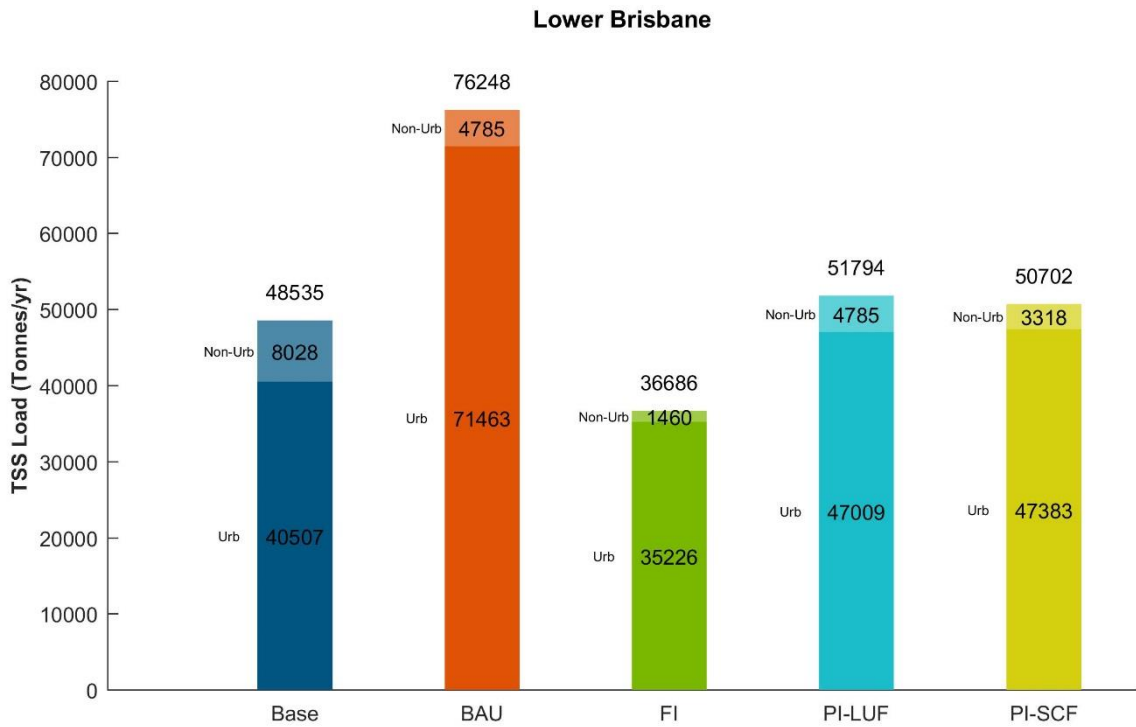


Figure 3-59 TSS catchment loads from Lower Brisbane

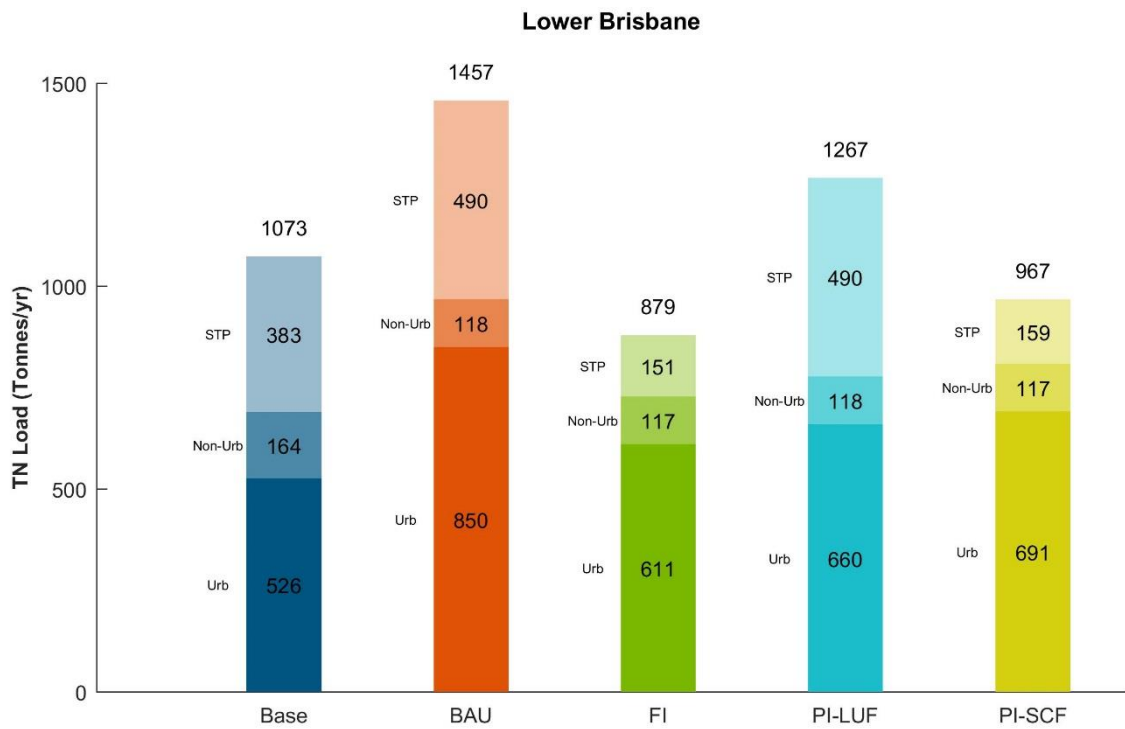


Figure 3-60 TN catchment loads from Lower Brisbane

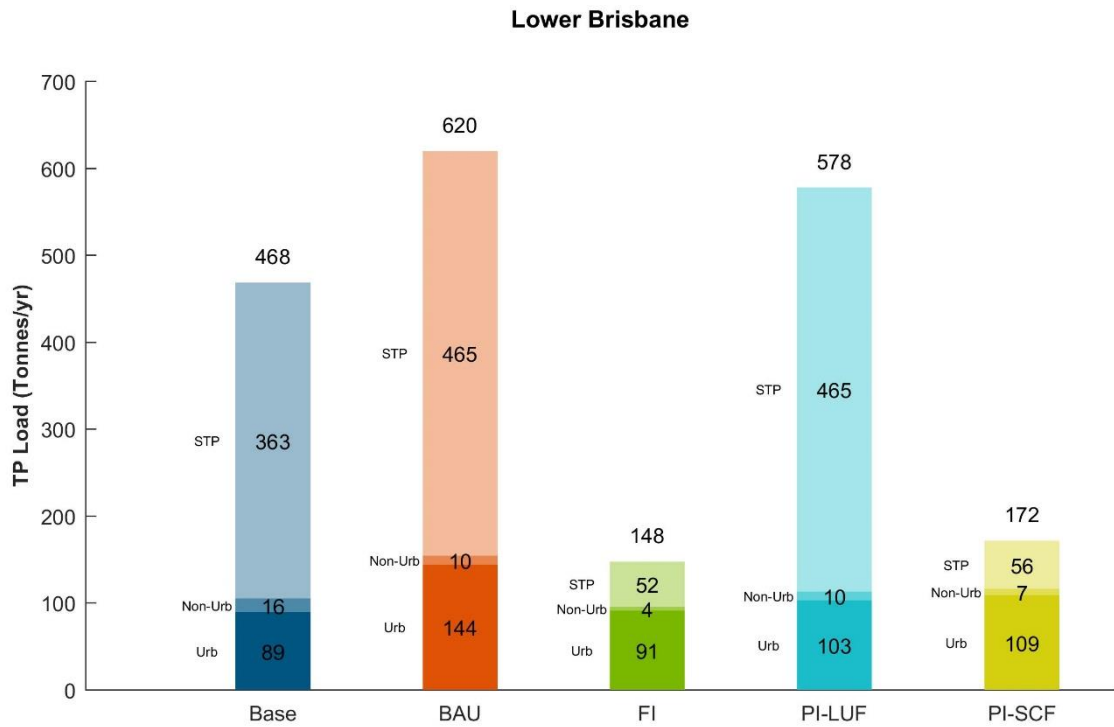


Figure 3-61 TP catchment loads from Lower Brisbane Turbidity

### 3.6.2 Turbidity

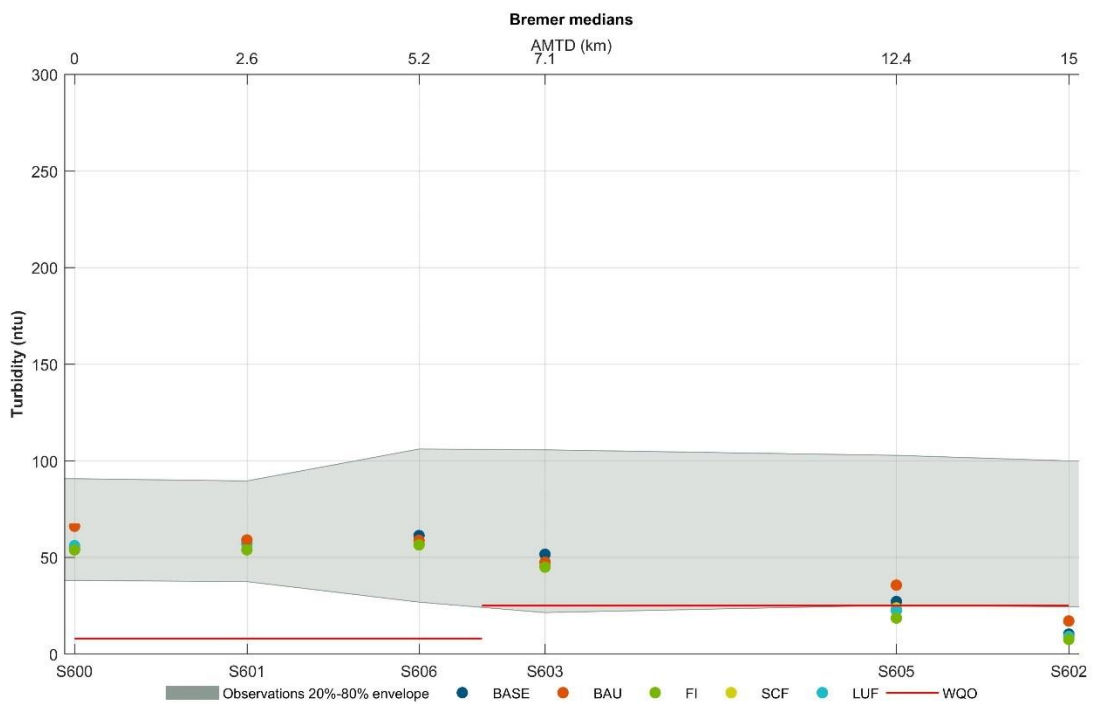
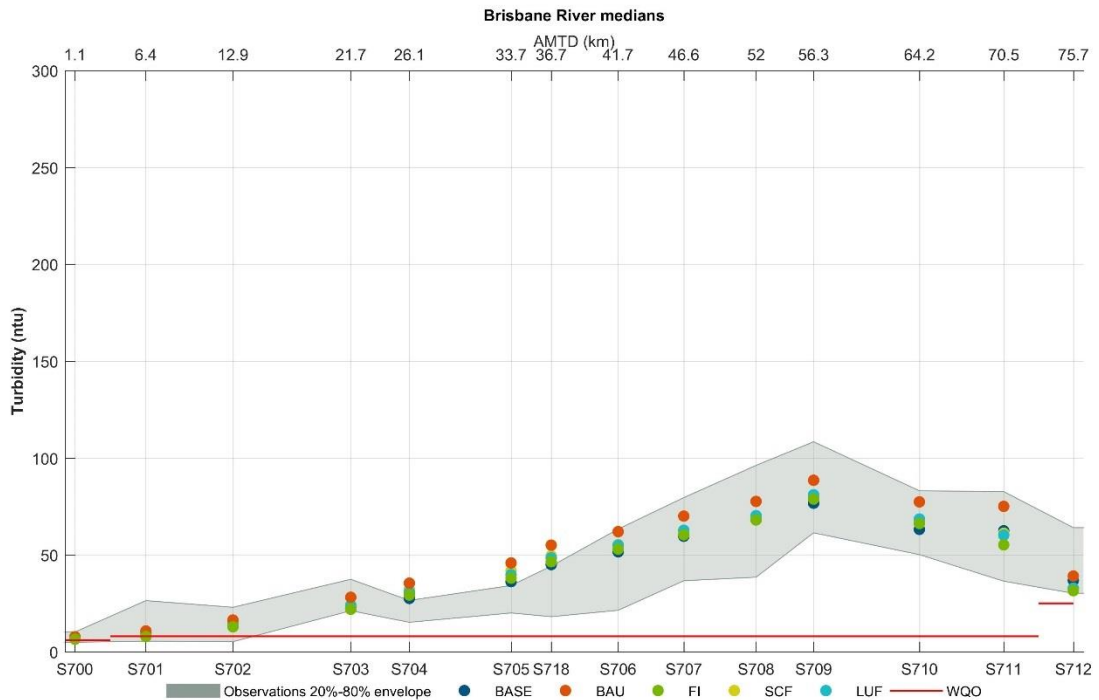


Figure 3-62 Comparison of Turbidity medians across scenarios for Bremer



**Figure 3-63 Comparison of Turbidity medians across scenarios for Brisbane**

For the Bremer River, the difference in TSS across all 5 scenarios is relatively small. In all 5 scenarios, the predicted TSS exceeded WQOs (Figure 3-62). In the upstream reaches of the river, the FI scenario came to within 10 NTU of the WQO. There was no pronounced difference in predicted TSS for the SCF and LUF scenarios as expected given the catchment loads were similar.

In the Brisbane River, the predicted difference between the BAU and FI scenarios is greatest in the more active middle and upper reaches of the estuary, exceeding WQOs by an order of magnitude for BAU (Figure 3-63). Conversely, turbidity close to the mouth of the estuary for all scenarios was similar and predicted as close to meeting the WQOs. As with the Bremer River, there was no pronounced difference in predicted TSS for the SCF and LUF scenarios.

### 3.6.3 Total nitrogen

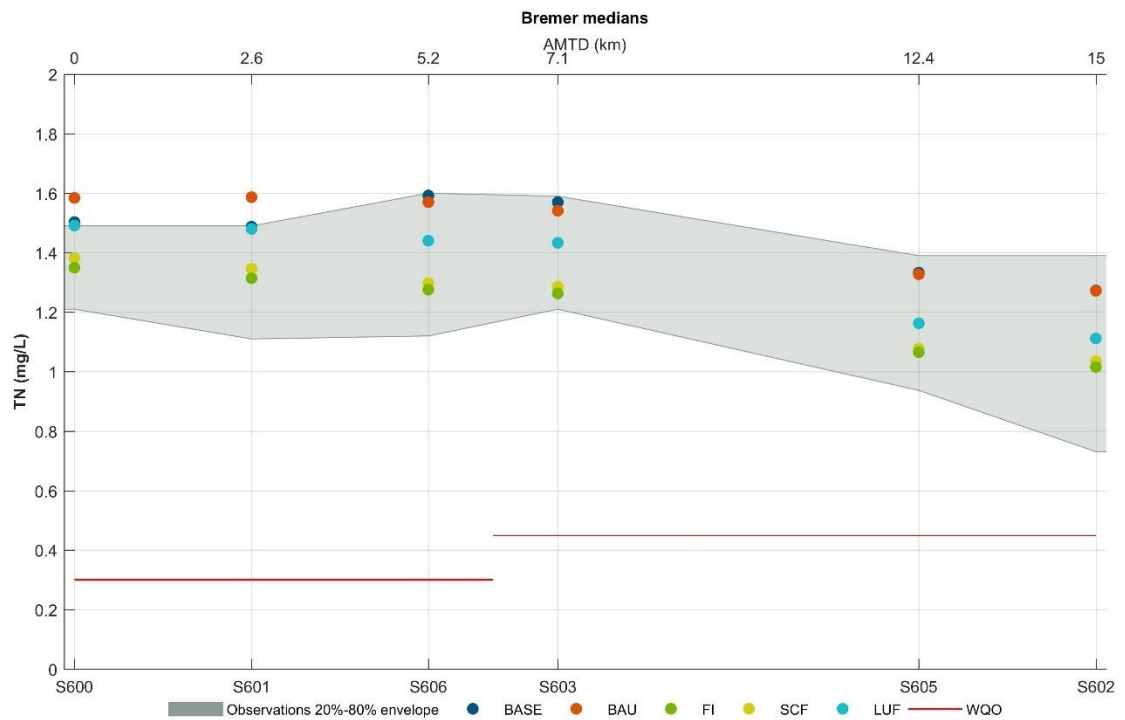


Figure 3-64 Comparison of TN medians across scenarios for Bremer

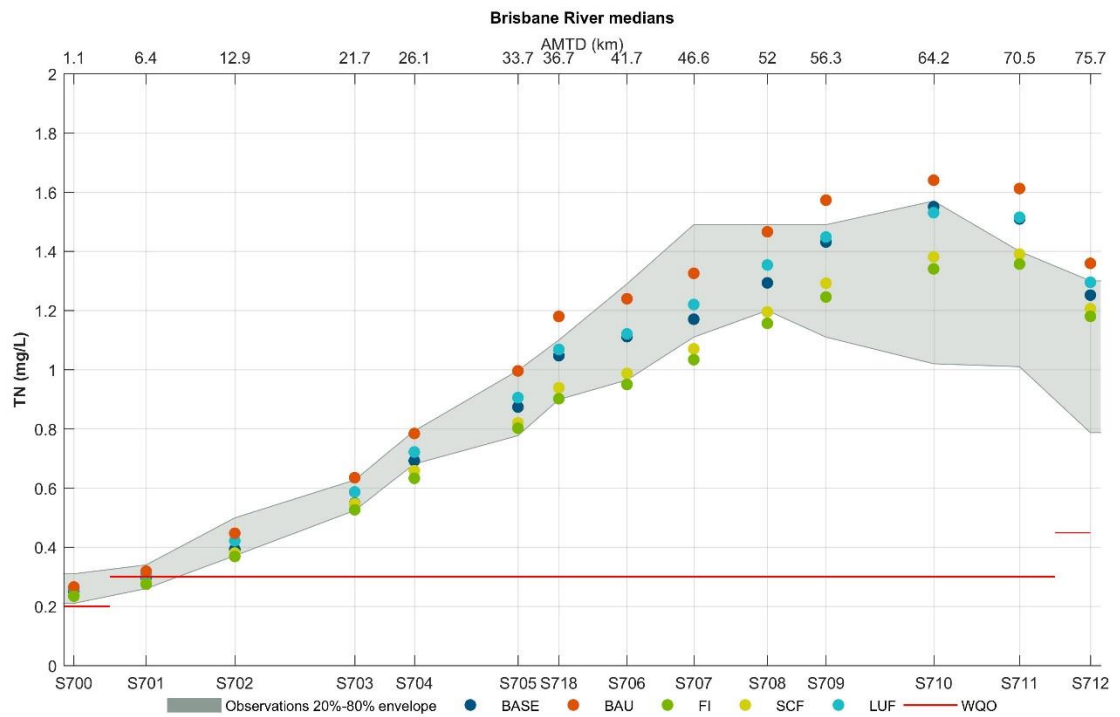


Figure 3-65 Comparison of TN medians across scenarios for Brisbane

The predicted median TN concentrations in the Bremer River for the BAU scenario were similar to the BASE scenario (Figure 3-64). The FI scenario predicted a significant reduction (~30%) in TN for all regions in the river. The SCF scenario predicted a similar reduction and the LUF scenario predicted a 10-20% reduction in concentrations of TN.

Predicted TN for the Brisbane River BAU scenario was approximately 15% greater than the BASE concentrations and the FI scenario predicted a 20% reduction in TN concentrations (Figure 3-65). The differences were most pronounced in the middle to upper reaches of the river where the greatest concentrations of TN are observed. The SCF scenario predicted similar reductions to the FI scenario although predicted concentrations were slightly higher. The LUF predicted TN was close to the BASE scenario.

### 3.6.4 Total phosphorus

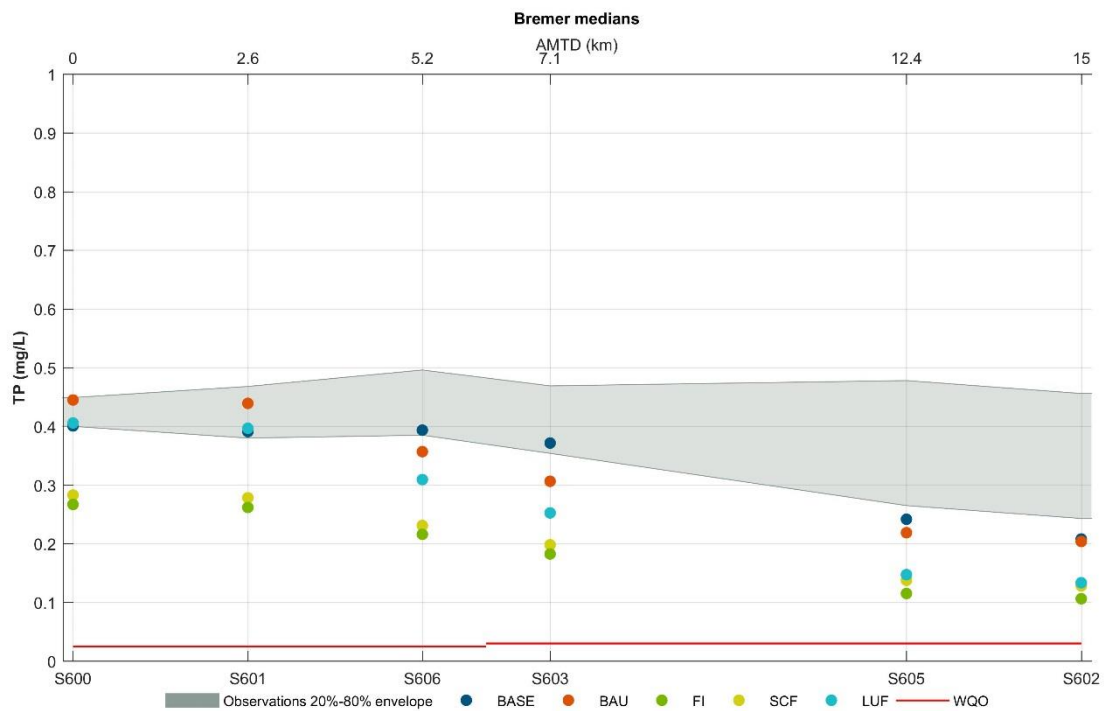
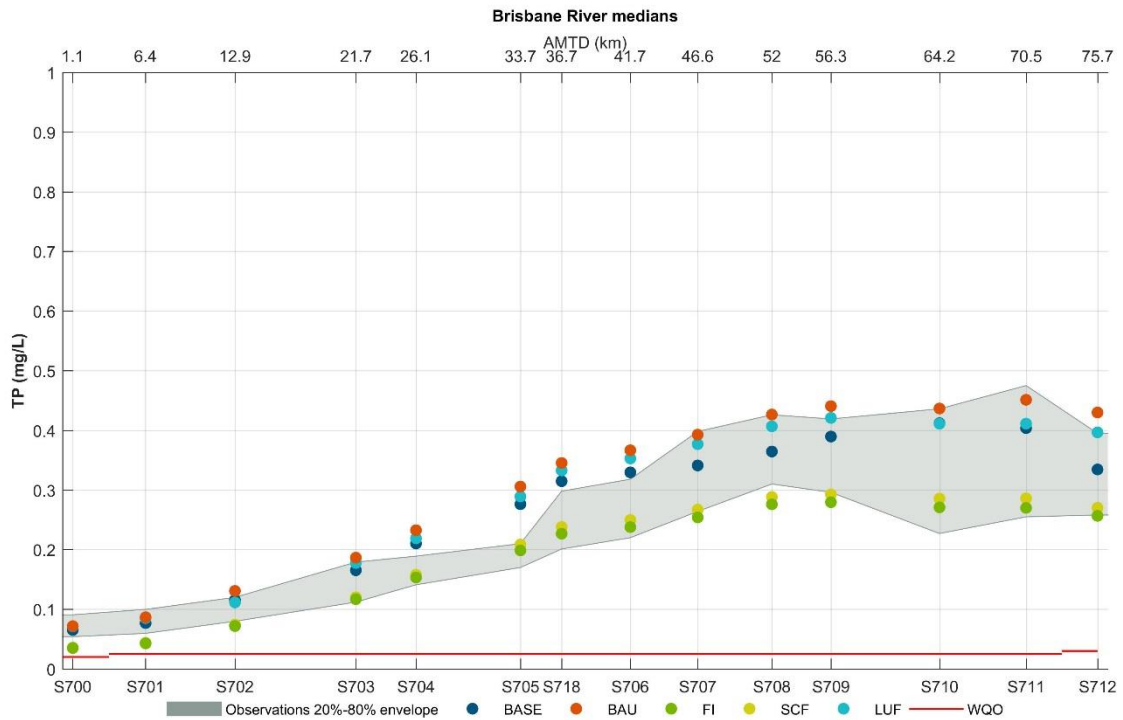


Figure 3-66 Comparison of TP medians across scenarios for Bremer



**Figure 3-67 Comparison of TP medians across scenarios for Brisbane**

The predicted concentrations for TP in the Bremer River were all lower than BASE with FI predicting a reduction of more than 50% (Figure 3-66). The TP concentrations for the SCF scenario were similar to FI with LUF prediction of approximately 30% reduction in TP concentrations. All predicted TP concentrations were still well over the WQOs with greatest exceedances located in the downstream reaches of the river.

For the Brisbane River, the BAU predicted concentrations for TP were approximately 20% greater than the BASE scenario (Figure 3-67). The greatest concentrations predicted in the BAU scenario were in the middle to upper reaches of the estuary where observed concentrations of TP are greatest. The LUF scenario predicted a similar reduction in TP to the FI scenario and the SCF TP predictions were comparable to the BAU scenario.

### 3.6.5 Dissolved Oxygen Saturation

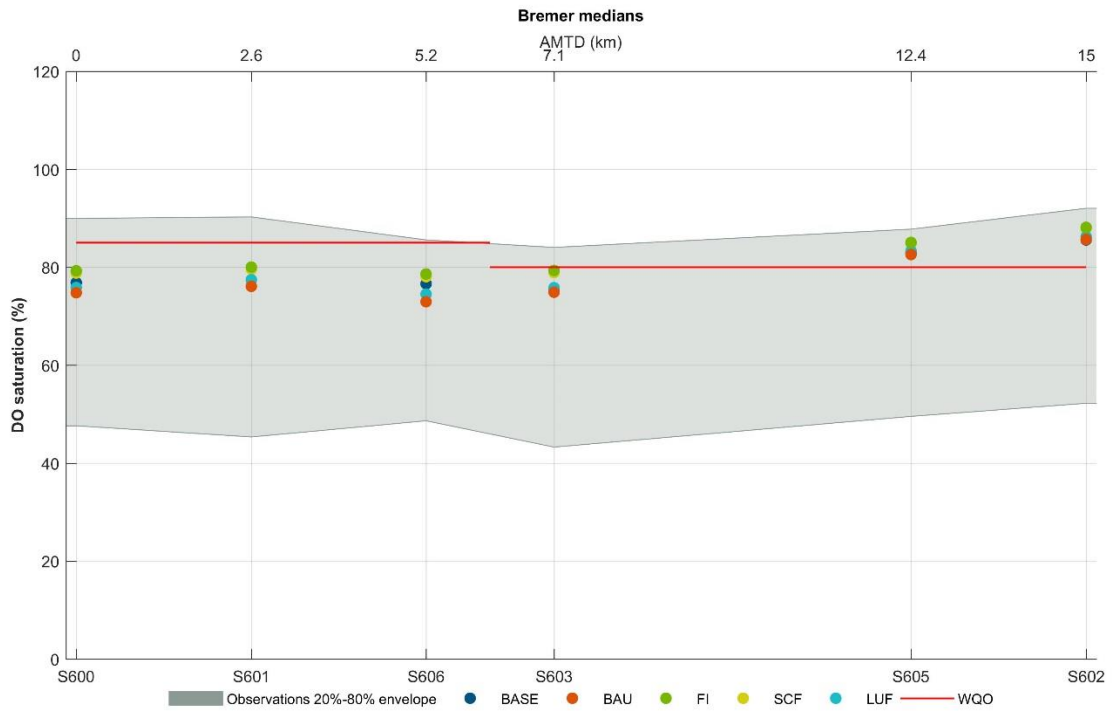


Figure 3-68 Comparison of DO saturation medians across scenarios for Bremer

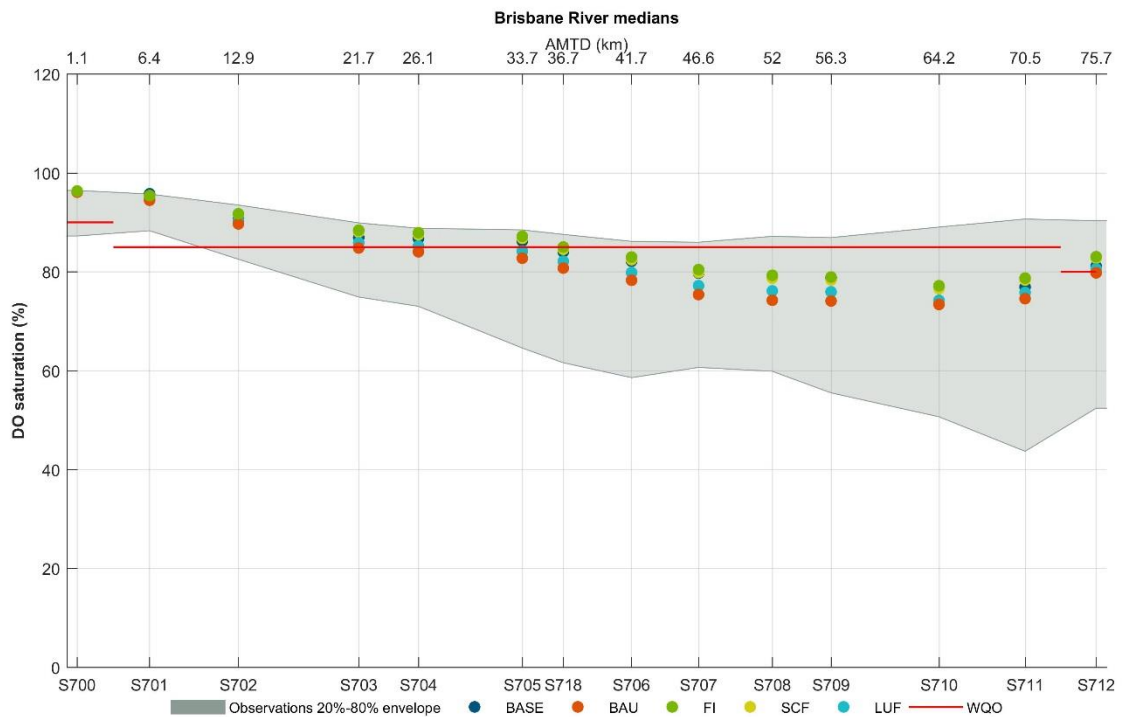


Figure 3-69 Comparison of DO saturation medians across scenarios for Brisbane

In the Bremer River, the difference between predicted DO saturation for the BAU and FI scenarios was approximately 7% with the greatest difference occurring in the region surrounding the Bundamba waste water treatment plant (WWTP) discharge (Figure 3-68). The LUF scenario predicted similar DO to BAU where the predicted increase in DO for the SCF scenario was almost as much as the FI scenario.

Comparable results for DO were predicted in the Brisbane River with the FI scenario predicting up to 8% increase in the middle to upper reaches of the estuary (Figure 3-69). This increase in DO predictions was significant in the middle to lower reaches of the estuary with FI predicting DO within the WQOs and BAU falling below WQOs. Again, the difference between the FI and BAU scenarios was most pronounced in regions of WWTP release.

### 3.6.6 Chlorophyll-a

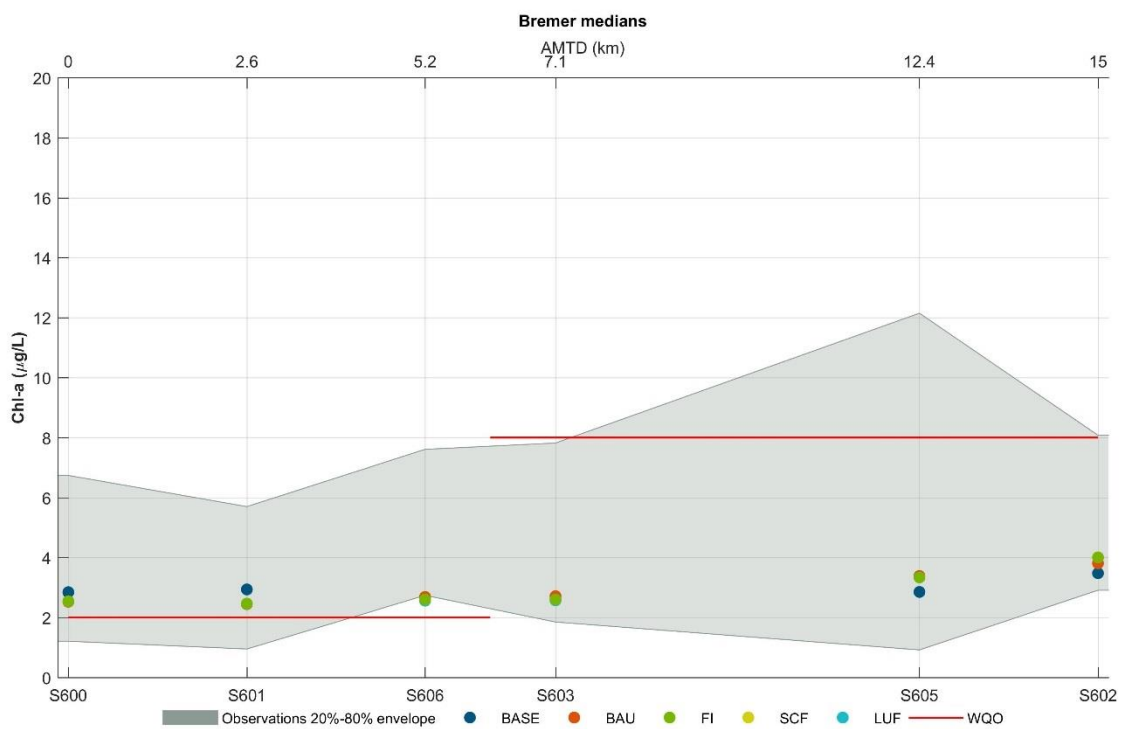
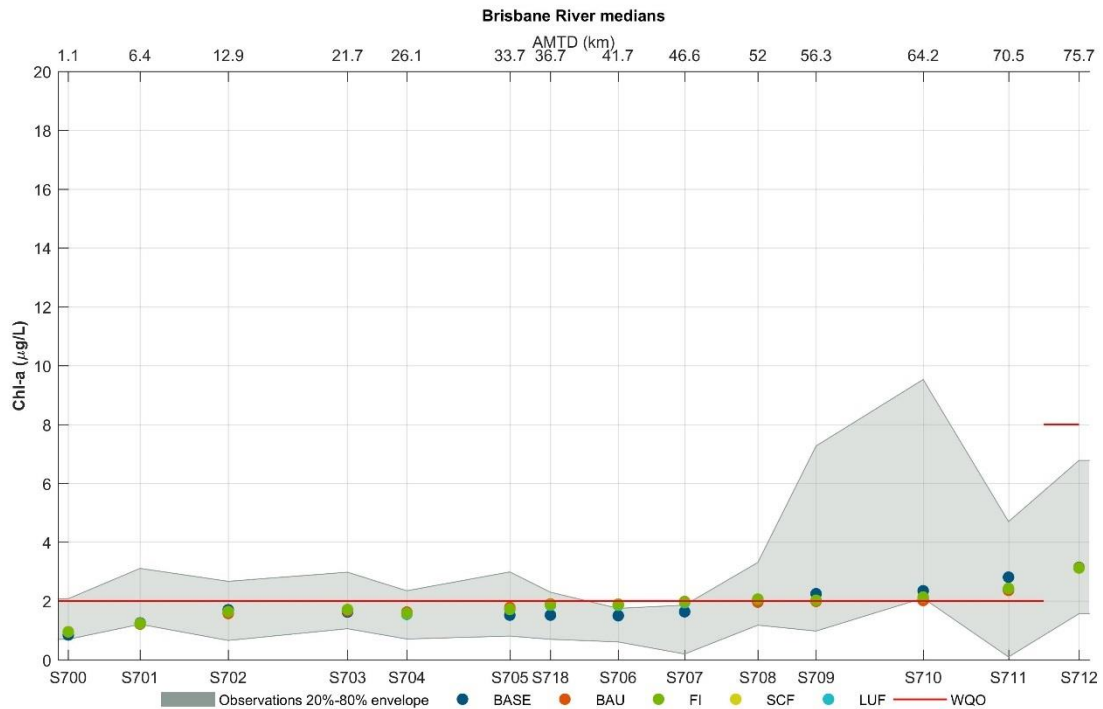


Figure 3-70 Comparison of chlorophyll-a medians across scenarios for Bremer



**Figure 3-71 Comparison of chlorophyll-a medians across scenarios for Brisbane**

No significant difference between scenario results were observed in predicted Chl-a concentrations for either the Bremer (Figure 3-70) or Brisbane rivers (Figure 3-71).

### 3.6.7 Conclusions

- The catchment model predicted significant reduction in TSS, TN & TP for FI compared to BAU. For TSS both SCF & LUF predicted similar loads at approximately half way between BAU & FI. For TN LUF predicted a small decrease from BAU and SCF almost as much as FI. For TP, LUF predicted almost no decrease from BAU and SCF almost as much as FI.
- Small differences in TSS were observed between scenarios with the greatest difference in the most active middle region of the Brisbane estuary.
- Significant differences in predicted TN concentrations were observed between BAU and FI scenarios, with the greatest difference in the middle and upper reaches of the estuary where WWTP discharges occur. The LUF scenario predicted a smaller decrease in TN.
- Significant differences in predicted TP concentrations between BAU and FI scenarios were observed with the greatest differences occurring in the middle and upper reaches of the estuary.
- Smaller differences in predicted DO concentrations between BAU and FI scenarios were predicted with the greatest difference in the middle and upper reaches of the estuary where WWTP discharges occur.

- There was no significant difference in prediction of Chl-a concentrations in either the Bremer or Brisbane rivers.

### 3.7 Logan Albert

#### 3.7.1 Catchment Loads

For the combined Logan and Albert River catchments, the BAU scenario predicted over 34% increase in TSS load from current conditions with full investment yielding a reduction of 66% (Figure 3-72 and Figure 3-75). The SCF and LUF scenarios predicted significant catchment load reductions to the BASE load of 42% and 32% respectively.

For TN, the catchment loads are expected to rise by 30% in the BAU scenario, where by applying FI the resultant TN load was comparable with the BASE load (Figure 3-73 and Figure 3-76). Similarly, SCF yielded a similar load to current conditions and LUF a 17% increase.

For TP, the catchment scenarios predicted that while BAU will yield an increase in load of 47% and, the FI will yield a 56% reduction in load (Figure 3-74 and Figure 3-77).

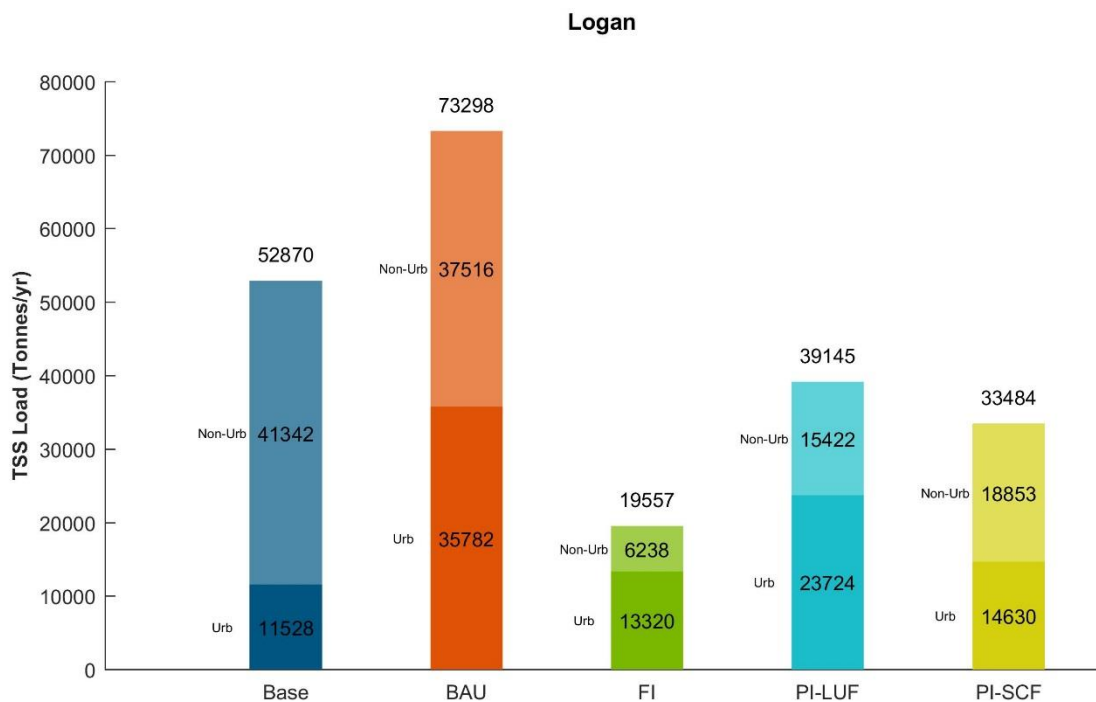


Figure 3-72 TSS catchment loads from Logan

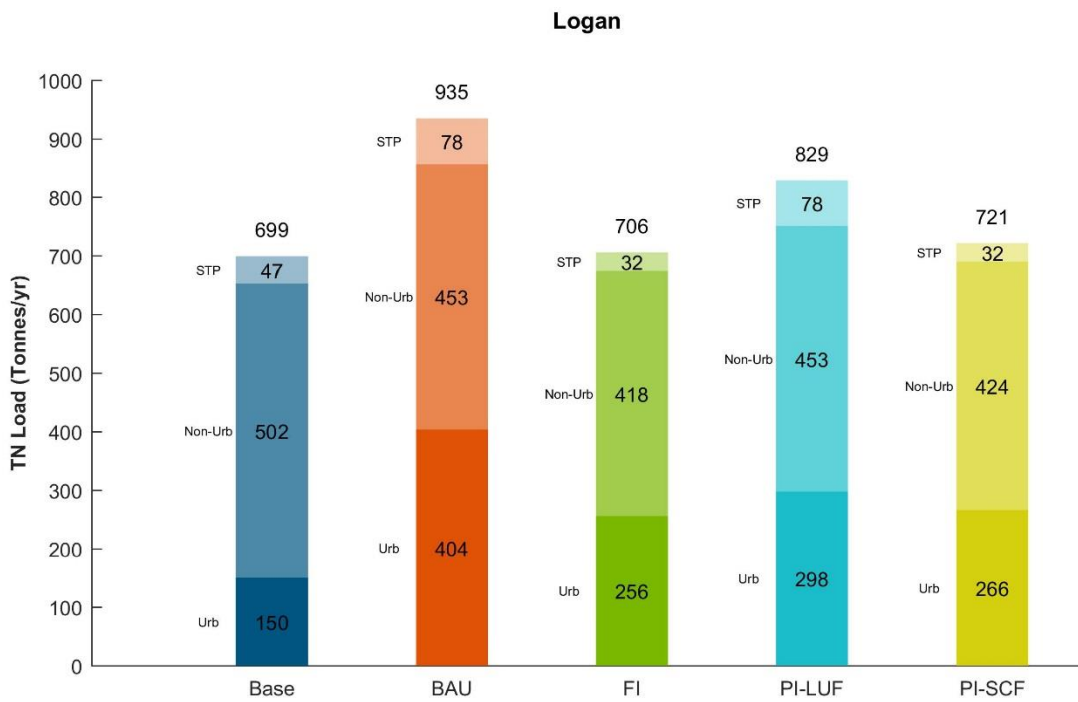


Figure 3-73 TN catchment loads from Logan

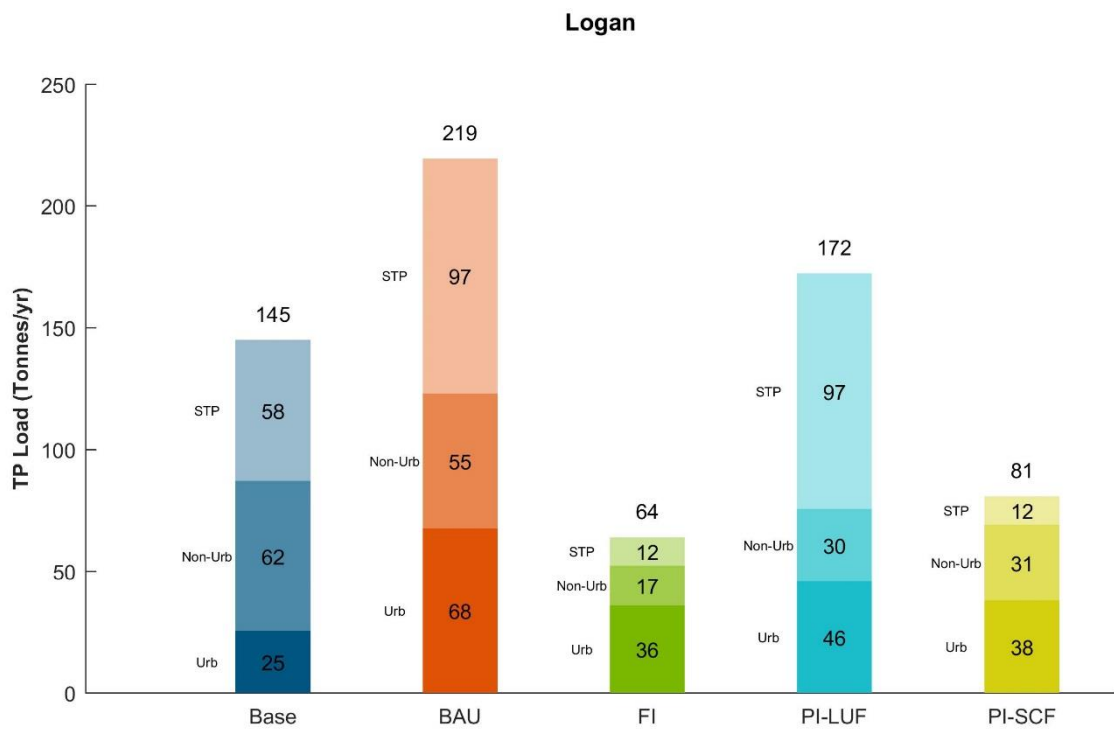


Figure 3-74 TP catchment loads from Logan

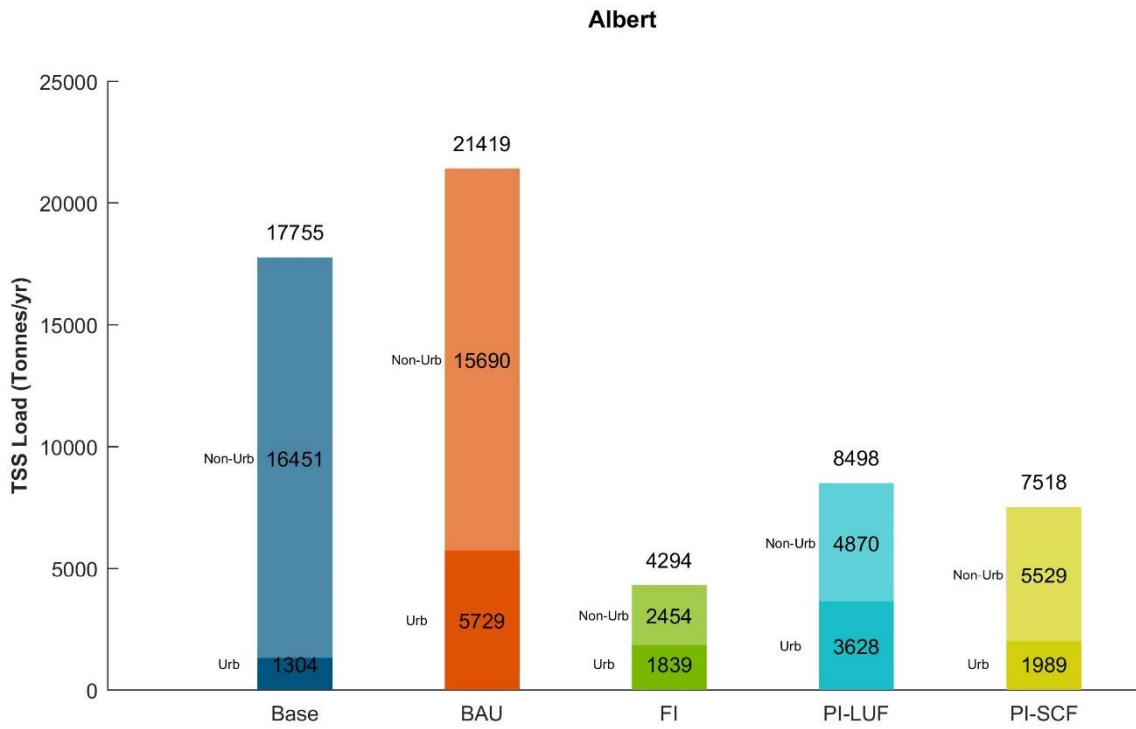


Figure 3-75 TSS catchment loads from Albert

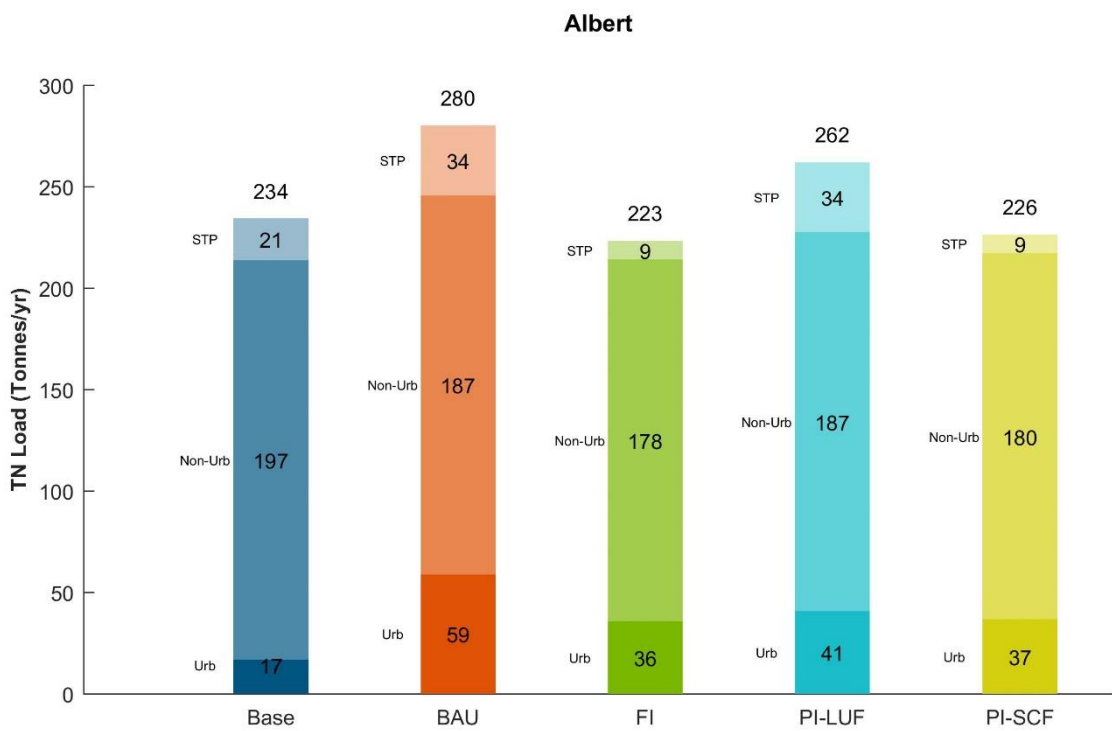


Figure 3-76 TN catchment loads from Albert

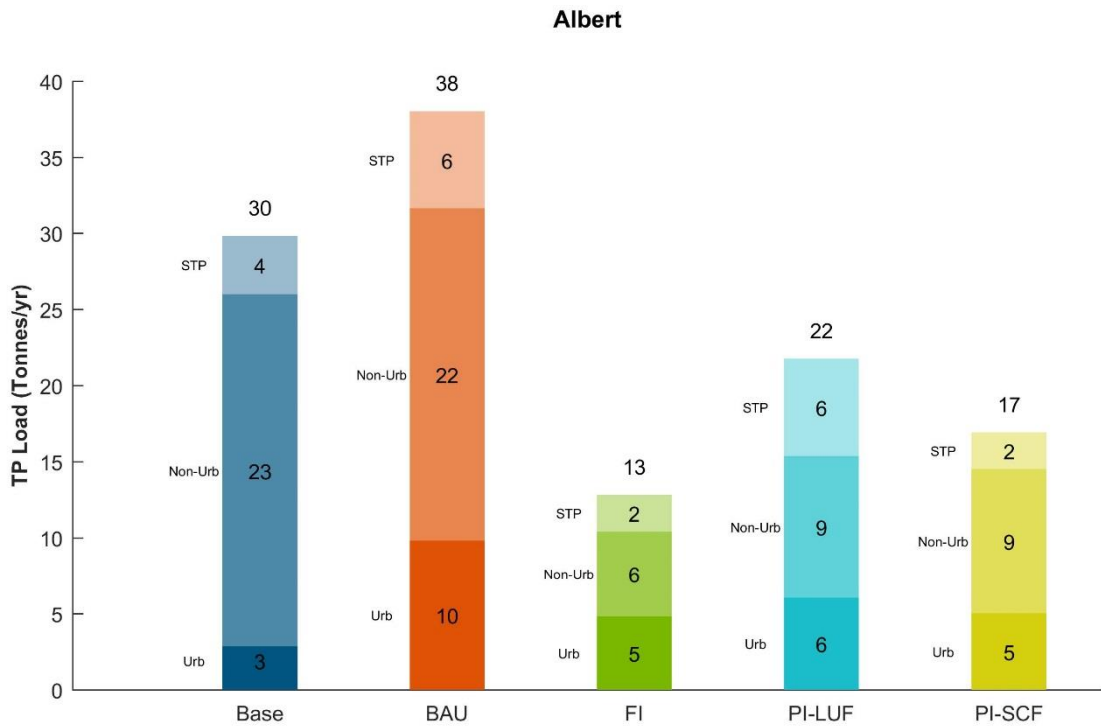


Figure 3-77 TP catchment loads from Albert

### 3.7.2 Turbidity

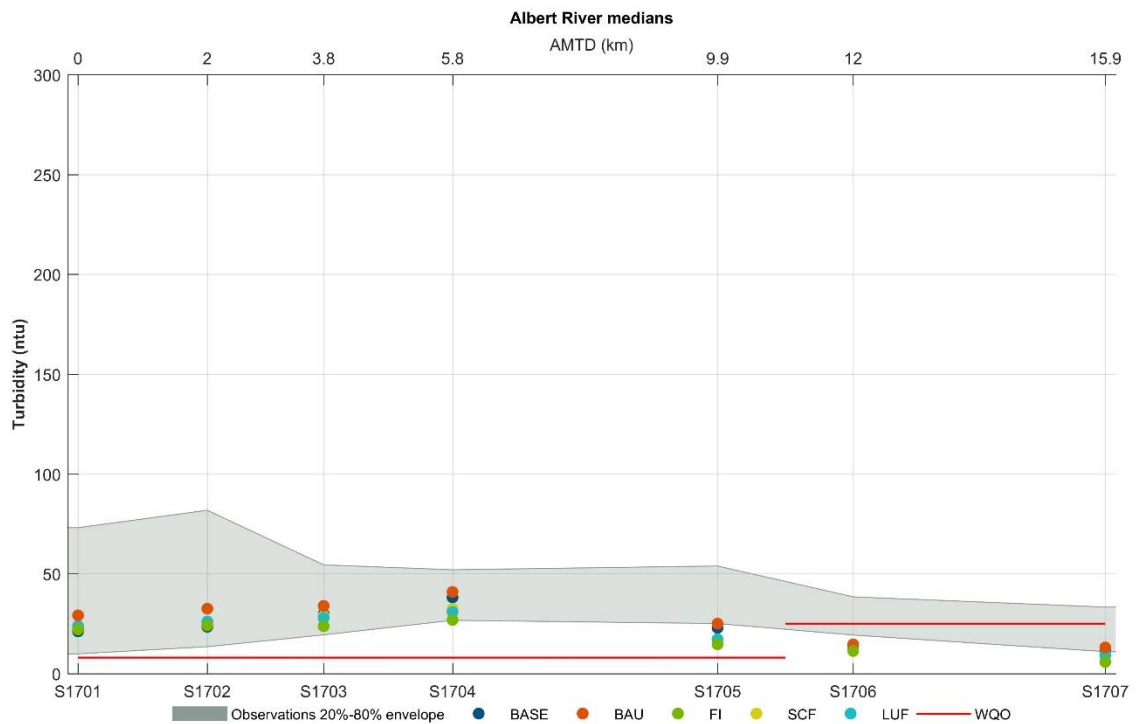
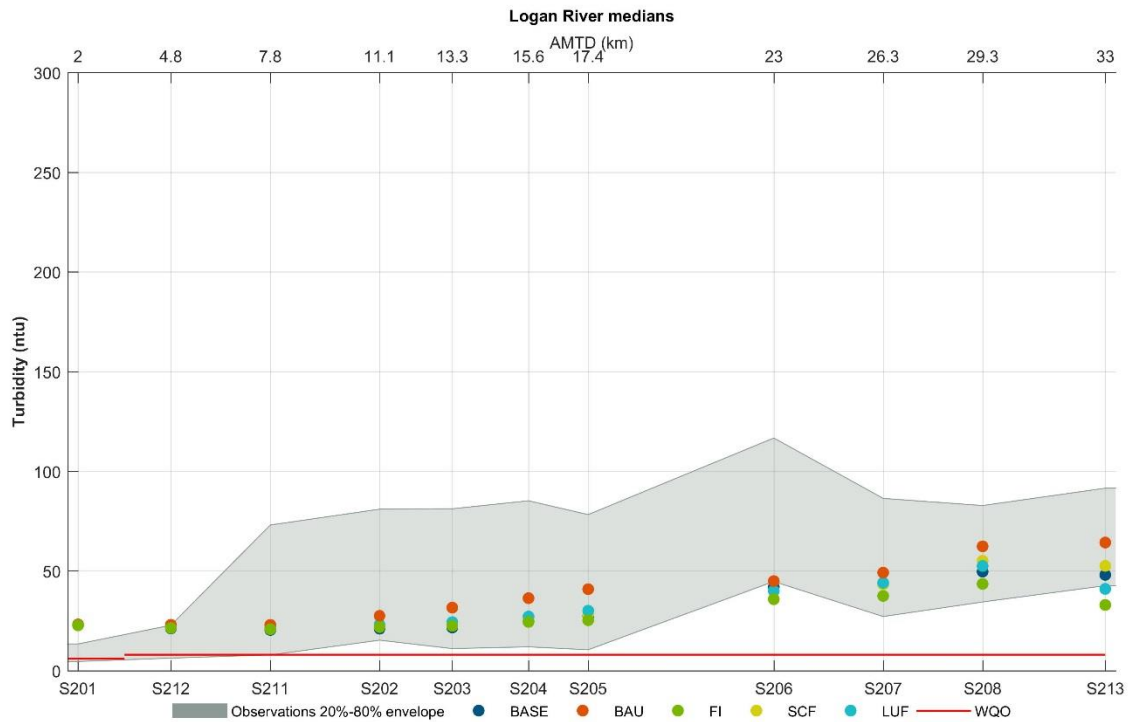


Figure 3-78 Comparison of Turbidity medians across scenarios for Albert



**Figure 3-79 Comparison of Turbidity medians across scenarios for Logan**

For the Albert River, the difference in TSS across all 5 scenarios is relatively low (Figure 3-78). In all 5 scenarios, the predicted Turbidity exceeded WQOs except the two upstream sites. There was no pronounced difference in predicted Turbidity for the SCF and LUF scenarios as expected given the catchment loads were similar.

In the Logan River, the predicted difference between the BAU and FI scenarios is greatest in the more active middle and upper reaches of the estuary exceeding WQOs by an order of magnitude throughout (Figure 3-79). Conversely, the turbidities close to the mouth of the estuary for all scenarios are similar and predicted as being close to meeting the WQOs. As with the Bremer River, there was no pronounced difference in predicted turbidity for the SCF and LUF scenarios.

### 3.7.3 Total nitrogen

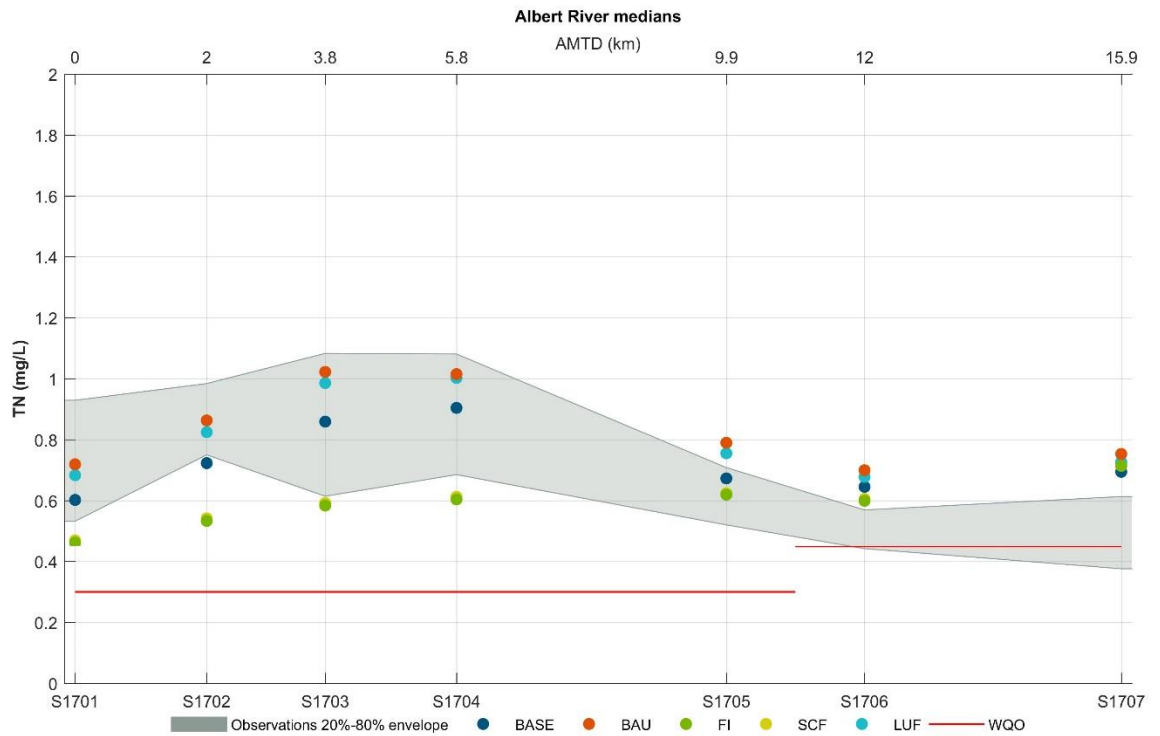


Figure 3-80 Comparison of TN medians across scenarios for Albert

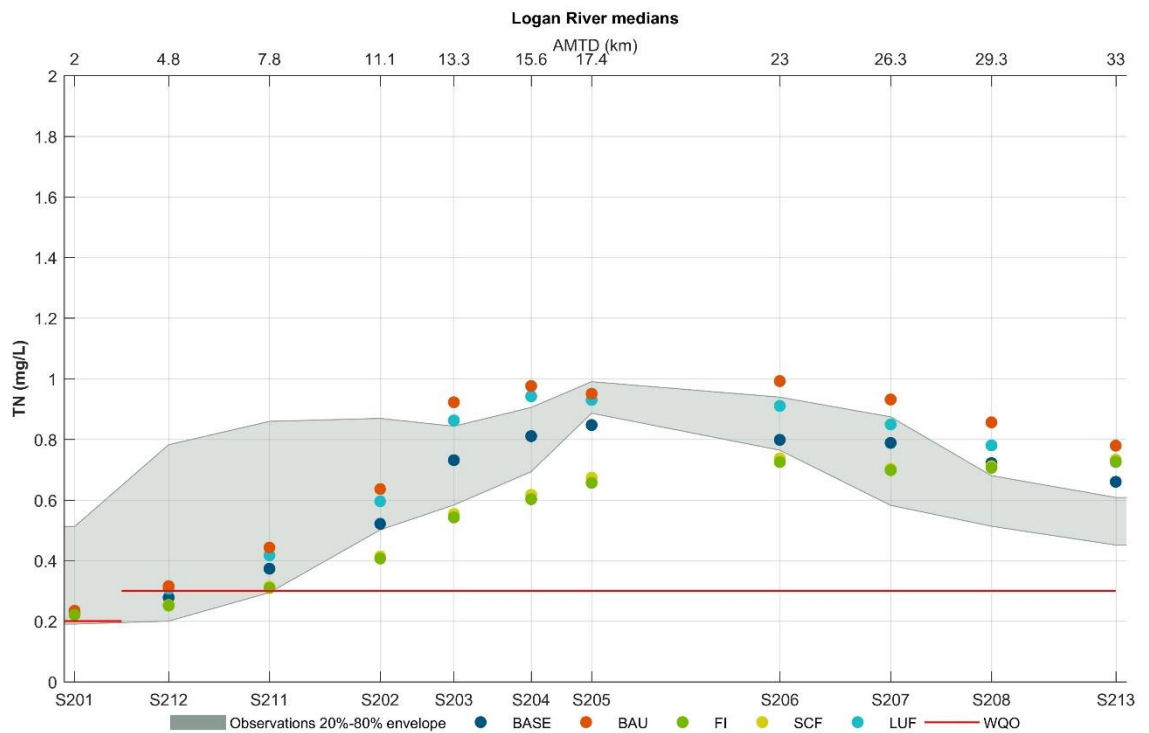


Figure 3-81 Comparison of TN medians across scenarios for Logan

The predicted concentrations of TN in the Albert were similar to the current scenario in the upstream reaches and there was significant divergence in the downstream reaches (Figure 3-80). The FI scenario predicted a significant reduction (approximately 30%) in TN for all regions of the river. The SCF scenario predicted a similar reduction to FI and the LUF scenario predicted values similar to the BAU scenario.

Predicted TN for the Logan river BAU scenario was approximately 15% greater than the BASE concentrations and the FI scenario predicted a 20% reduction in TN concentrations (Figure 3-81). The differences were most pronounced in the middle to upper reaches of the river where the greatest concentrations of TN are observed. The SCF scenario predicted similar reductions to the FI scenario and the LUF predicted TN was close to the BAU scenario.

### 3.7.4 Total phosphorus

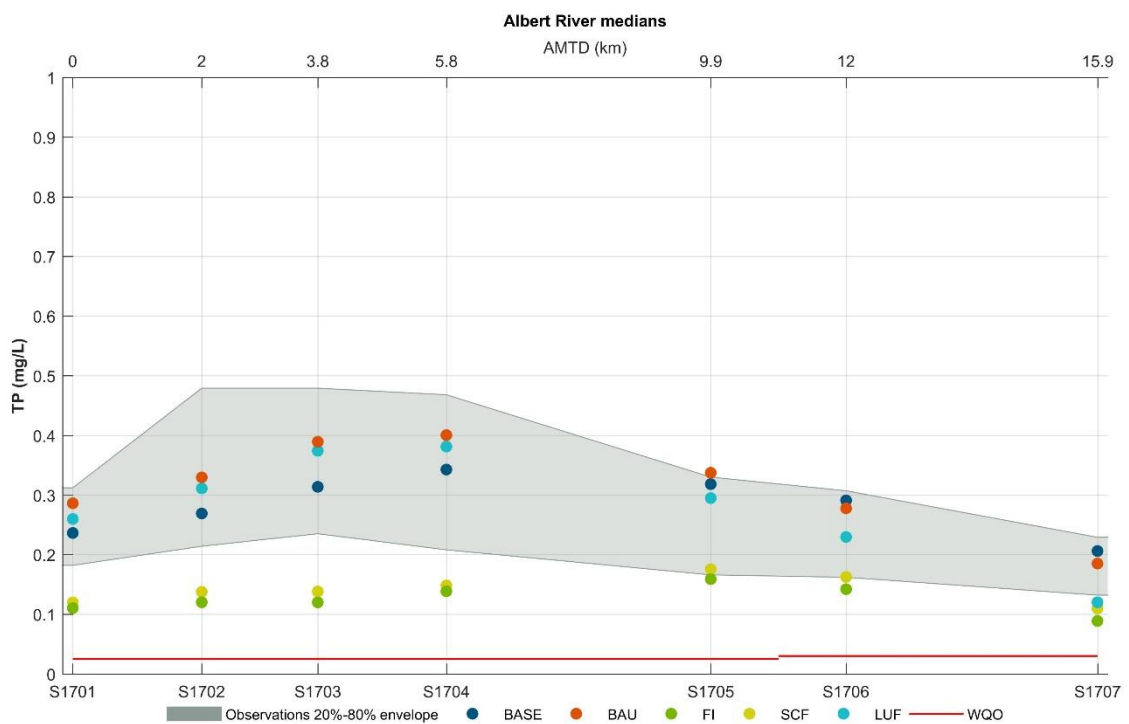
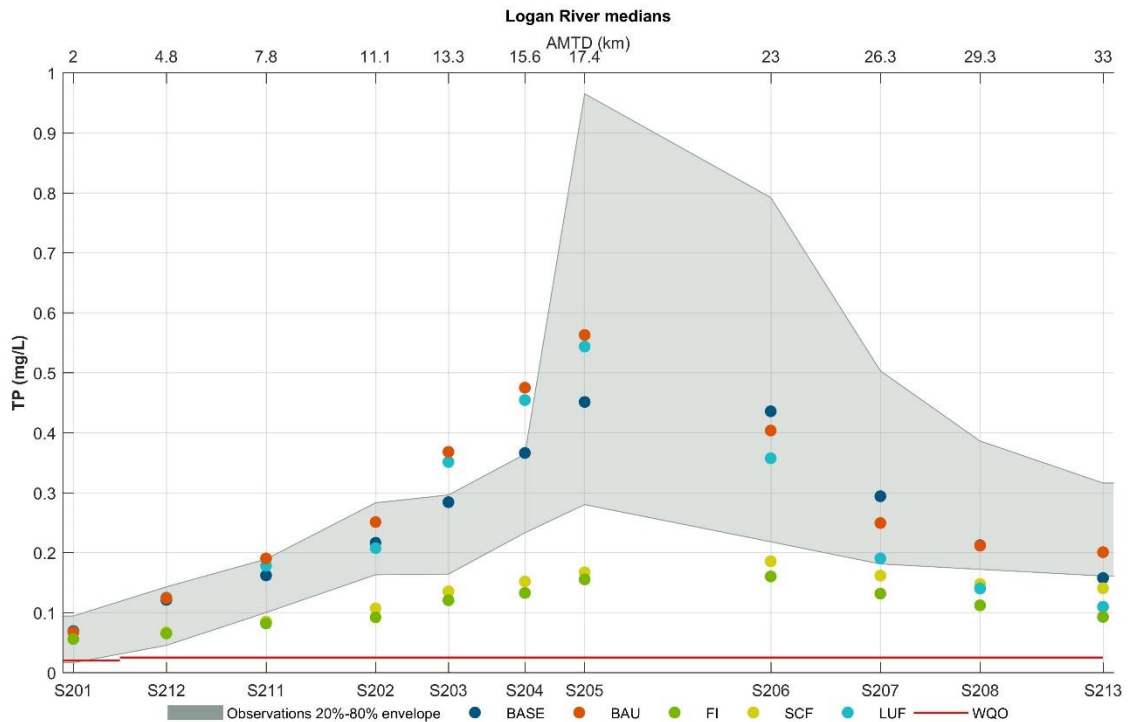


Figure 3-82 Comparison of TP medians across scenarios for Albert



**Figure 3-83 Comparison of TP medians across scenarios for Logan**

The predicted concentrations for TP in the Albert River were all lower than BASE at the two most upstream sites with FI predicting a reduction of more than 50% (Figure 3-82). The concentration in the BAU scenario exceeded BASE case by 20% in the lower and middle estuary, while the FI and SCF scenario were constantly below 50%. The lower values of BAU when compared to the BASE case in the upstream reaches can be explained by the behaviour of the TP plumes from the Beenleigh treatment plant which do not migrate upstream to the same extent due to the increased catchment flows.

For the Logan River, the BAU scenario predicted 20% increase in TP concentrations which tapered closer to the BASE case concentrations in the upstream and downstream reaches (Figure 3-83). The SCF and FI scenarios predicted reductions greater than 50% through most of the river. The LUF predictions were closer to the BAU predictions.

The lower TP predictions of all the scenarios compared to the current (BASE) scenario for sites S206/S207 in the Logan and S1706/S1707 in the Albert can be attributed to the movement of the more saline tidal water which bring TP releases from the treatment plants upstream. With higher flows in the future scenario the movement of this plume upstream is restricted and hence the TP concentrations are higher for the BASE scenario.

### 3.7.5 Dissolved Oxygen Saturation

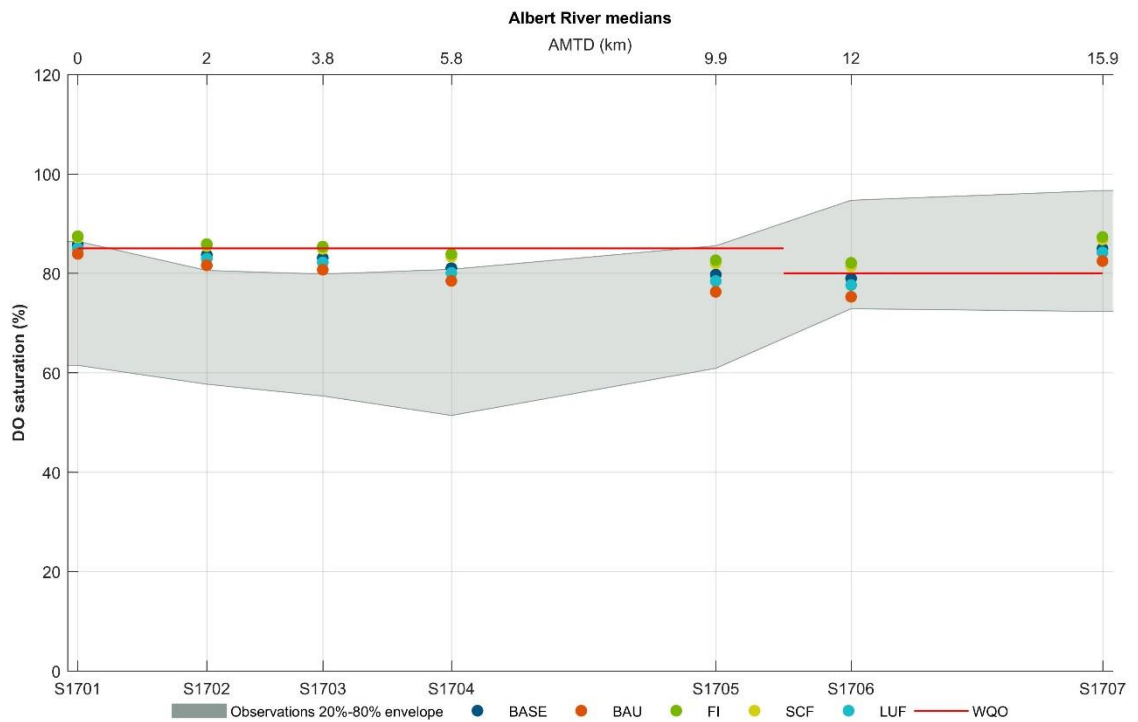


Figure 3-84 Comparison of DO saturation medians across scenarios for Albert

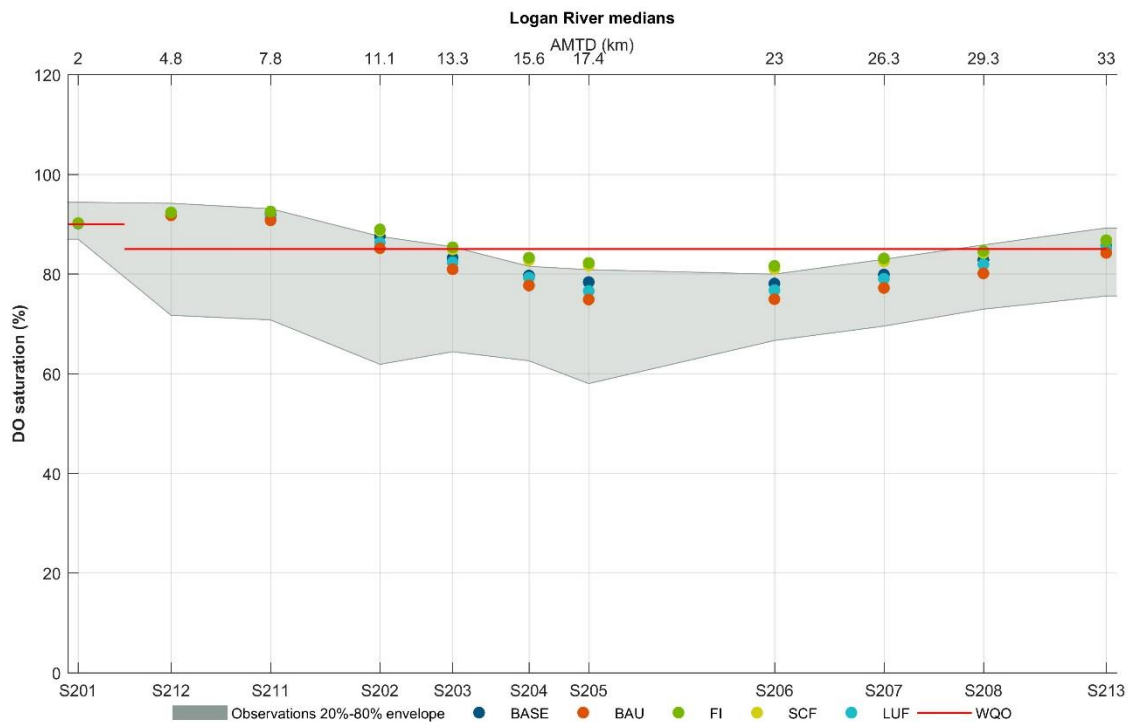


Figure 3-85 Comparison of DO saturation medians across scenarios for Logan

In the Albert River, the difference between predicted DO saturation for the BAU and FI scenarios was approximately 7% with the greatest difference occurring in the region surrounding the Beenleigh waste water treatment plant (WWTP) discharge (Figure 3-84). The LUF scenario predicted similar DO to BASE where the predicted increase in DO for the SCF scenario was almost as much as the FI scenario.

Comparable results for DO were predicted in the Logan River with the FI scenario predicting up to 8% increase in the middle to upper reaches of the estuary (Figure 3-85). This increase in DO predictions was significant in the middle to lower reaches of the estuary with FI predicting DO within the WQOs and BAU falling below WQOs. Again, the difference between the FI and BAU scenarios was most pronounced in regions of Loganholme WWTP release.

### 3.7.6 Chlorophyll-a

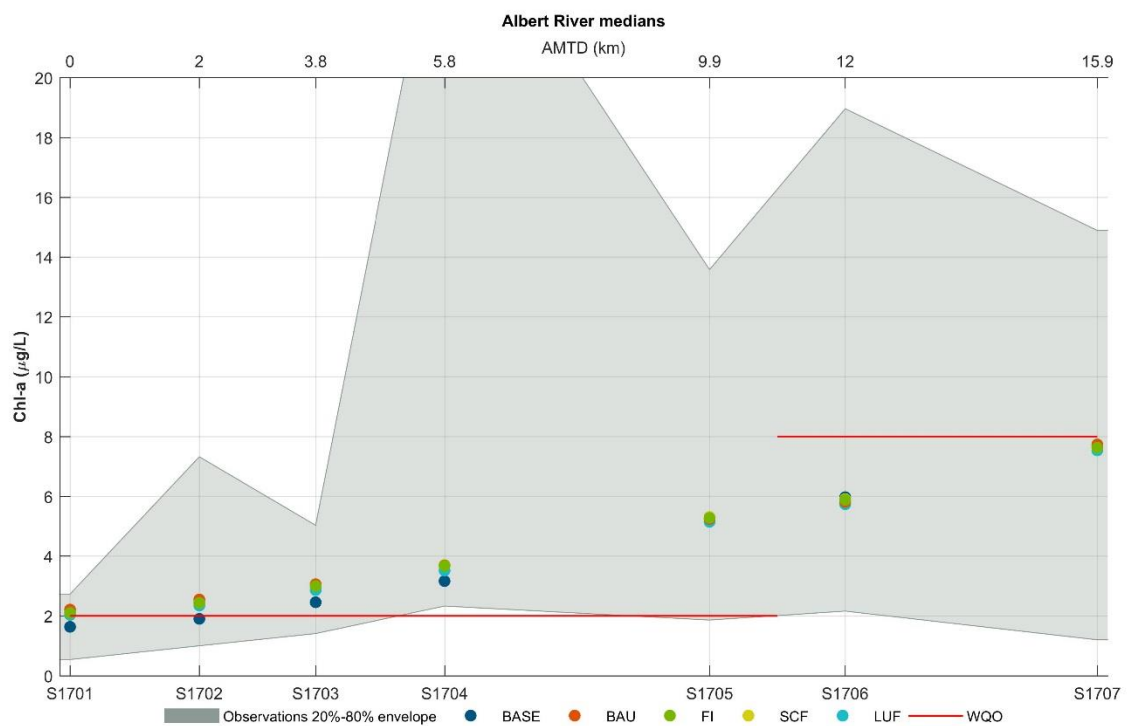


Figure 3-86 Comparison of chlorophyll-a medians across scenarios for Albert

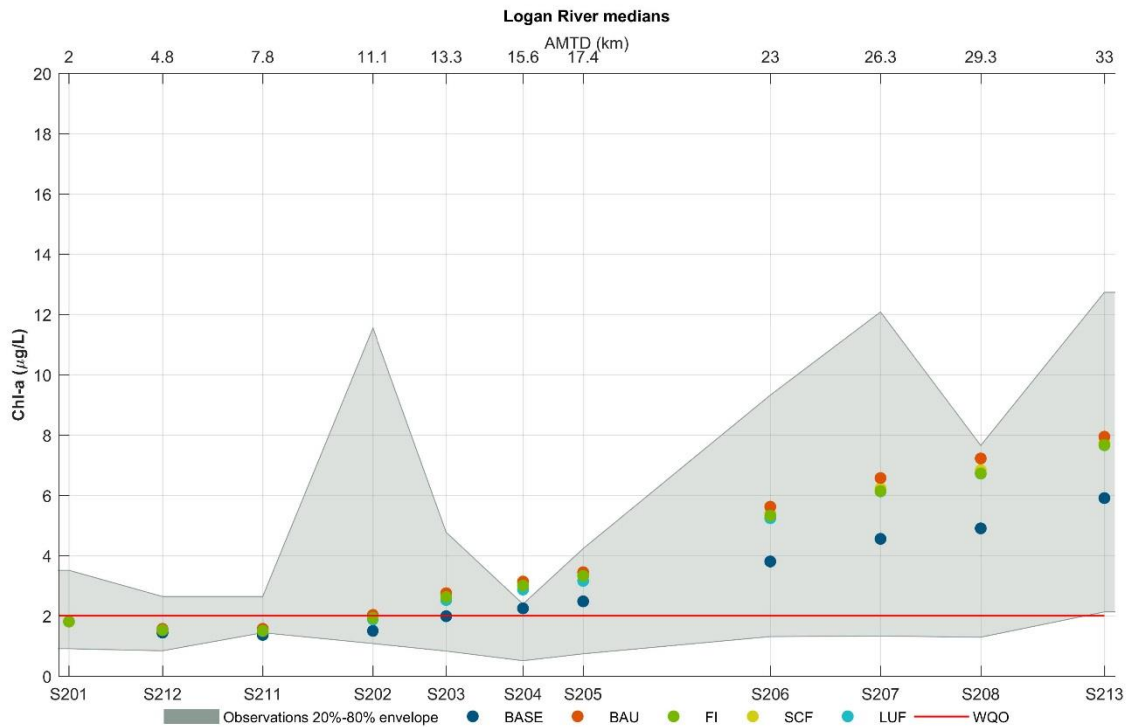


Figure 3-87 Comparison of chlorophyll-a medians across scenarios for Logan

No significant difference between scenario results were observed in predicted Chl-a concentrations for either the Albert (Figure 3-86) or Logan rivers (Figure 3-87).

### 3.7.7 Conclusions

- The catchment model predicted significant reductions in TSS, TN & TP for FI compared to BAU. For TSS both SCF & LUF predicted similar loads at approximately half way between BAU & FI. For TN LUF predicted a small decrease from BAU and SCF almost as much as FI. For TP, LUF predicted almost no decrease from BAU and SCF almost as much as FI.
- Small differences in TSS between scenarios was observed with the greatest differences being in the most active middle and upstream regions of the Logan and Albert estuaries.
- Significant differences in the predicted TN concentrations was observed between BAU and FI scenarios with the greatest differences occurring in the middle and upper reaches of the estuary.
- Significant differences in the predicted TP concentrations between BAU and FI scenarios were observed, with the greatest differences seen in the middle and upper reaches of the estuary.
- Significant differences in predicted DO concentrations between BAU and FI scenarios were observed, with the greatest differences being again in the middle and upper reaches of the estuary.

There was no significant difference in prediction of Chl-a concentrations in either the Logan or Albert rivers.

### 3.8 Moreton Bay

#### 3.8.1 Turbidity

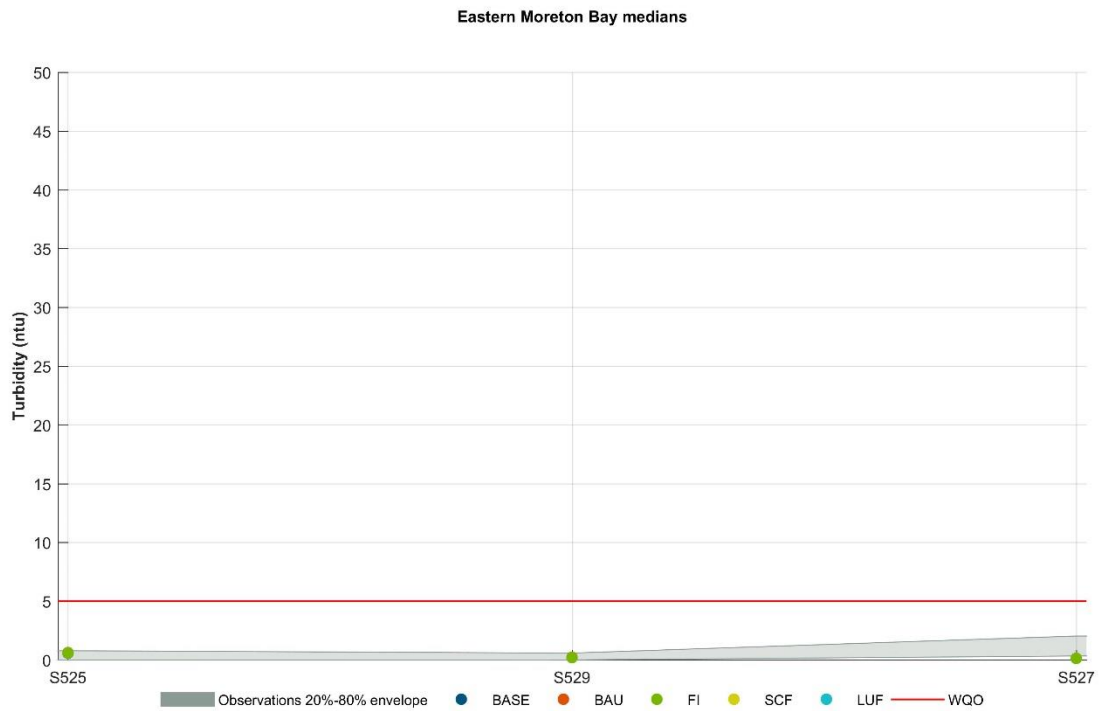


Figure 3-88 Comparison of Turbidity across scenarios for Eastern Moreton Bay

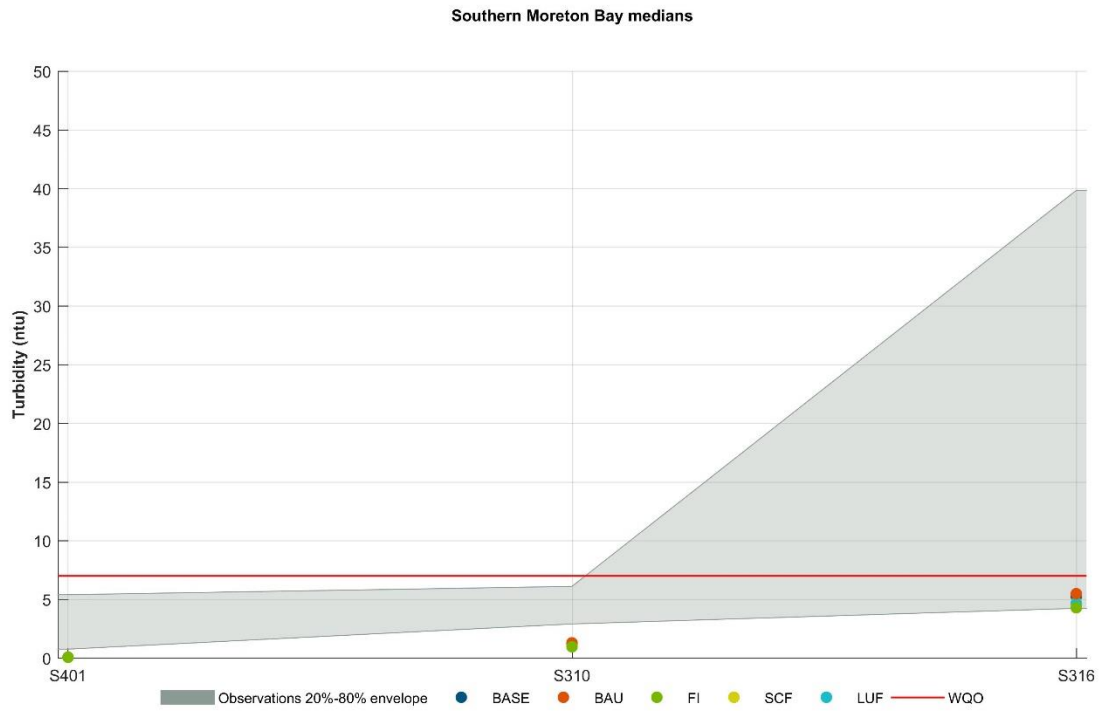


Figure 3-89 Comparison of Turbidity across scenarios for Southern Moreton Bay

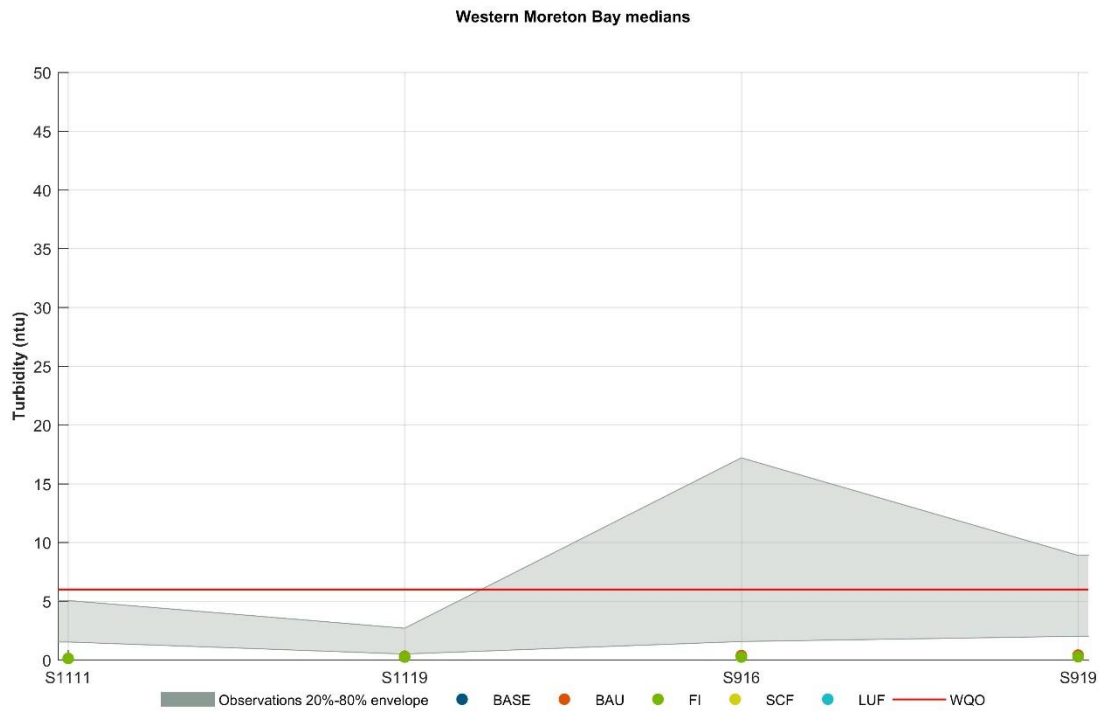


Figure 3-90 Comparison of Turbidity across scenarios for Western Moreton Bay

The predicted median values for all sites across all scenarios are coincident and below the WQO guideline for each zone (Figure 3-88, Figure 3-89, Figure 3-90).

### 3.8.2 Total nitrogen

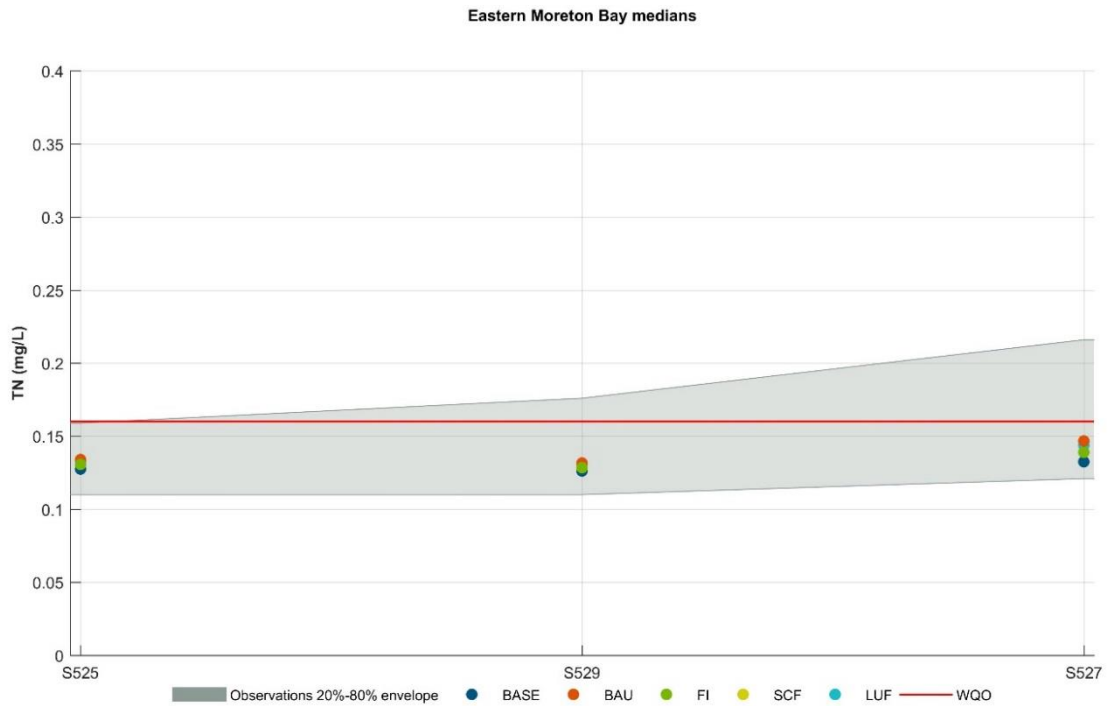


Figure 3-91 Comparison of TN medians across scenarios for Eastern Moreton Bay

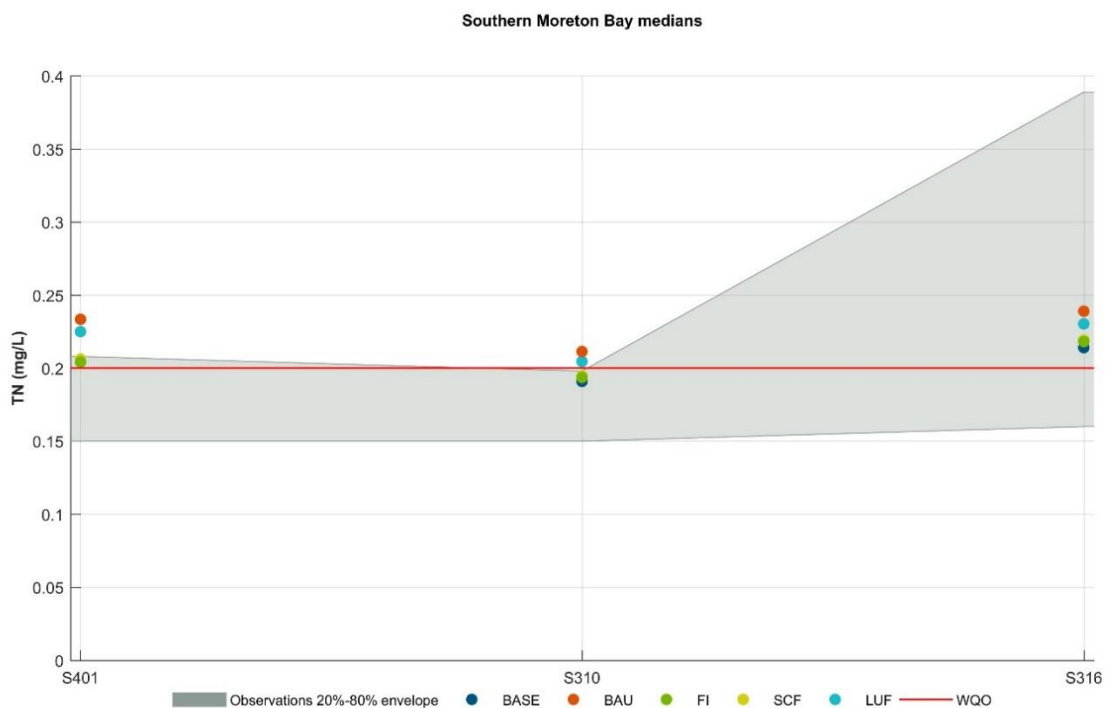
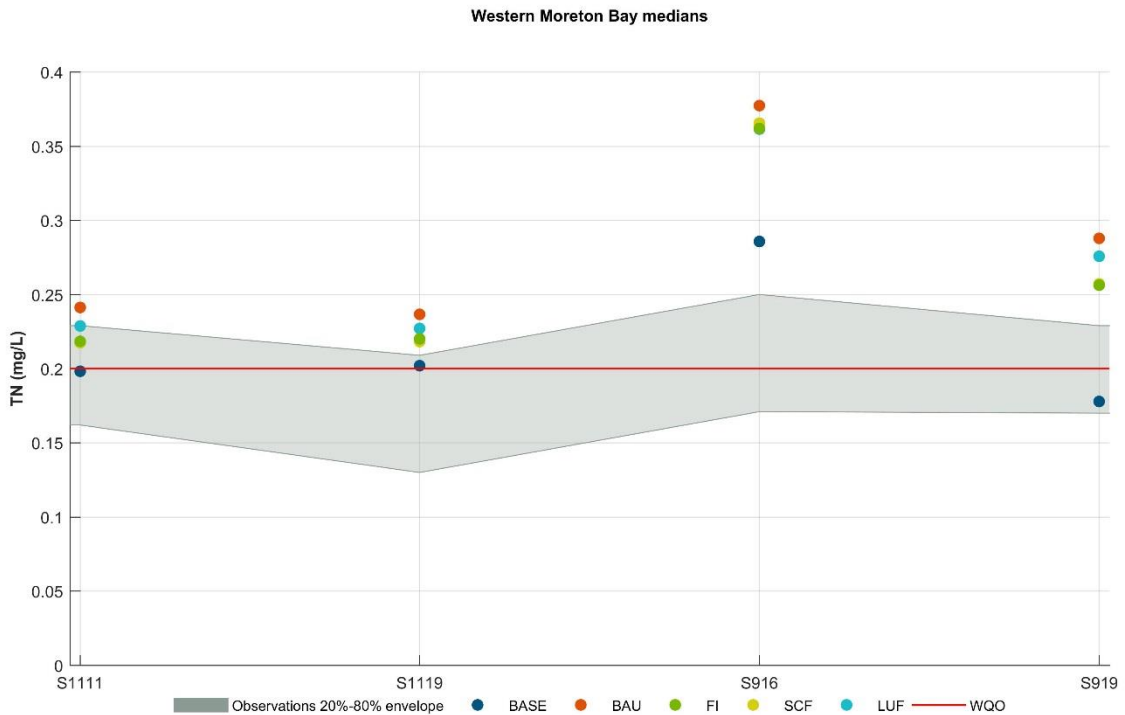


Figure 3-92 Comparison of TN medians across scenarios for Southern Moreton Bay



**Figure 3-93 Comparison of TN medians across scenarios for Western Moreton Bay**

The TN predictions in Eastern Moreton Bay shows that all five scenarios were below WQO limits and as would be expected, the BAU has the highest median value (Figure 3-91). Contrary to expectations, the BASE case had the lowest value indicating that the changing loads and higher inflows from the catchments cause all future cases to be worse than the baseline.

In Southern Moreton Bay, all scenarios predicted exceedances of the WQOs (Figure 3-92). BAU had the highest value and both FI and BASE predicted similar concentrations.

In Western Moreton Bay, all scenarios exceeded the WQOs (Figure 3-93). Similar to Eastern Moreton Bay, BAU had the highest levels of TN and all future scenarios showed deterioration when compared to the BASE scenario.

The results for TN at station S916 stem from the applicability of the model calibration undertaken between 2006-2007 to the 2014-2015 financial year. Whilst for the 2006-2007 calibration the model median was within the 20-80 percentile envelope (see BMT WBM 2015), results for the ensuing 2007-2008 period were not (although just above). Note overprediction was the case in all Deception Bay stations (S902, S916, and S919).

Adopting the same calibration for the 2014-2015 without any further adjustments were likely the reasons for overprediction of background conditions, and thus the results obtained for TN medians. It can be seen that the observed 20-80 percentile envelope around S916 for the 2014-2015 year were more akin to the envelope for the 2007-2008 simulation, which also presented overprediction. Results for the other scenarios reflected the methodology adopted for catchment flows and sediment fluxes.

### 3.8.3 Total phosphorus

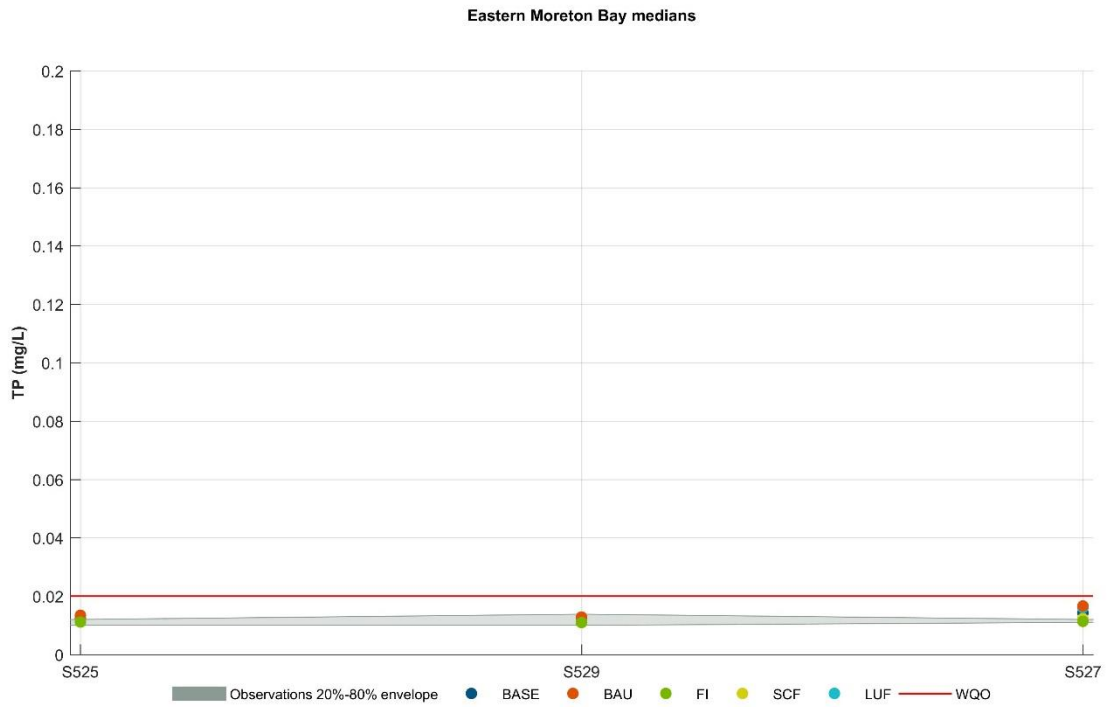


Figure 3-94 Comparison of TP medians across scenarios for Eastern Moreton Bay

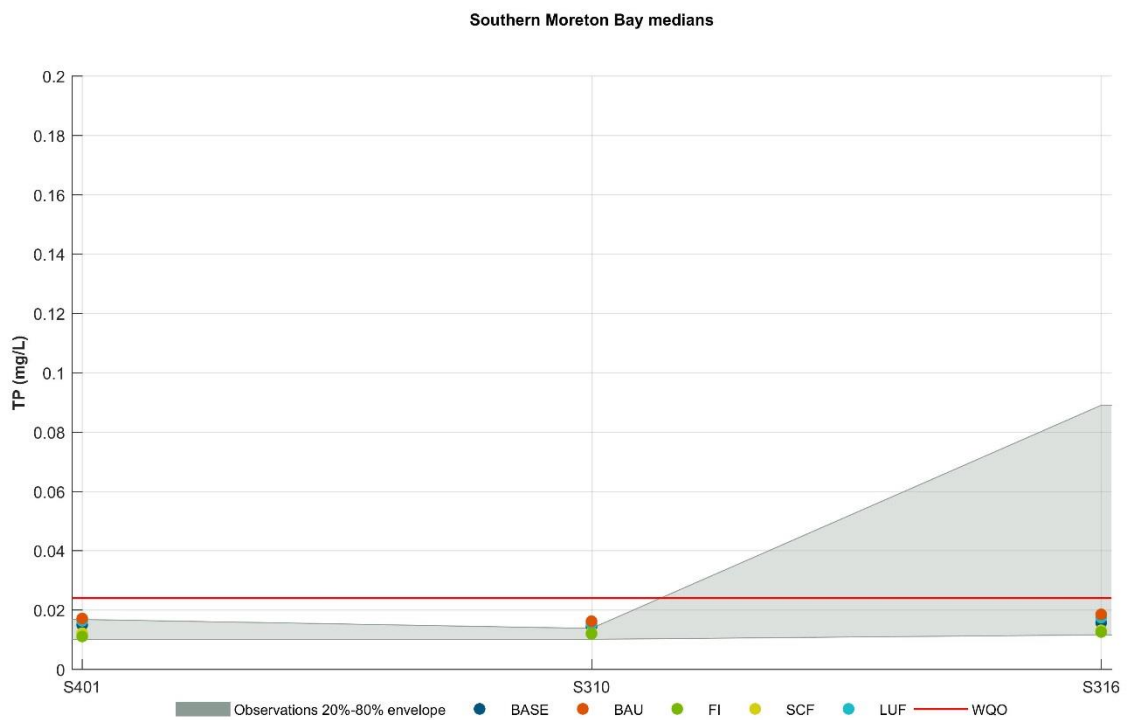
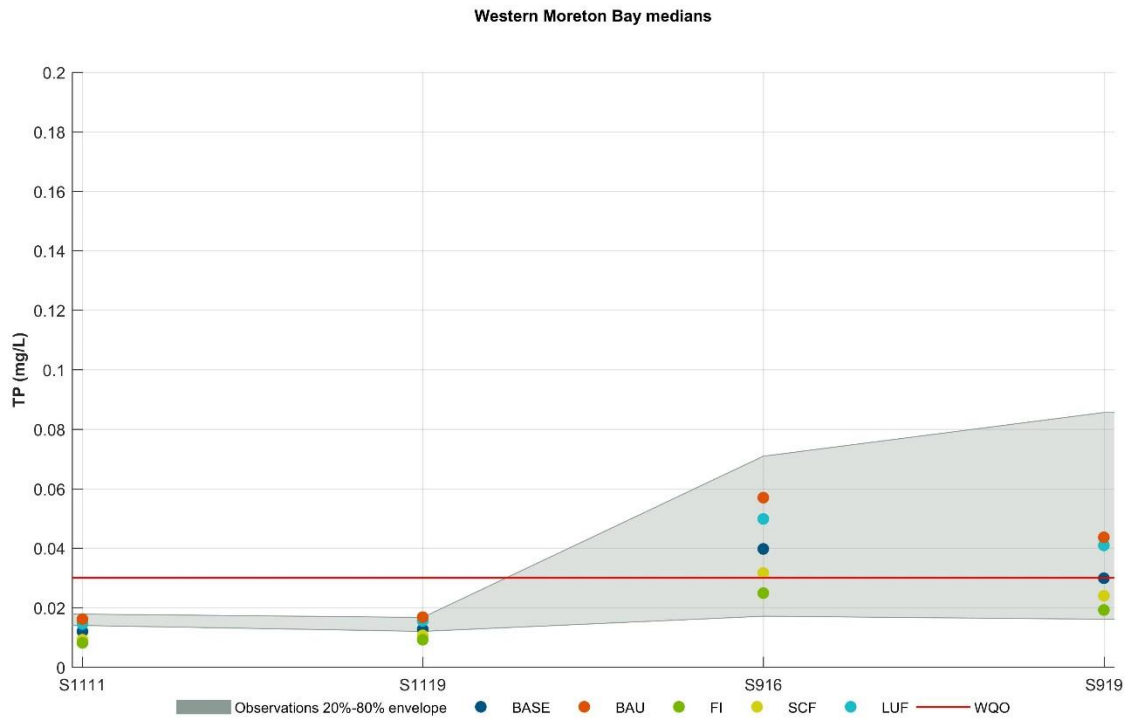


Figure 3-95 Comparison of TP medians across scenarios for Southern Moreton Bay



**Figure 3-96 Comparison of TP medians across scenarios for Western Moreton Bay**

TP concentrations in Eastern Moreton Bay predicted that all five scenarios were below the WQOs (Figure 3-94). There was also very little difference between the scenario predictions. Results from Southern Moreton Bay were similar (Figure 3-95).

In Western Moreton Bay, TP concentrations exceeded WQOs at two sites (S919 and S916) (Figure 3-96). The FI scenario predicted concentrations close to its WQO and was also the lowest amongst all the five scenarios. Concentrations predicted by SCF track closely with the FI scenario. As expected, the BAU scenario predicted the highest concentrations and LUF concentrations track closely to BAU.

### 3.8.4 Dissolved Oxygen Saturation

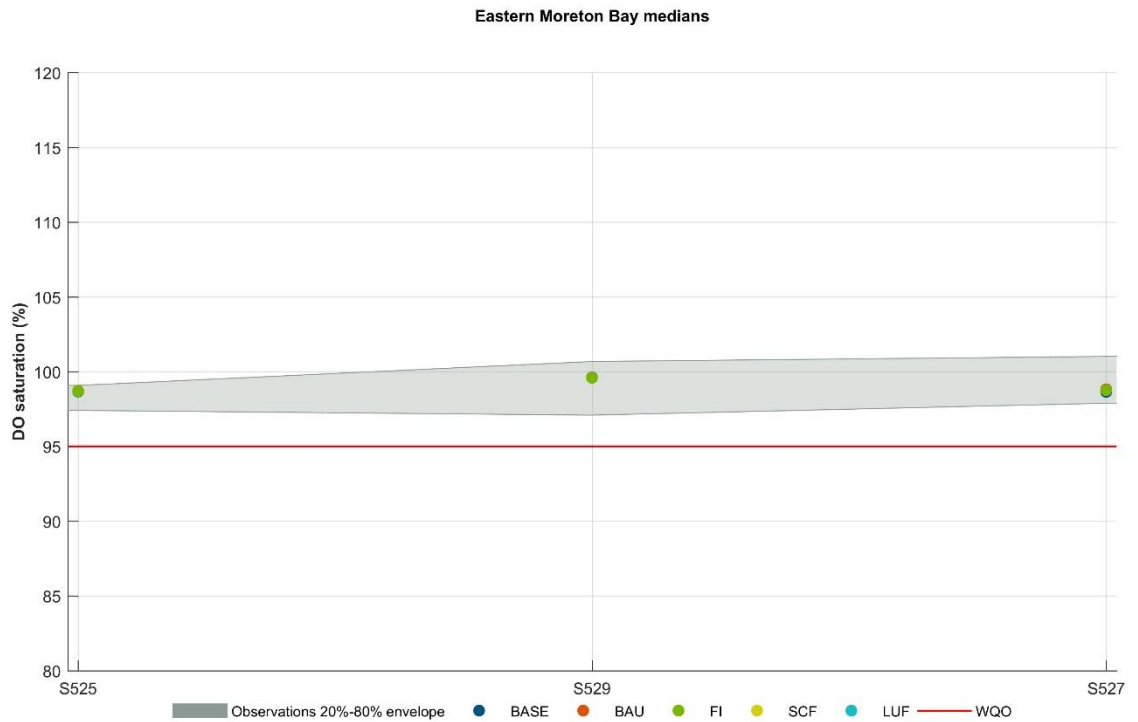


Figure 3-97 Comparison of DO saturation medians across scenarios for Eastern Moreton Bay

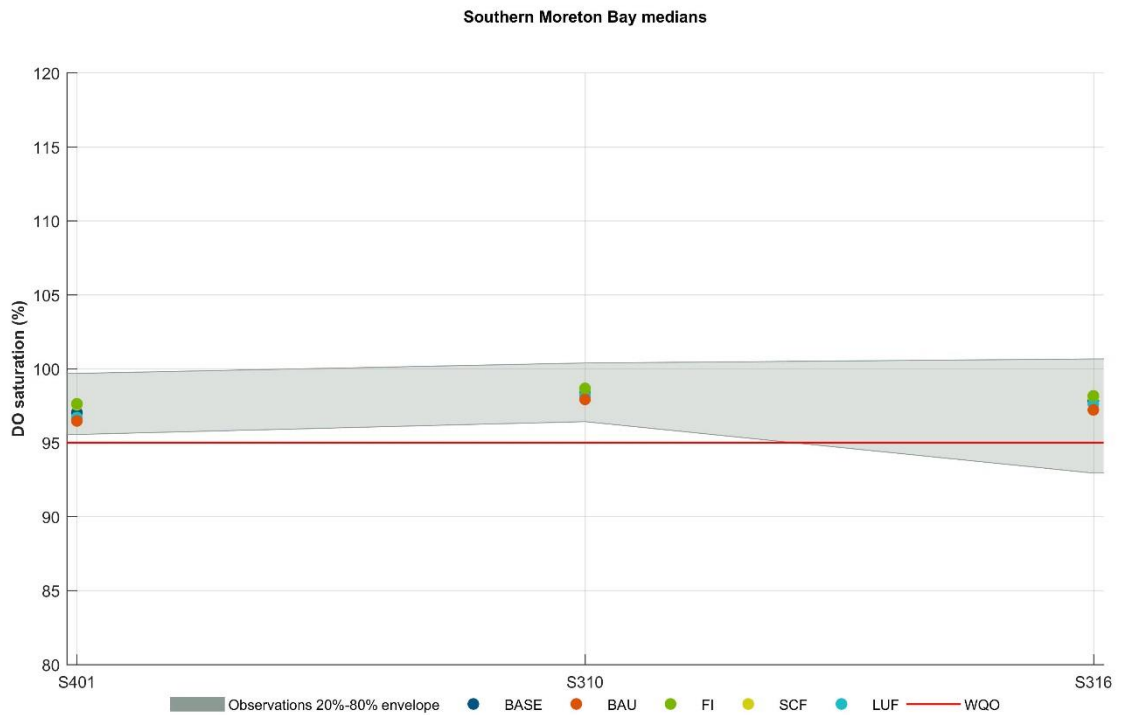
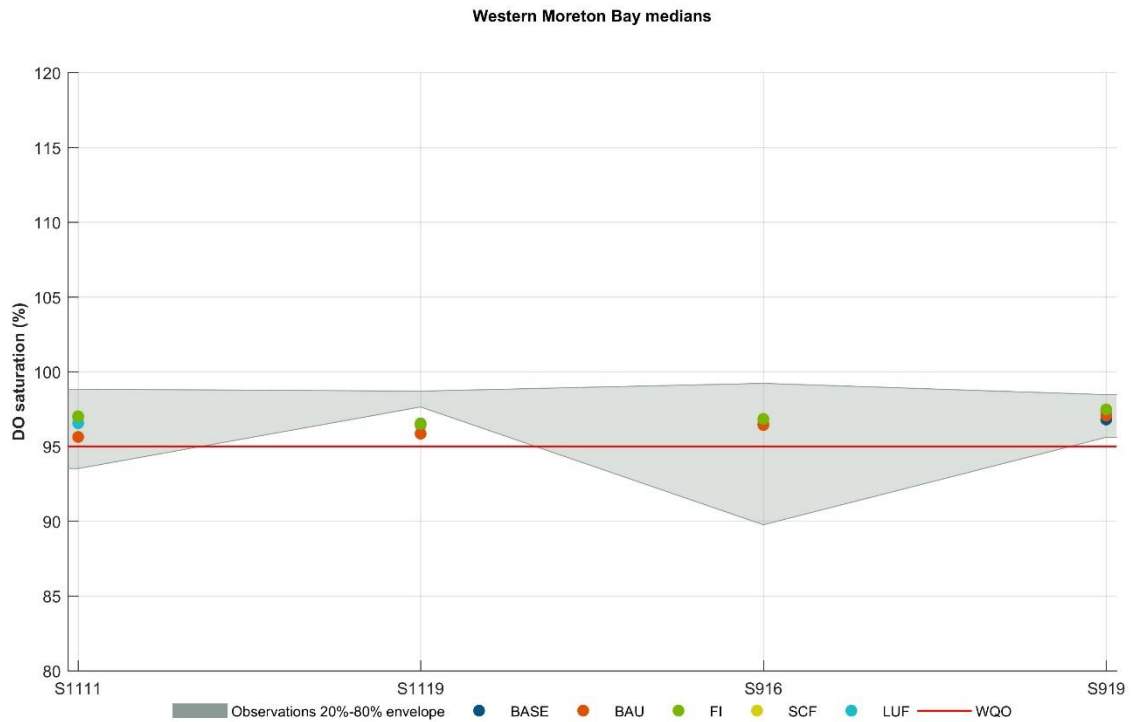


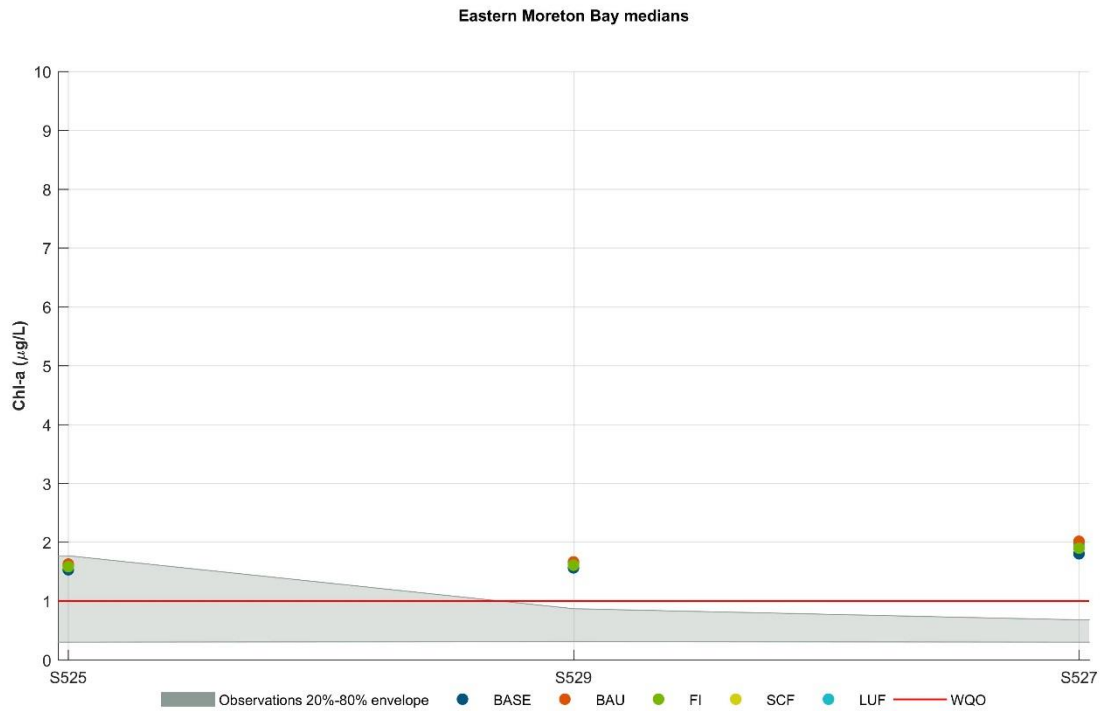
Figure 3-98 Comparison of DO saturation medians across scenarios for Southern Moreton Bay



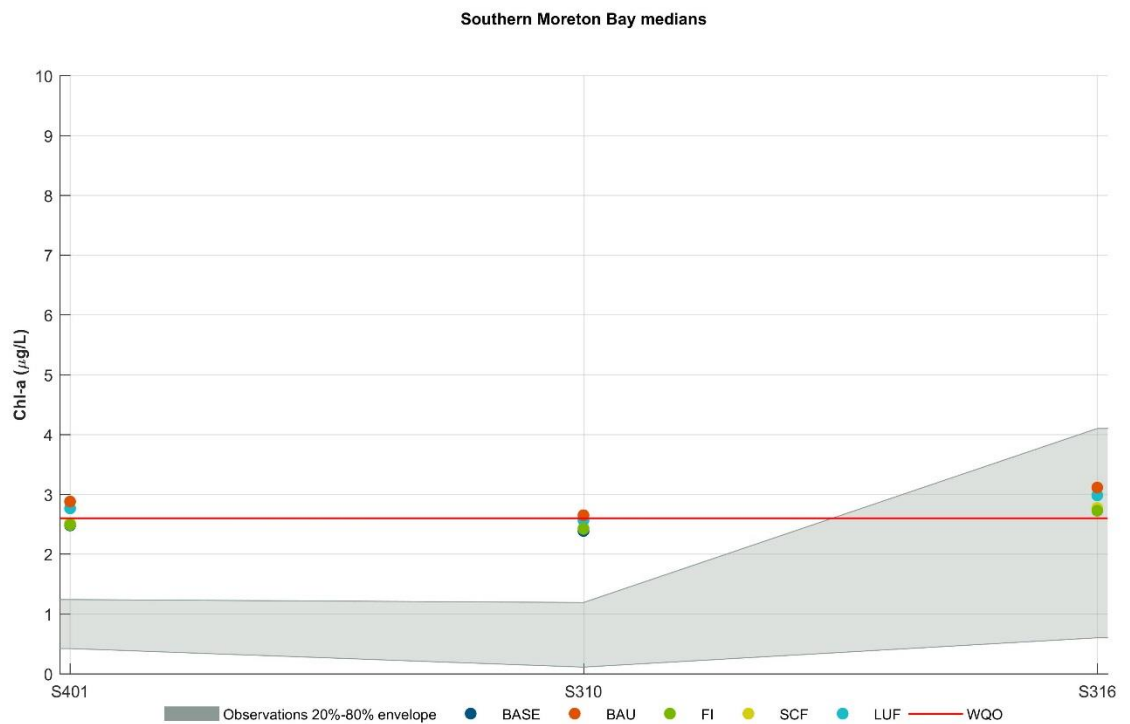
**Figure 3-99 Comparison of DO saturation medians across scenarios for Western Moreton Bay**

The DO concentrations across all regions of Moreton Bay were close to 95% saturation and there were only minor improvements between FI (highest) and BAU (lowest) (Figure 3-97, Figure 3-98, Figure 3-99).

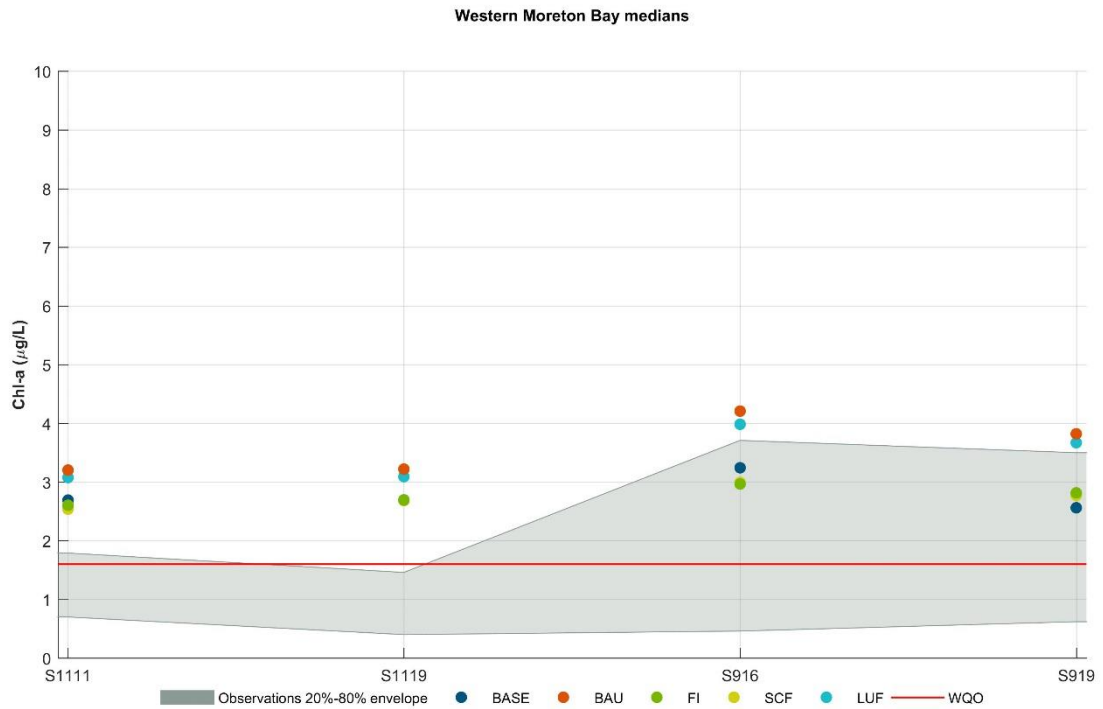
### 3.8.5 Chlorophyll-a



**Figure 3-100 Comparison of chlorophyll-a medians across scenarios for Eastern Moreton Bay**



**Figure 3-101 Comparison of chlorophyll-a medians across scenarios for Southern Moreton Bay**



**Figure 3-102 Comparison of chlorophyll-a medians across scenarios for Western Moreton Bay**

No significant difference between scenario results were observed in predicted Chl-a concentrations for Eastern Moreton Bay and all stations were observed to be above WQO guidelines (Figure 3-100). In Southern Moreton Bay there were minor differences between the scenarios with FI being the lowest and BAU being the highest (Figure 3-101). The values were close to the WQOs.

In Western Moreton Bay, FI and SCF predictions were closest to the BASE case and WQOs (Figure 3-102). BAU and LUF scenario predictions were the highest and exceeded WQOs.

### 3.8.6 Conclusions

- There were insignificant differences in turbidity across all scenarios.
- TN concentrations did not vary in Eastern Moreton Bay. The variations were within expected levels in the Western and Southern Bay where all values exceed WQOs. In Western Moreton Bay, all future scenarios exceed BASE case values.
- In the Southern and Eastern Moreton Bay there were insignificant differences between the scenarios. Variations in Western Moreton Bay were in line with expectations and two sites exceeded WQOs.
- There were no significant variations amongst the model scenarios for DO and all scenarios predicted values within the WQOs.

- The Chl-a values exceeded WQOs in Eastern and Southern Moreton Bay. In Western Moreton Bay, FI and SCF were close to the WQOs, while the other scenarios predicted exceedances.
- The largest variations and potential for deterioration of water quality were the Bramble Bay sites. These sites are influenced by the contributions from the Brisbane and Bremer to the Pine River catchments.

### 3.9 Noosa

#### 3.9.1 Catchment Loads

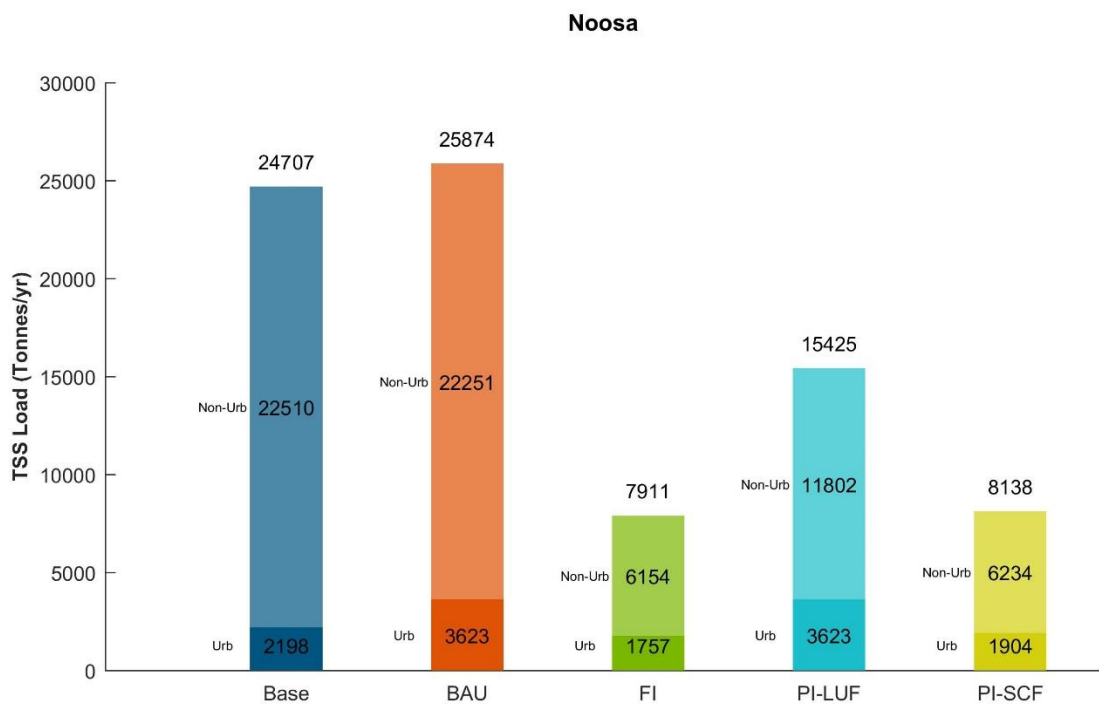


Figure 3-103 TSS catchment loads from Noosa

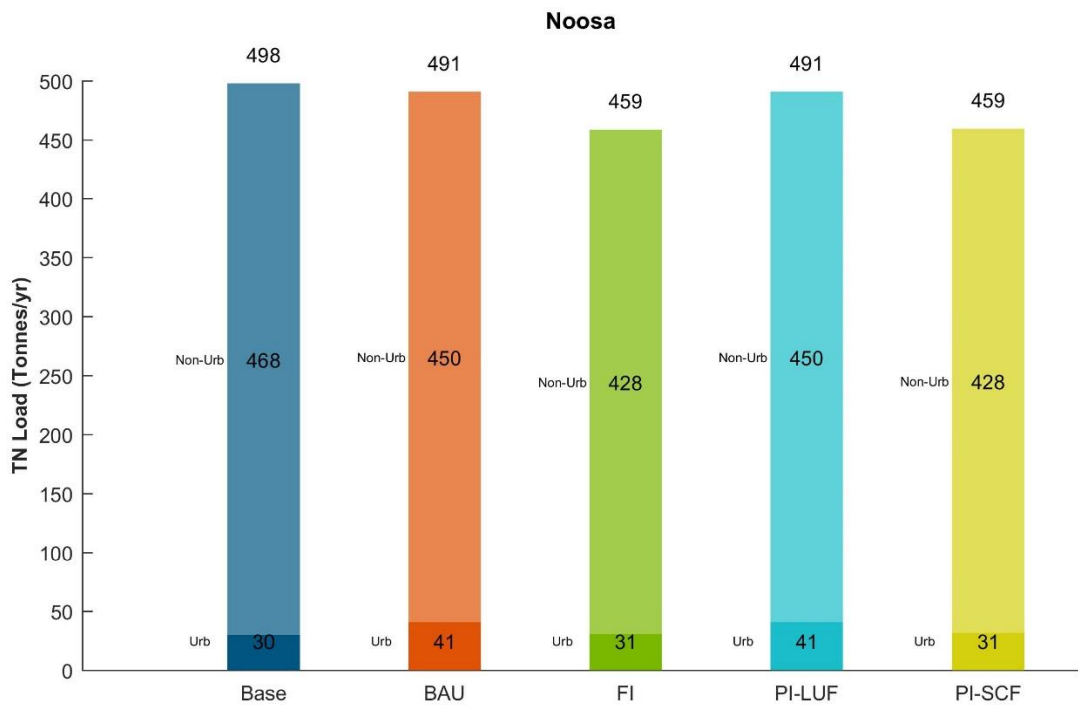


Figure 3-104 TN catchment loads from Noosa

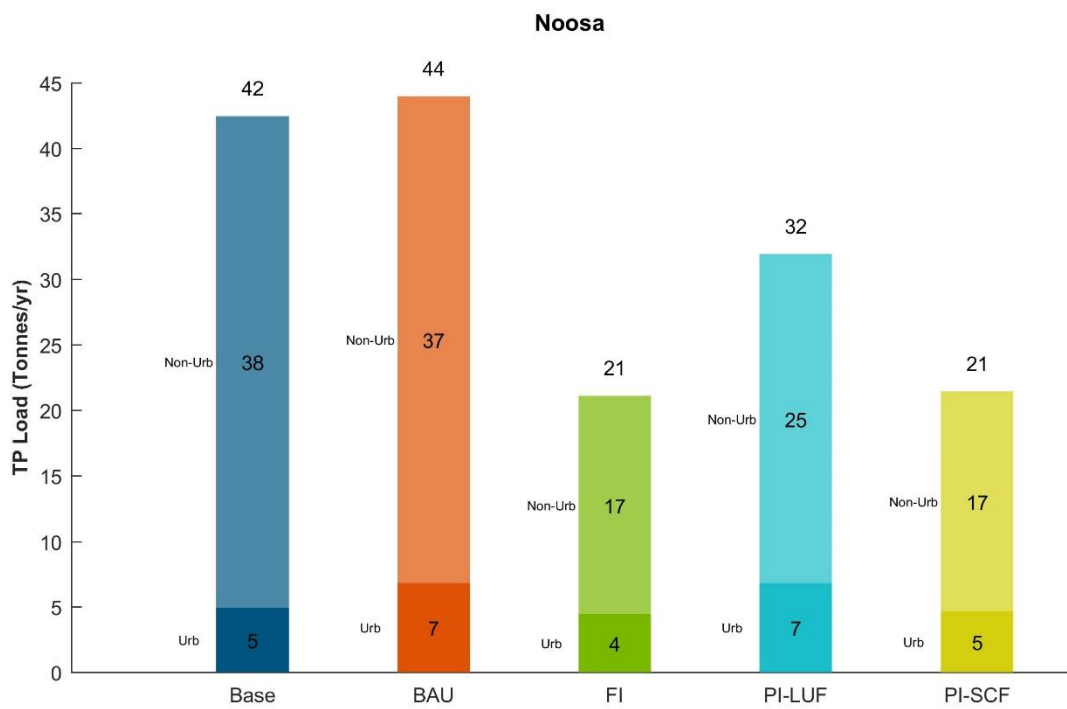


Figure 3-105 TP catchment loads from Noosa

### 3.10 Redlands

#### 3.10.1 Catchment Loads

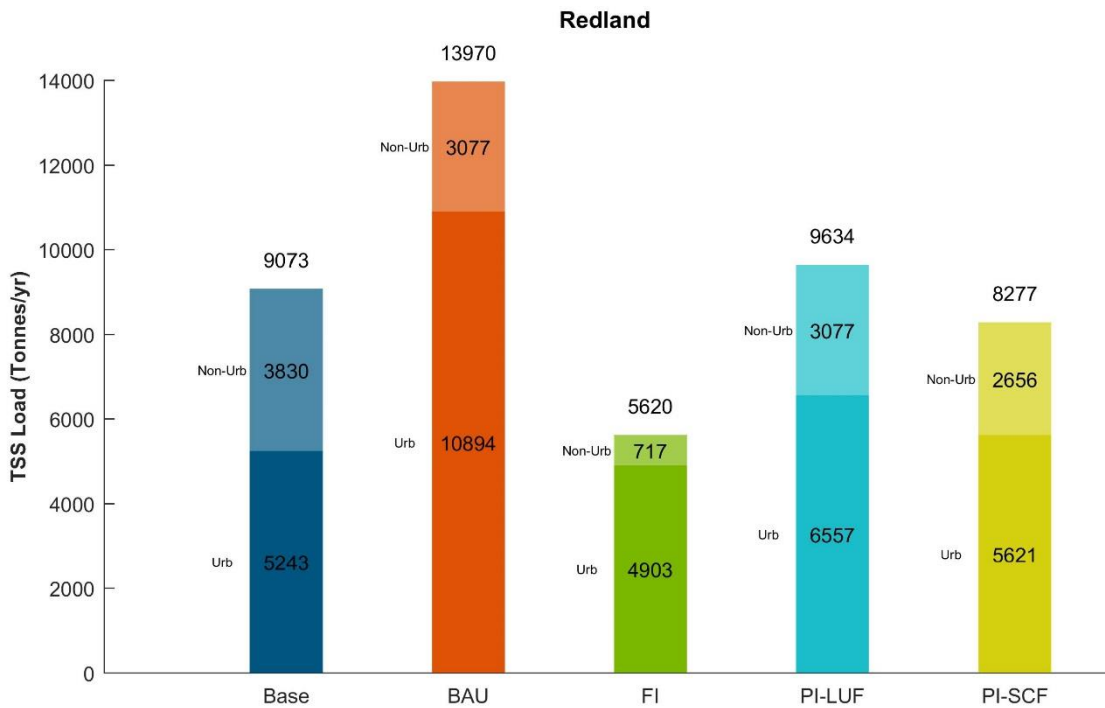


Figure 3-106 TSS catchment loads from Redlands

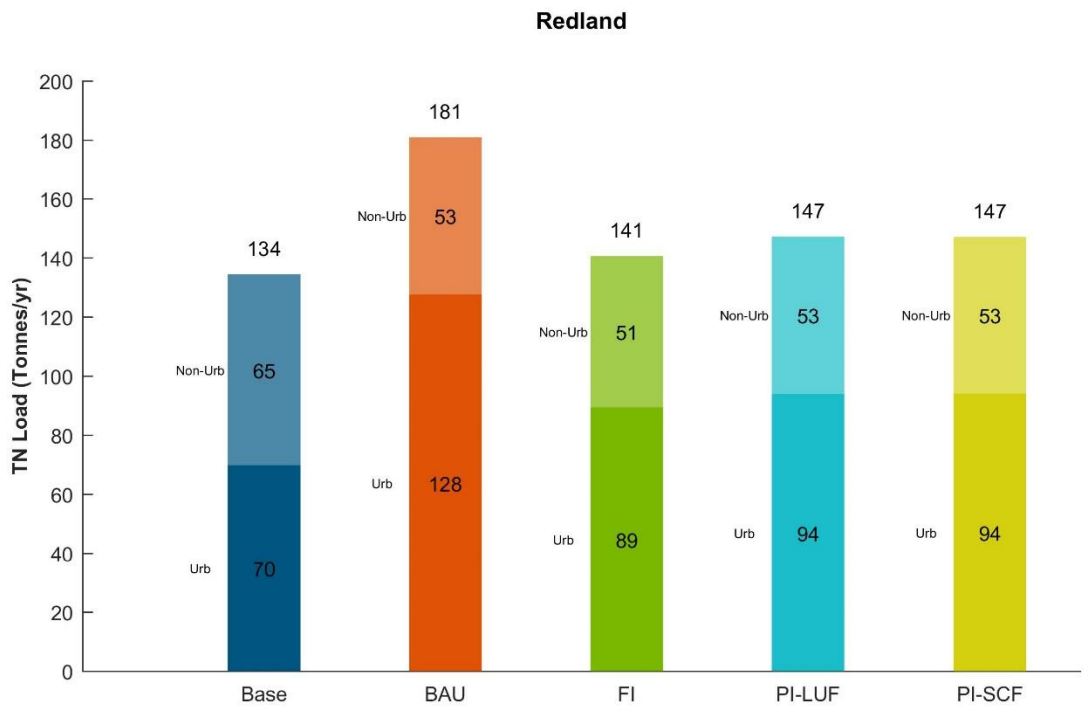
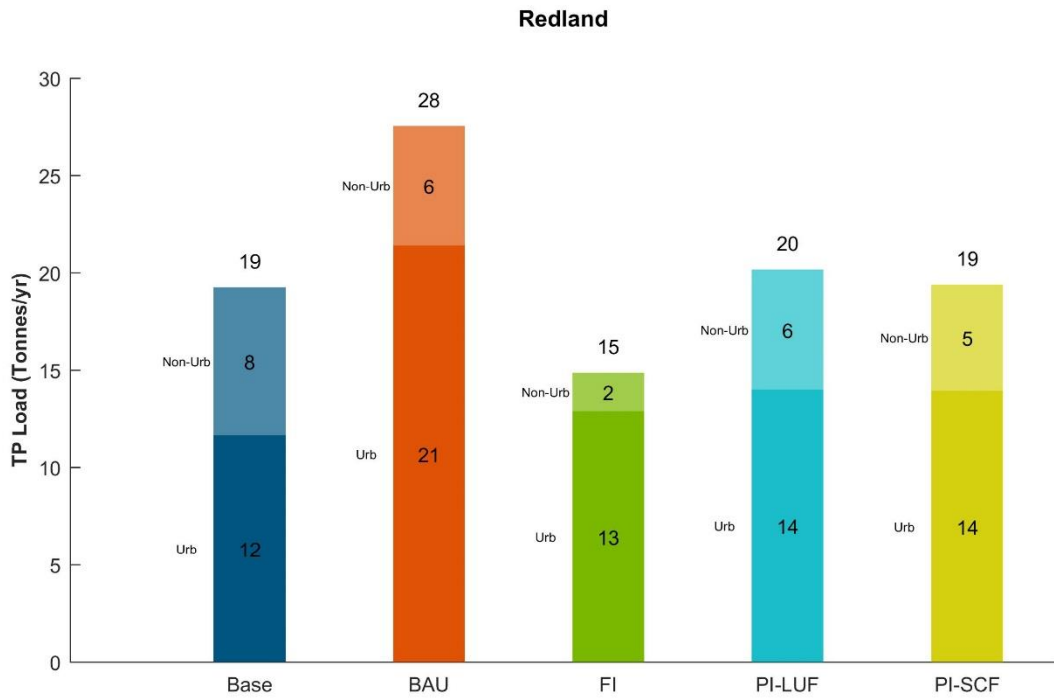


Figure 3-107 TN catchment loads from Redlands



**Figure 3-108 TP catchment loads from Redlands**

## 4 References

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Olley J. , Burton J. , Hermoso V. , Smolders K. , McMahon J. , Thomson B. , and Watkinson A. (2014) Remnant riparian vegetation, sediment and nutrient loads, and river rehabilitation in subtropical Australia, Hydrol. Process. , doi: 10. 1002/hyp. 10369.

## Appendix A Calibration Plots

### Maroochy

#### 4.1.1 Turbidity

Turbidity calibration information is presented below:

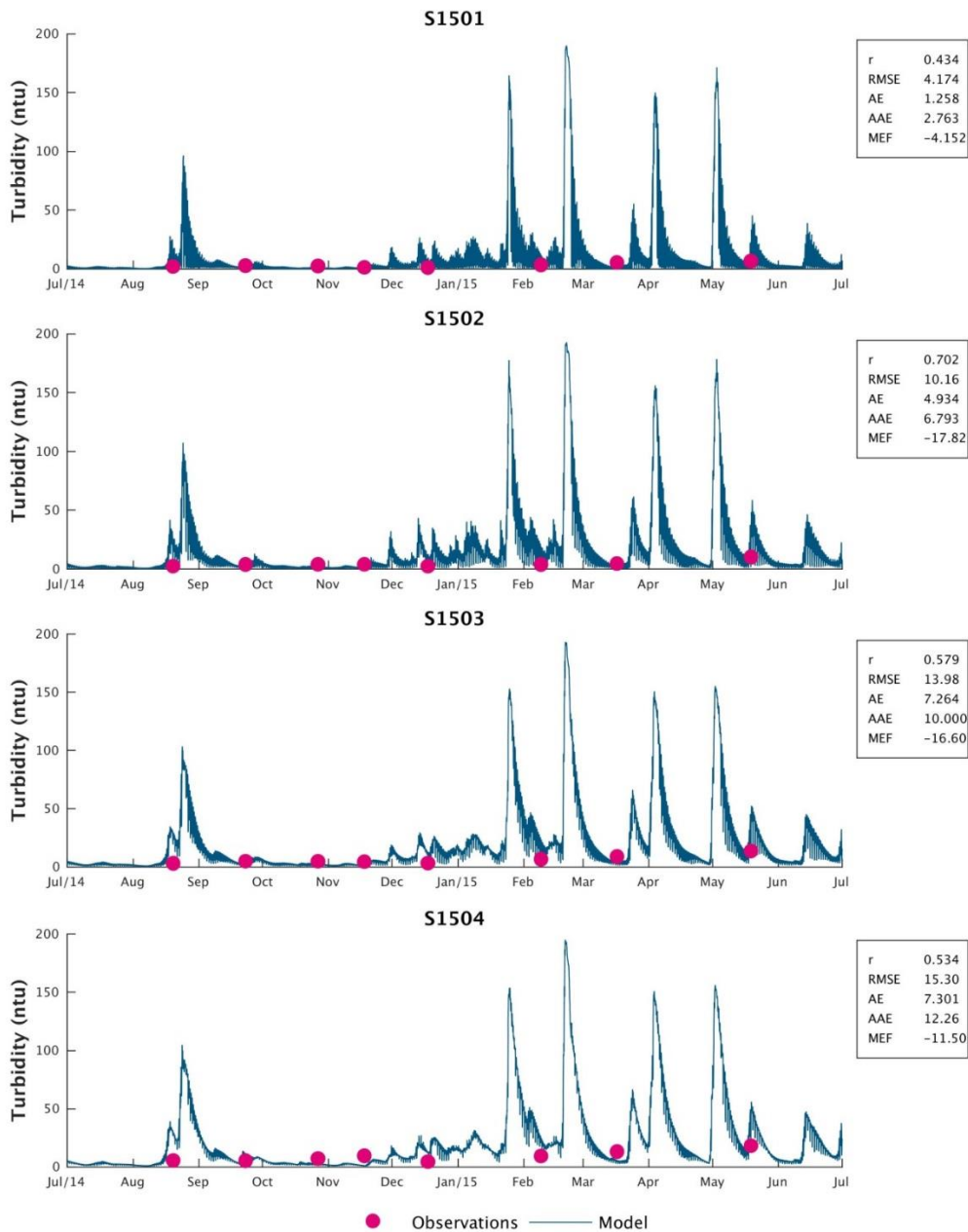


Figure A-1 Turbidity timeseries plot for Maroochy D/s

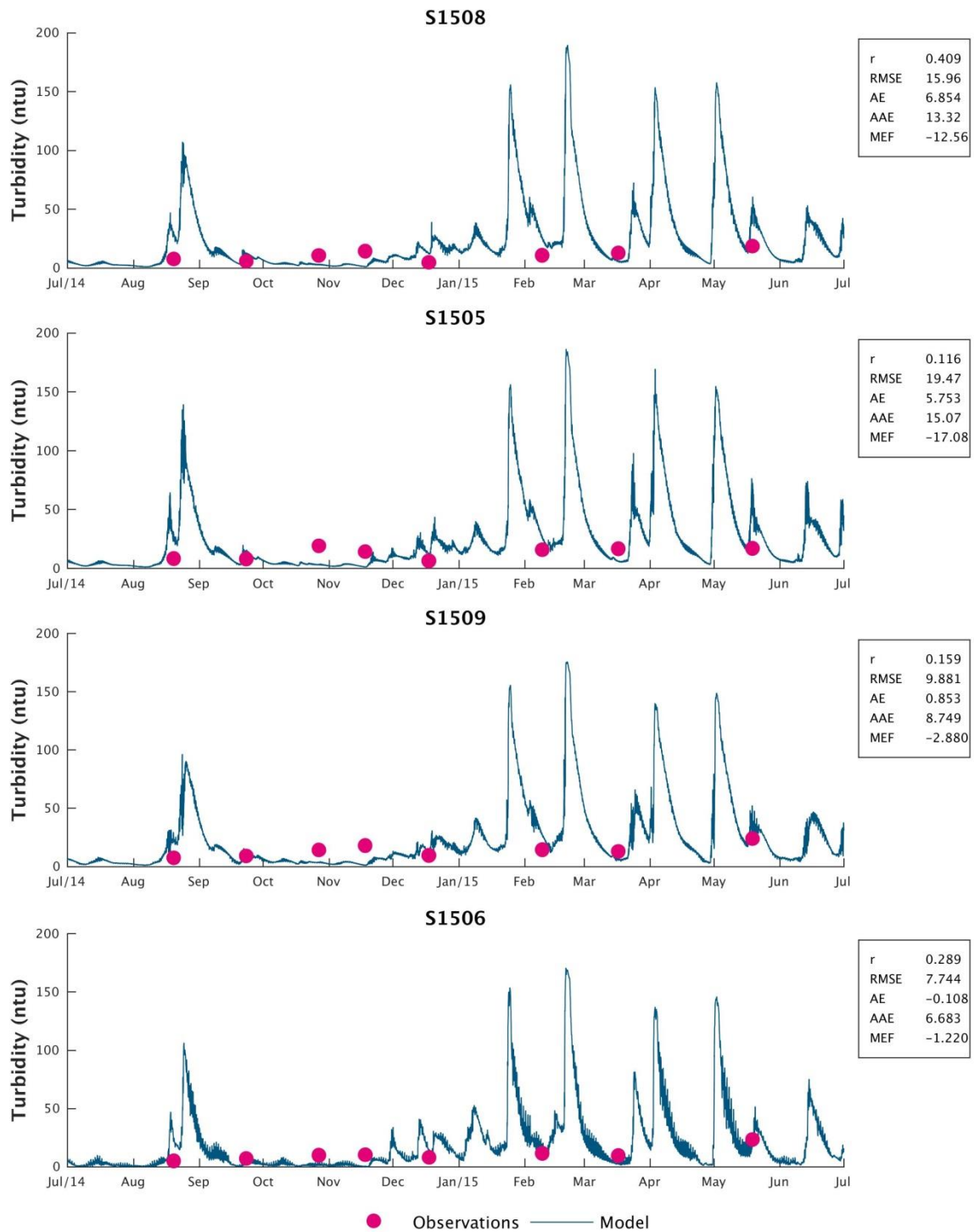


Figure A-2 Turbidity timeseries plot for Maroochy U/s

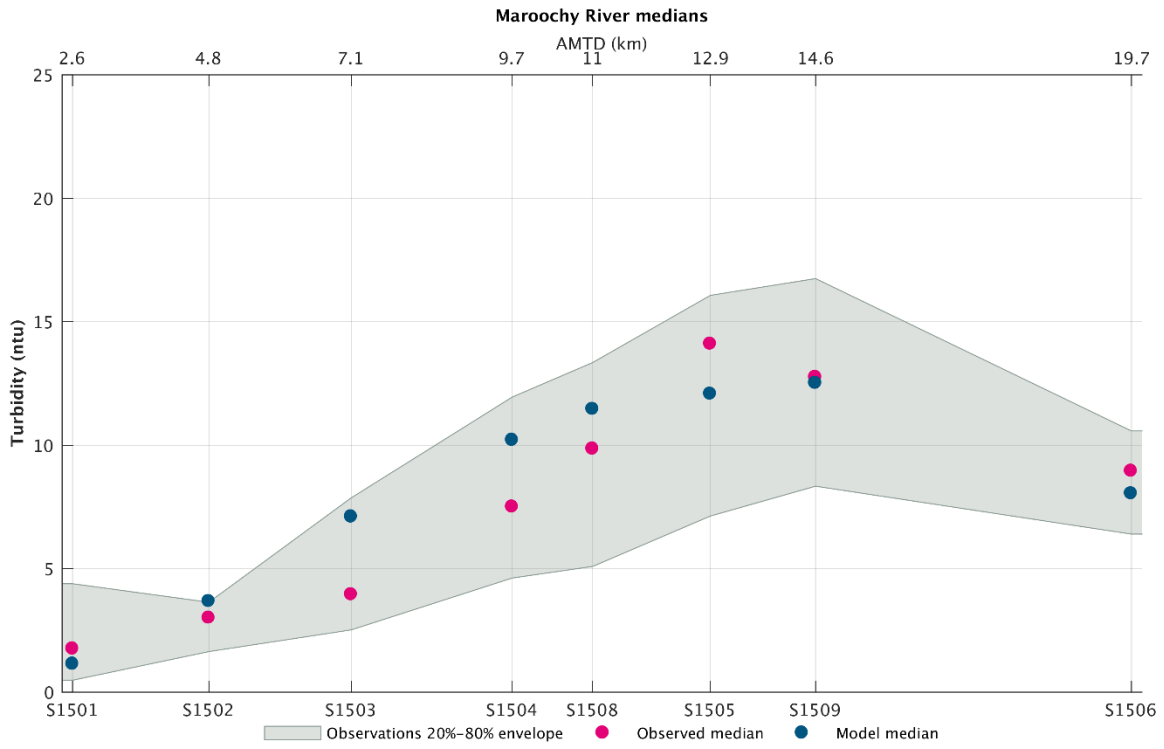


Figure A-3 Turbidity thalweg comparison

### A.1.1 Dissolved oxygen

Dissolved oxygen calibration information is presented below.

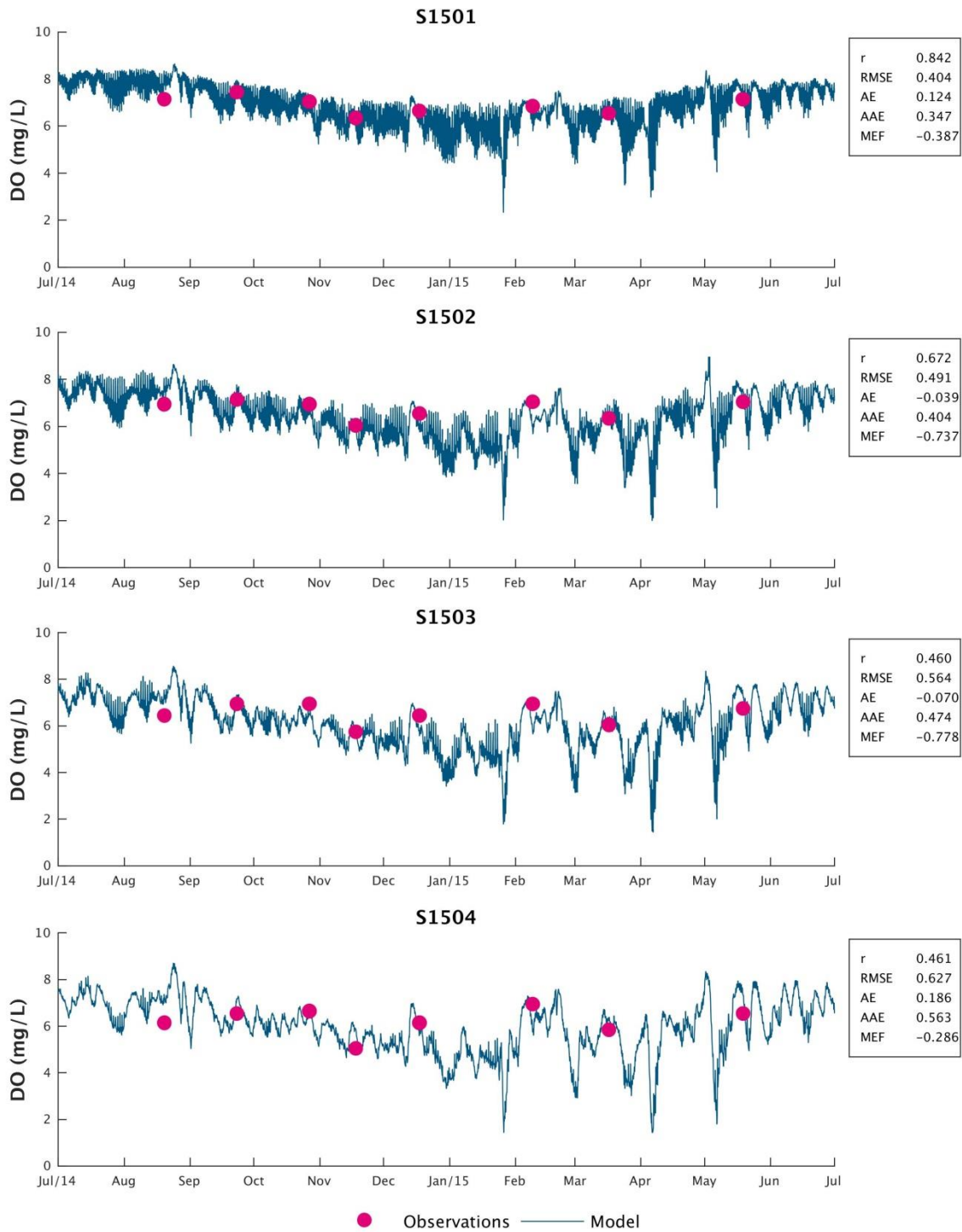


Figure A-4 Dissolved oxygen timeseries plot for Maroochy D/s

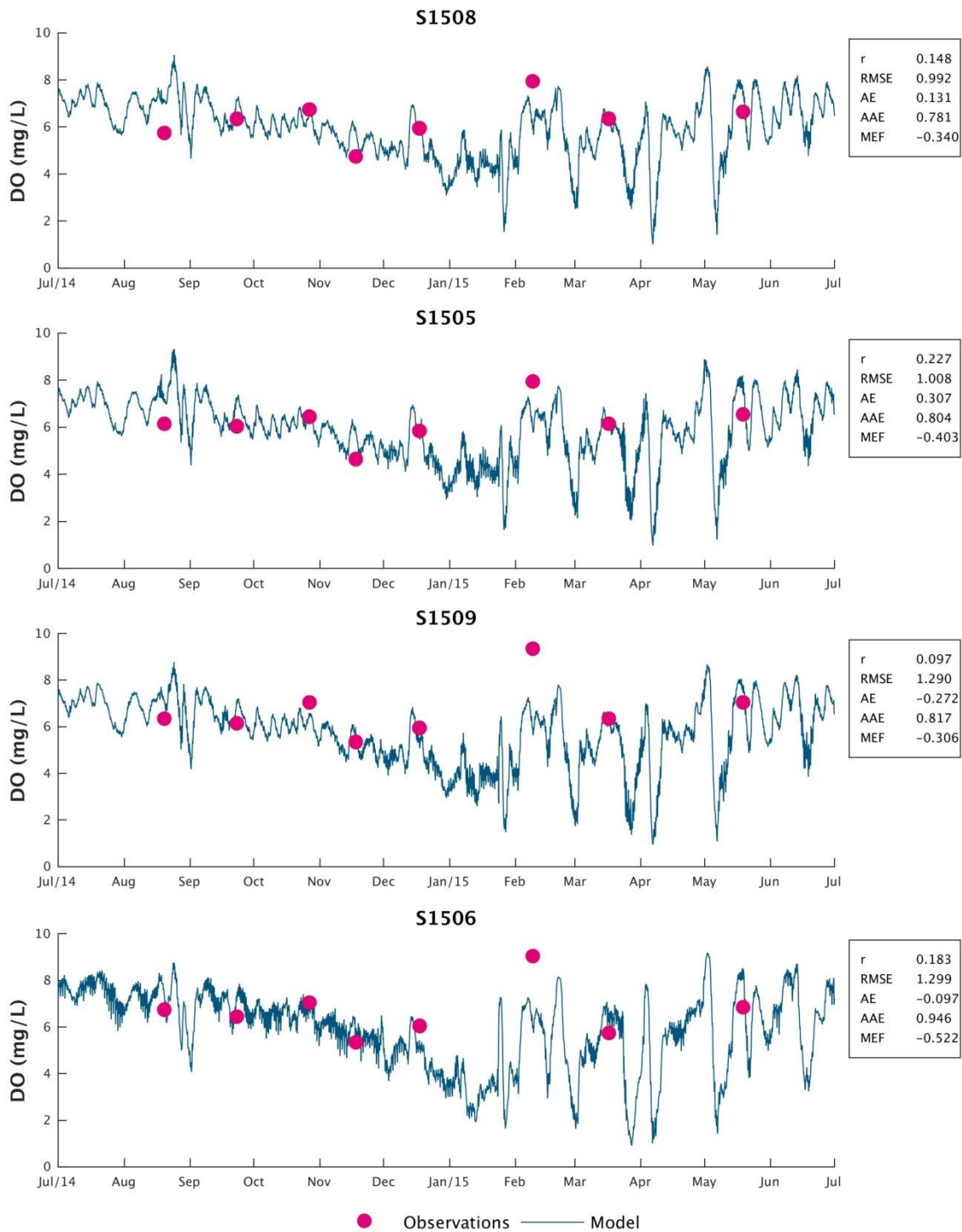


Figure A-5 Dissolved oxygen timeseries plot for Maroochy U/s

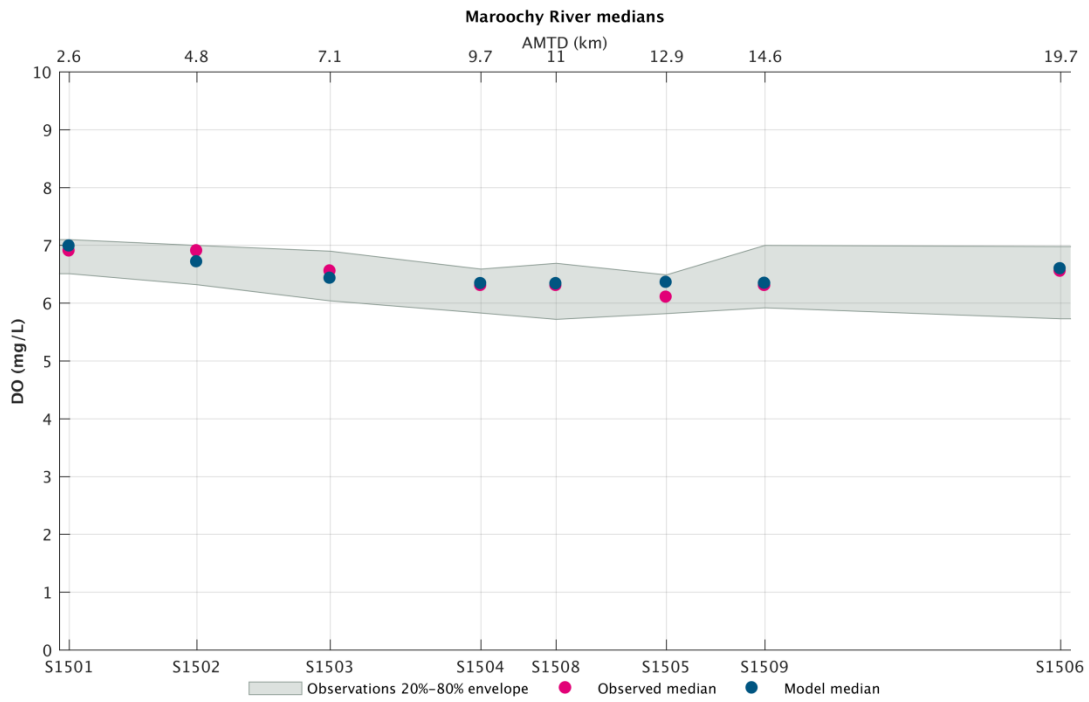


Figure A-6 Dissolved oxygen thalweg comparison

### A.1.2 Dissolved oxygen deficit

Dissolved oxygen deficit calibration information is presented below.

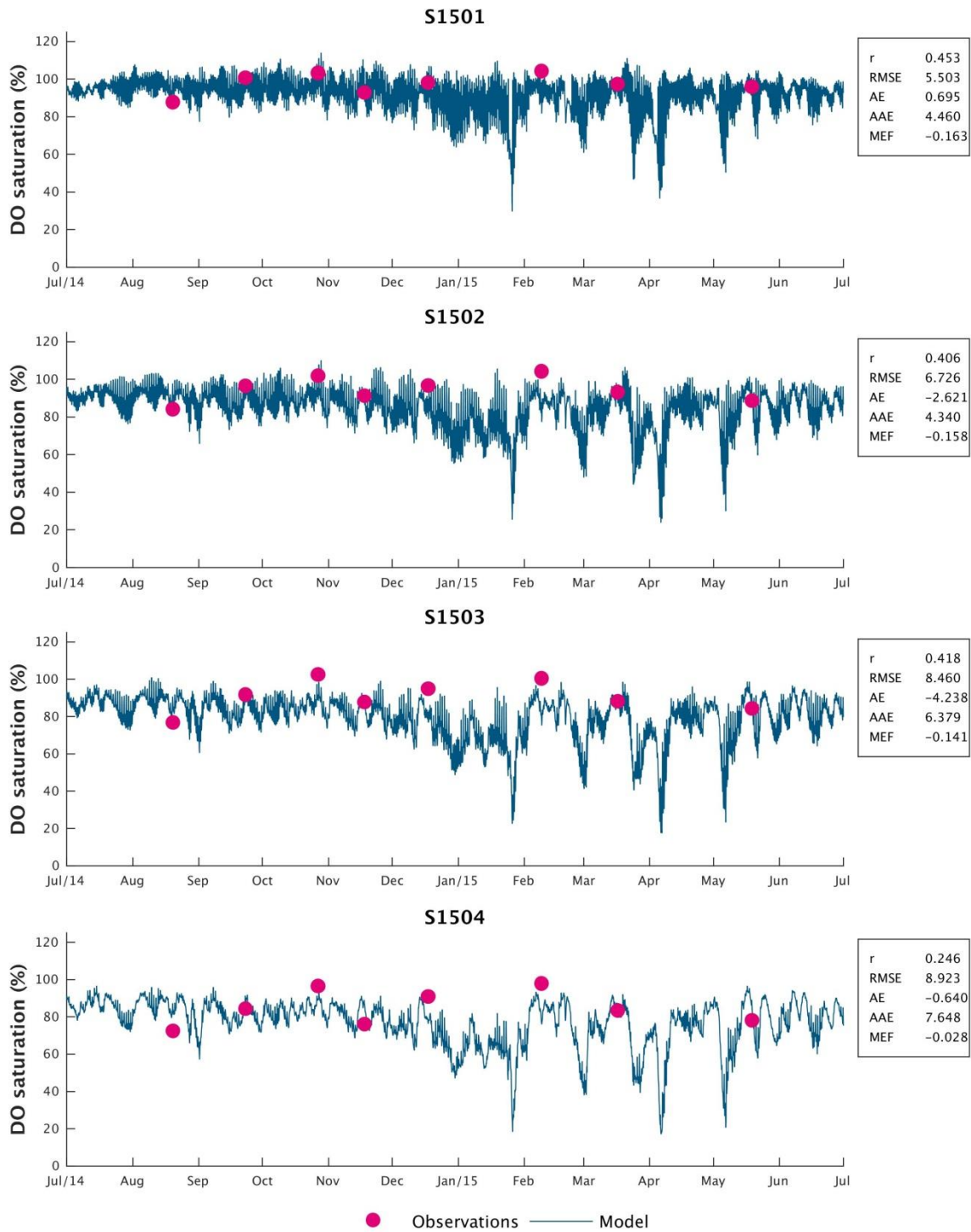


Figure A-7 Dissolved oxygen deficit timeseries plot for Maroochy D/s

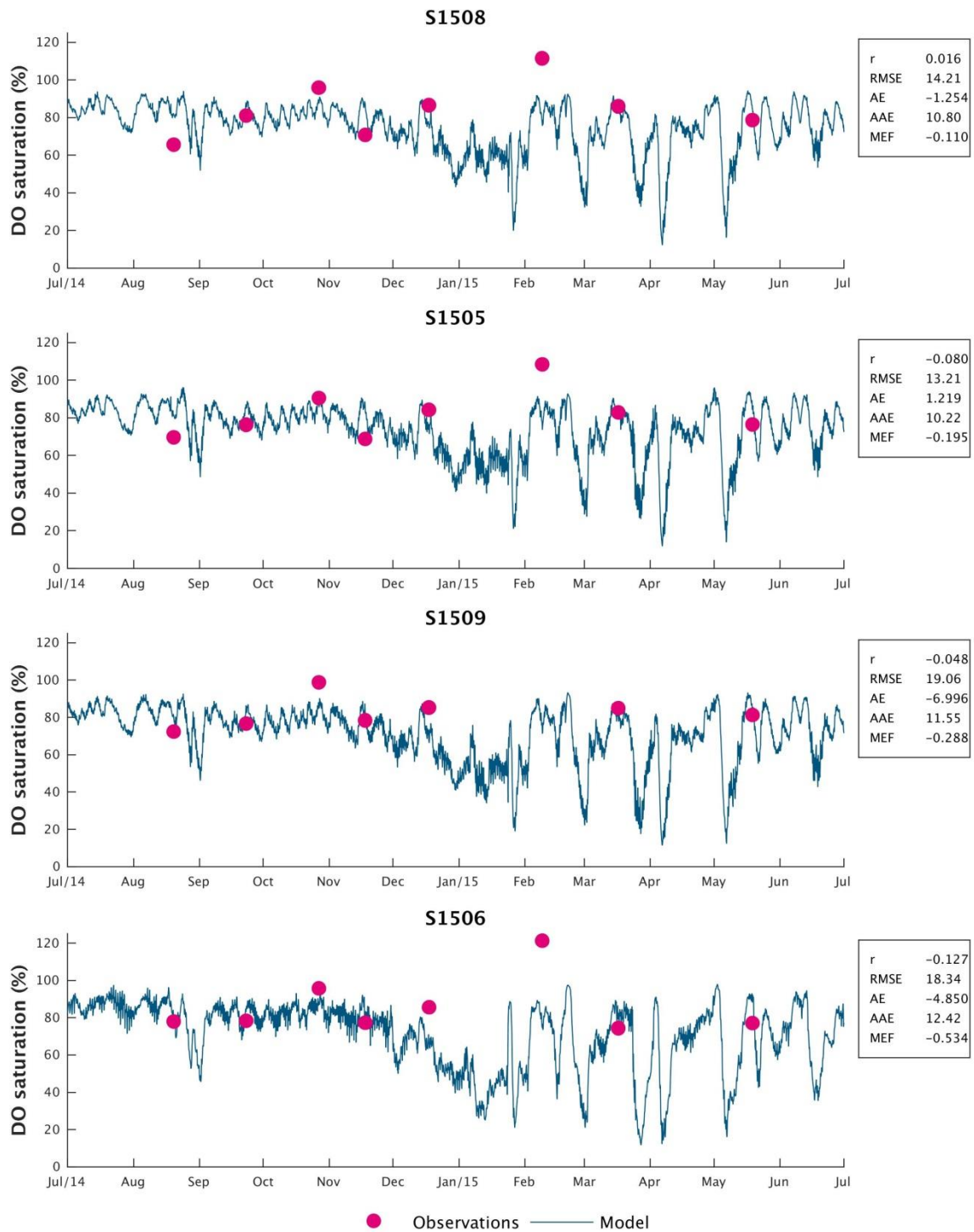


Figure A-8 Dissolved oxygen deficit timeseries plot for Maroochy U/s

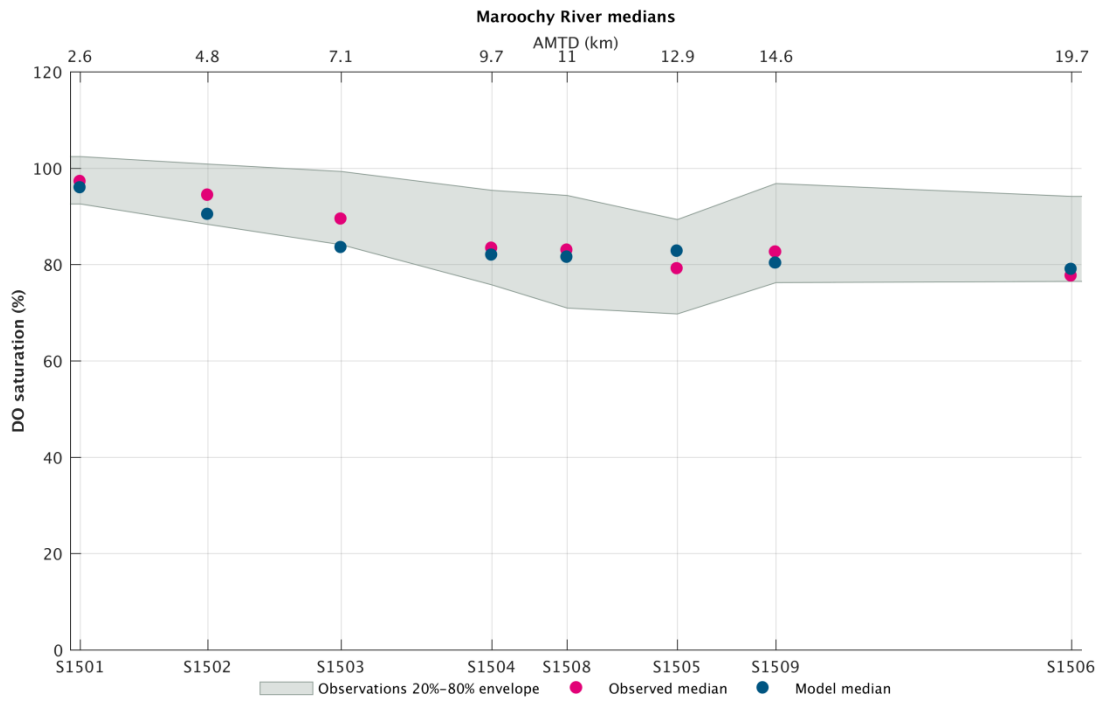


Figure A-9 Dissolved oxygen deficit thalweg comparison

### A.1.3 Total Nitrogen

Total Nitrogen calibration information is presented below.

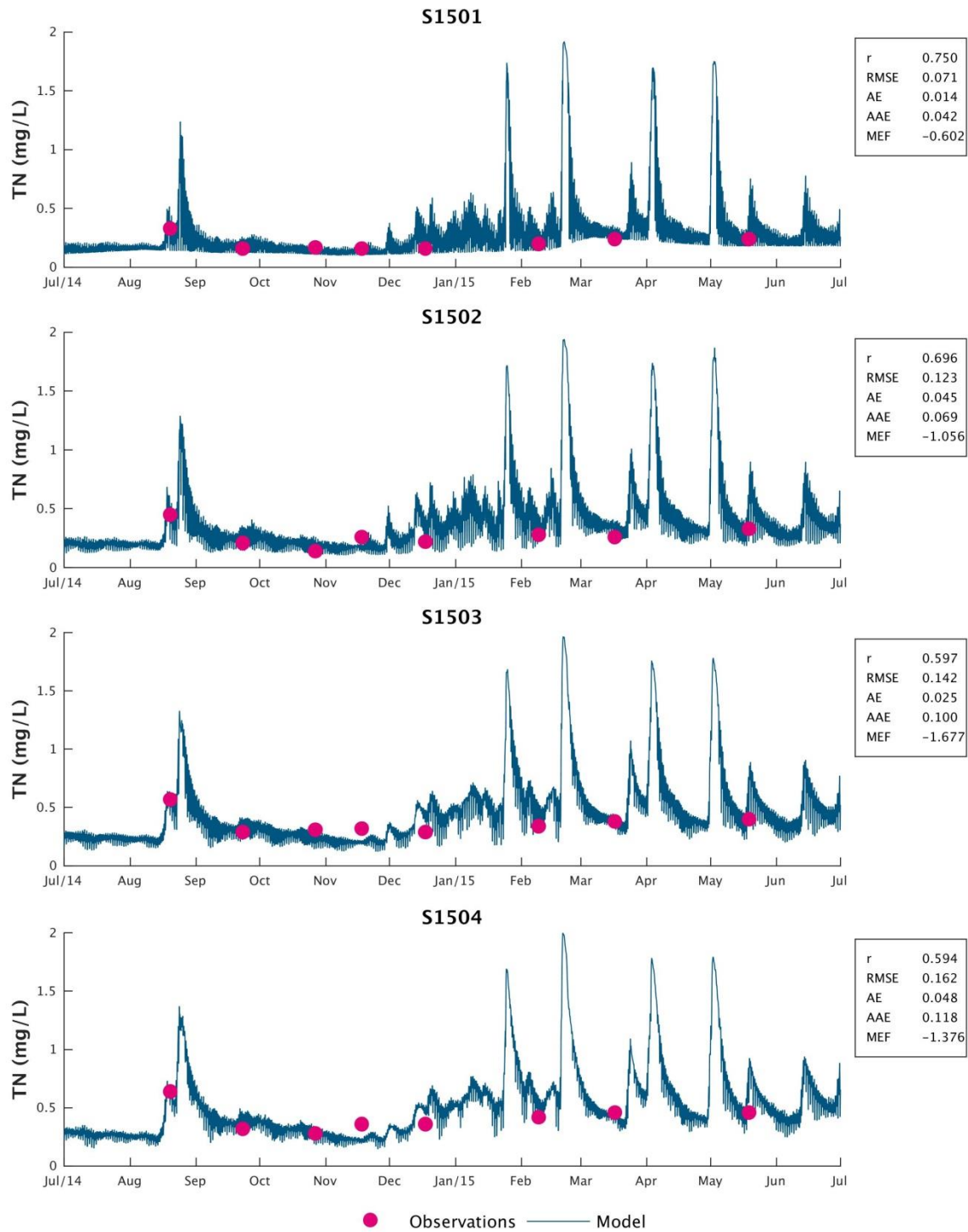


Figure A-10 Total Nitrogen timeseries plot for Maroochy D/s

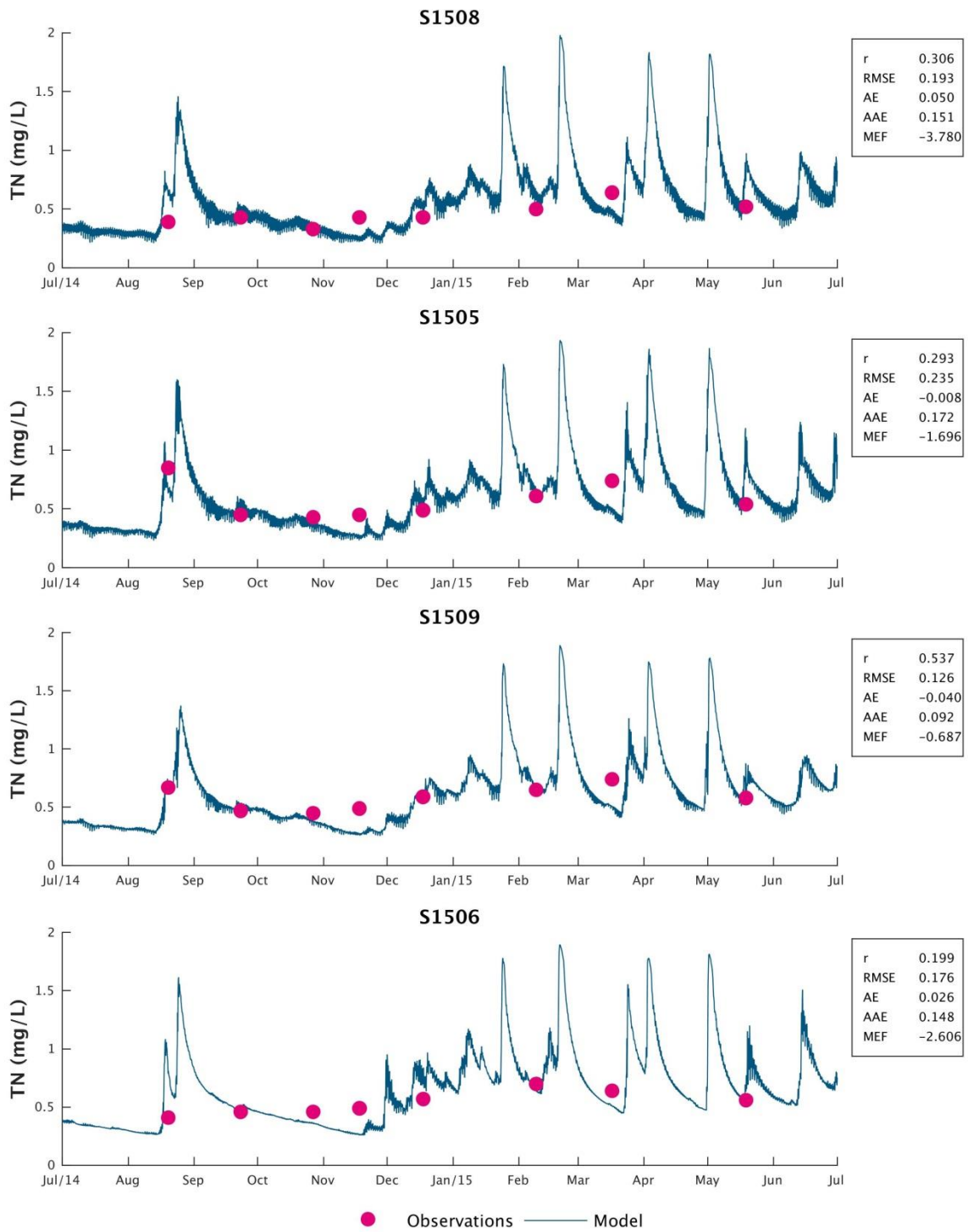


Figure A-11 Total Nitrogen timeseries plot for Maroochy U/s

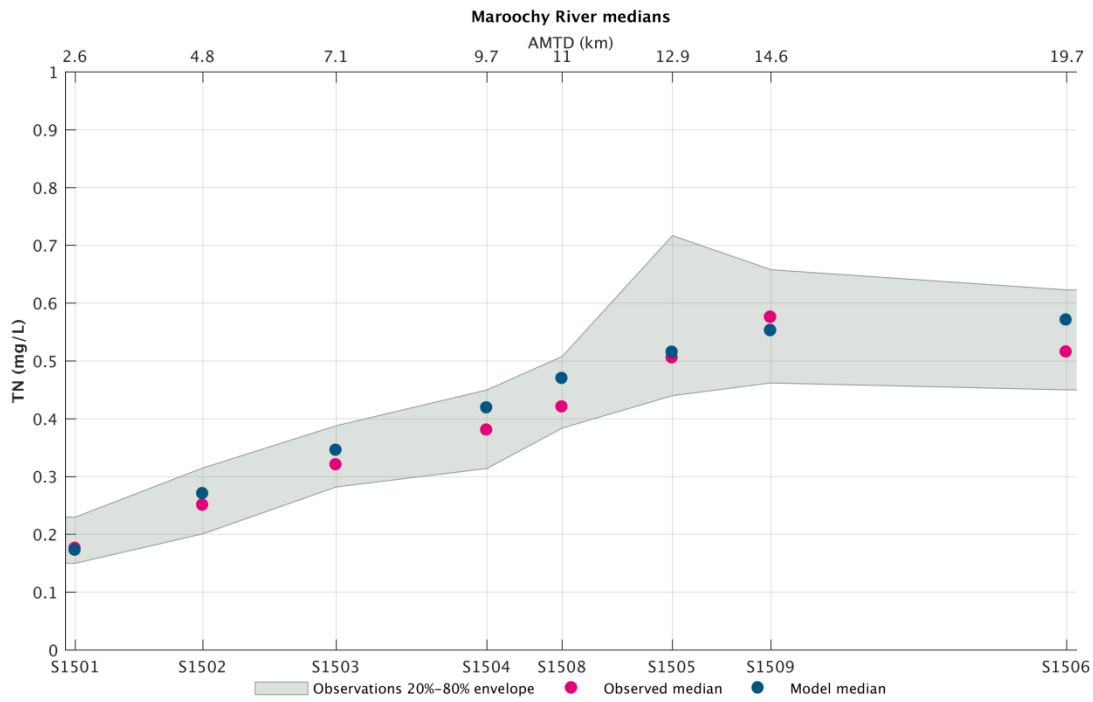


Figure A-12 Total Nitrogen thalweg comparison

### A.1.4 Total phosphorus

Total phosphorous calibration information is presented below.

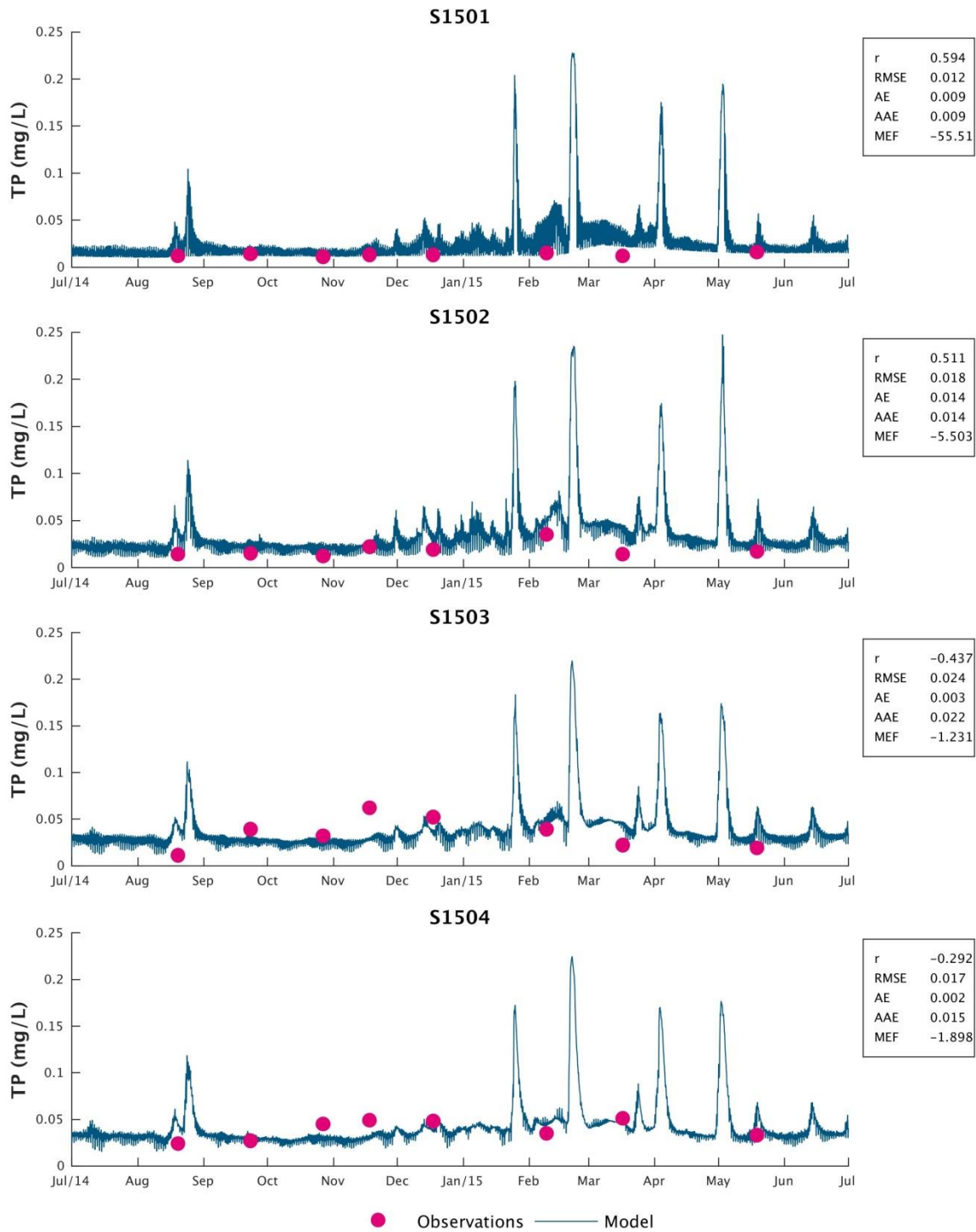


Figure A-13 Total phosphorus timeseries plot for Maroochy D/s

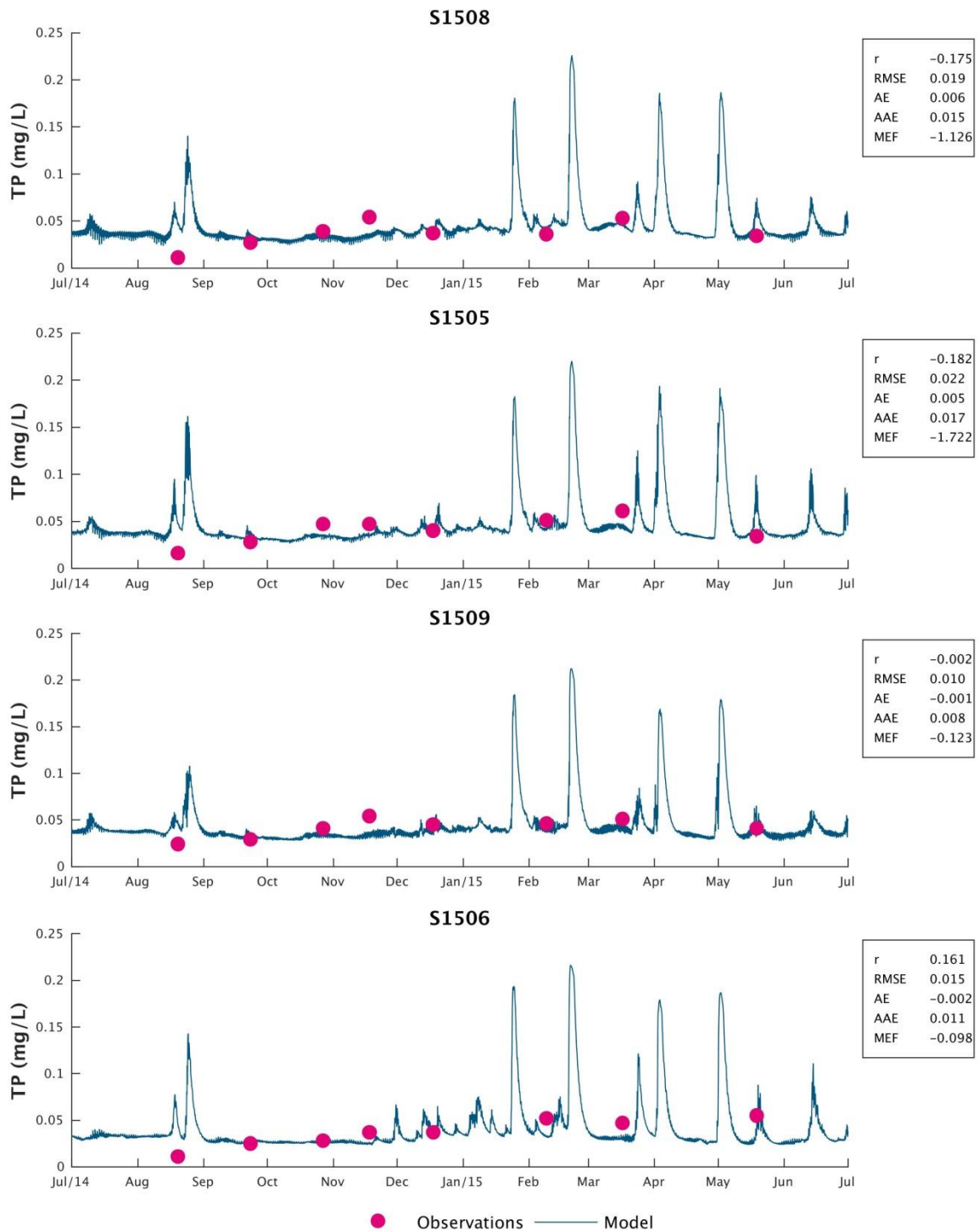


Figure A-14 Total phosphorus timeseries plot for Maroochy U/s

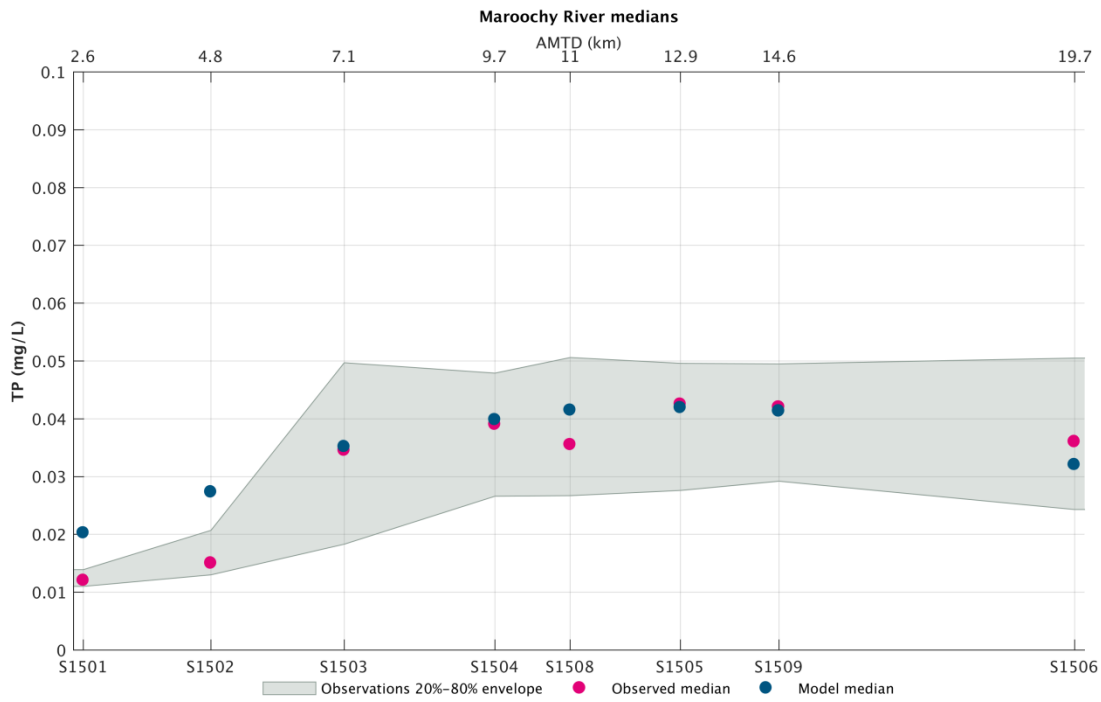


Figure A-15 Total phosphorus thalweg comparison

### A.1.5 Chlorophyll-a

Chlorophyll-a calibration information is presented below.

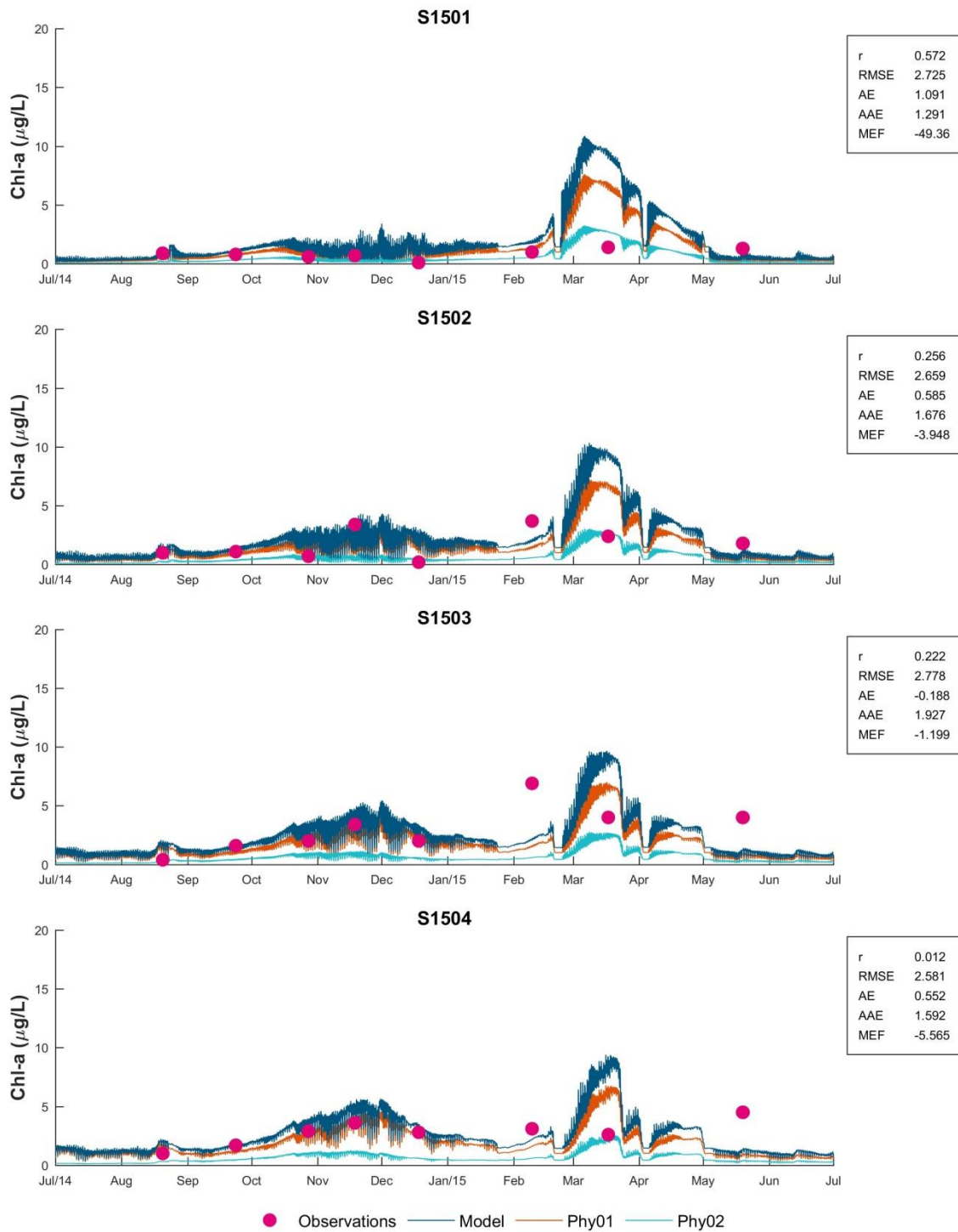


Figure A-16 Chlorophyll-a timeseries plot for Maroochy D/s

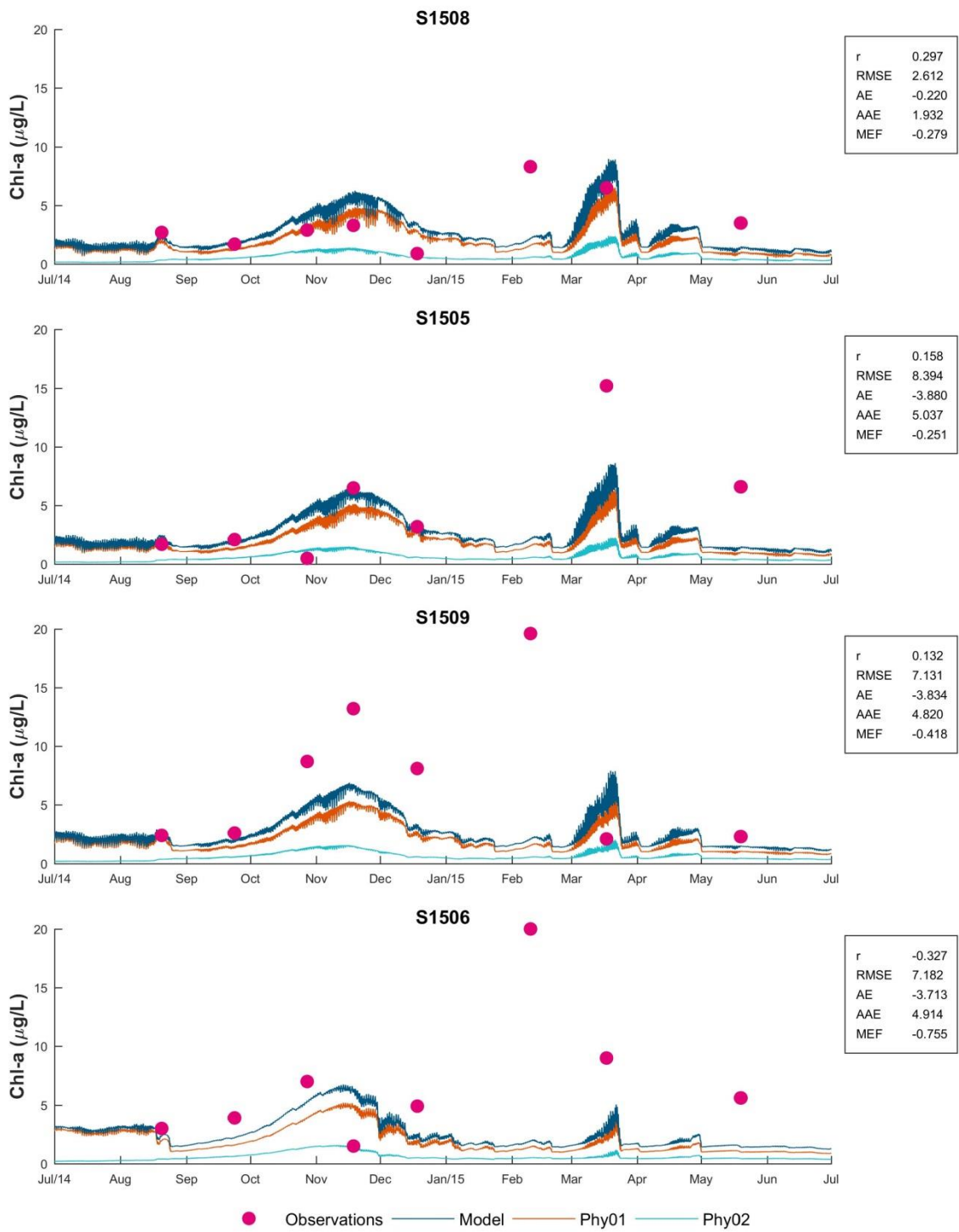


Figure A-17 Chlorophyll-a timeseries plot for Maroochy U/s

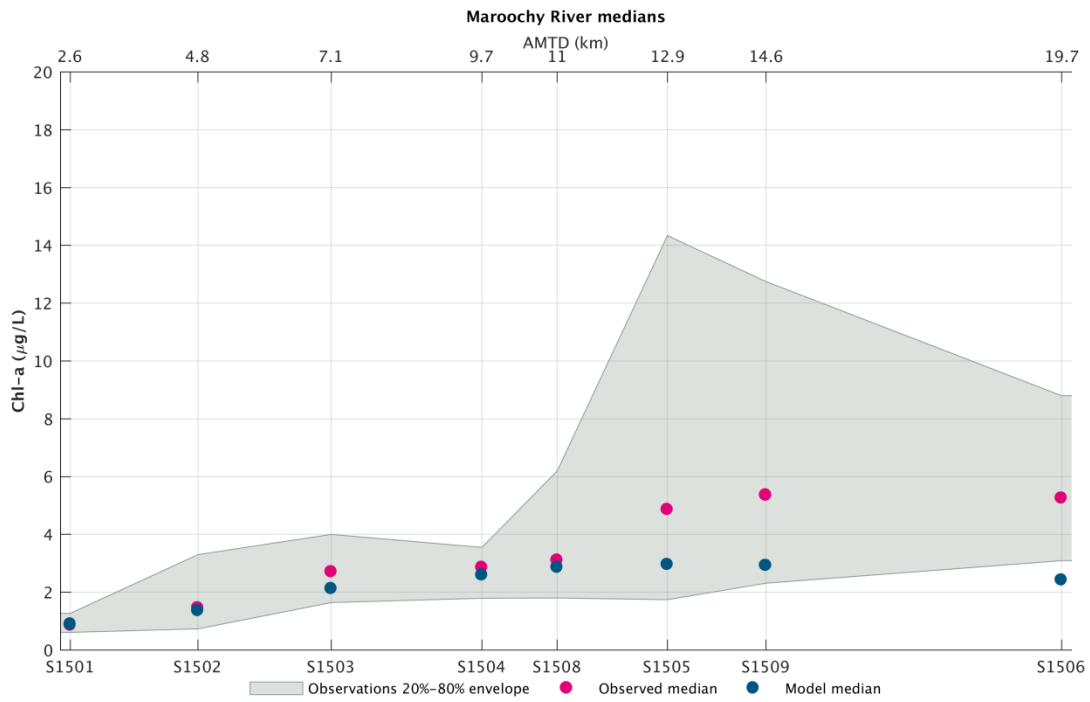


Figure A-18 Chlorophyll-a thalweg comparison

## A.2 Mooloolah

### A.2.1 Turbidity

Turbidity calibration information is presented below:

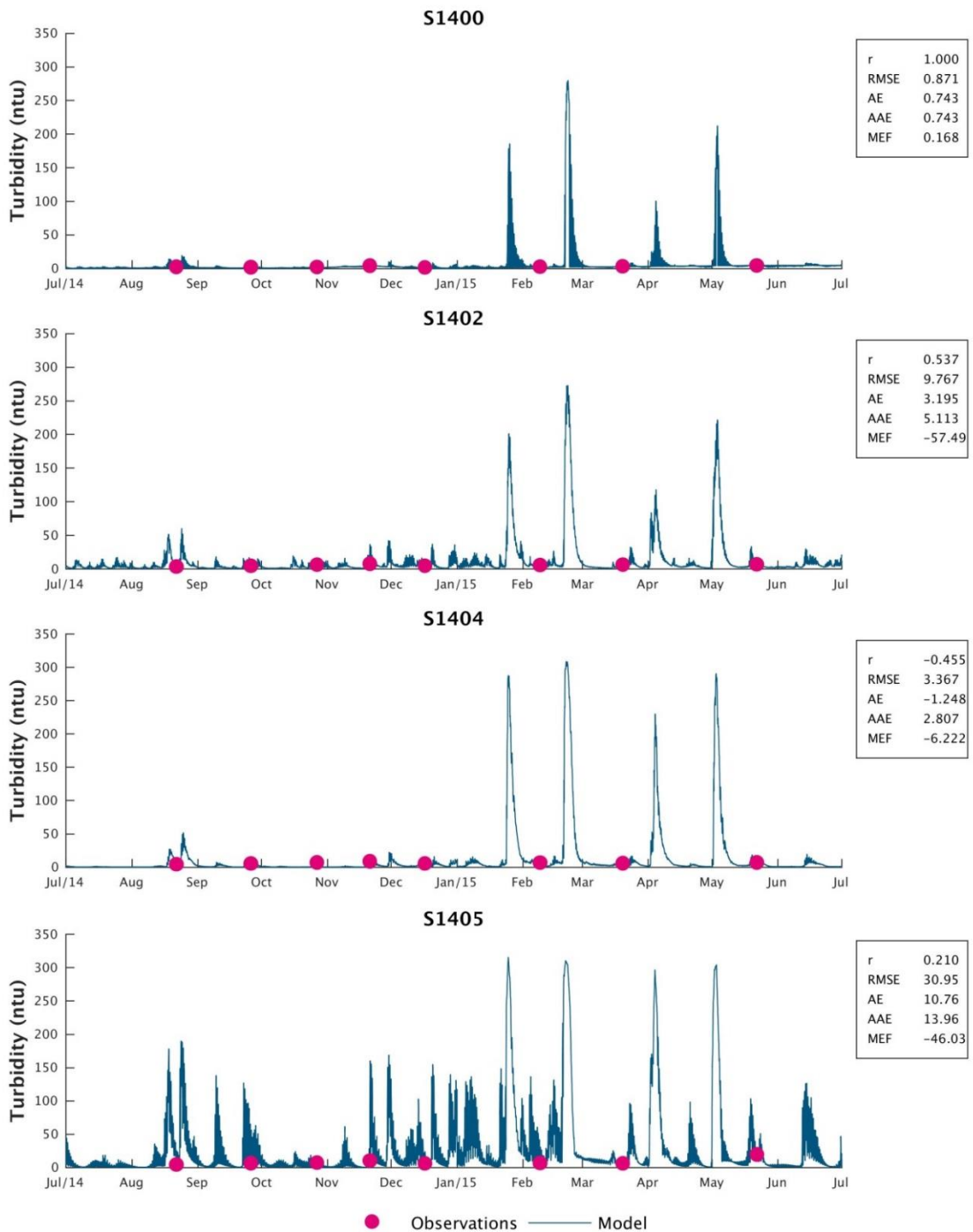


Figure A-19 Turbidity timeseries plot for Mooloolah

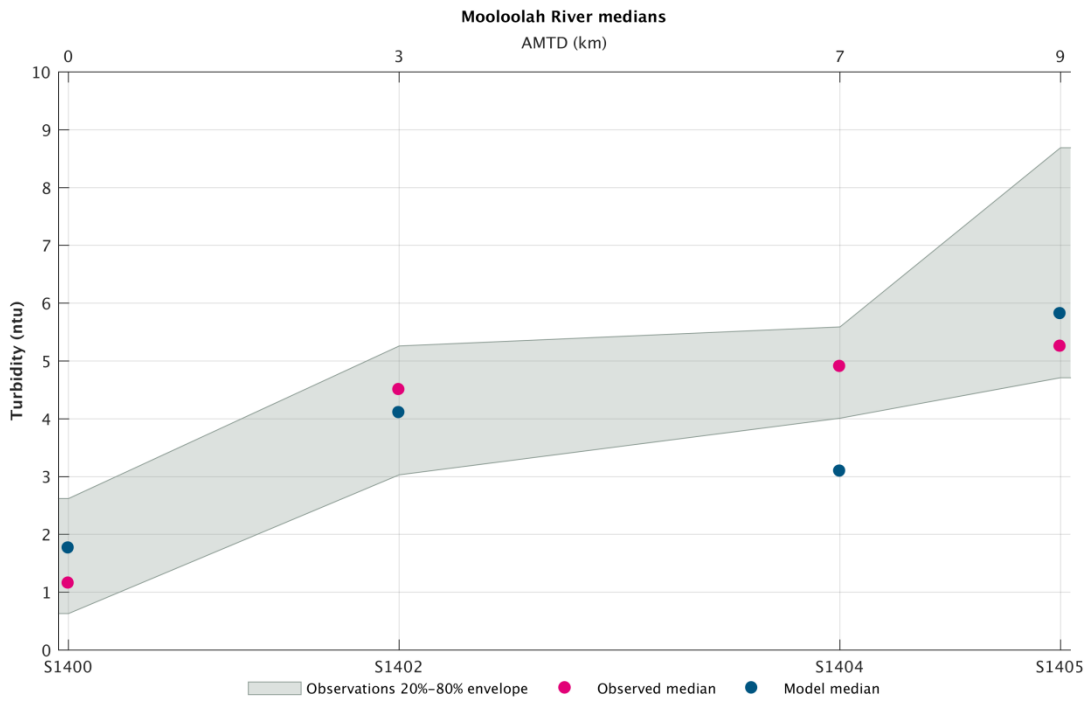


Figure A-20 Turbidity thalweg comparison for Mooloolah

### A.2.2 Dissolved oxygen

Dissolved oxygen calibration information is presented below.

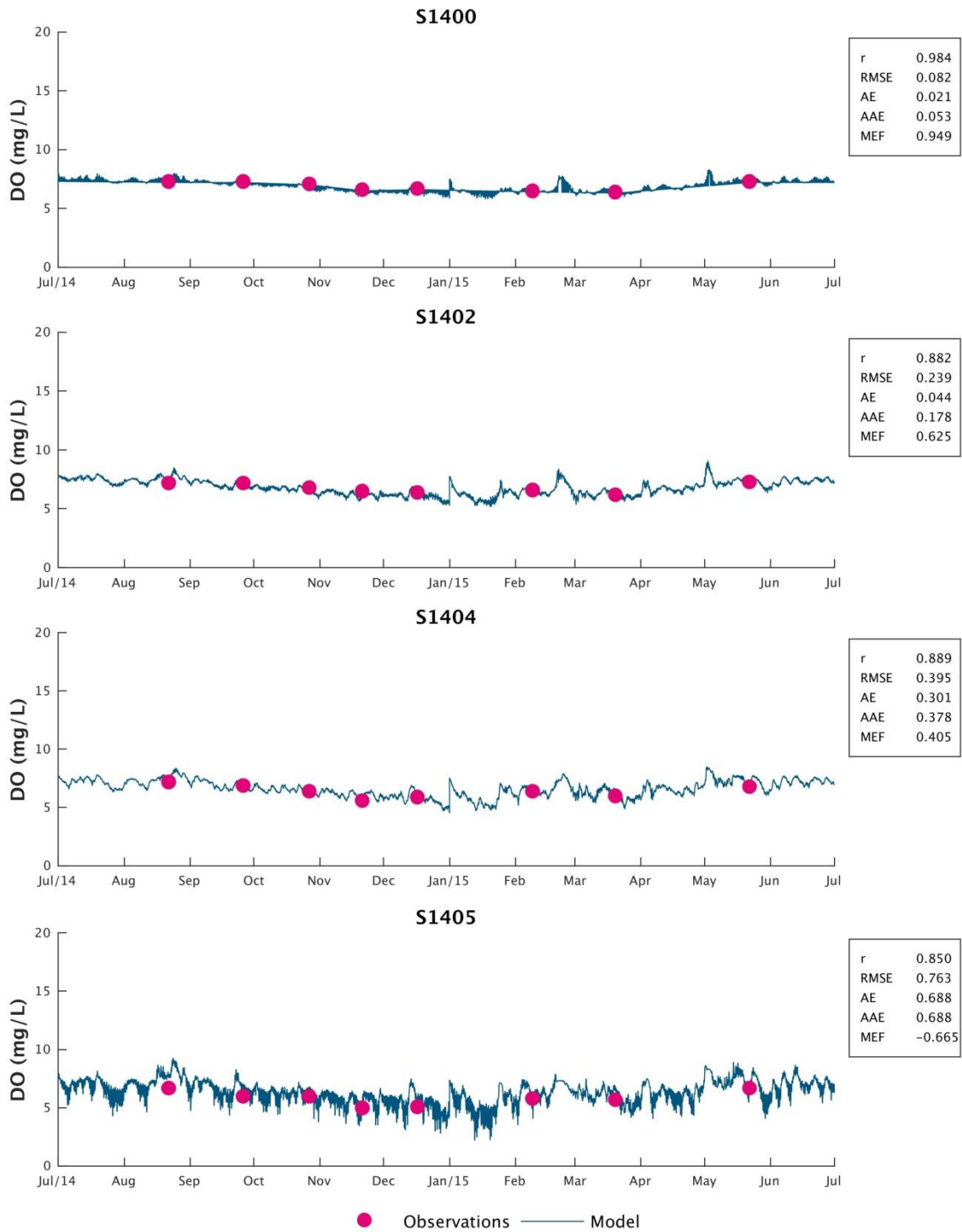


Figure A-21 Dissolved oxygen timeseries plot for Mooloolah

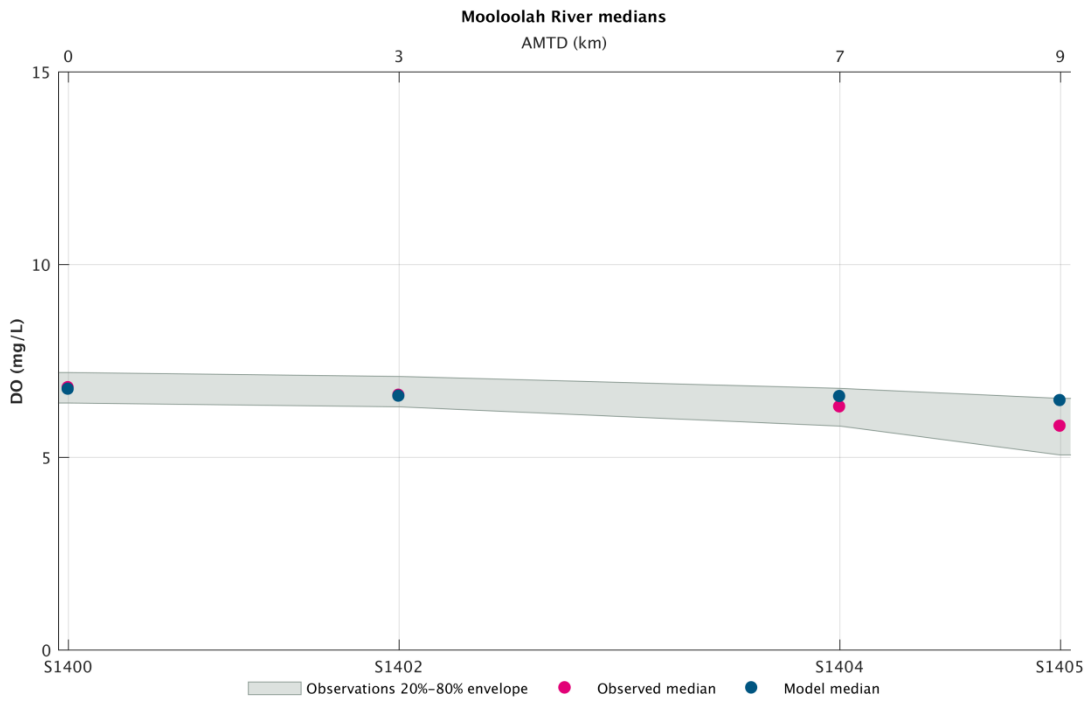


Figure A-22 Dissolved oxygen thalweg comparison for Mooloolah

### A.2.3 Dissolved oxygen deficit

Dissolved oxygen deficit calibration information is presented below.

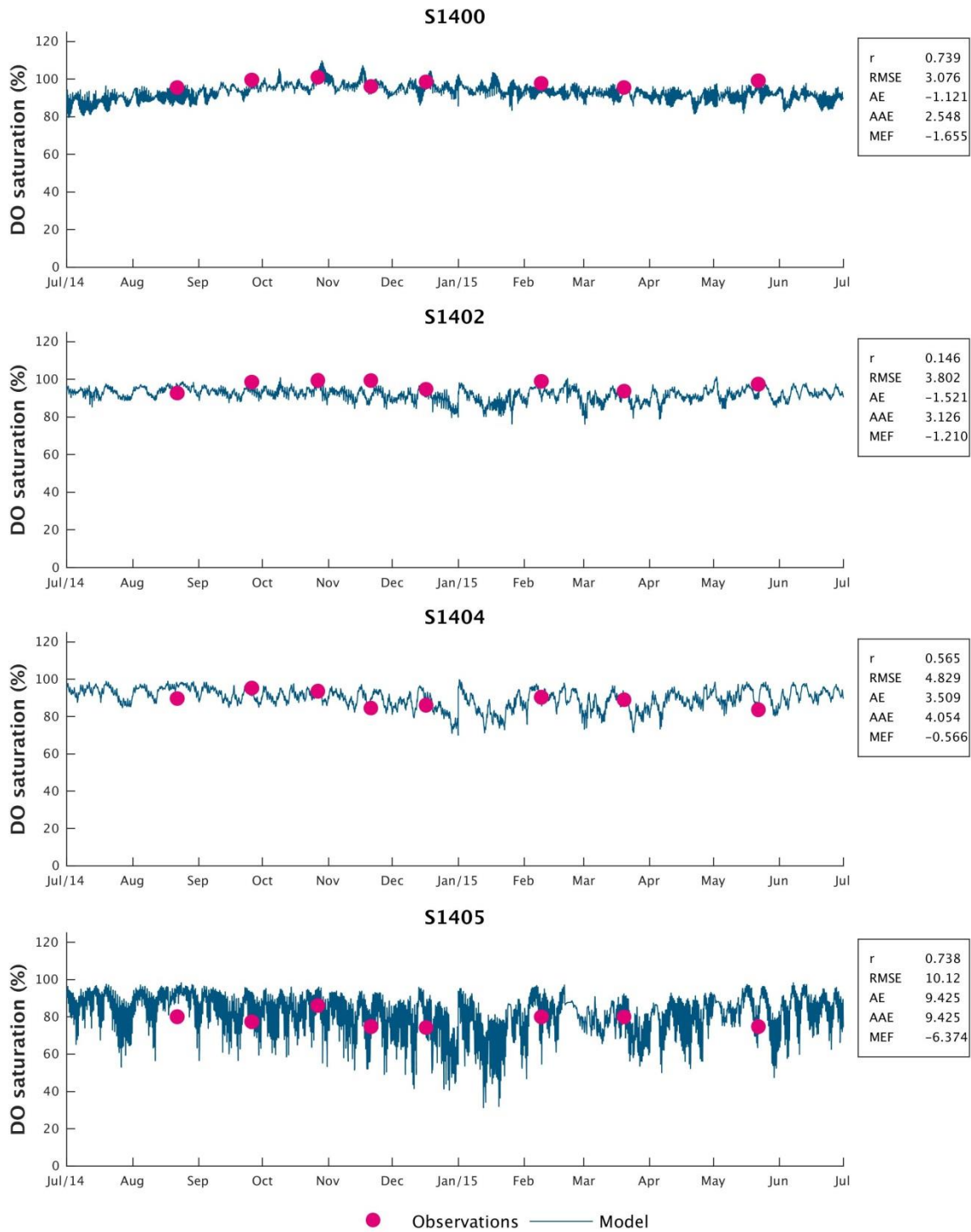


Figure A-23 Dissolved oxygen deficit timeseries plot for Mooloolah

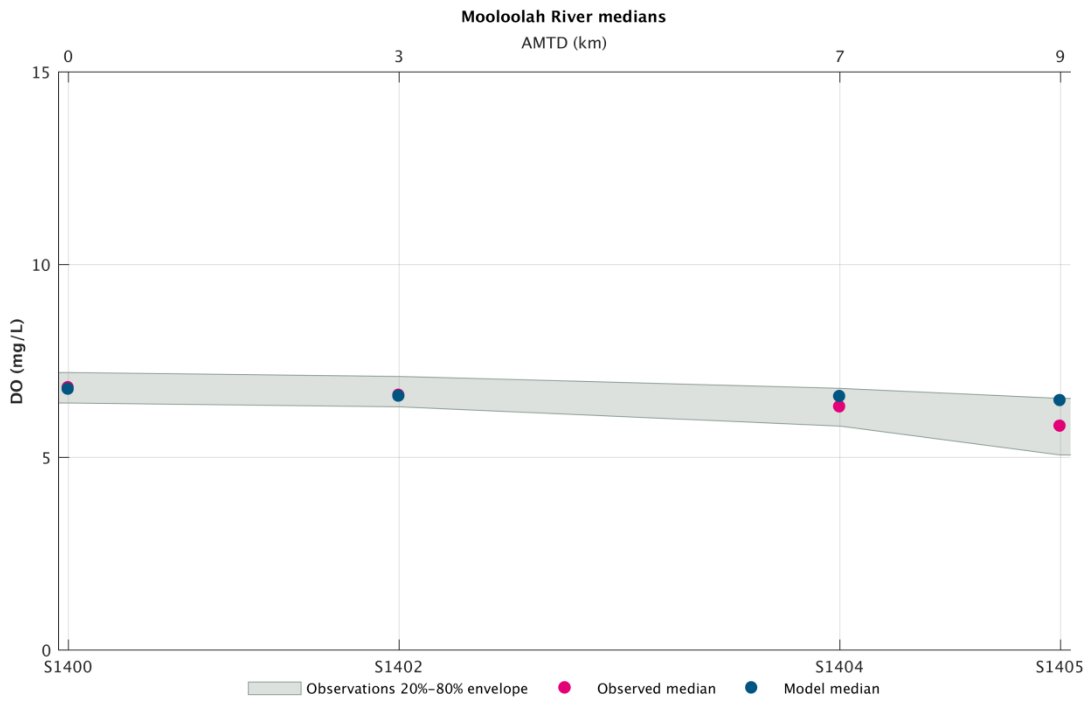


Figure A-24 Dissolved oxygen deficit thalweg comparison for Mooloolah

### A.2.4 Total Nitrogen

Total nitrogen calibration information is presented below.

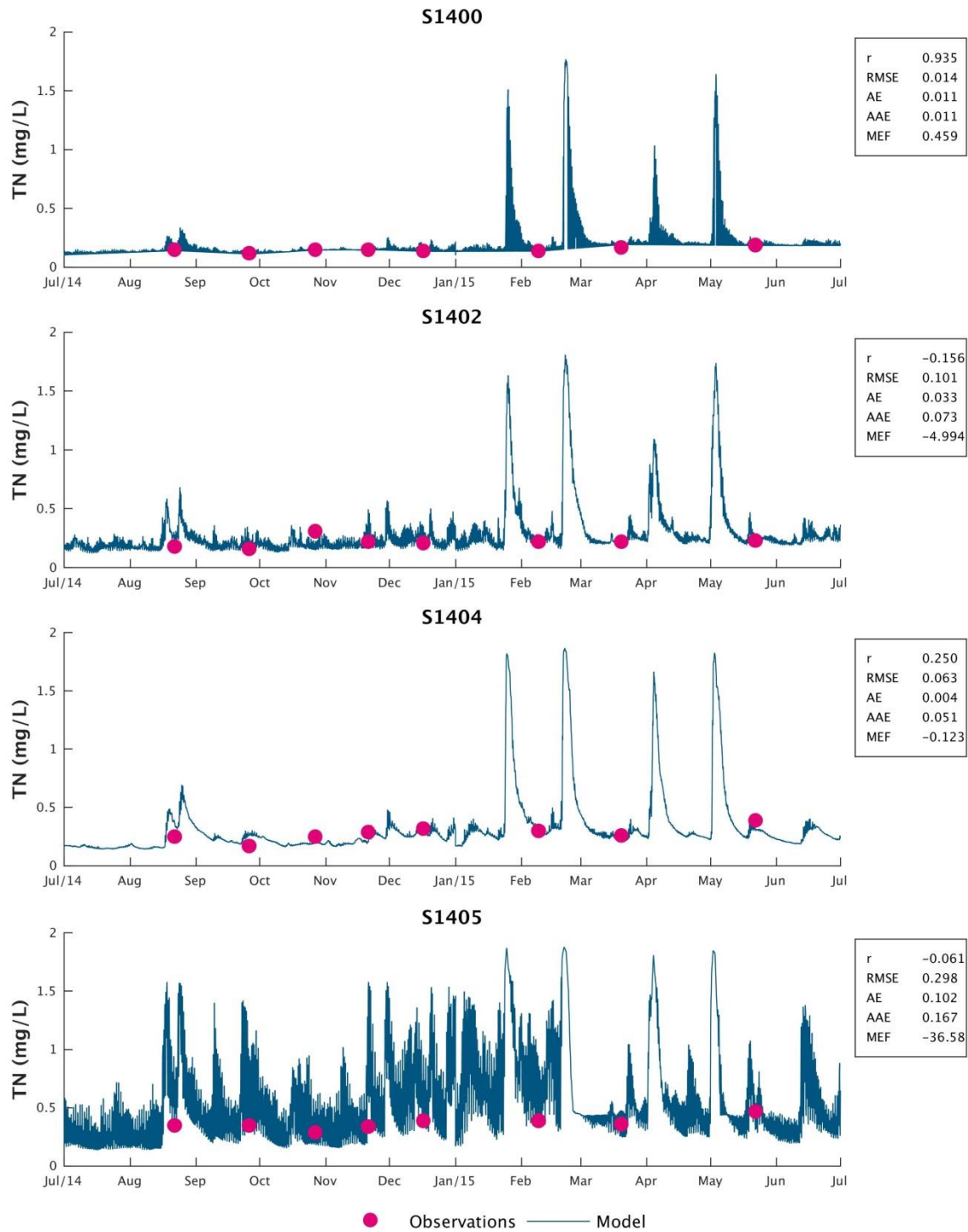


Figure A-25 Total nitrogen timeseries plot for Mooloolah

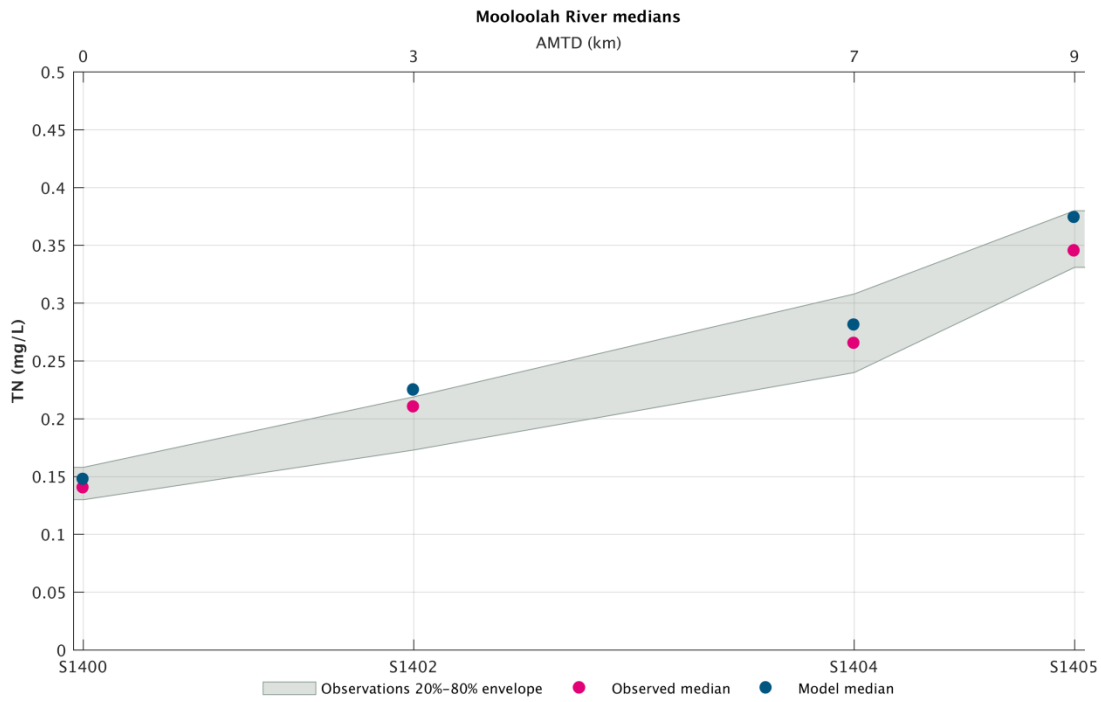


Figure A-26 Total nitrogen thalweg comparison for Mooloolah

### A.2.5 Total Phosphorus

Total phosphorus calibration information is presented below.

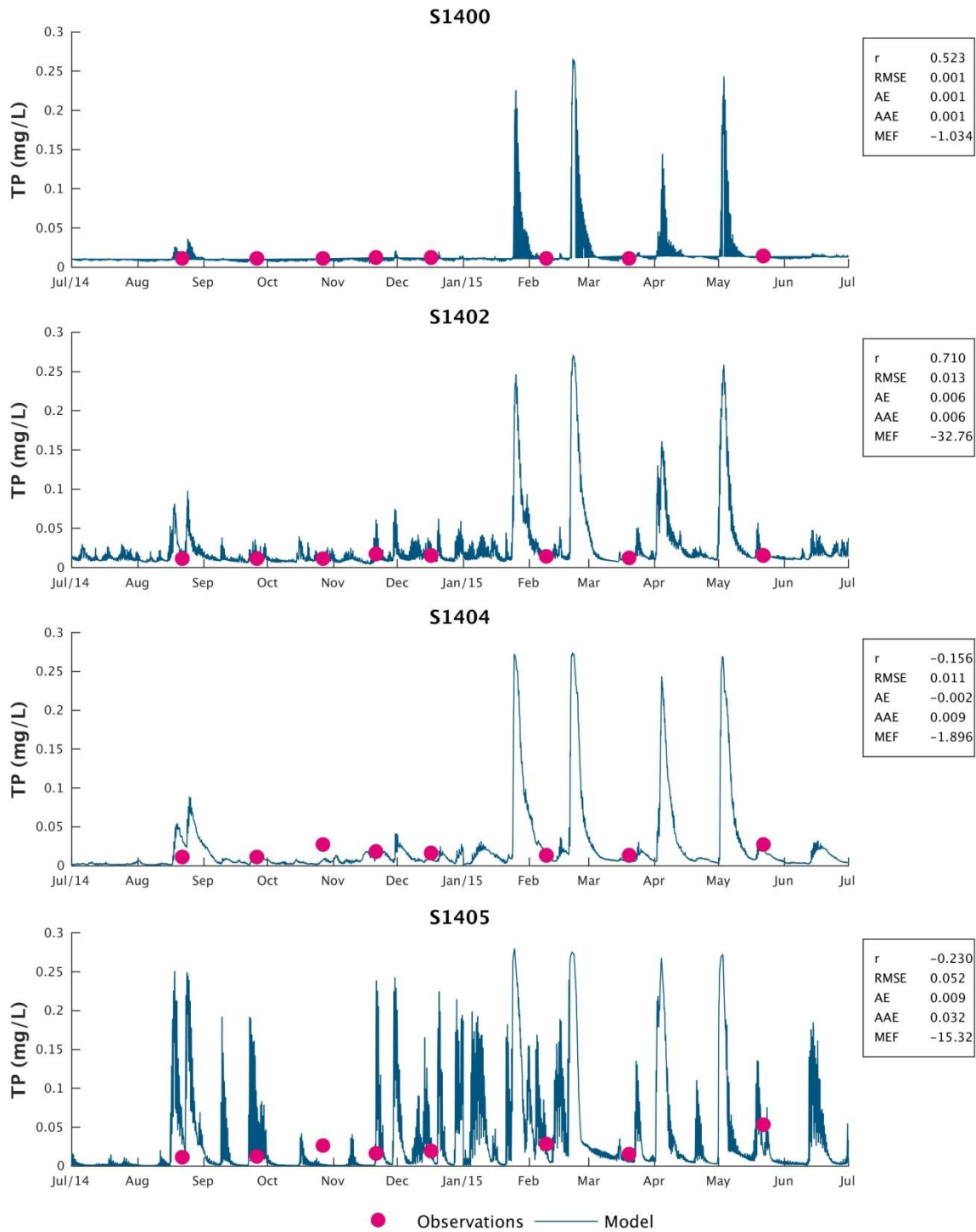


Figure A-27 Total phosphorus timeseries plot for Mooloolah

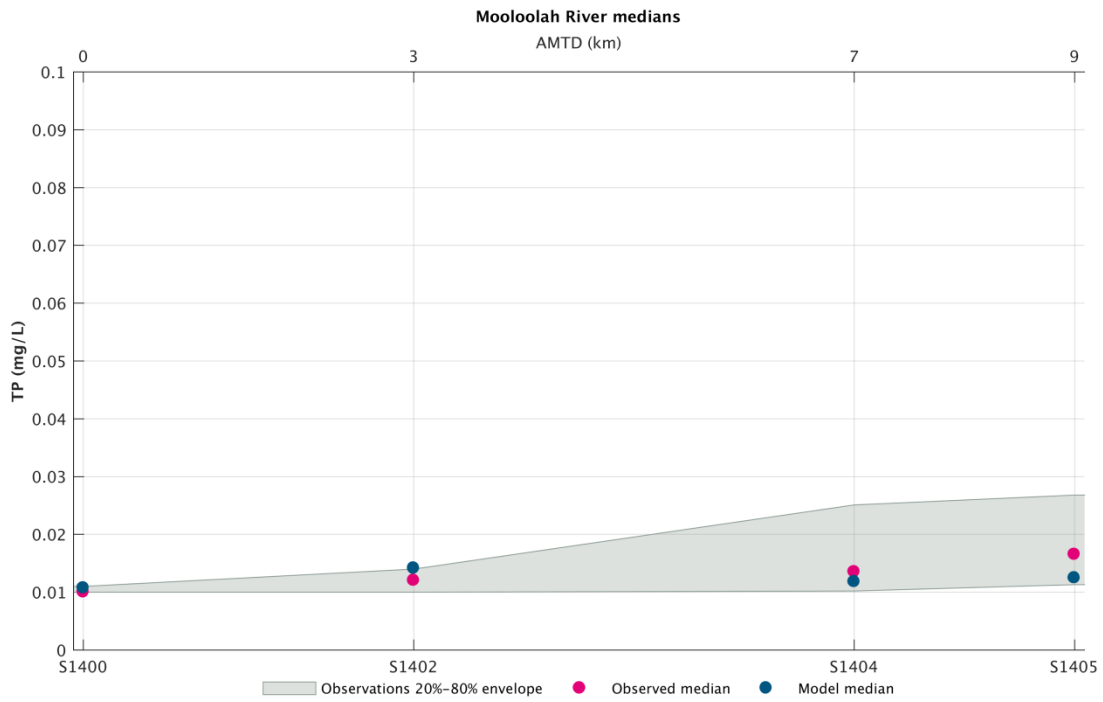


Figure A-28 Total phosphorus thalweg comparison for Mooloolah

### A.2.6 Chlorophyll-a

Chlorophyll-a calibration information is presented below.

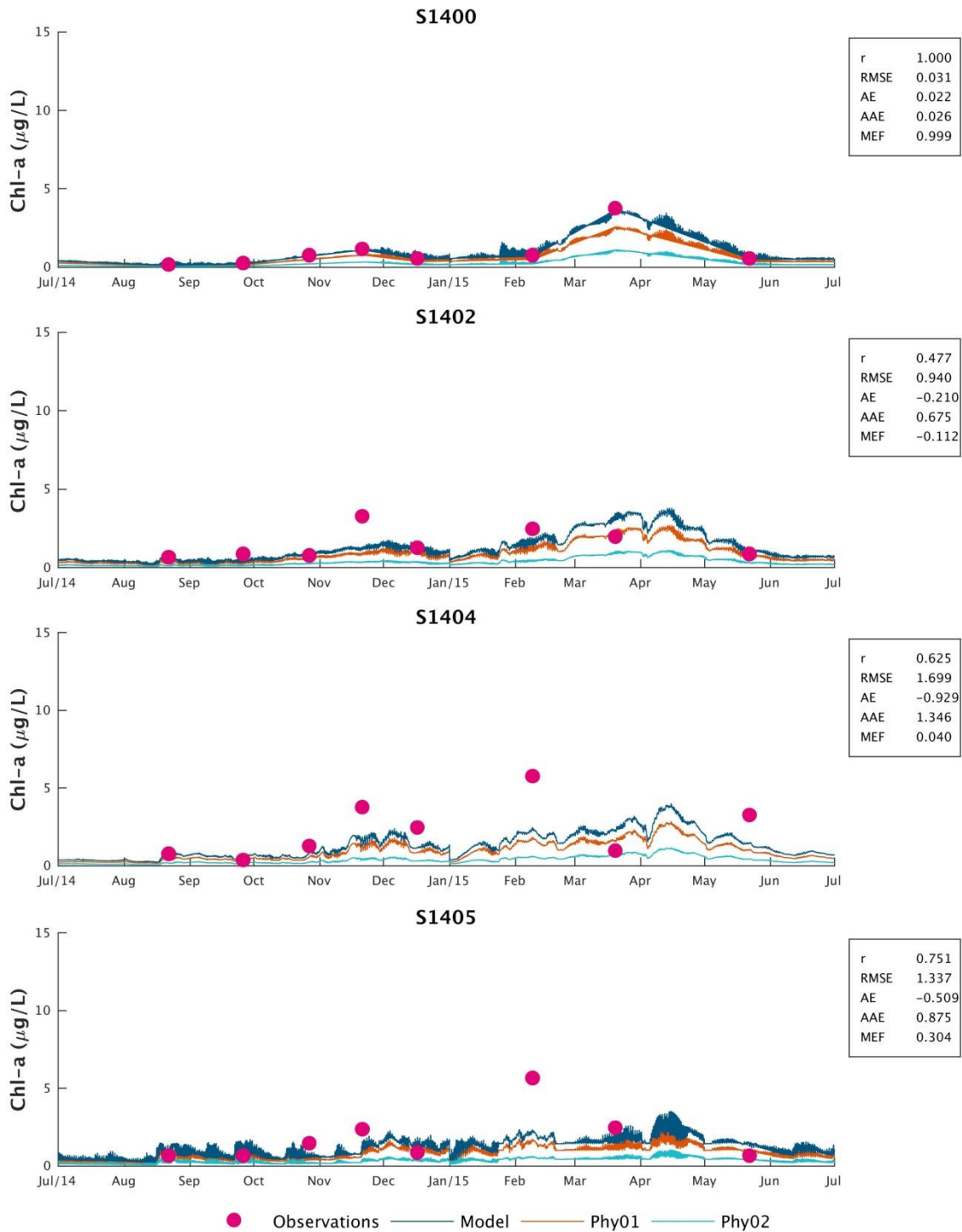


Figure A-29 Chlorophyll-a timeseries plot for Mooloolah

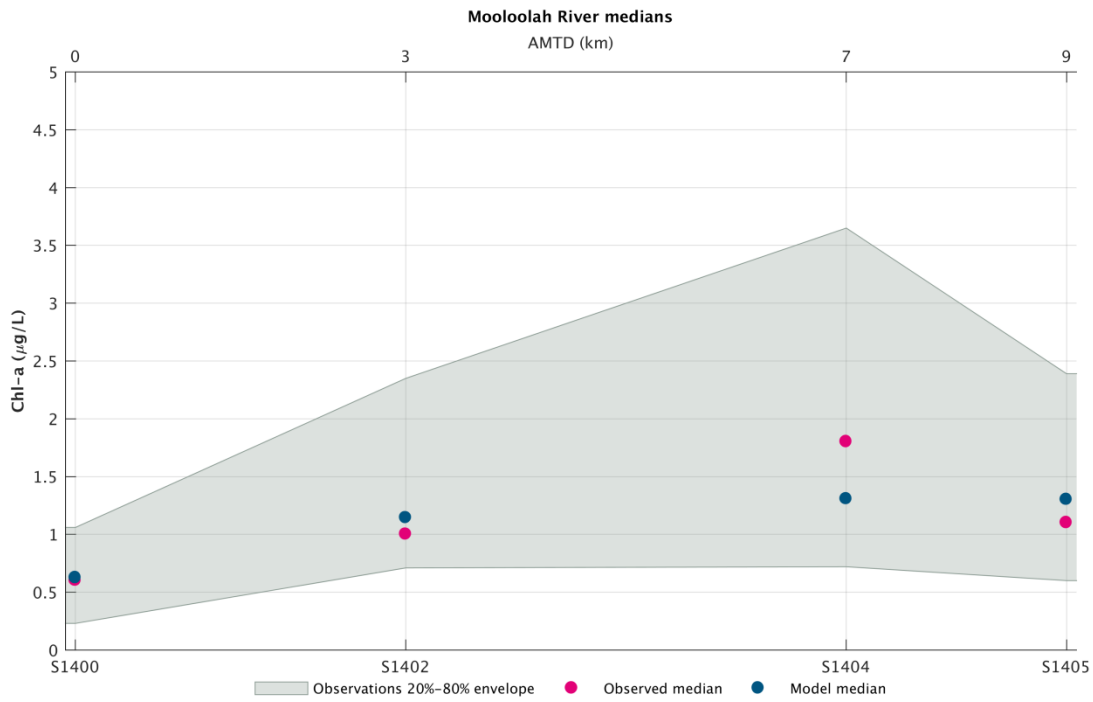


Figure A-30 Chlorophyll-a thalweg comparison for Mooloolah

### A.3 Pumicestone

#### A.3.1 Turbidity

Turbidity calibration information is presented below.

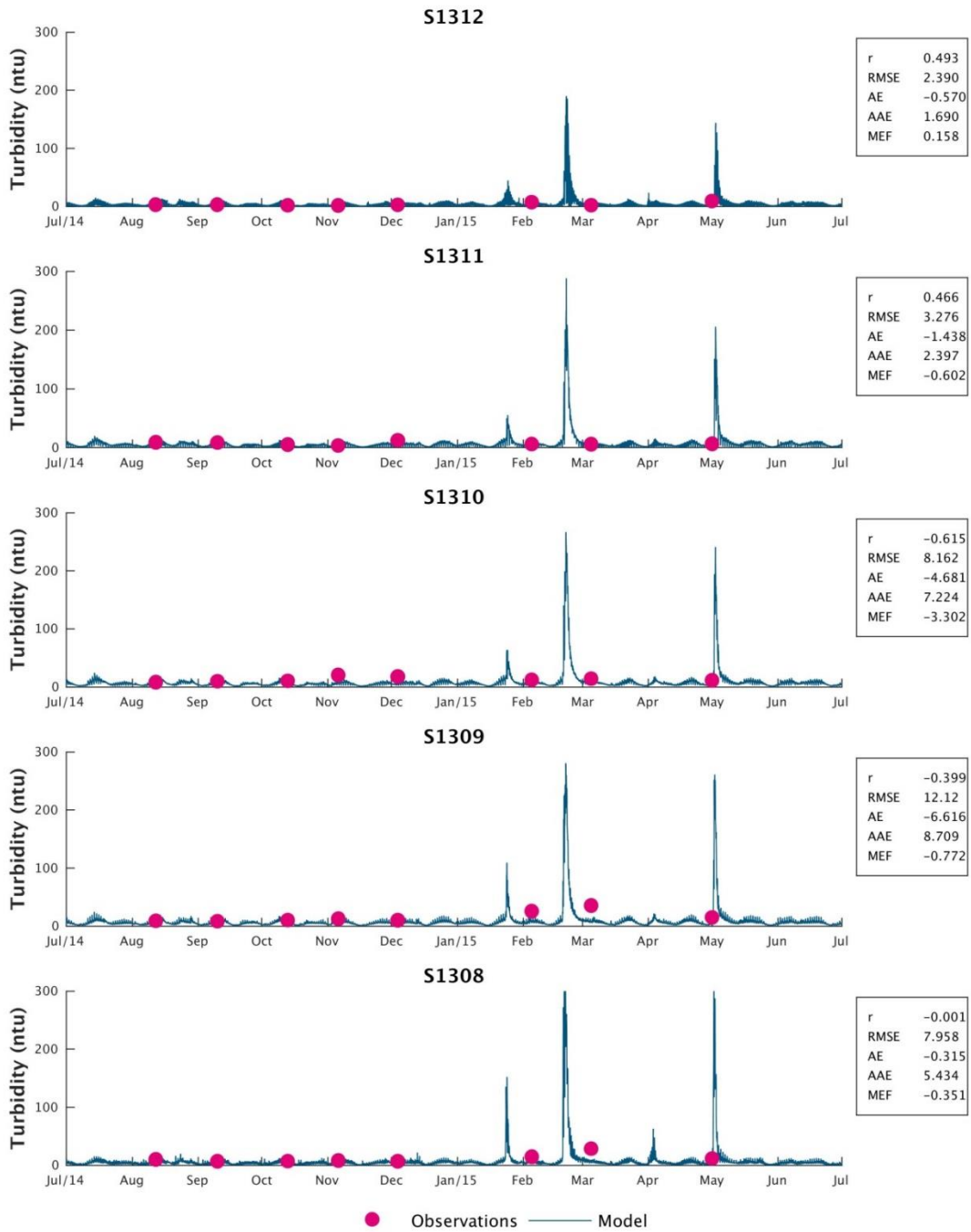


Figure A-31 Turbidity timeseries plot for Pumicestone Passage North

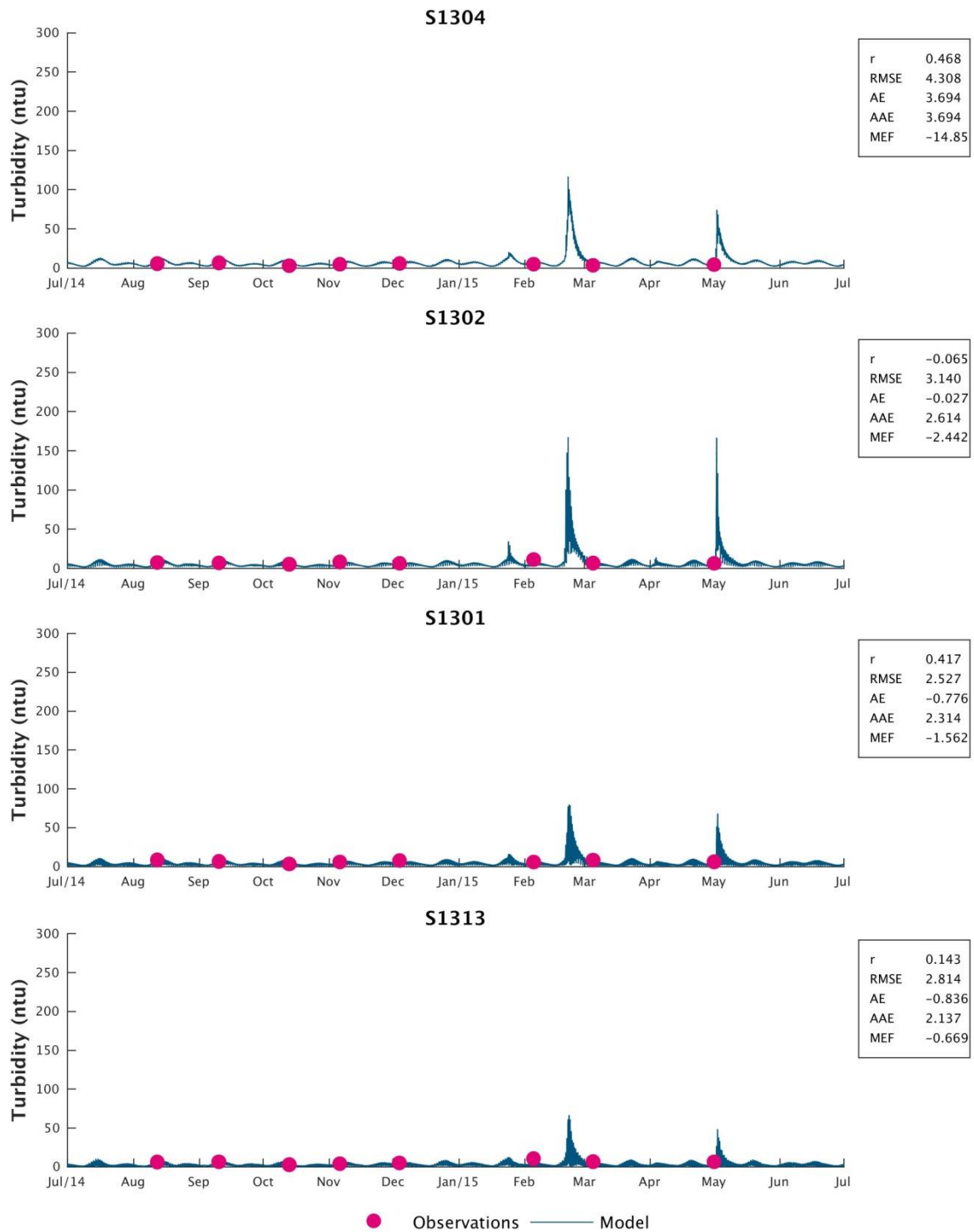


Figure A-32 Turbidity timeseries plot for Pumicestone Passage South

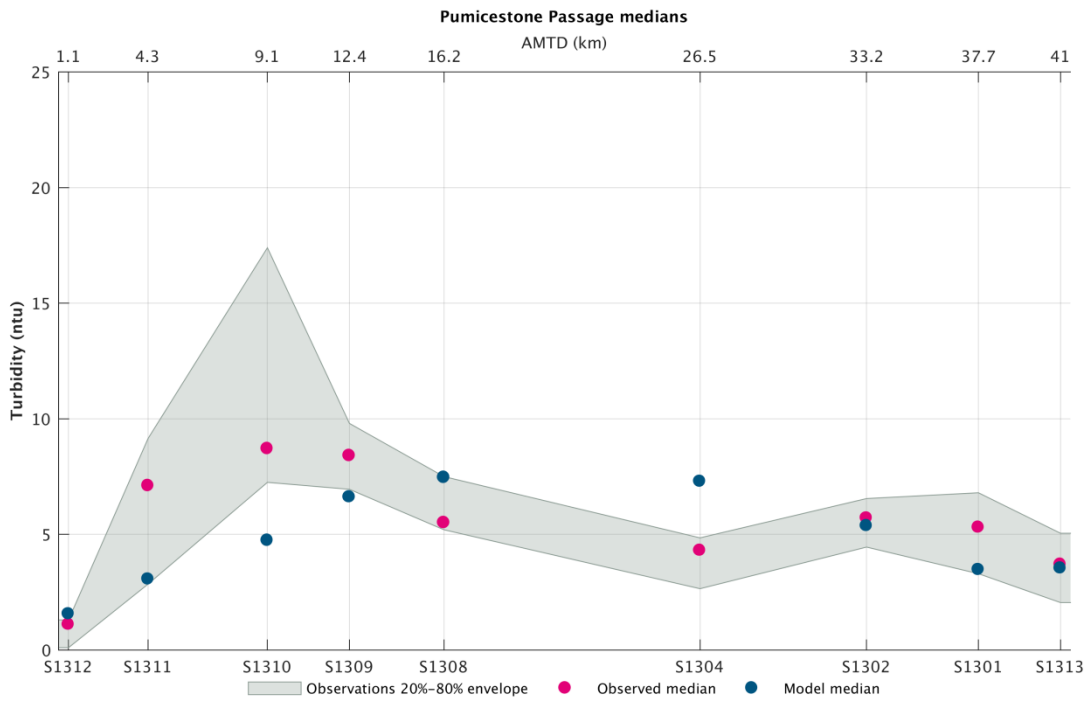


Figure A-33 Turbidity thalweg comparison for Pumicestone Passage

### A.3.2 Dissolved oxygen

Dissolved oxygen calibration information is presented below.

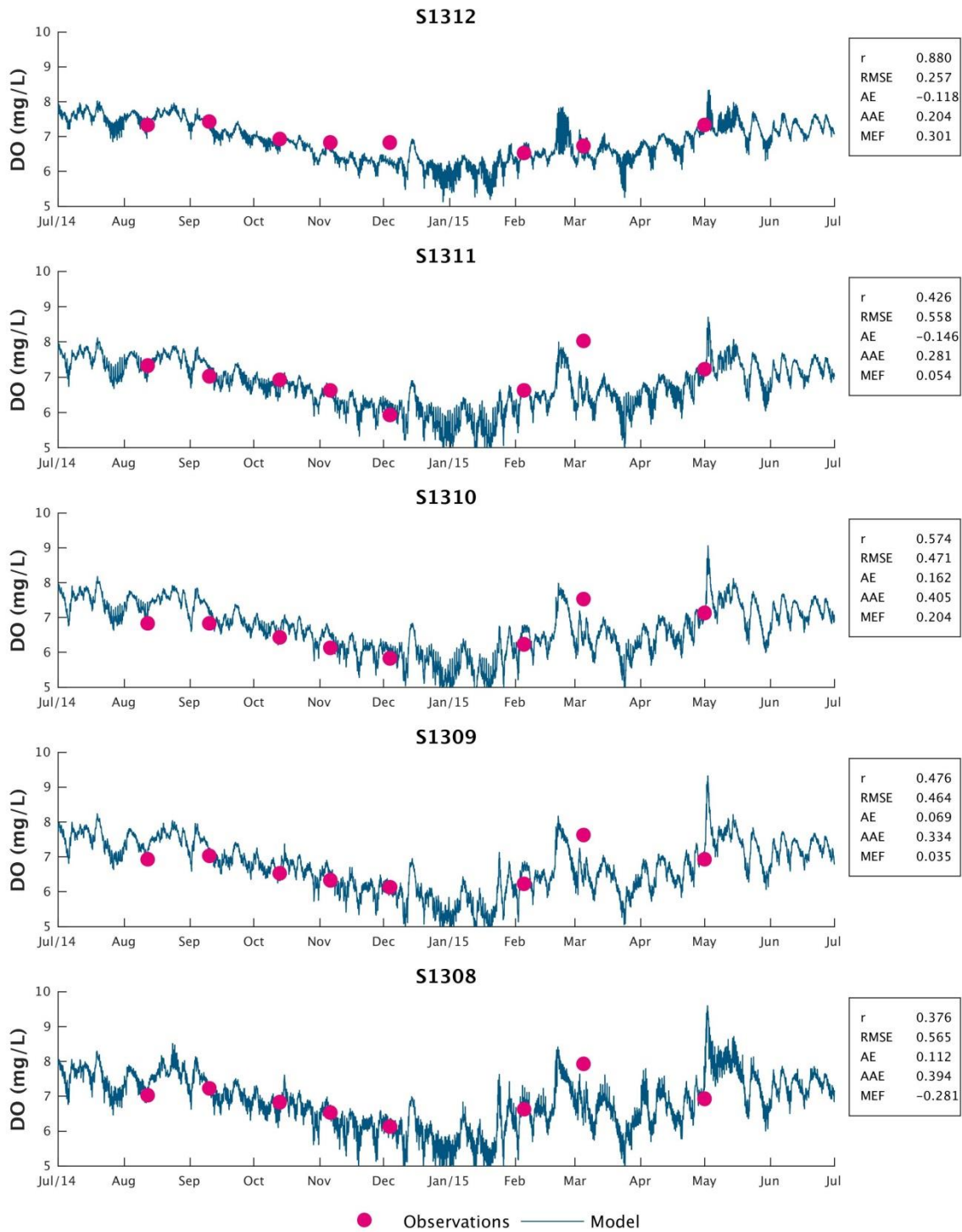


Figure A-34 Dissolved oxygen timeseries plot for Pumicestone Passage North

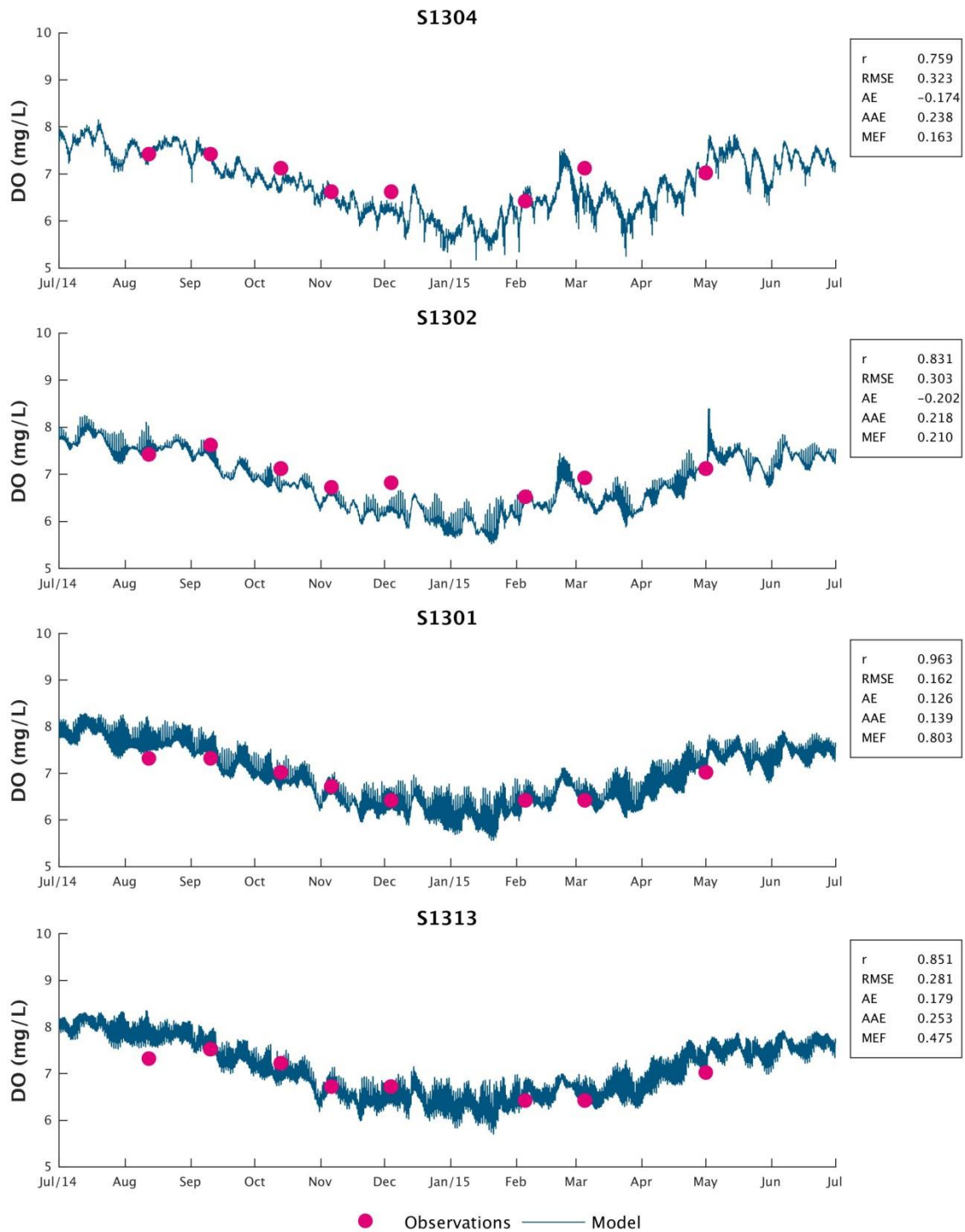


Figure A-35 Dissolved oxygen timeseries plot for Pumicestone Passage South

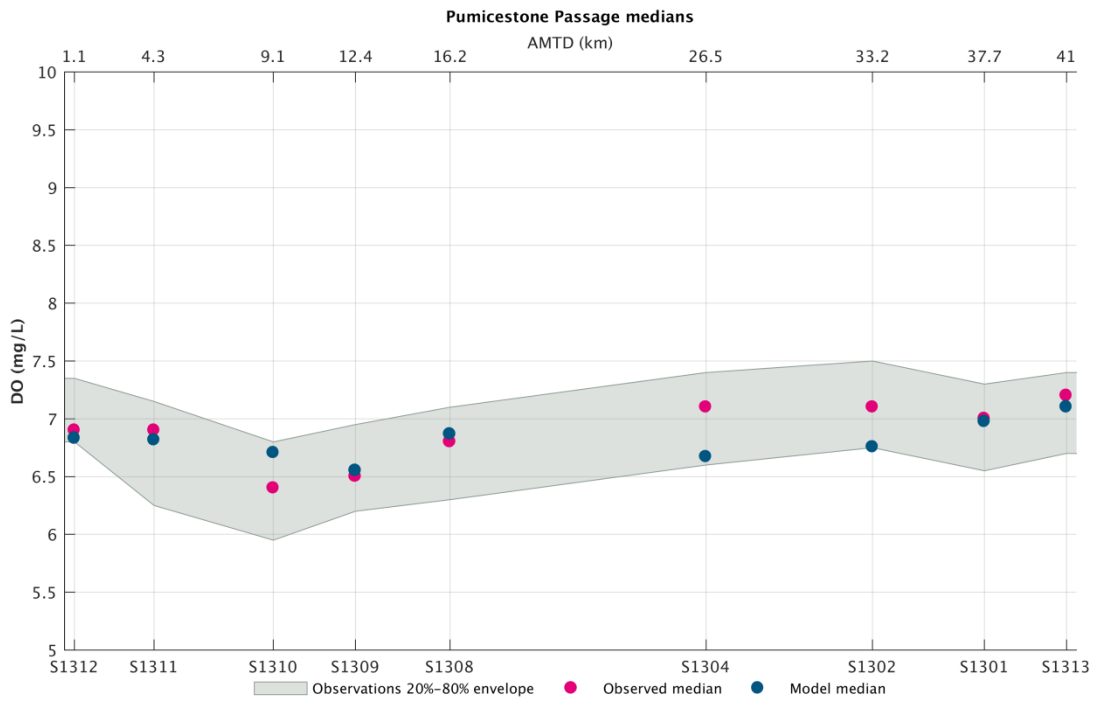


Figure A-36 Dissolved oxygen thalweg comparison for Pumicestone Passage

### A.3.3 Dissolved oxygen deficit

Dissolved oxygen deficit calibration information is presented below.

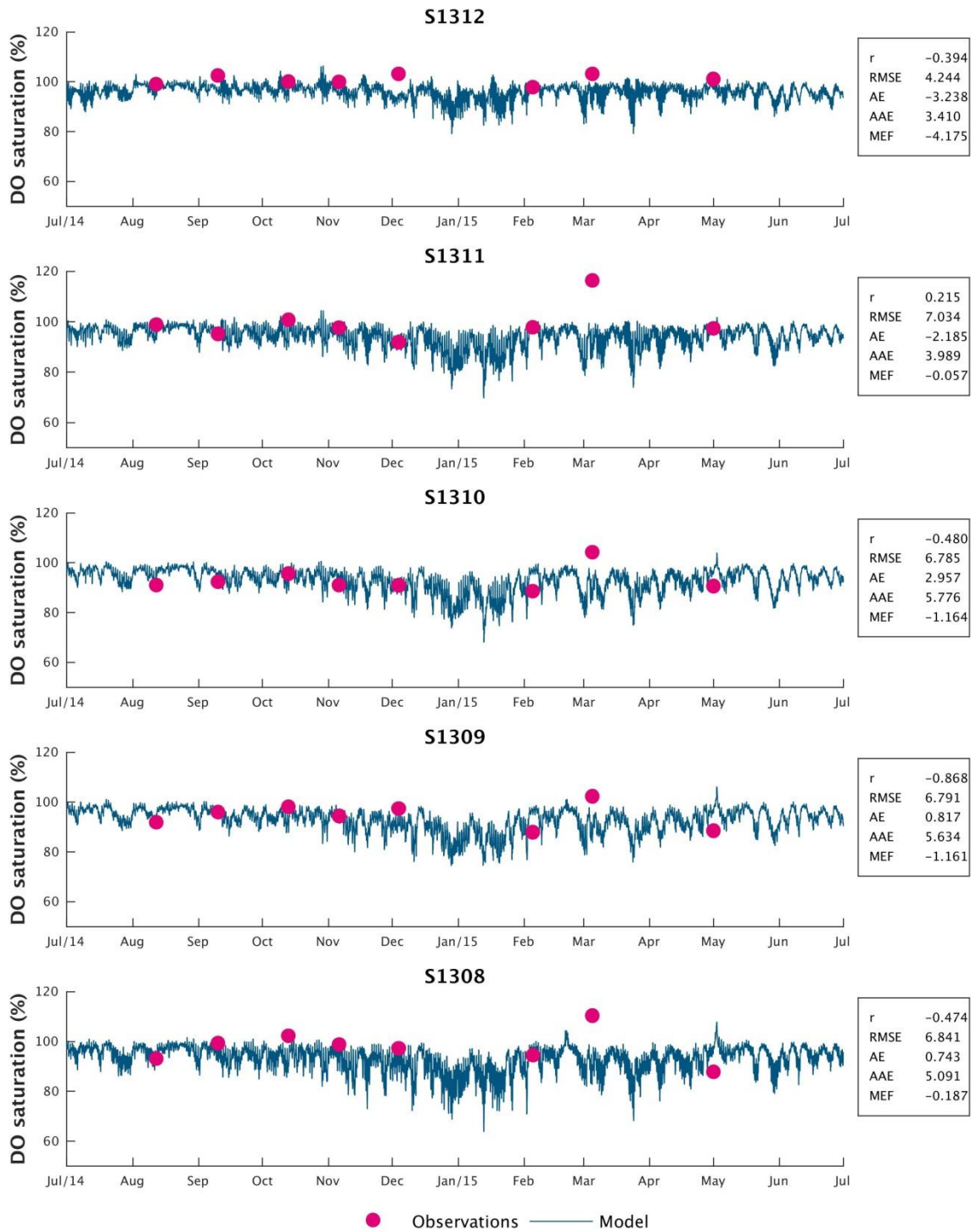


Figure A-37 Dissolved oxygen deficit timeseries plot for Pumicestone Passage North

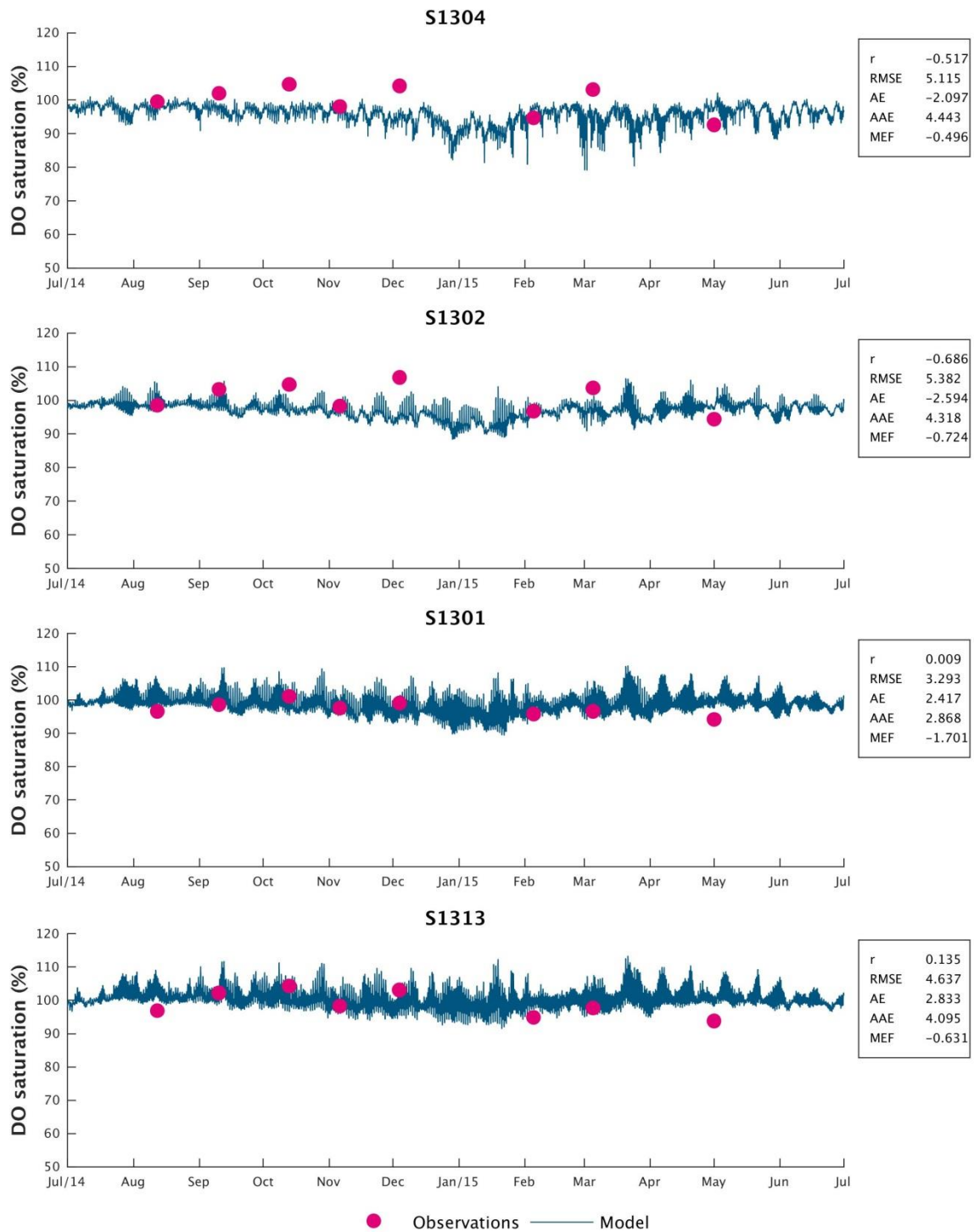


Figure A-38 Dissolved oxygen deficit timeseries plot for Pumicestone Passage South

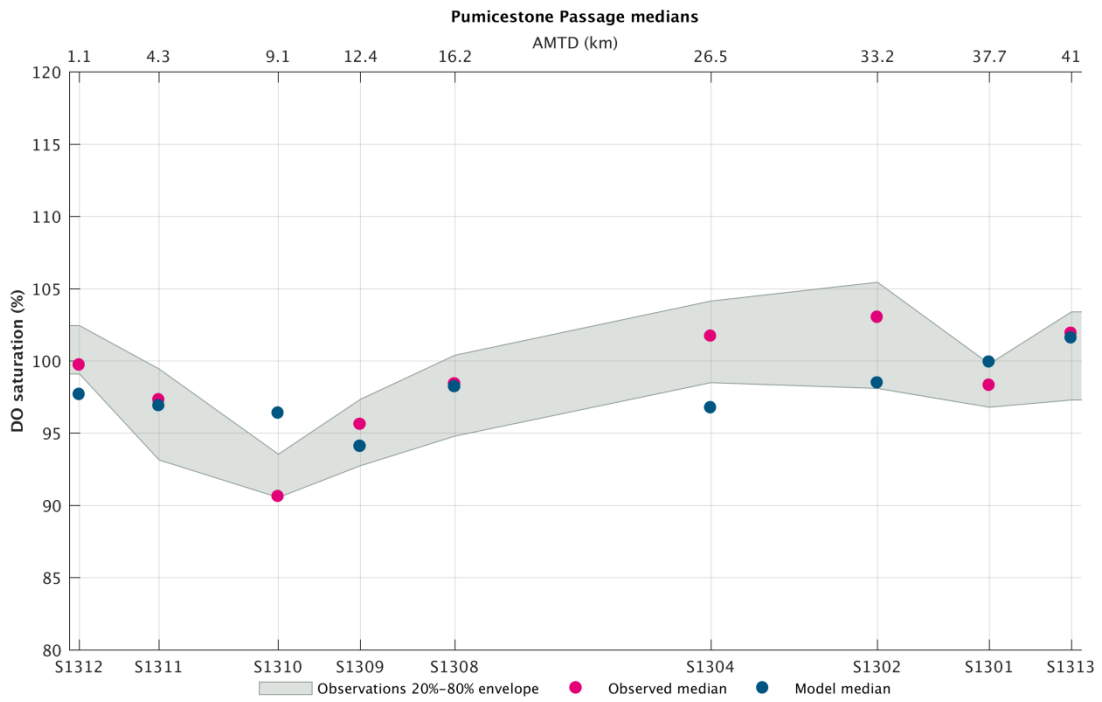


Figure A-39 Dissolved oxygen deficit thalweg comparison for Pumicestone Passage

### A.3.4 Total Nitrogen

Total nitrogen calibration information is presented below.

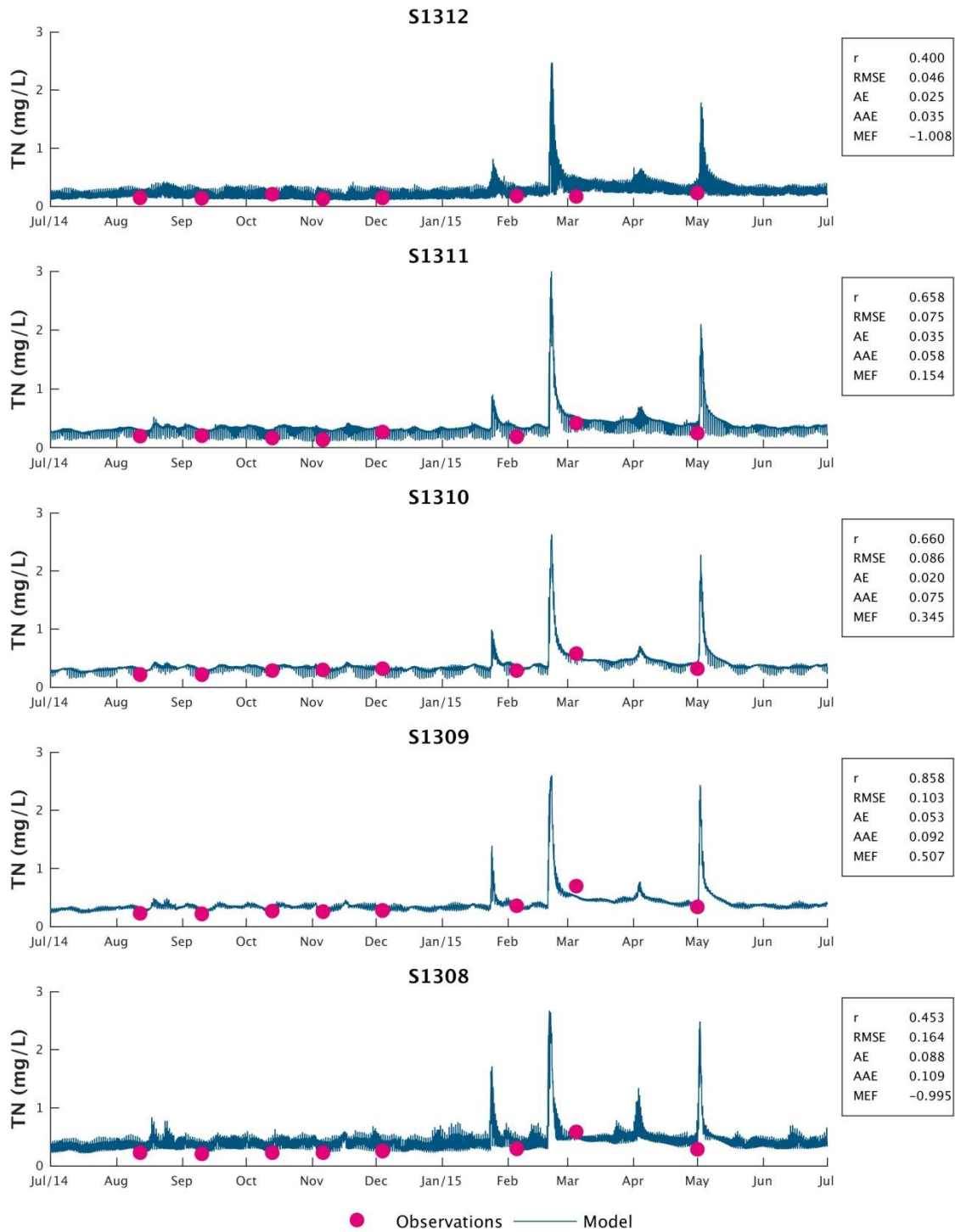


Figure A-40 Total nitrogen timeseries plot for Pumicestone Passage North

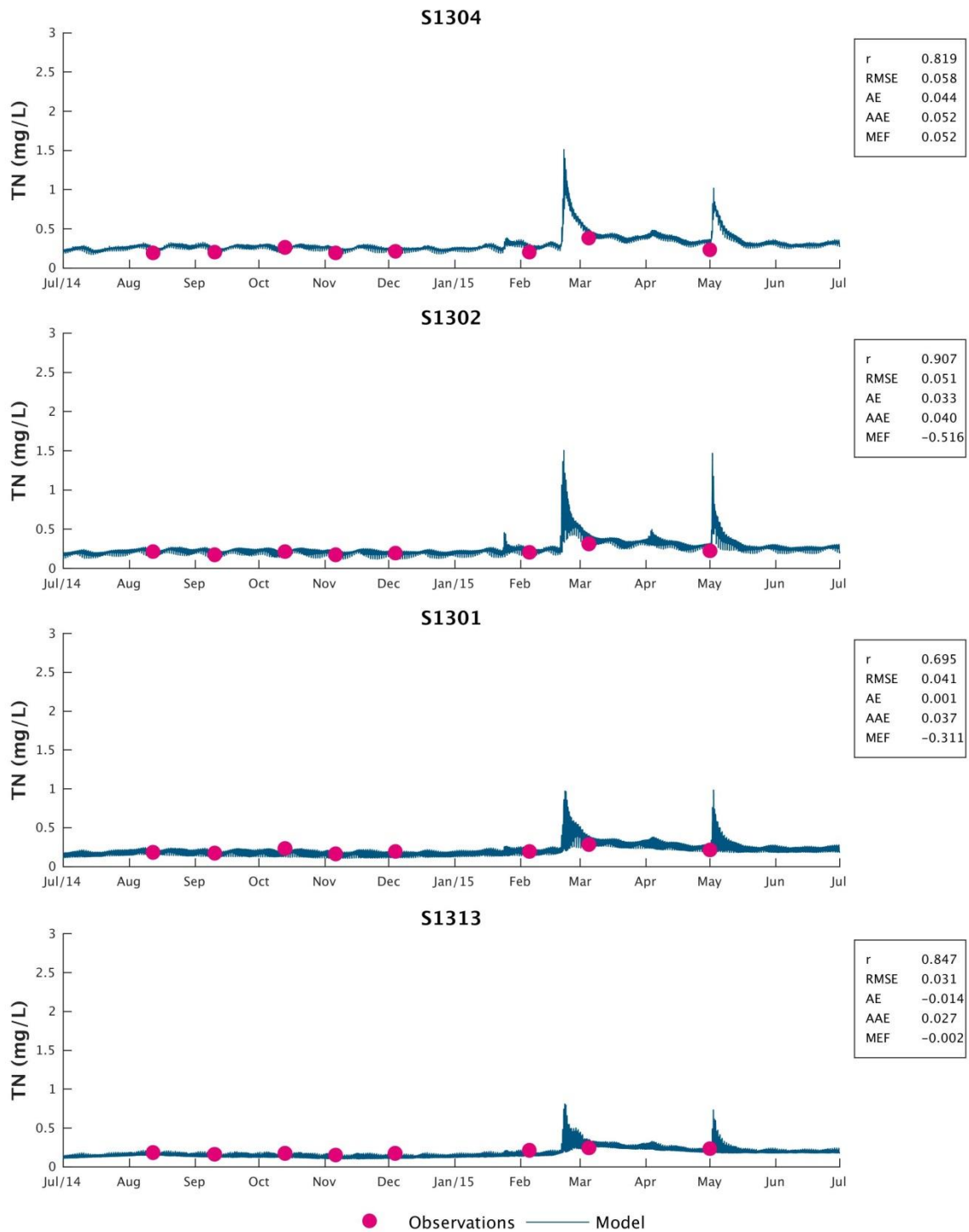


Figure A-41 Total nitrogen timeseries plot for Pumicestone Passage South

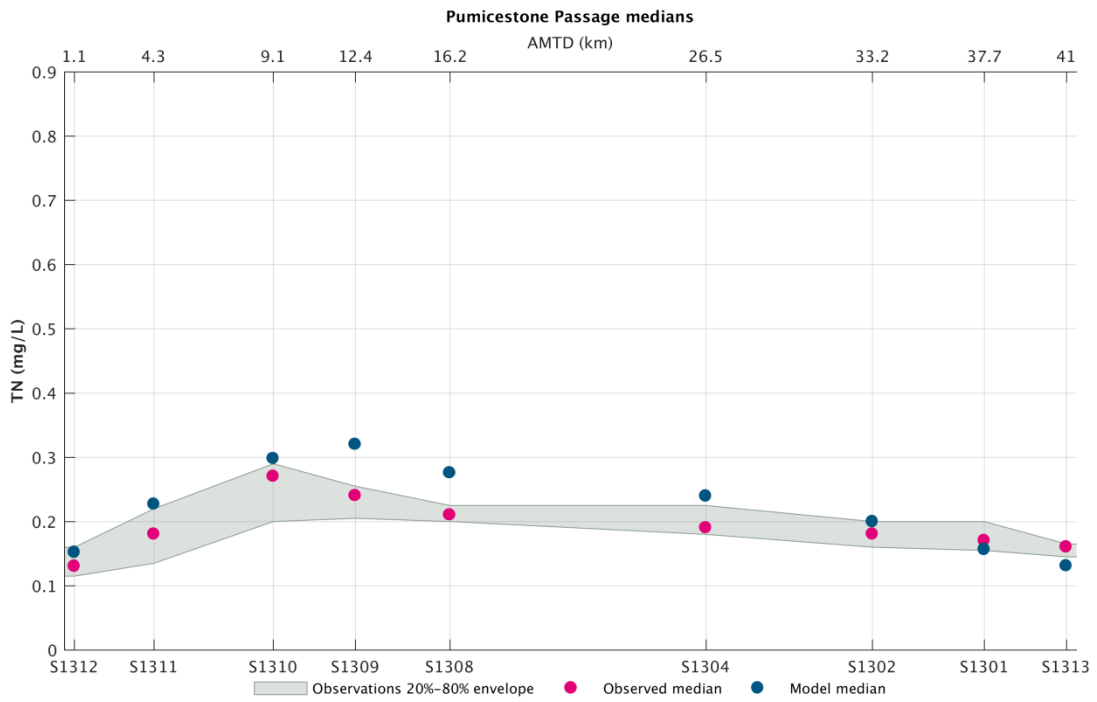


Figure A-42 Total nitrogen thalweg comparison for Pumicestone Passage

### A.3.5 Total Phosphorus

Total phosphorus calibration information is presented below.

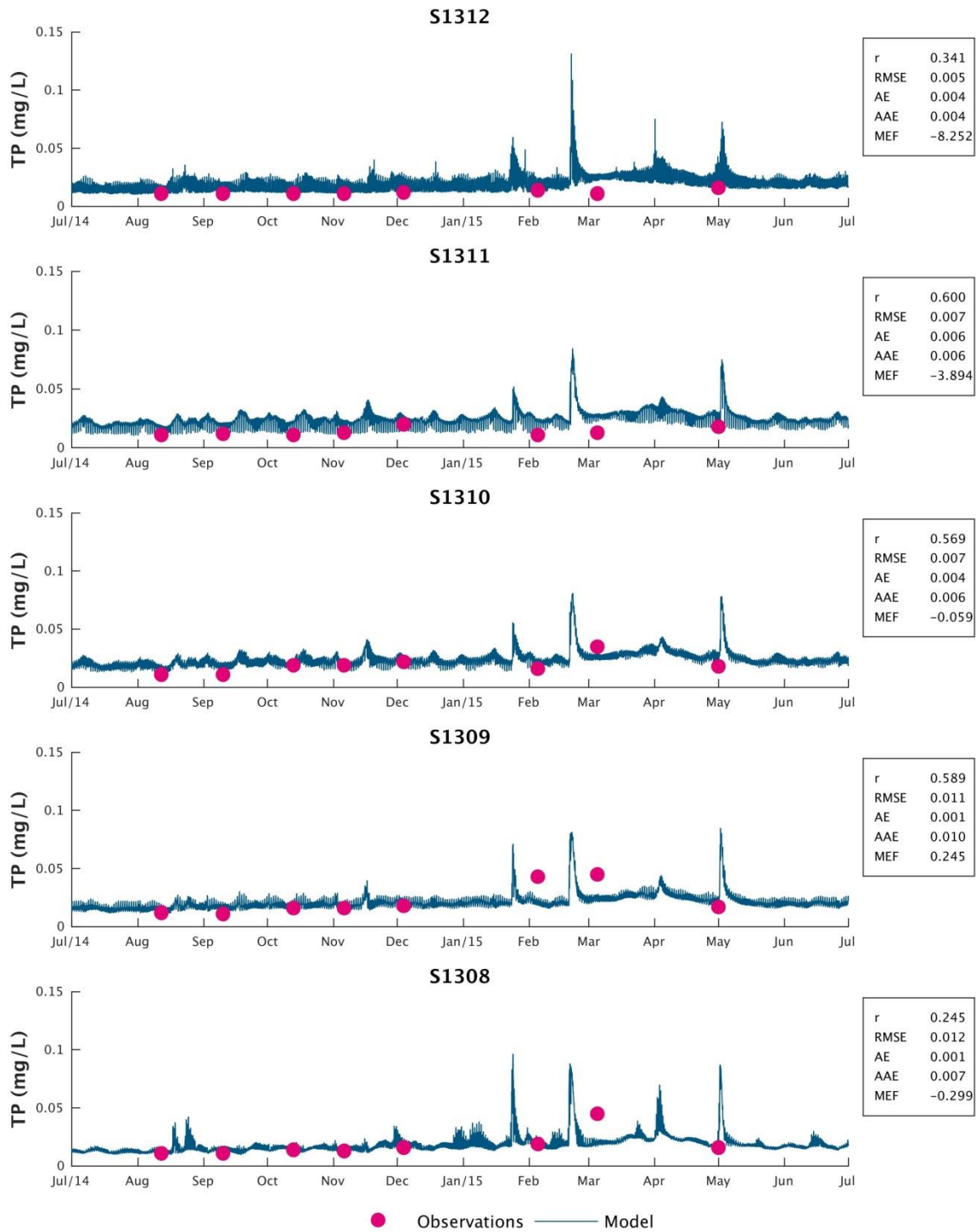


Figure A-43 Total phosphorus timeseries plot for Pumicestone Passage North

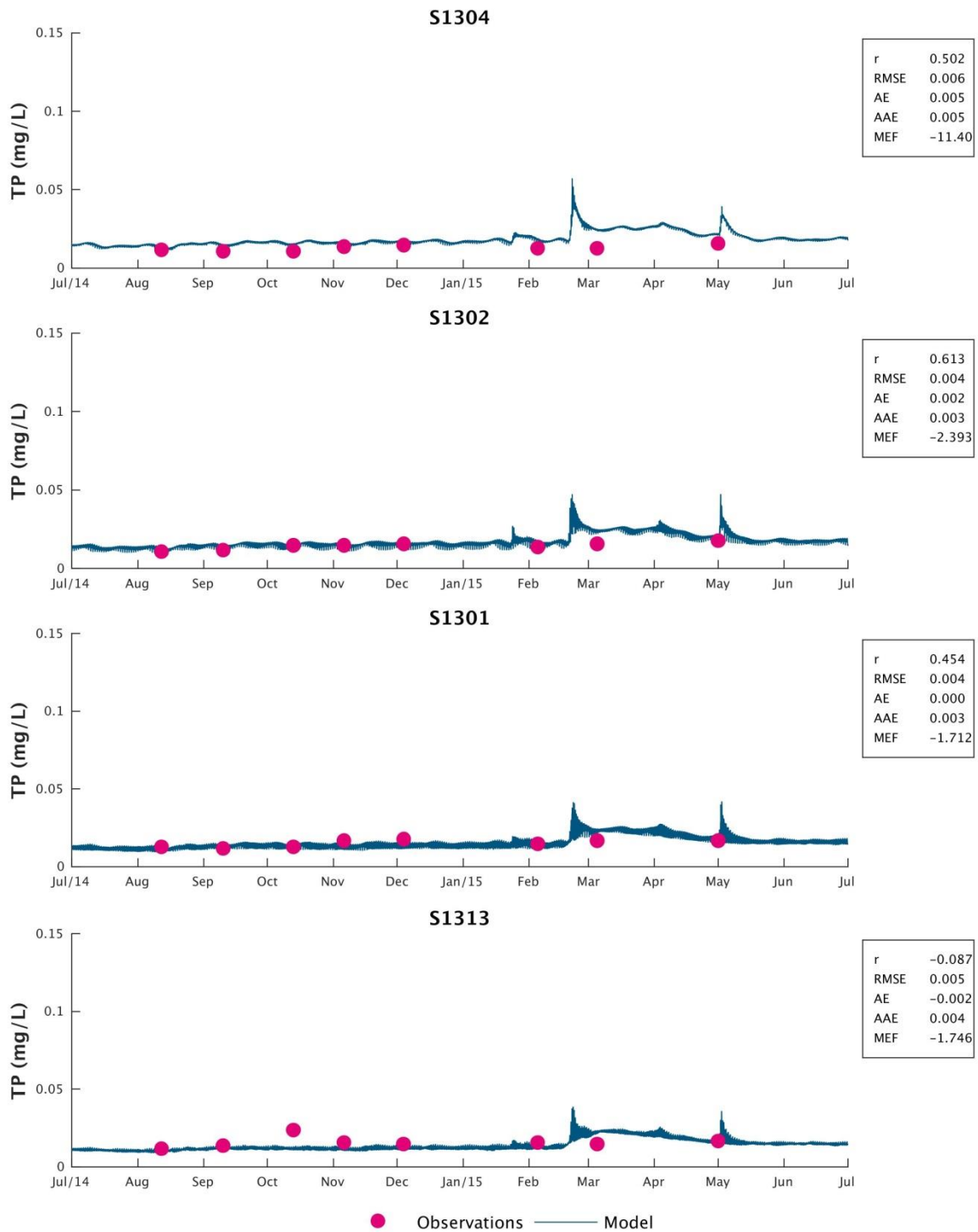


Figure A-44 Total phosphorus timeseries plot for Pumicestone Passage South

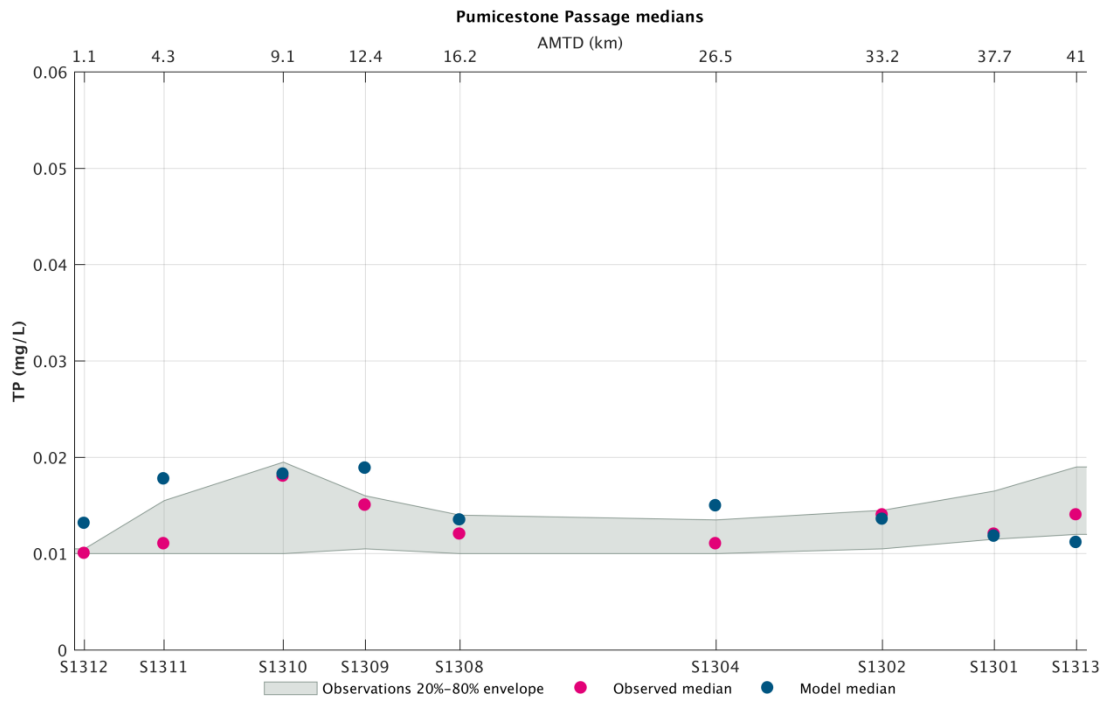


Figure A-45 Total phosphorus thalweg comparison for Pumicestone Passage

### A.3.6 Chlorophyll-a

Chlorophyll-a calibration information is presented below.

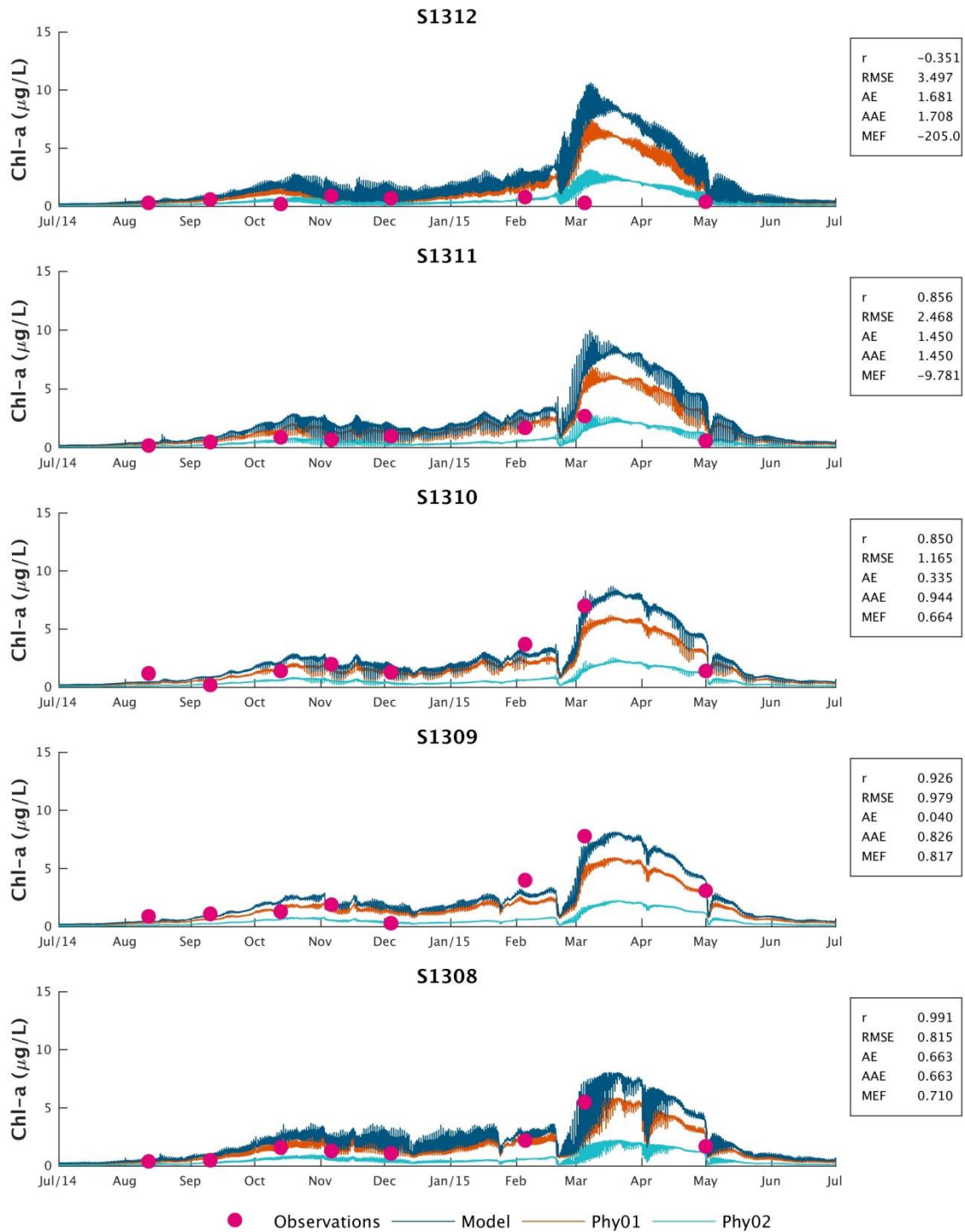


Figure A-46 Chlorophyll-a timeseries plot for Pumicestone Passage North

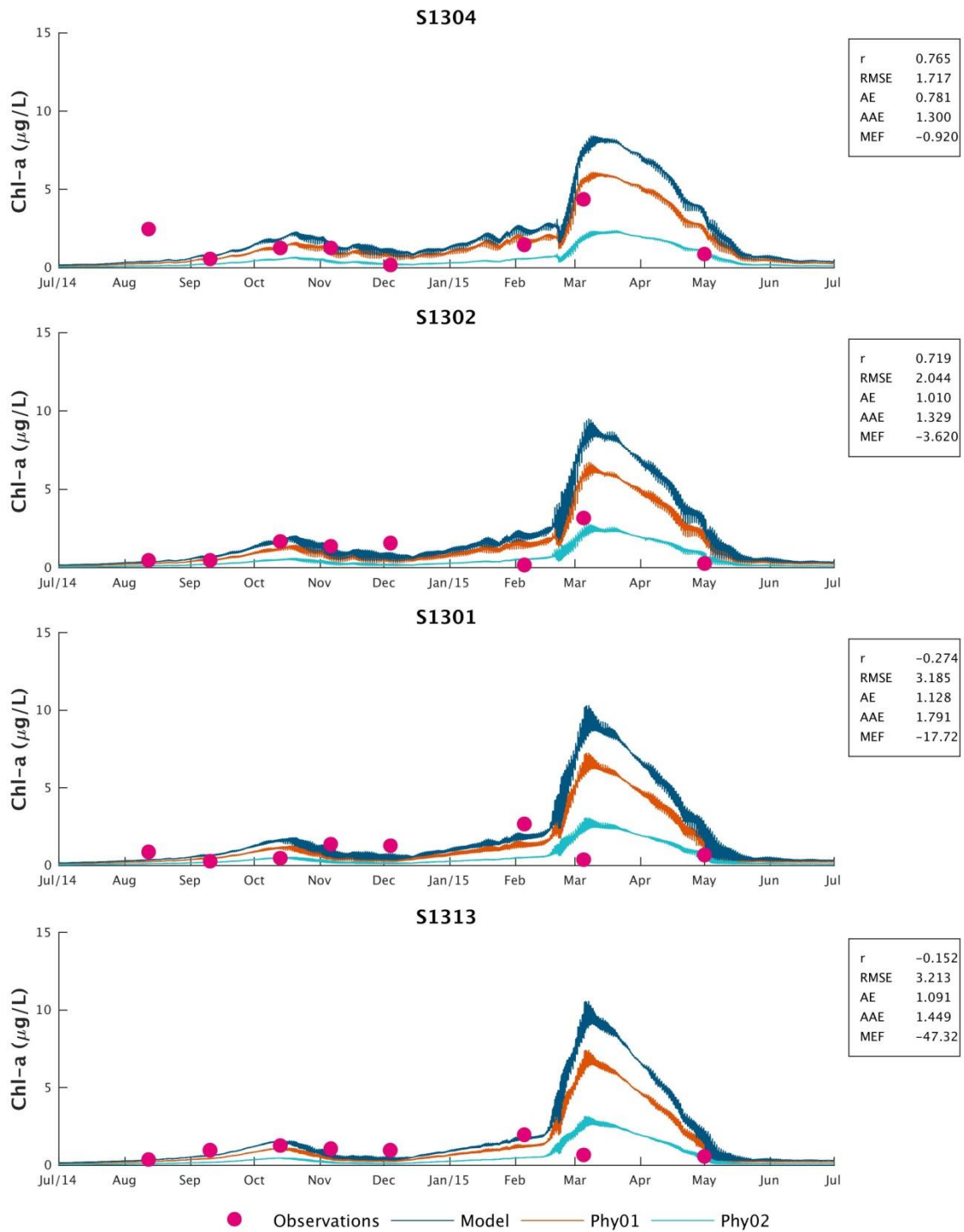


Figure A-47 Chlorophyll-a timeseries plot for Pumicestone Passage South

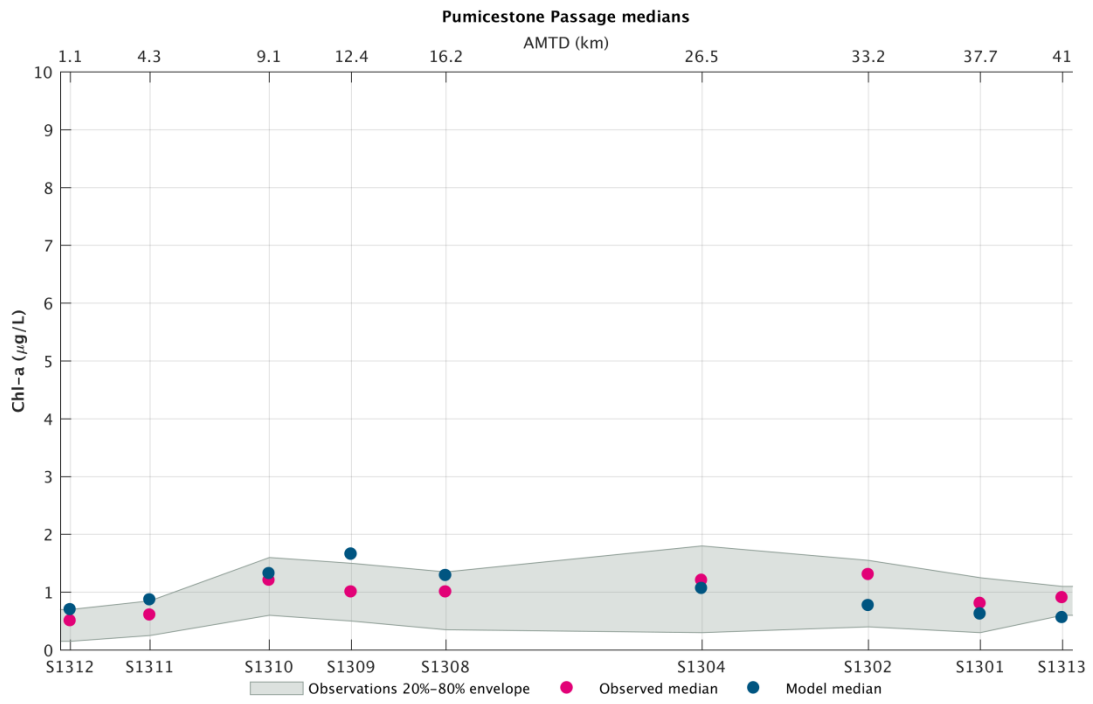


Figure A-48 Chlorophyll-a thalweg comparison for Pumicestone Passage

## A.4 Caboolture

### A.4.1 Turbidity

Turbidity calibration information is presented below.

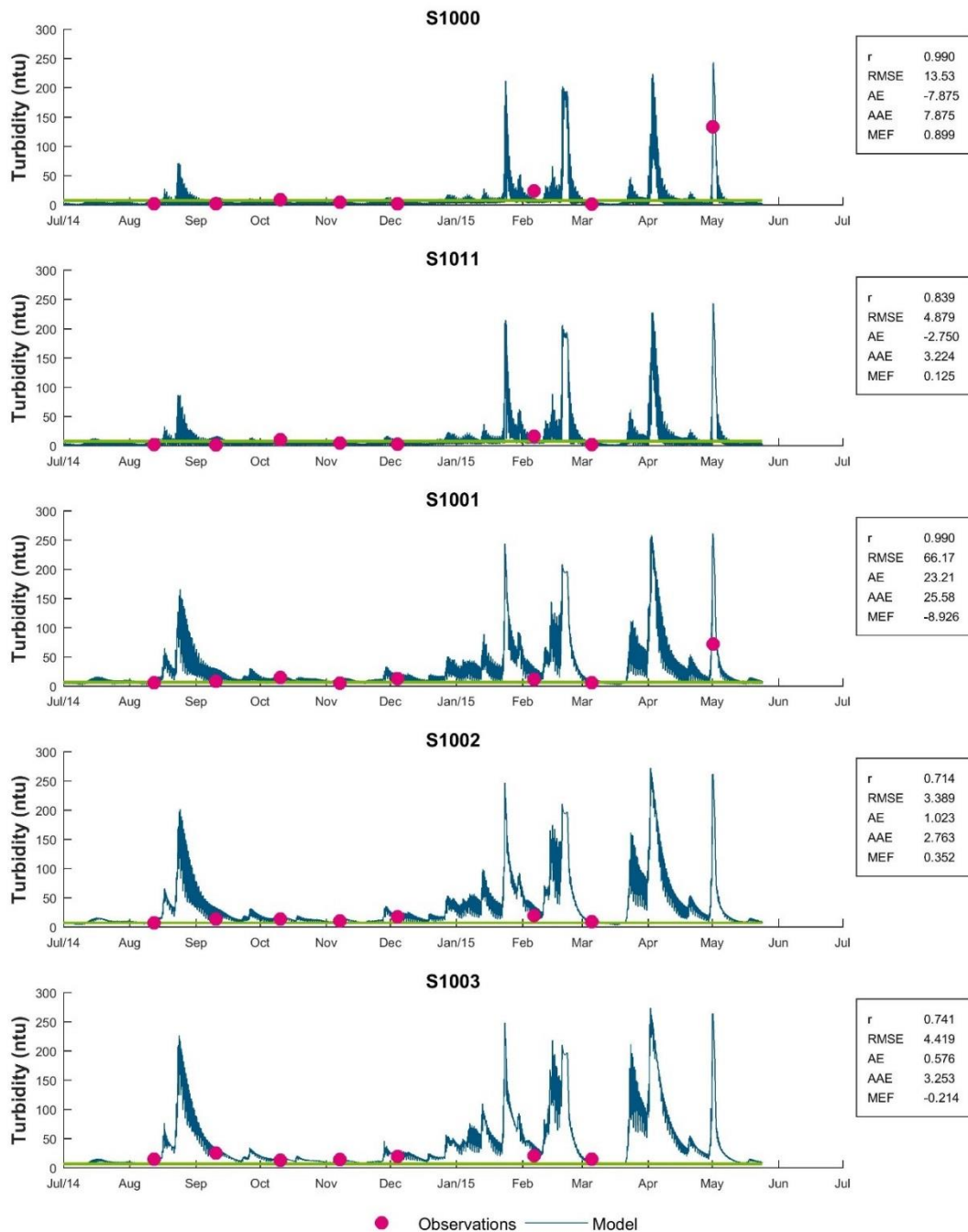


Figure A-49 Turbidity timeseries plot for Caboolture D/s

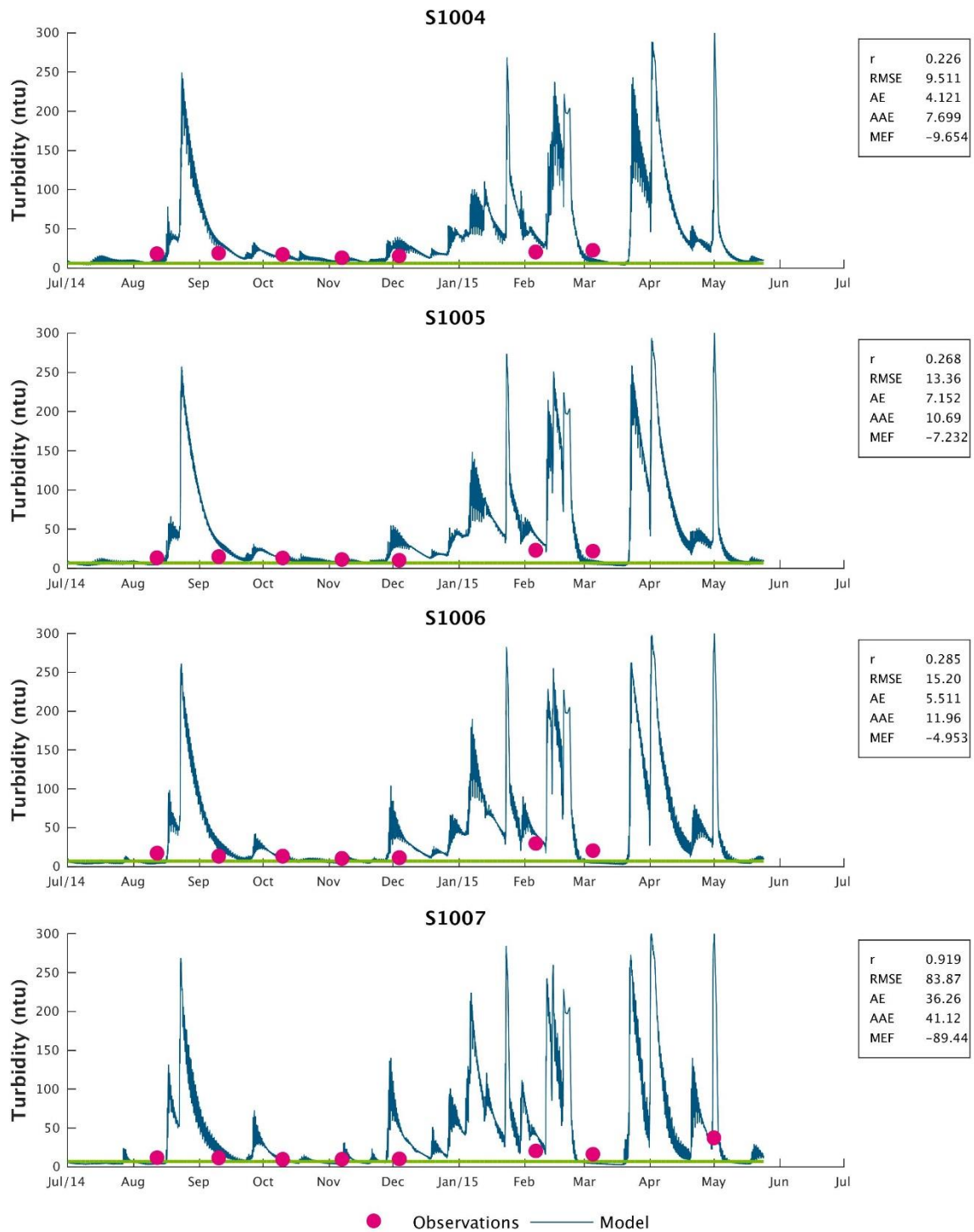


Figure A-50 Turbidity timeseries plot for Caboolture U/s

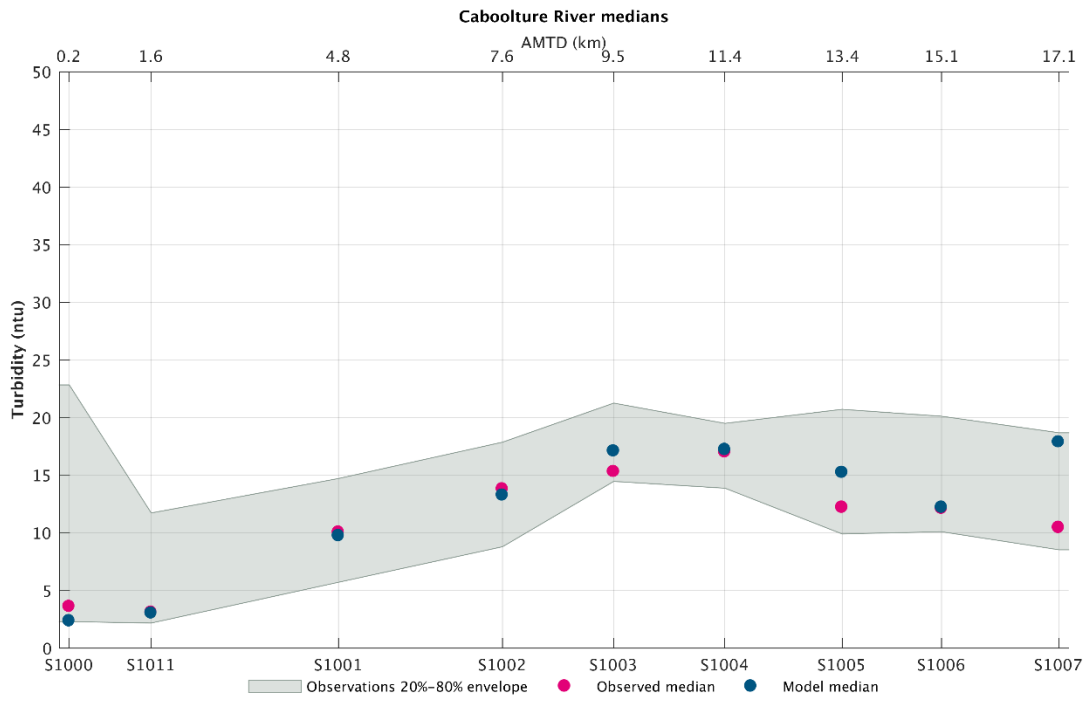


Figure A-51 Turbidity thalweg comparison for Caboolture

### A.4.2 Dissolved oxygen deficit

Dissolved oxygen deficit calibration information is presented below.

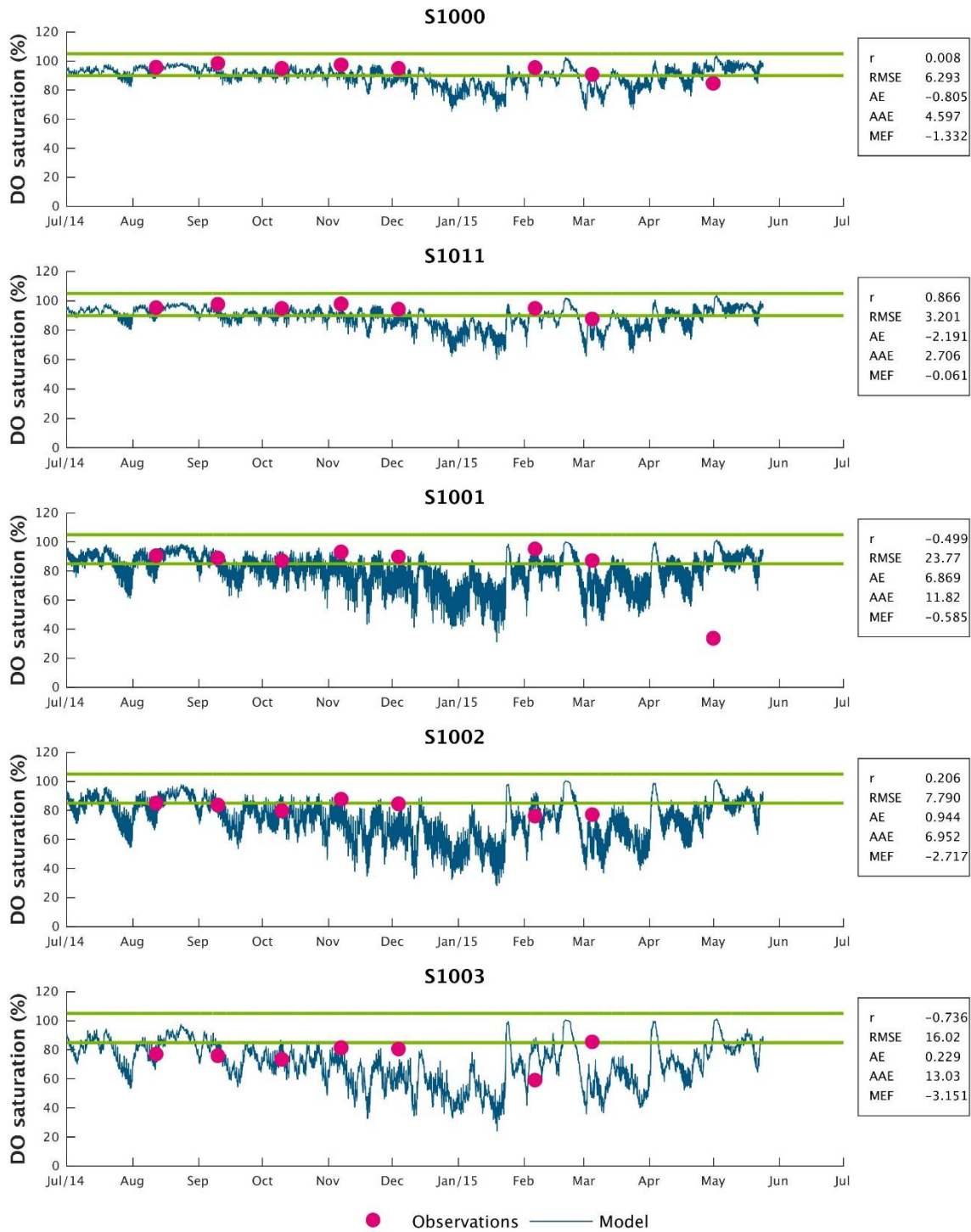


Figure A-52 Dissolved oxygen deficit timeseries plot for Caboolture D/s

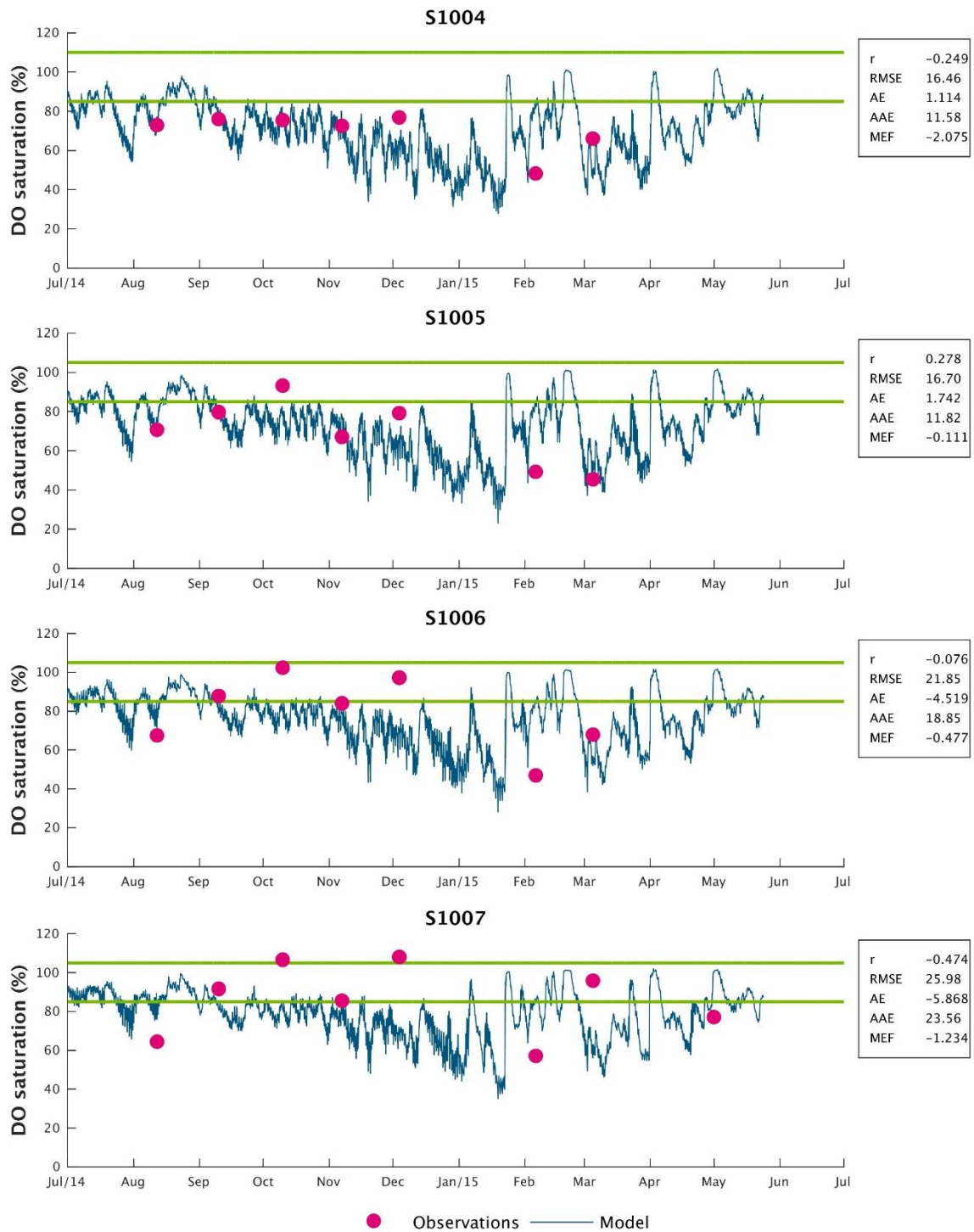


Figure A-53 Dissolved oxygen deficit timeseries plot for Cabooture U/s

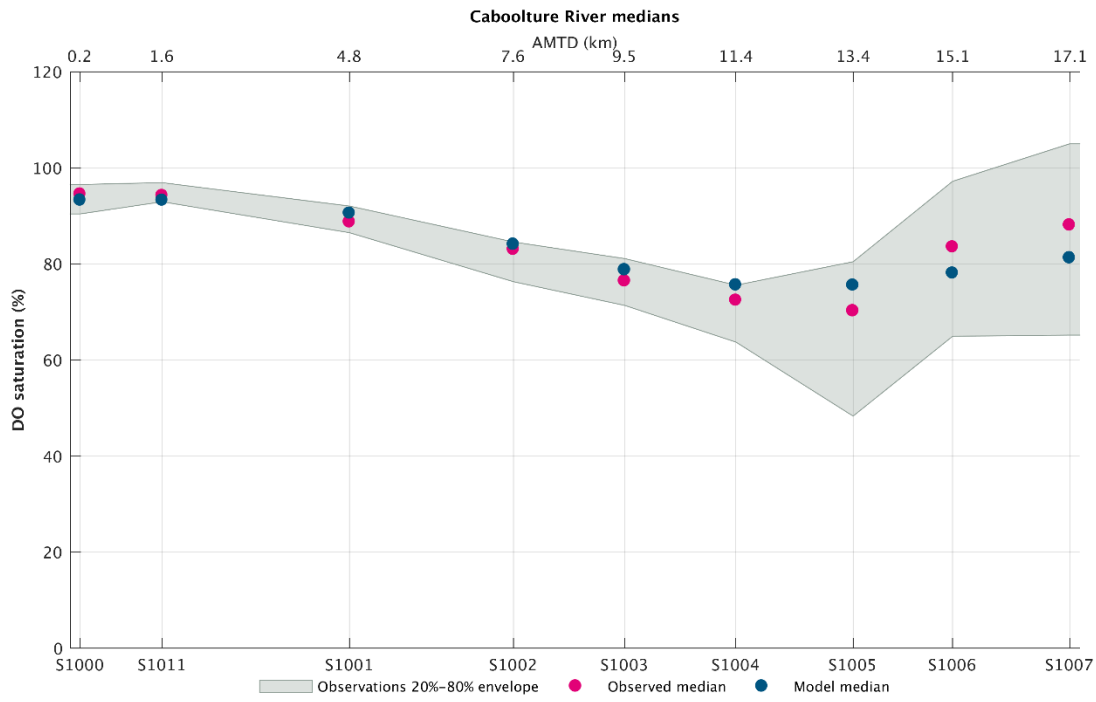


Figure A-54 Dissolved oxygen deficit thalweg comparison for Caboolture

### A.4.3 Total Nitrogen

Total Nitrogen calibration information is presented below.

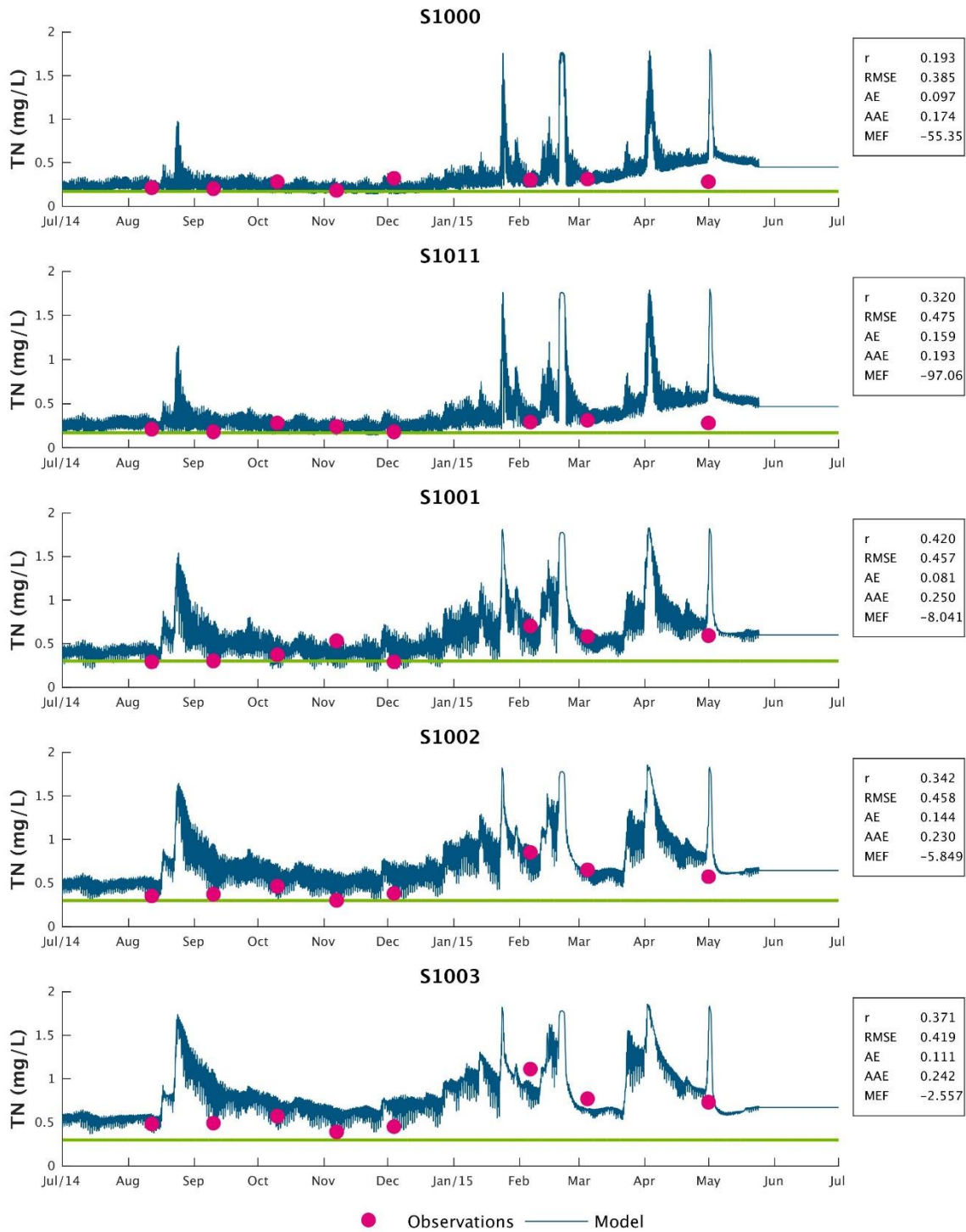


Figure A-55 Total Nitrogen timeseries plot for Caboolture D/s

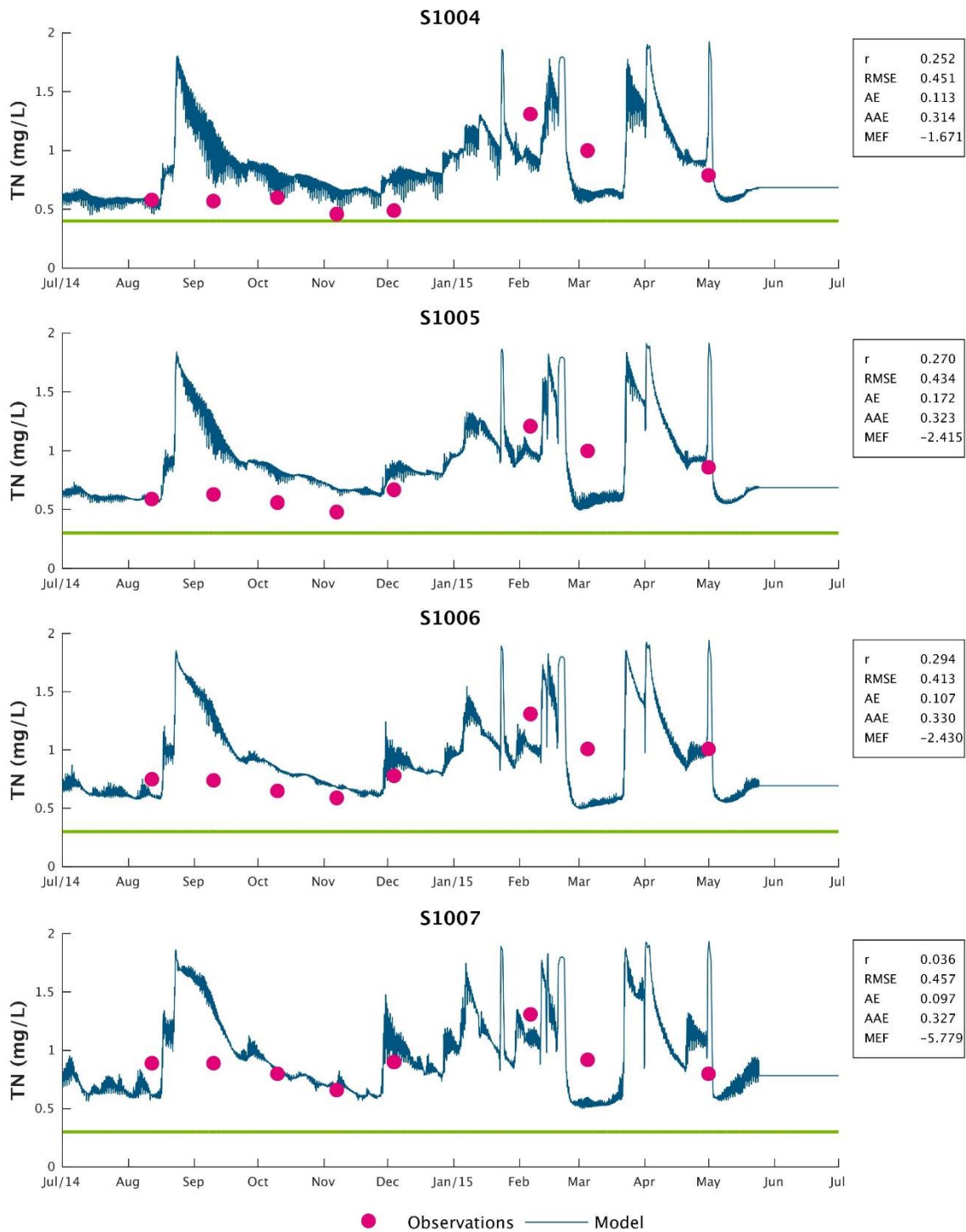


Figure A-56 Total Nitrogen timeseries plot for Cabooture U/s

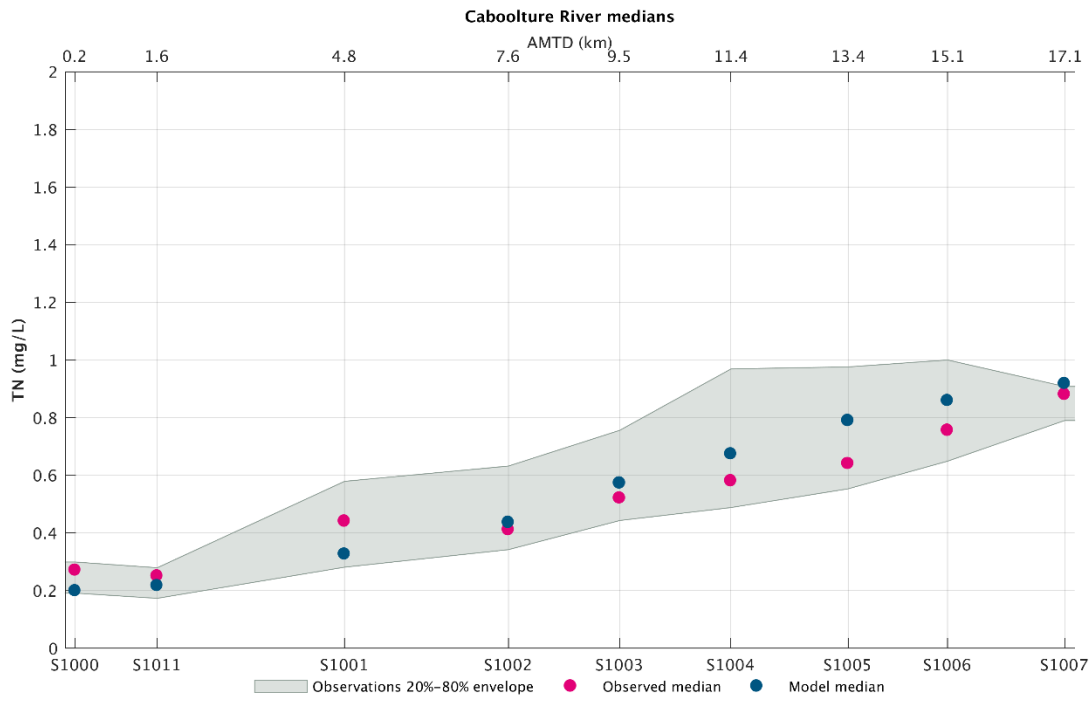


Figure A-57 Total Nitrogen thalweg comparison for Caboolture

### A.4.4 Total phosphorus

Total phosphorous calibration information is presented below.

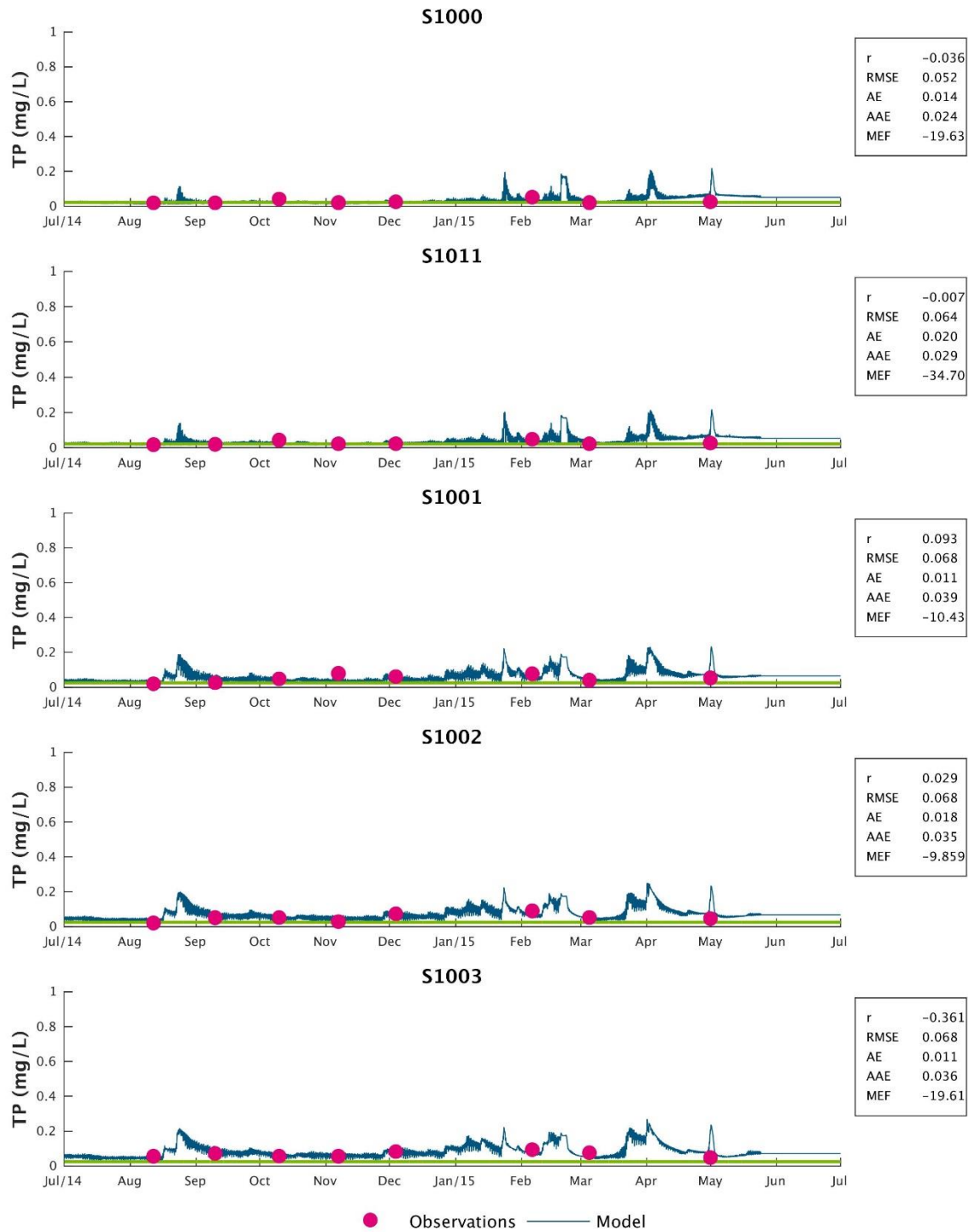


Figure A-58 Total phosphorus timeseries plot for Caboolture D/s

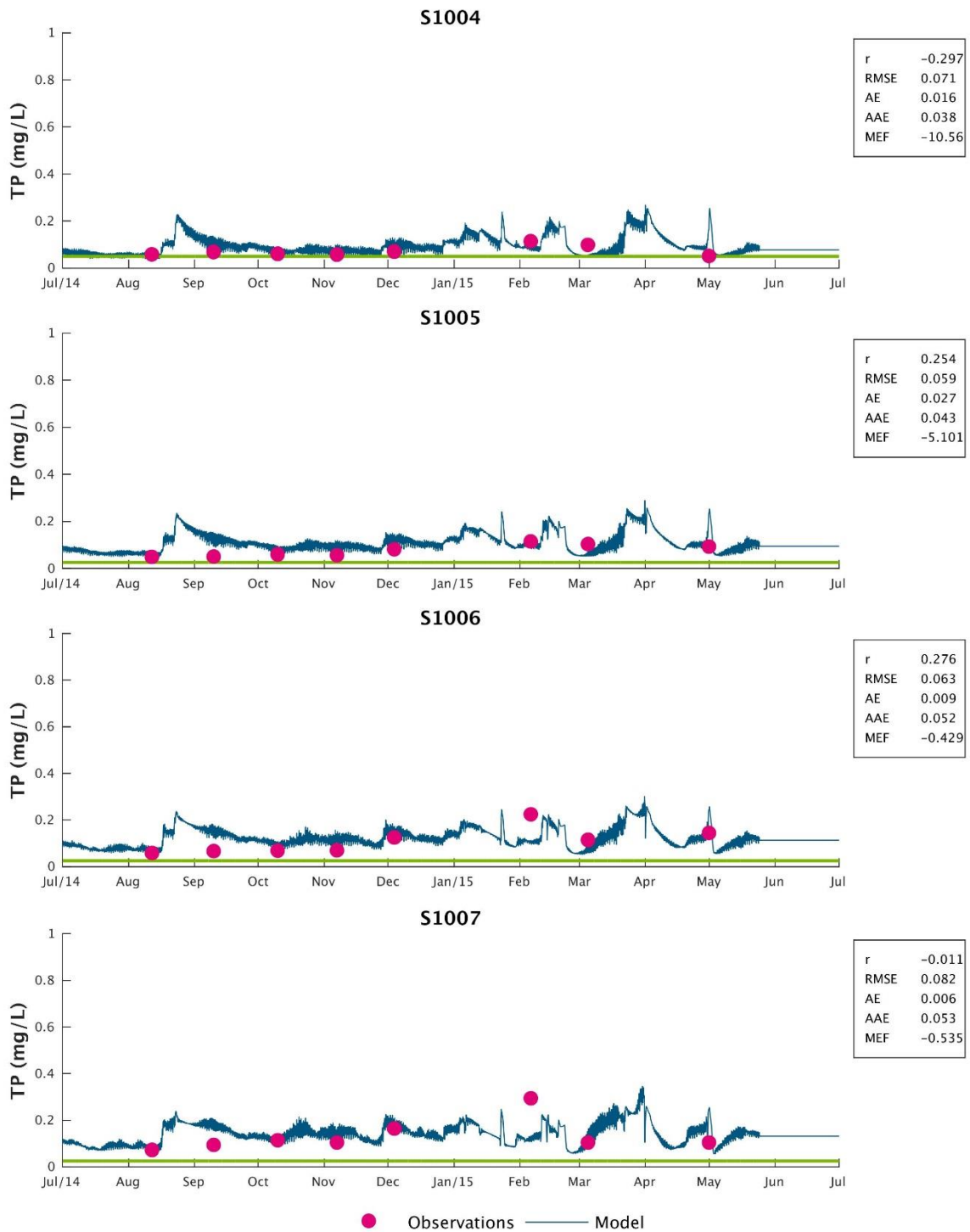


Figure A-59 Total phosphorus timeseries plot for Cabooture U/s

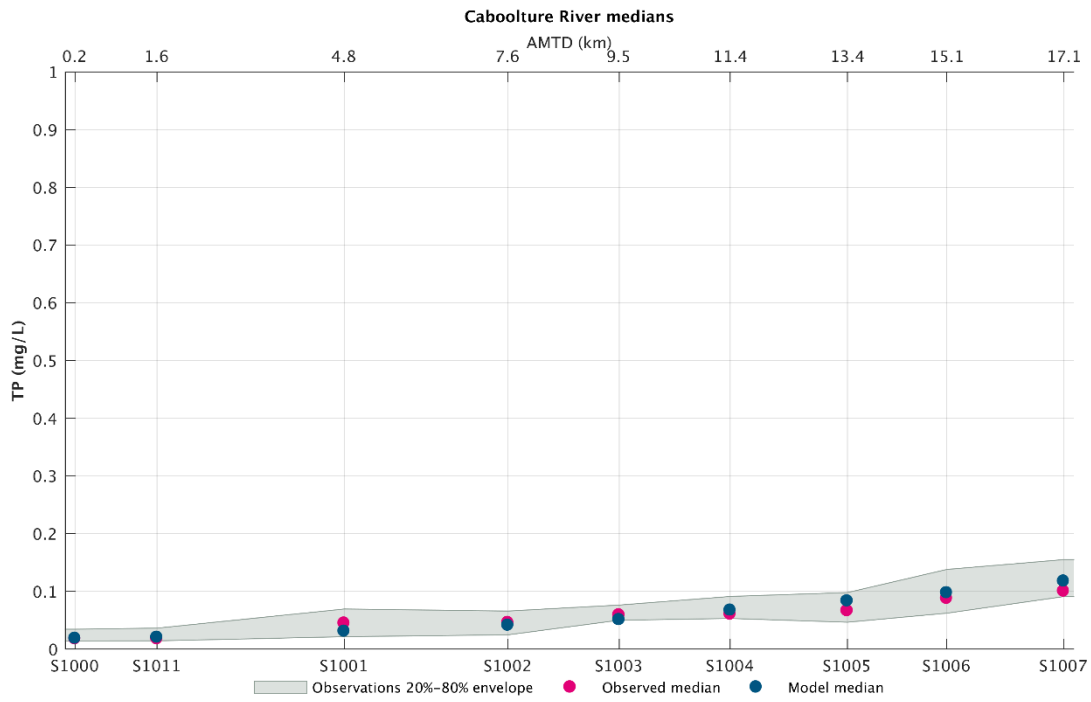


Figure A-60 Total phosphorus thalweg comparison Caboolture

### A.4.5 Chlorophyll-a

Chlorophyll-a calibration information is presented below.

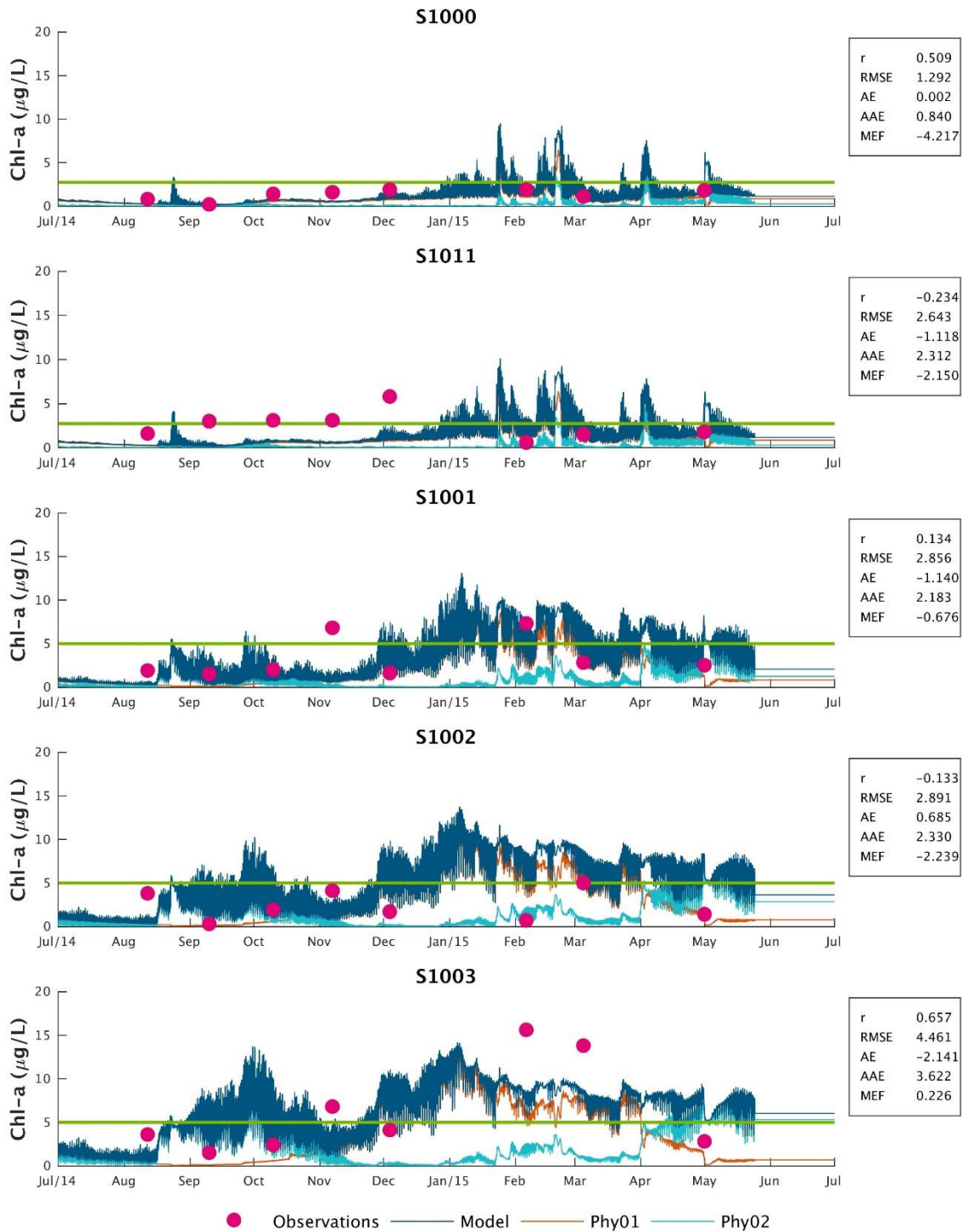


Figure A-61 Chlorophyll-a timeseries plot for Caboolture D/s

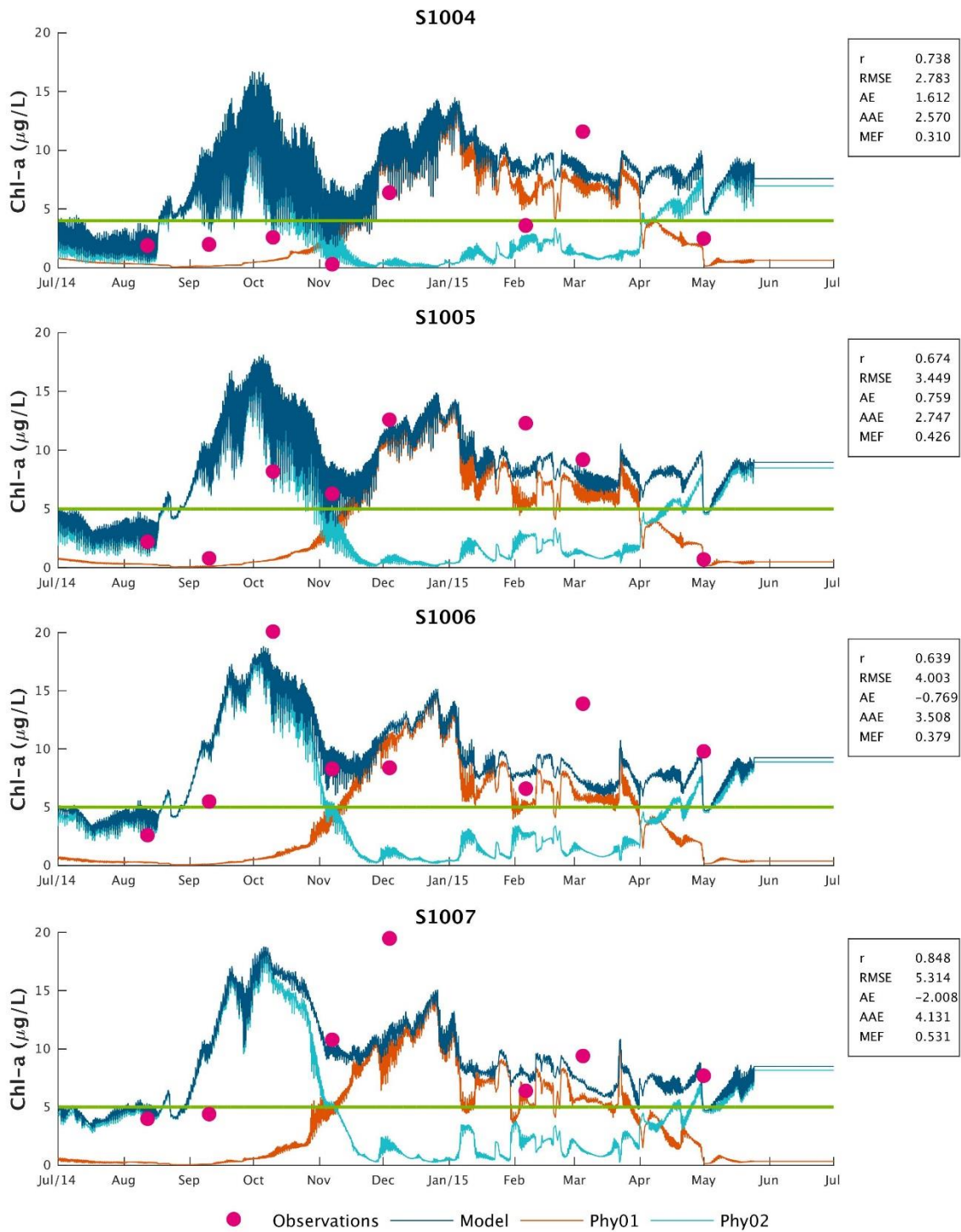


Figure A-62 Chlorophyll-a timeseries plot for Caboolture U/S

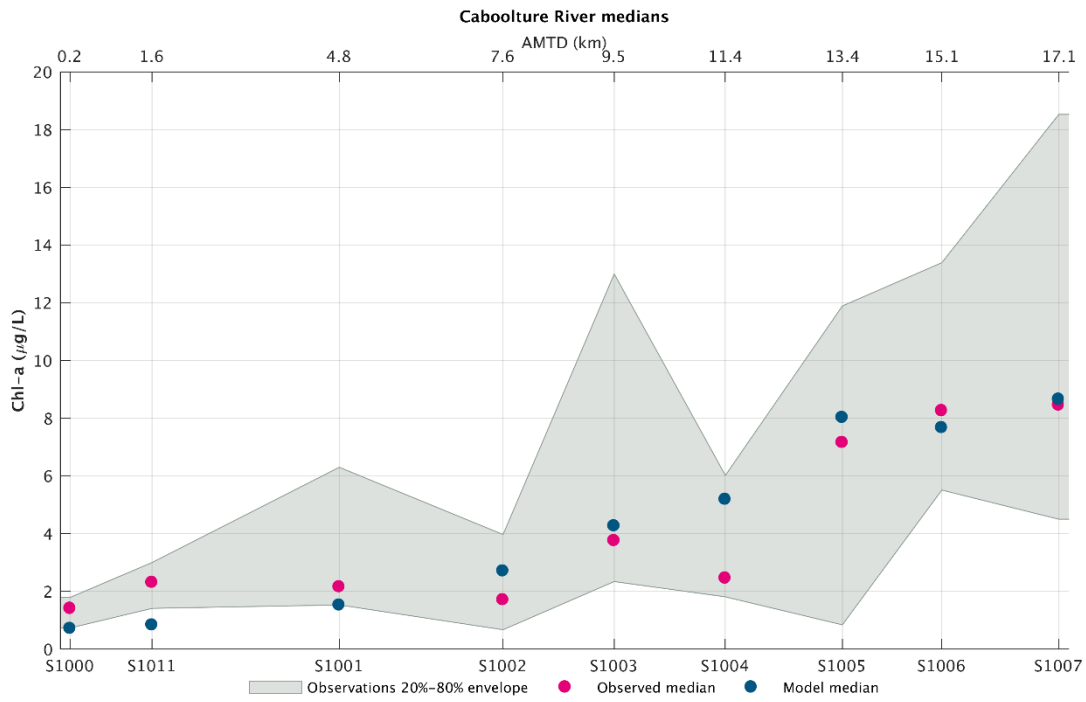


Figure A-63 Chlorophyll-a thalweg comparison for Caboolture

## A.5 Pine

### A.5.1 Turbidity

Turbidity calibration information is presented below.

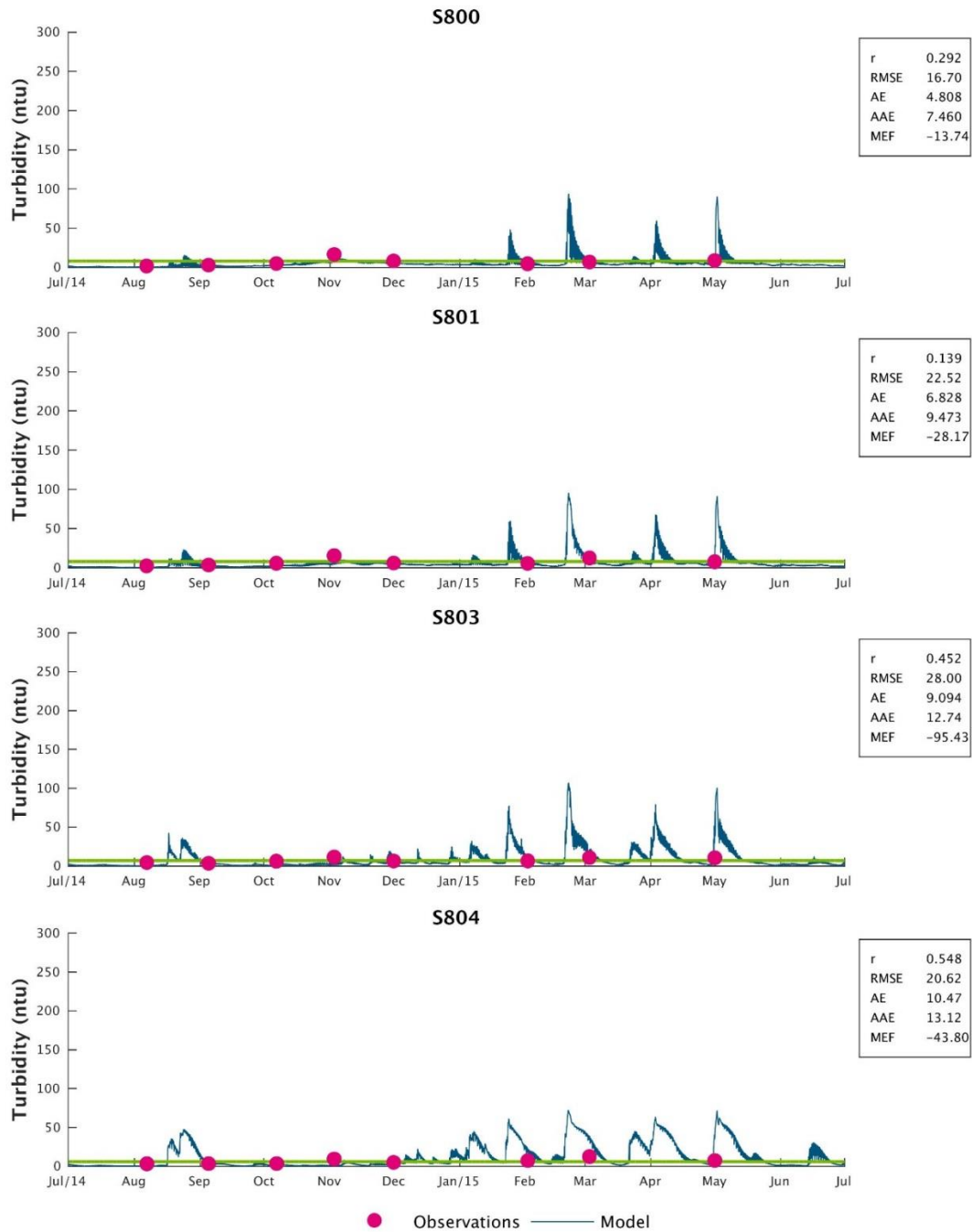


Figure A-64 Turbidity timeseries plot for Pine

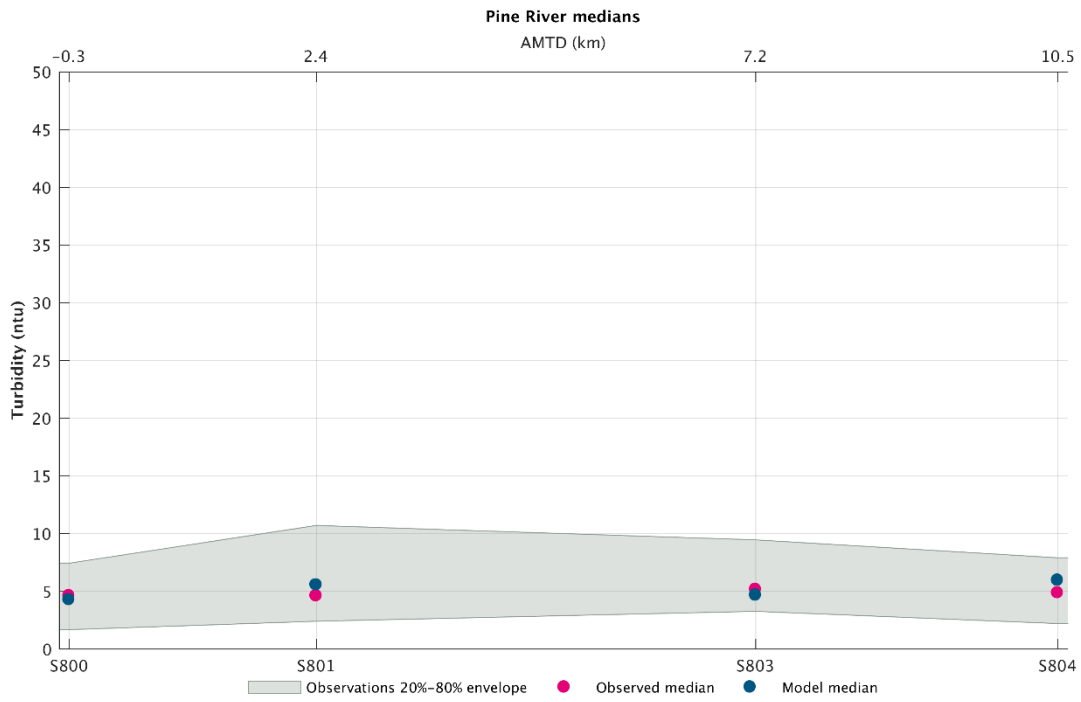


Figure A-65 Turbidity thalweg comparison for Pine

### A.5.2 Dissolved oxygen deficit

Dissolved oxygen deficit calibration information is presented below.

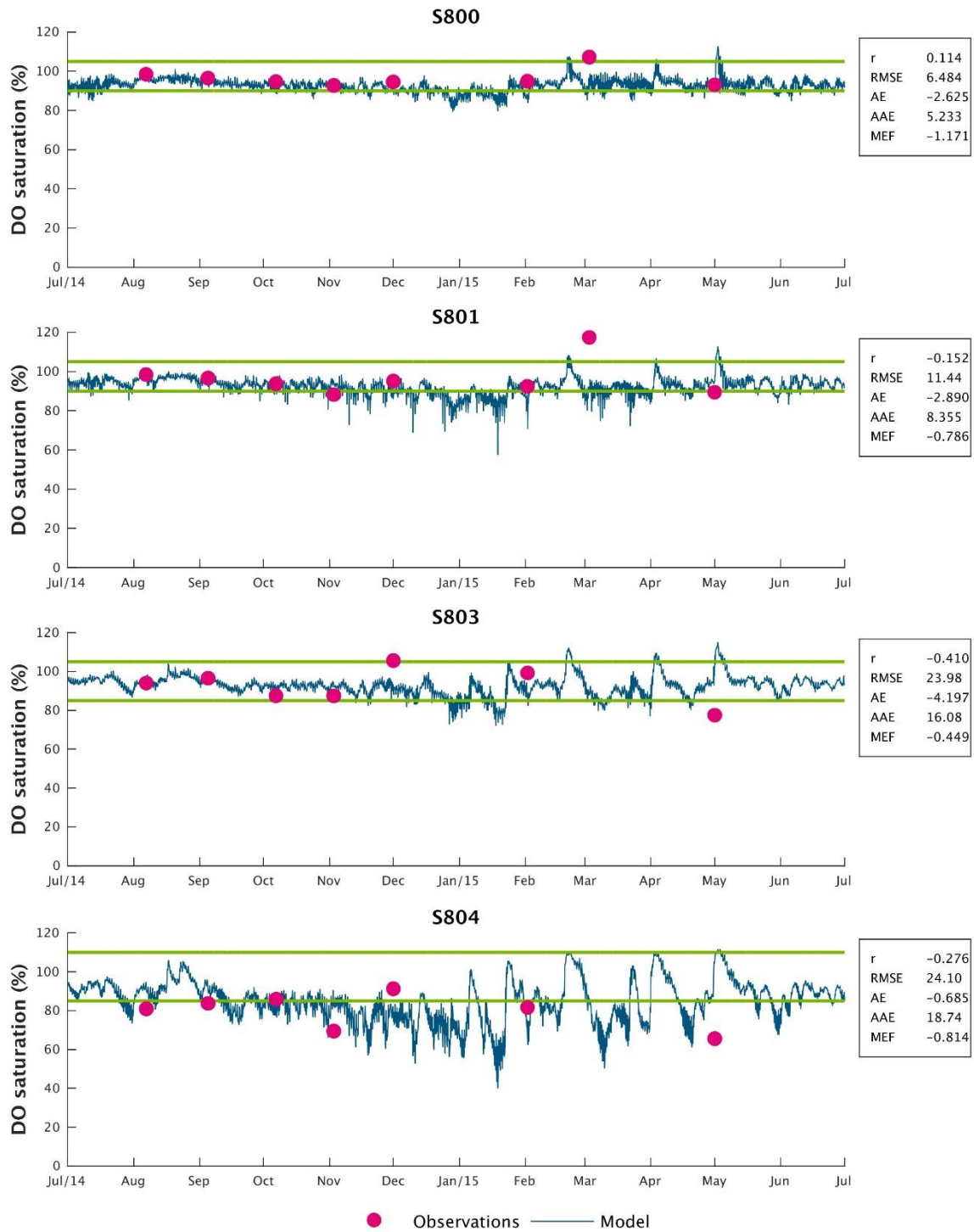


Figure A-66 Dissolved oxygen deficit timeseries plot for Pine

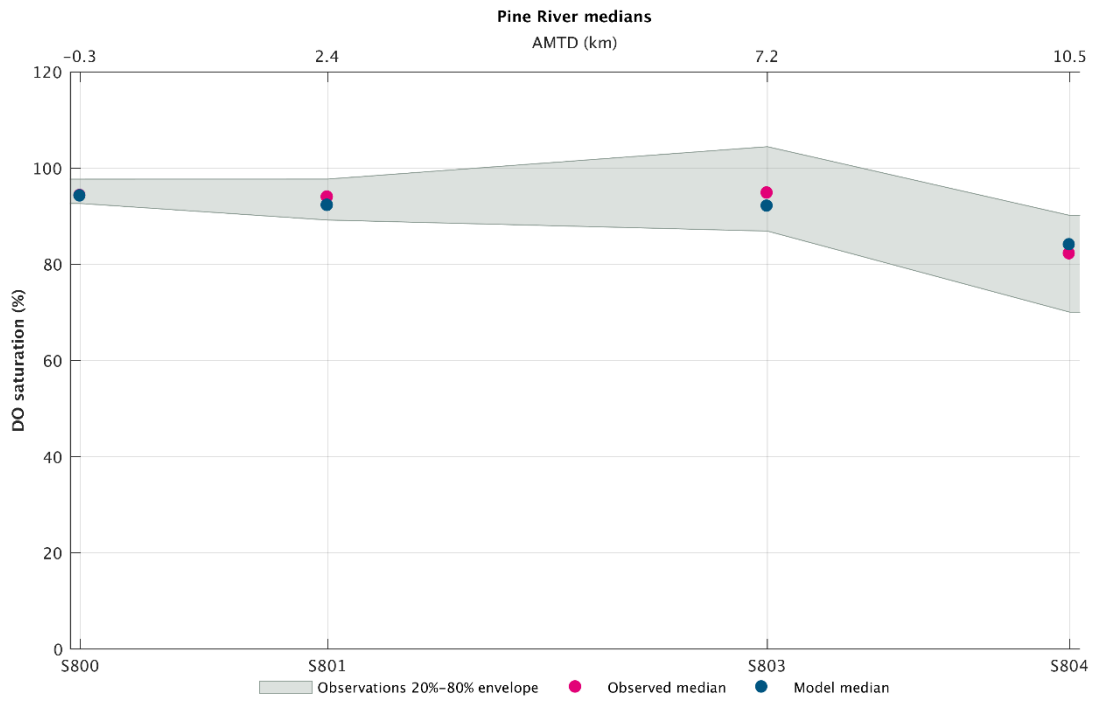


Figure A-67 Dissolved oxygen deficit thalweg comparison for Pine

### A.5.3 Total Nitrogen

Total Nitrogen calibration information is presented below.

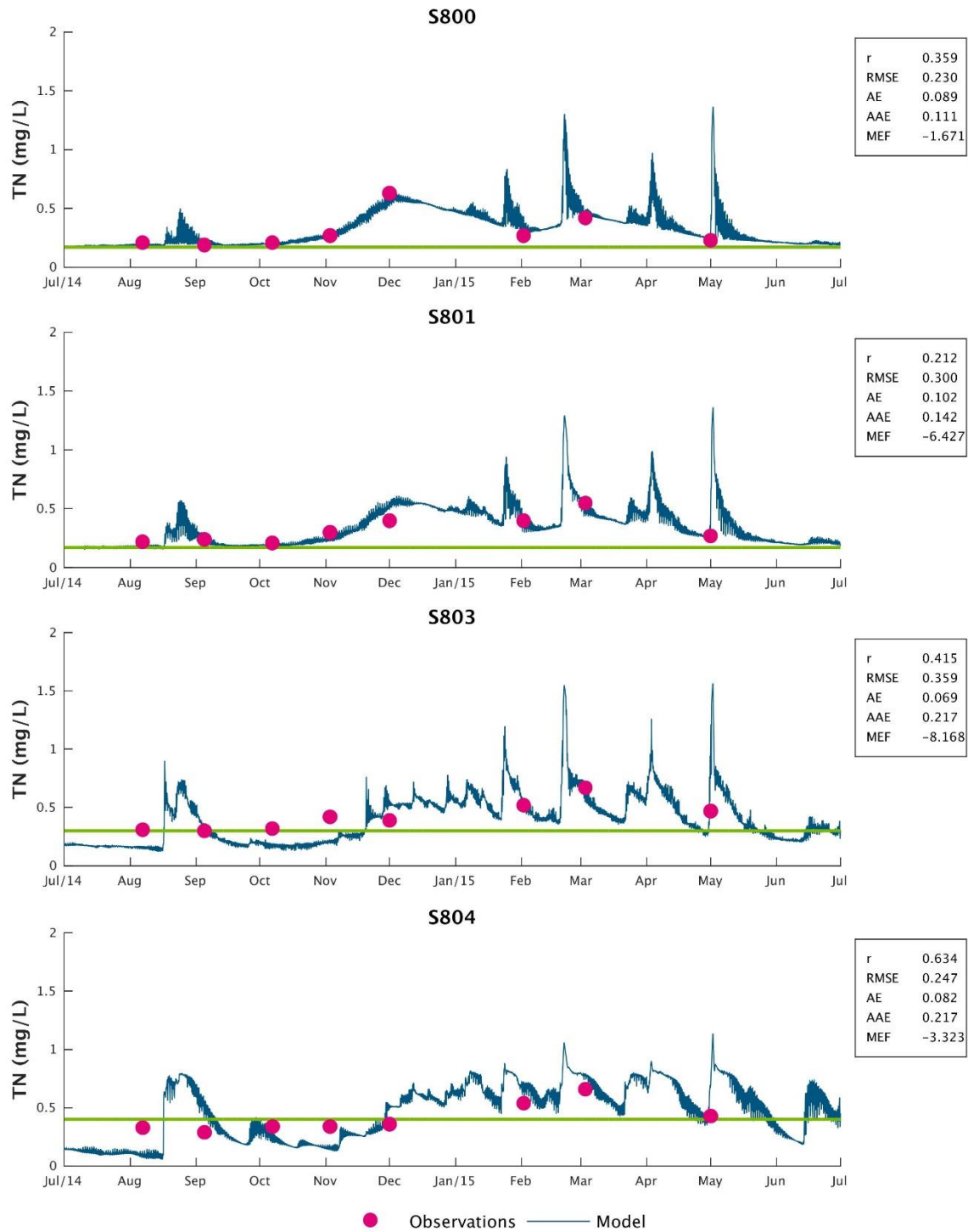


Figure A-68 Total Nitrogen timeseries plot for Pine

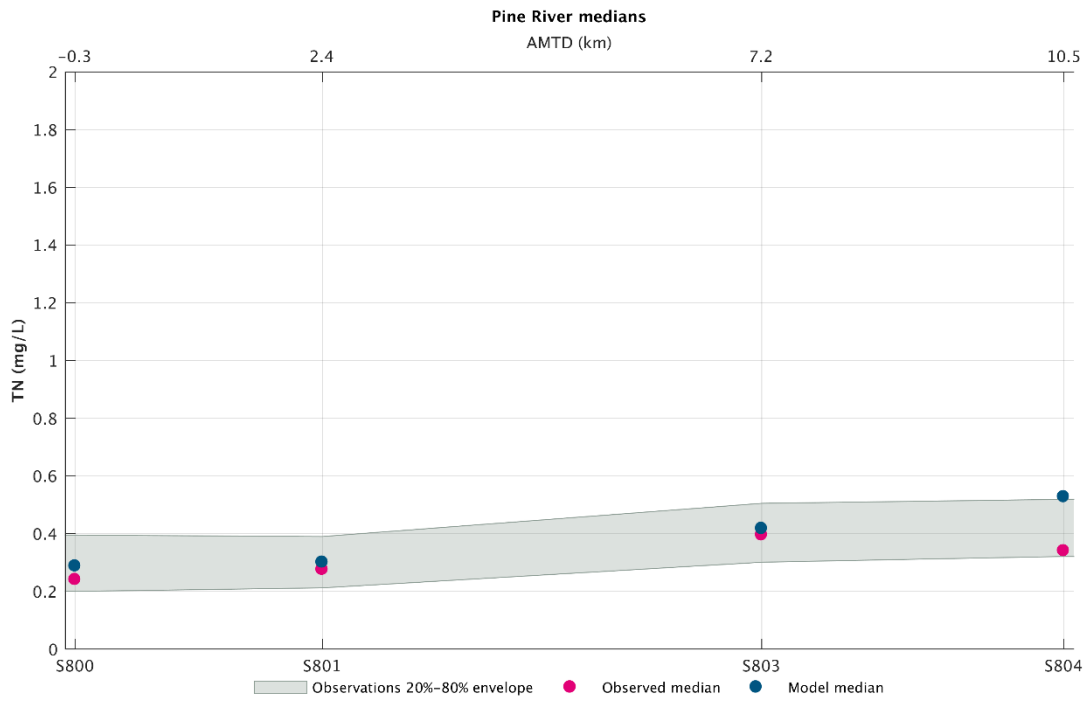


Figure A-69 Total Nitrogen thalweg comparison for Pine

### A.5.4 Total phosphorus

Total phosphorous calibration information is presented below.

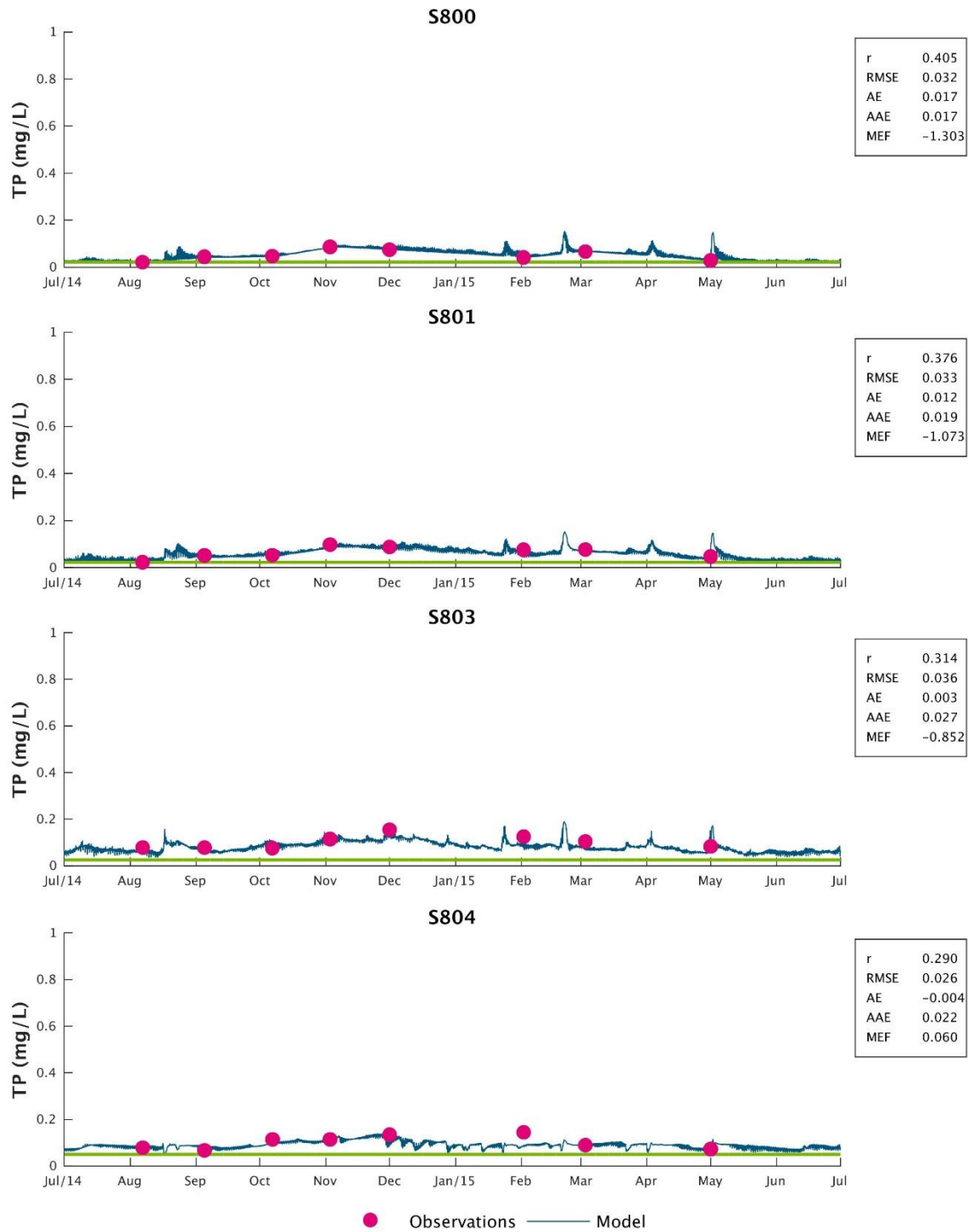


Figure A-70 Total phosphorus timeseries plot for Pine

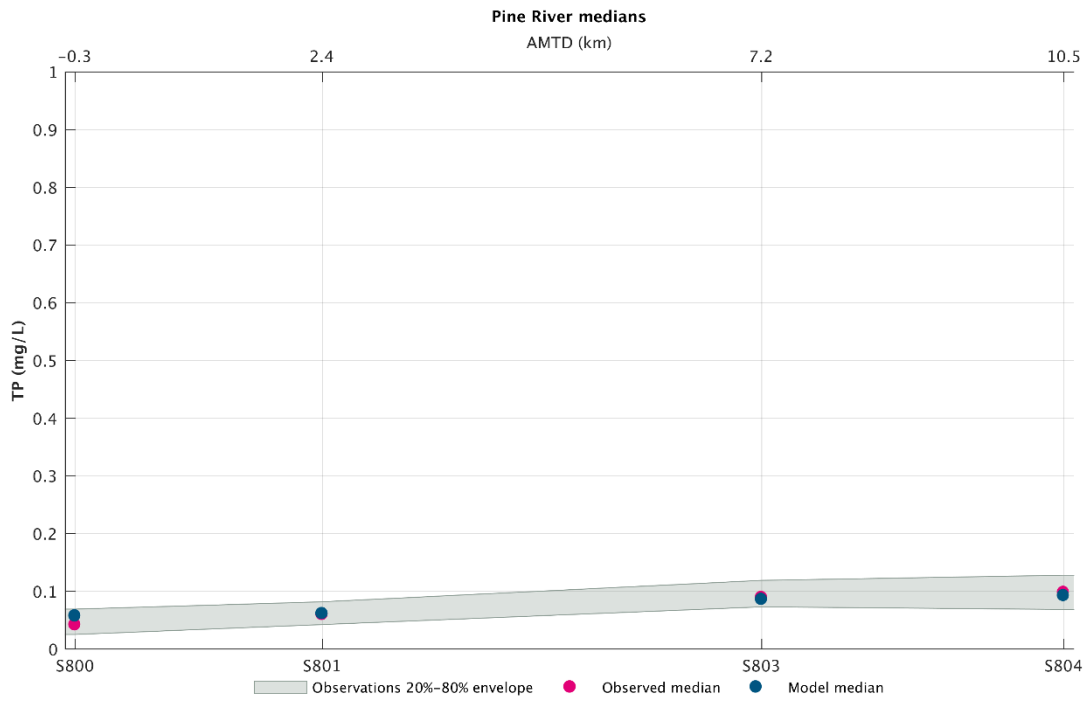


Figure A-71 Total phosphorus thalweg comparison for Pine

### A.5.5 Chlorophyll-a

Chlorophyll-a calibration information is presented below.

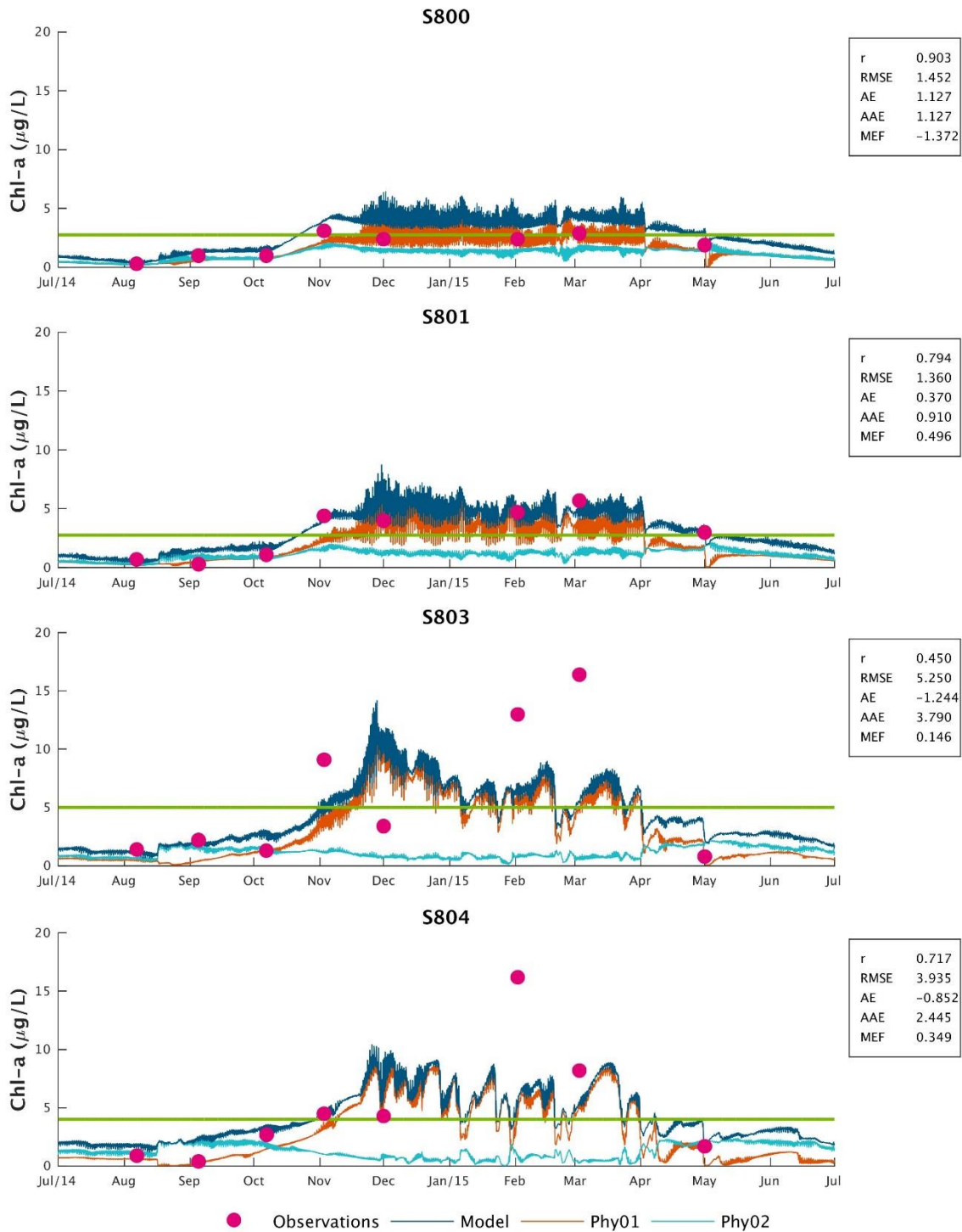


Figure A-72 Chlorophyll-a timeseries plot for Pine

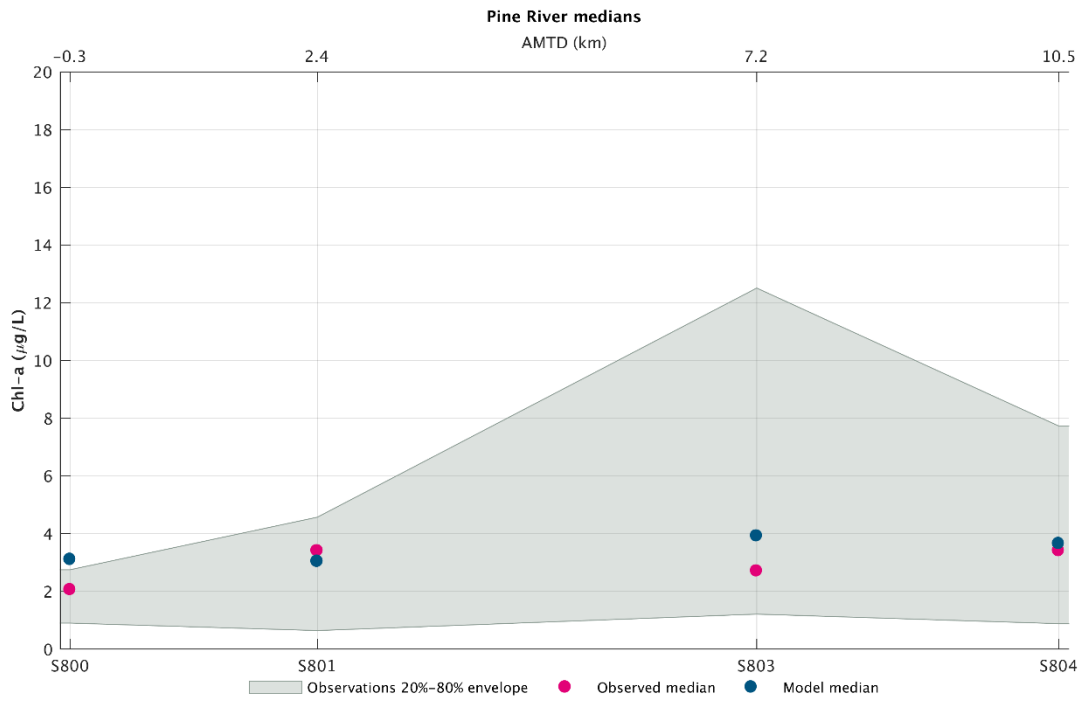


Figure A-73 Chlorophyll-a thalweg comparison for Pine

## A.6 Brisbane

### A.6.1 Turbidity

Turbidity calibration information is presented below.

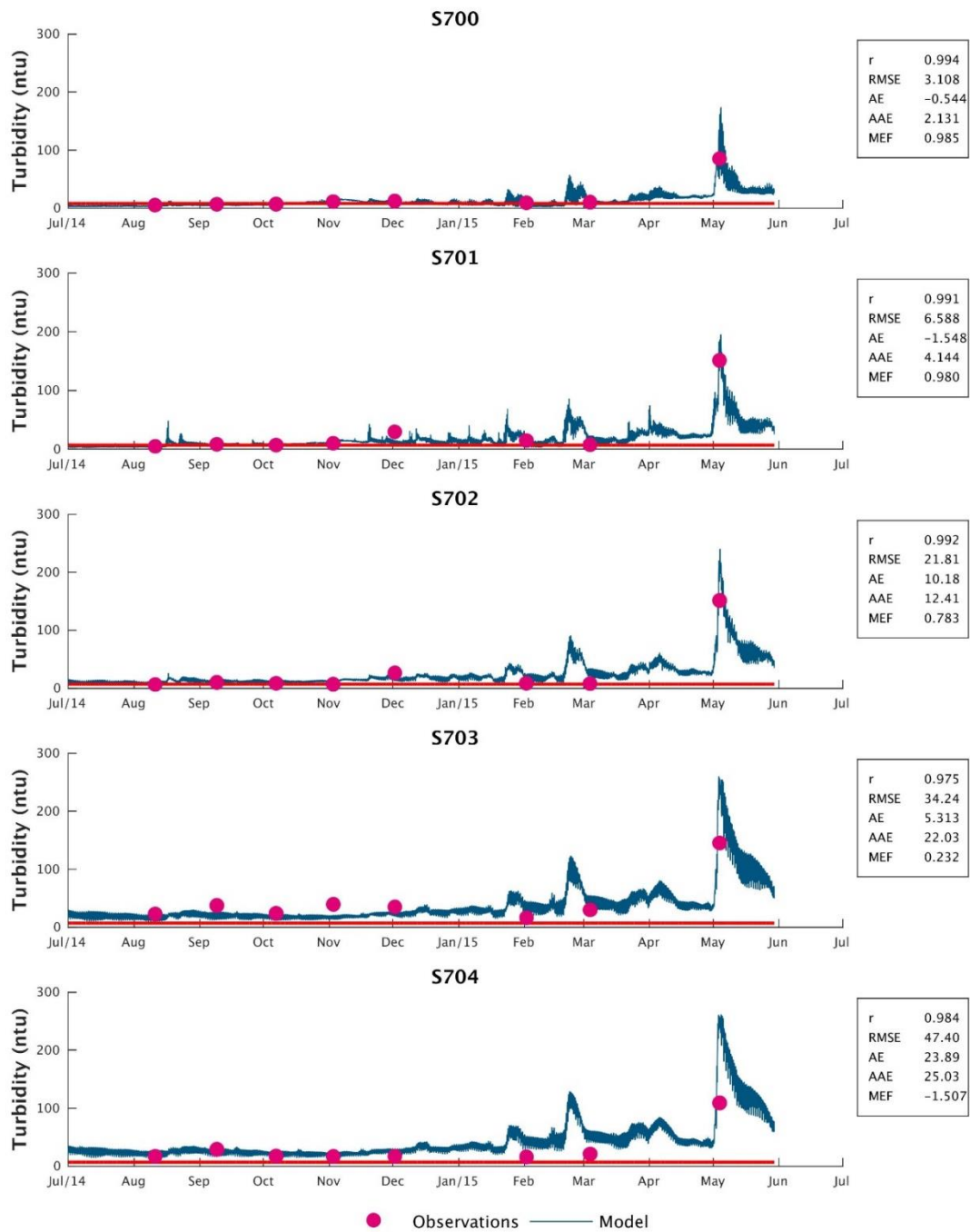


Figure A-74 Turbidity timeseries plot for Brisbane D/s

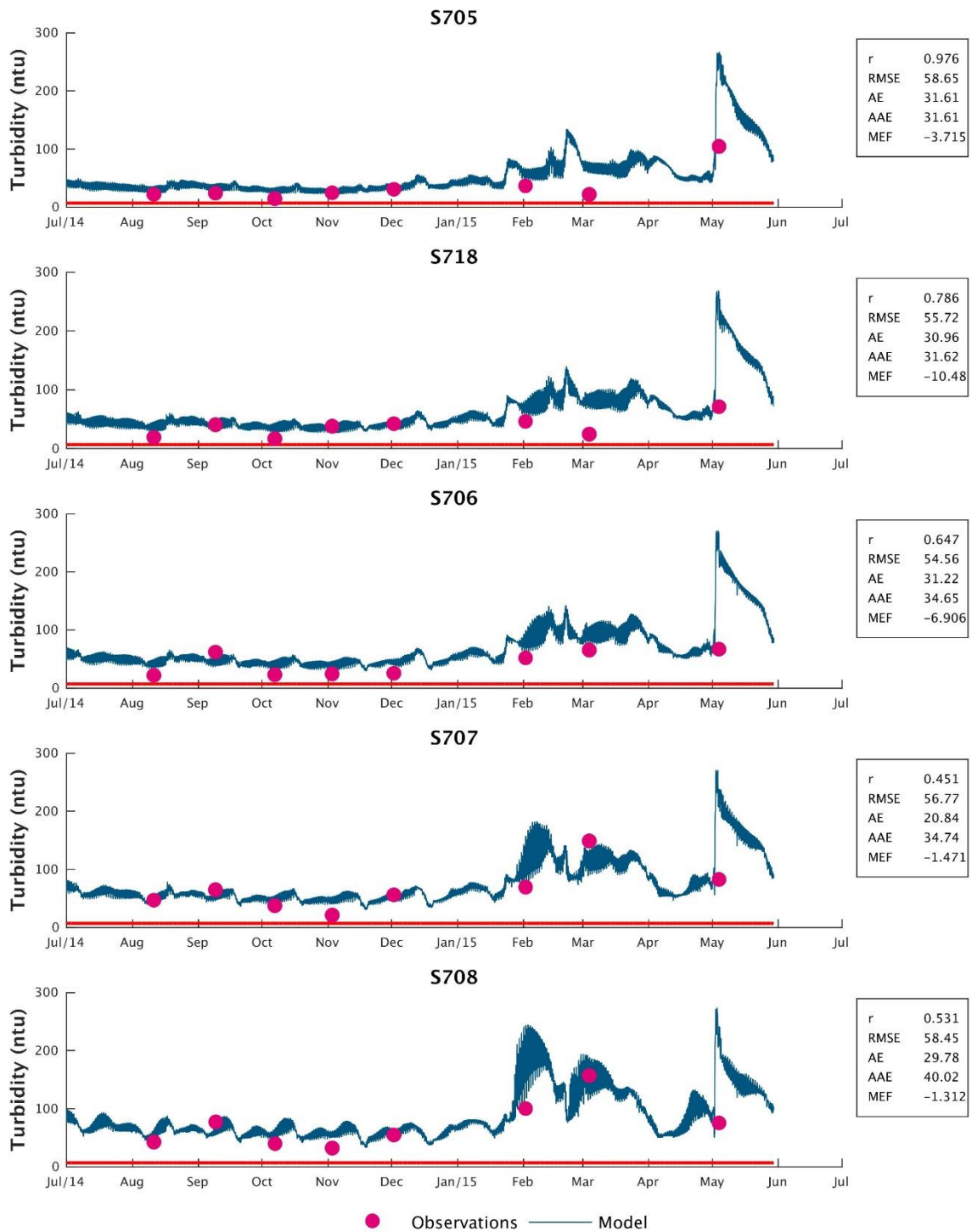


Figure A-75 Turbidity timeseries plot for Brisbane Mid

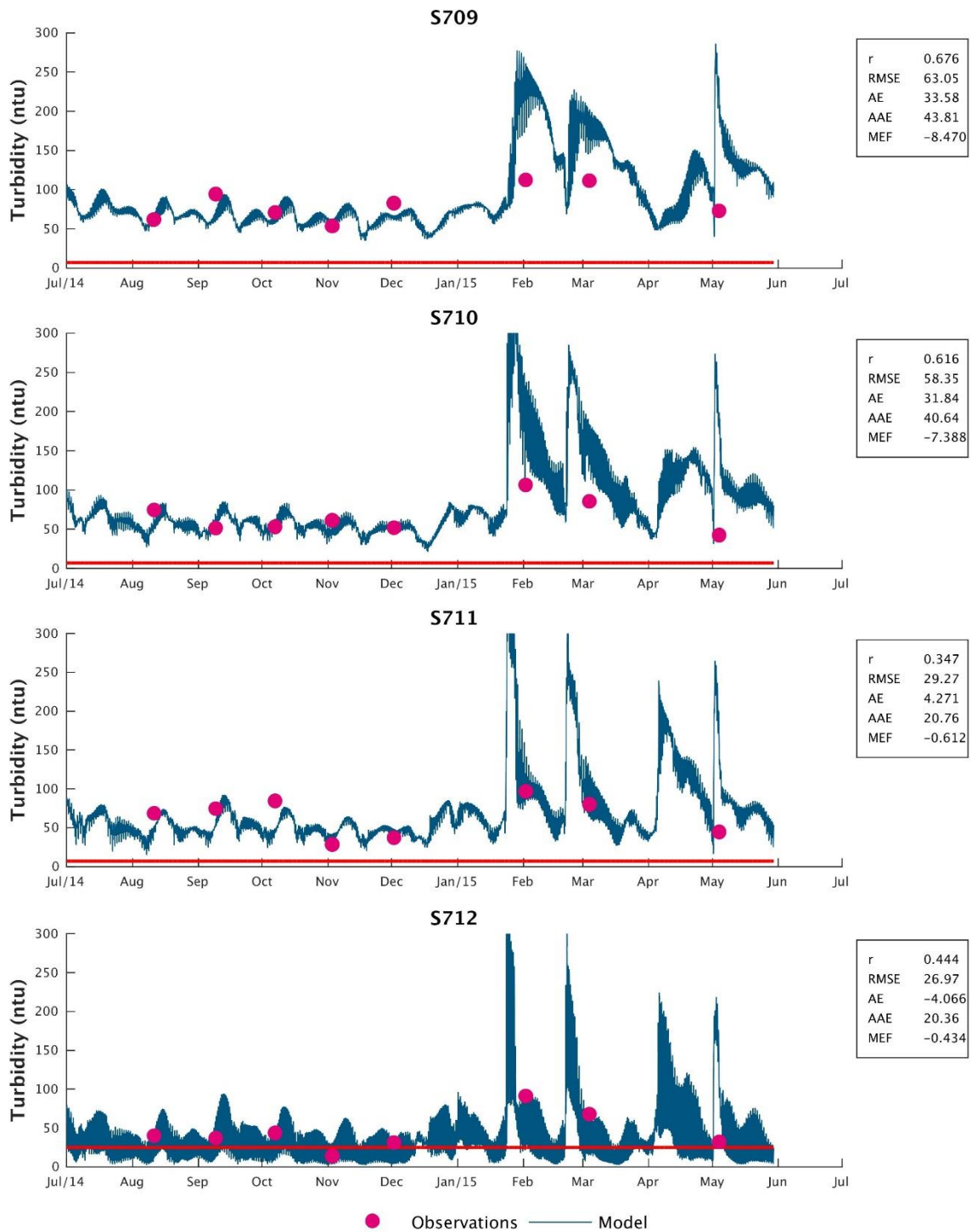


Figure A-76 Turbidity timeseries plot for Brisbane U/s

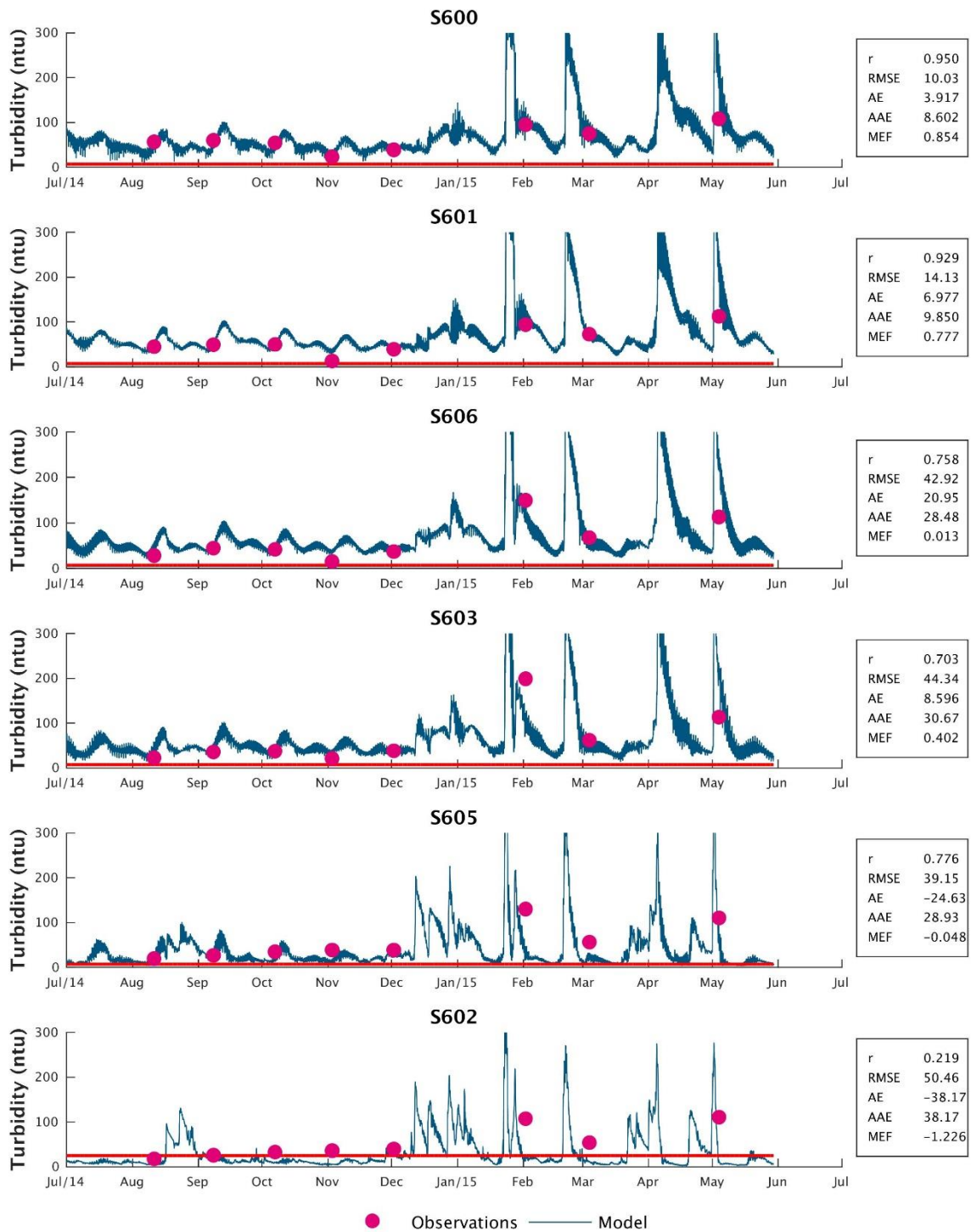


Figure A-77 Turbidity timeseries plot for Bremer

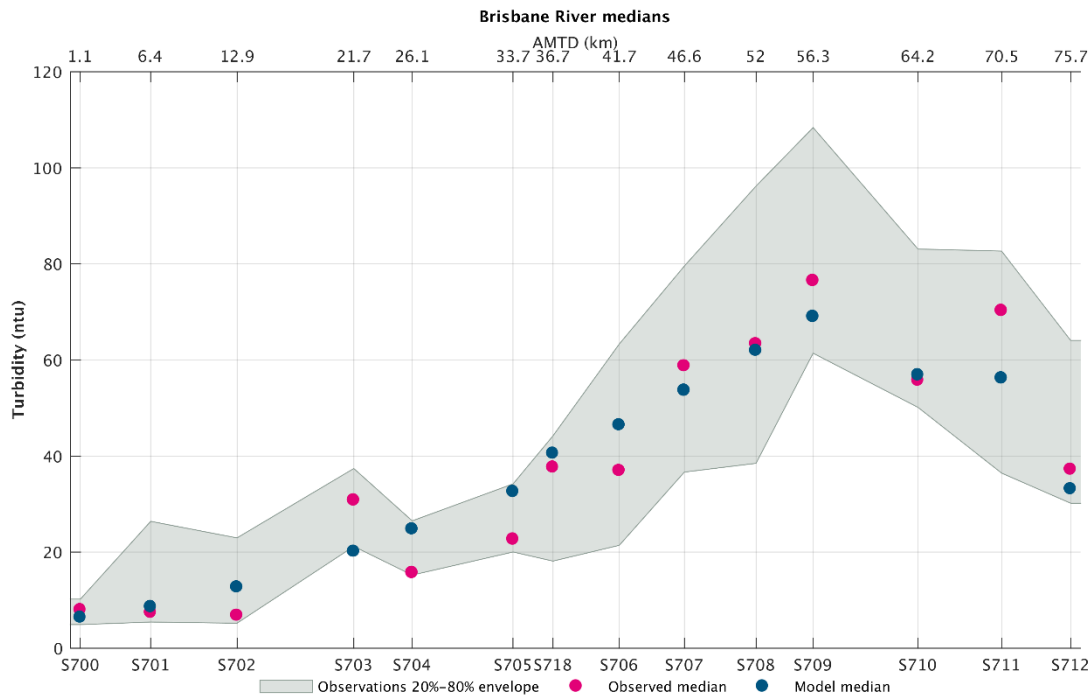


Figure A-78 Turbidity thalweg comparison for Brisbane

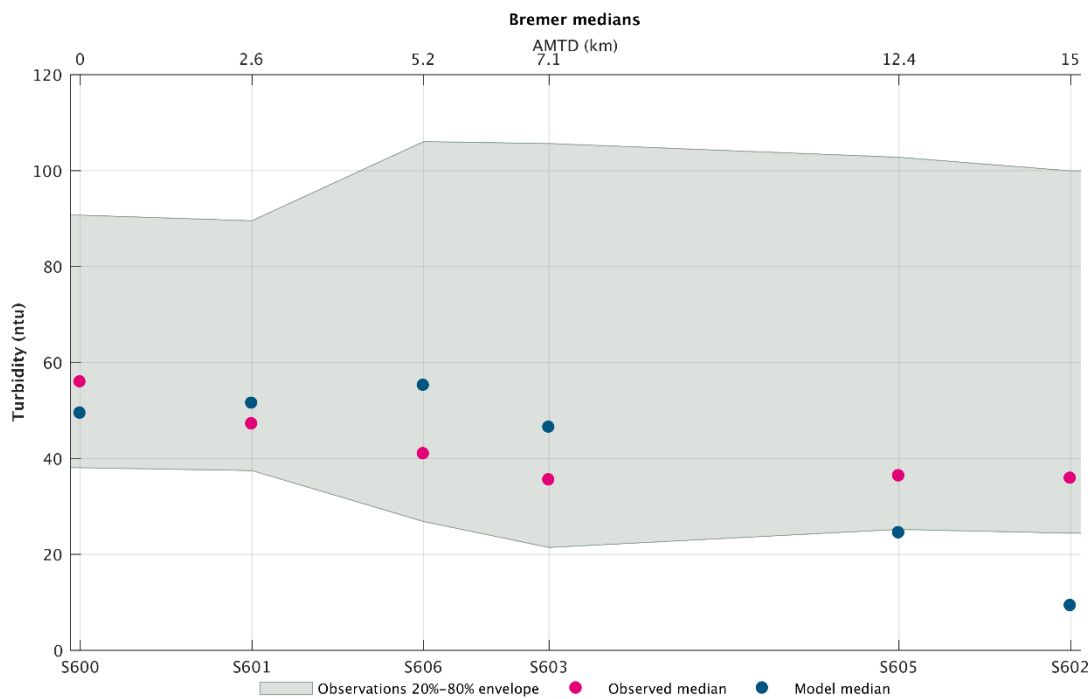


Figure A-79 Turbidity thalweg comparison for Bremer

### A.6.2 Dissolved oxygen deficit

Dissolved oxygen deficit calibration information is presented below.

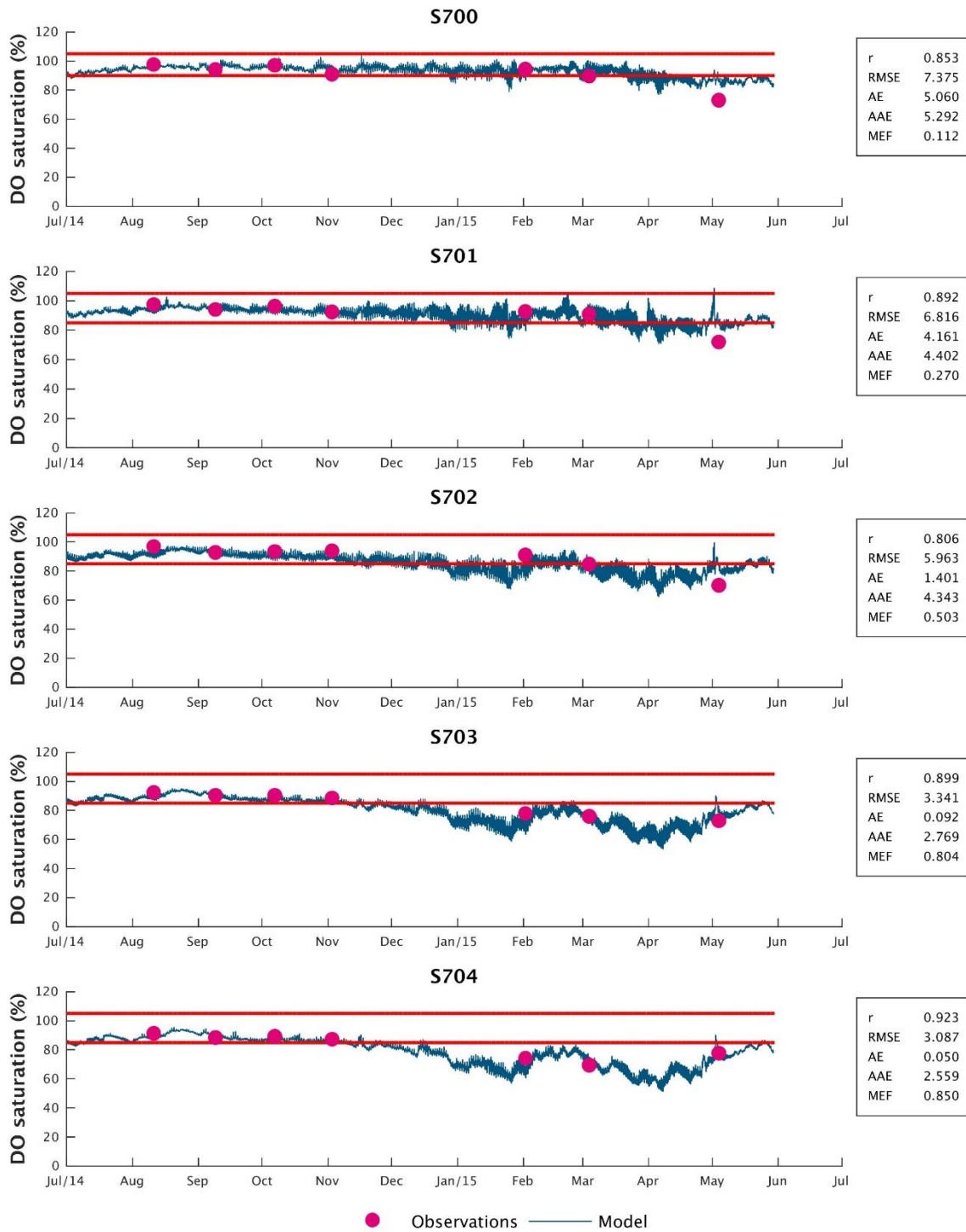


Figure A-80 Dissolved oxygen deficit timeseries plot for Brisbane D/s

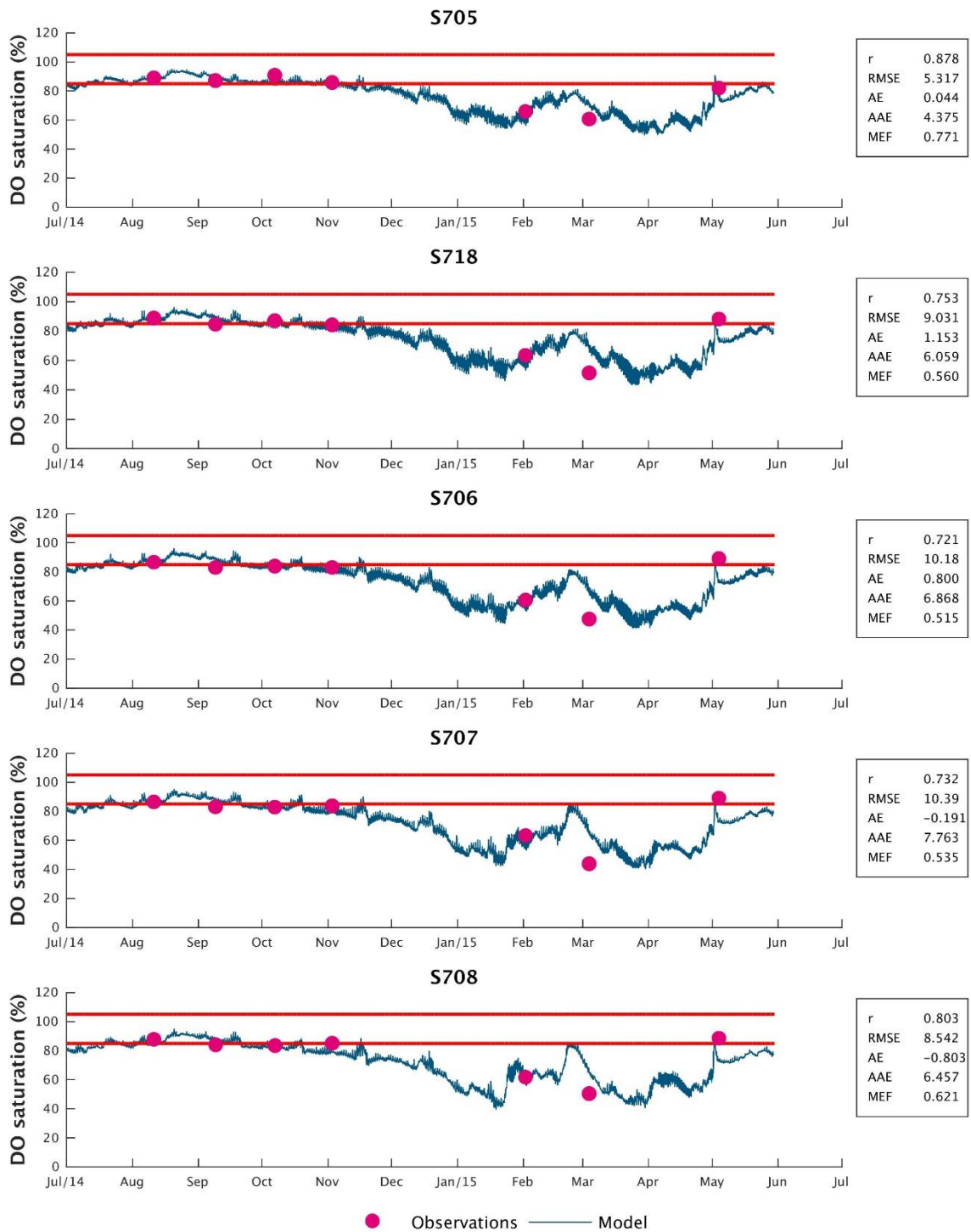


Figure A-81 Dissolved oxygen deficit timeseries plot for Brisbane mid

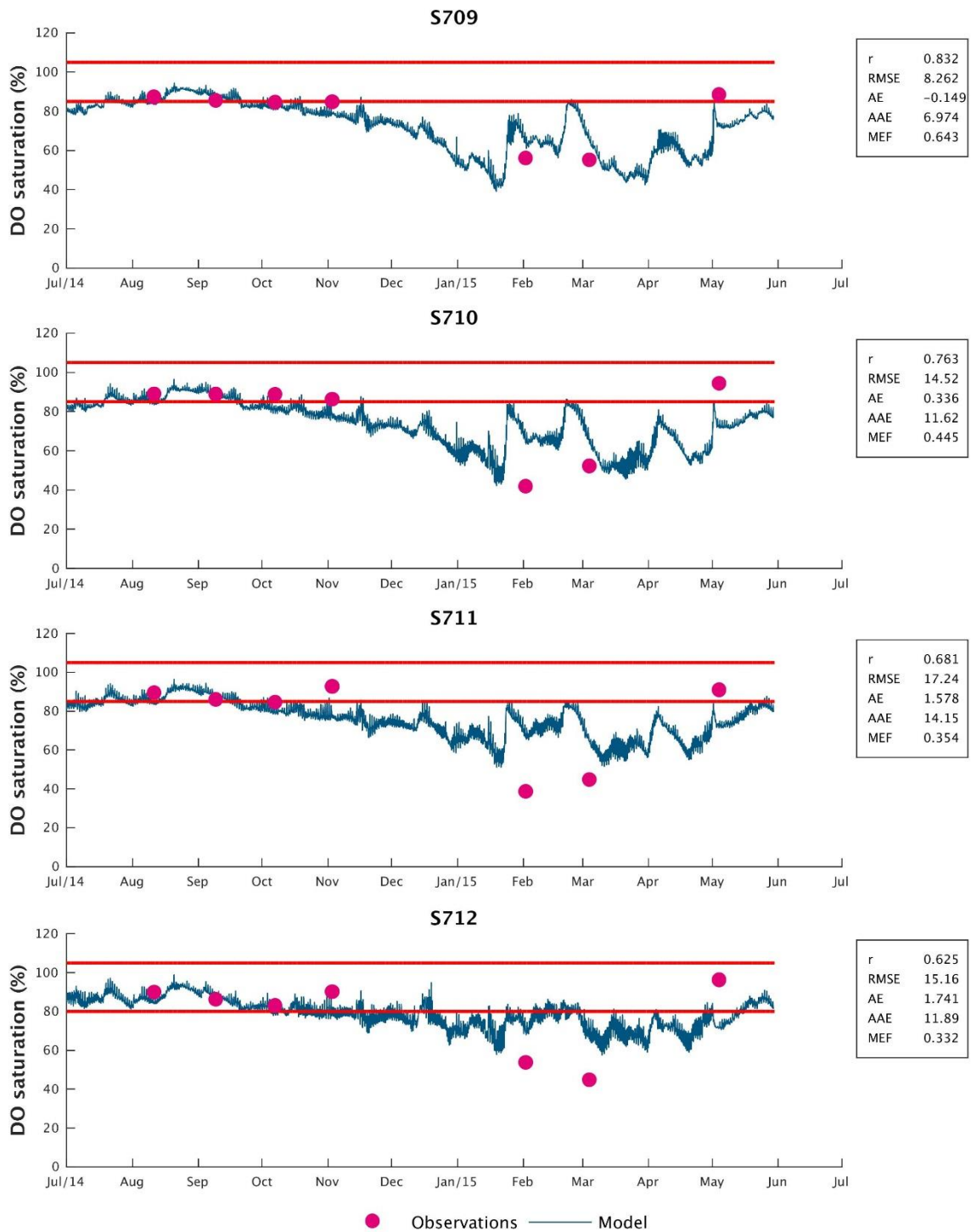


Figure A-82 Dissolved oxygen deficit timeseries plot for Brisbane U/s

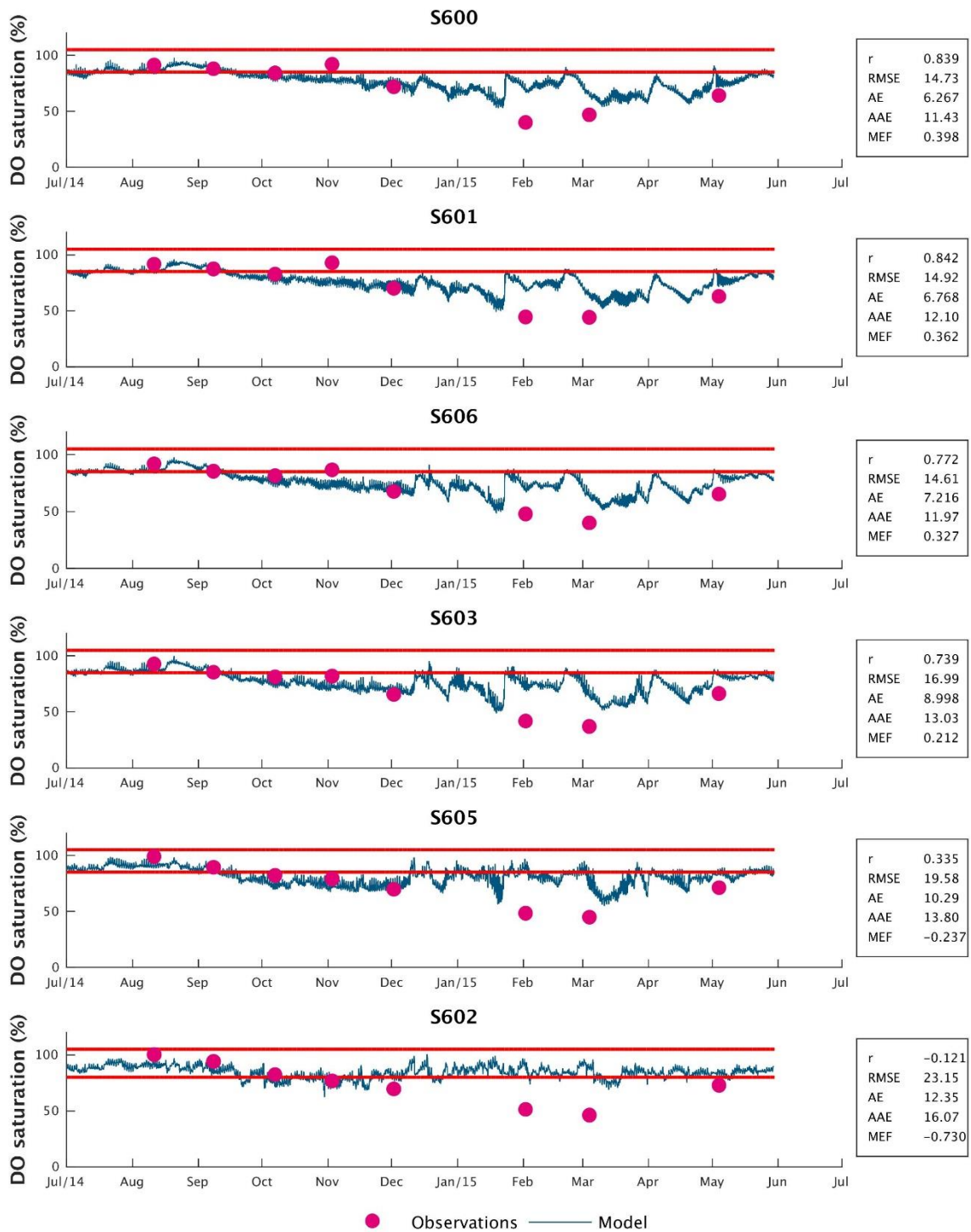


Figure A-83 Dissolved oxygen deficit timeseries plot for Bremer

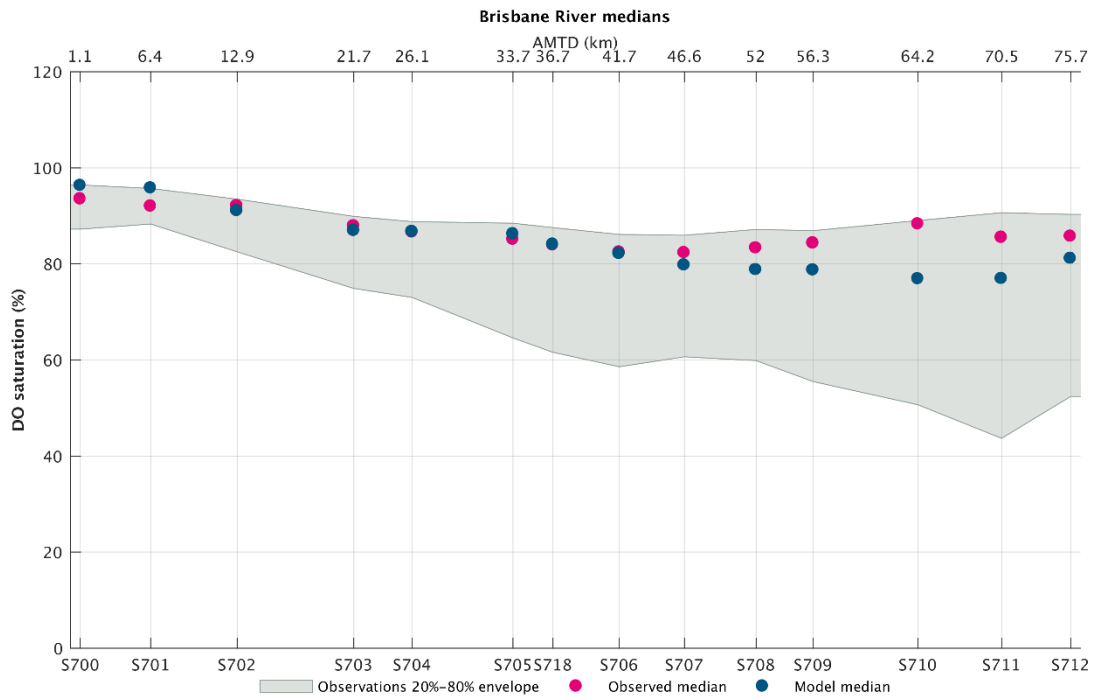


Figure A-84 Dissolved oxygen deficit thalweg comparison for Brisbane

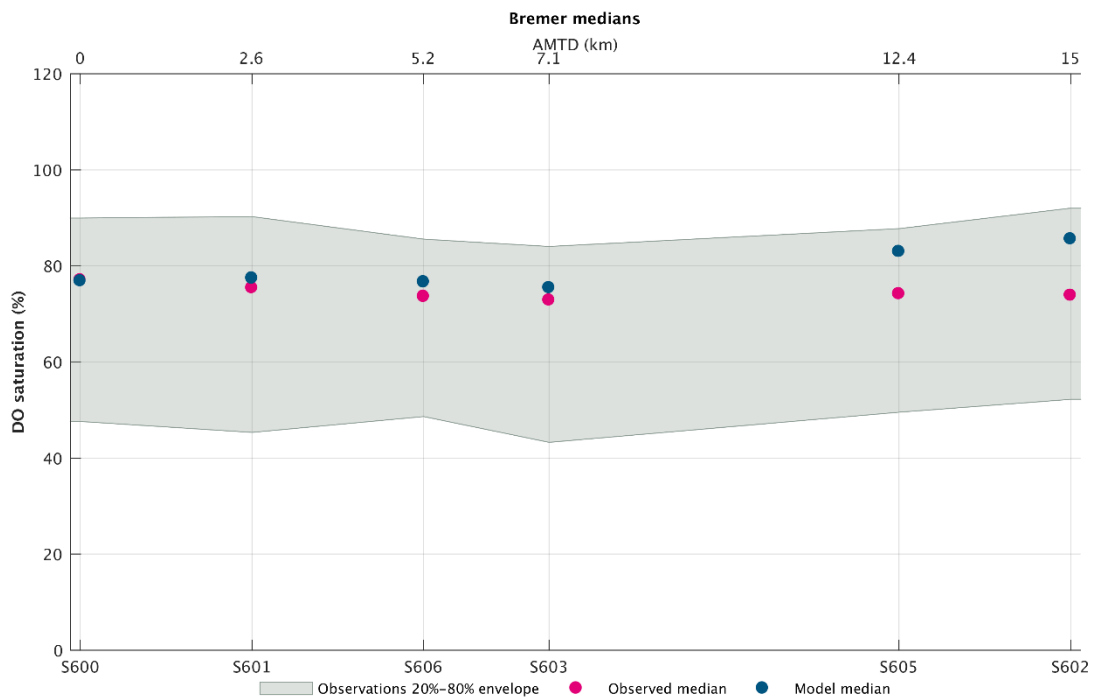


Figure A-85 Dissolved oxygen deficit thalweg comparison for Bremer

### A.6.3 Total Nitrogen

Total Nitrogen calibration information is presented below.

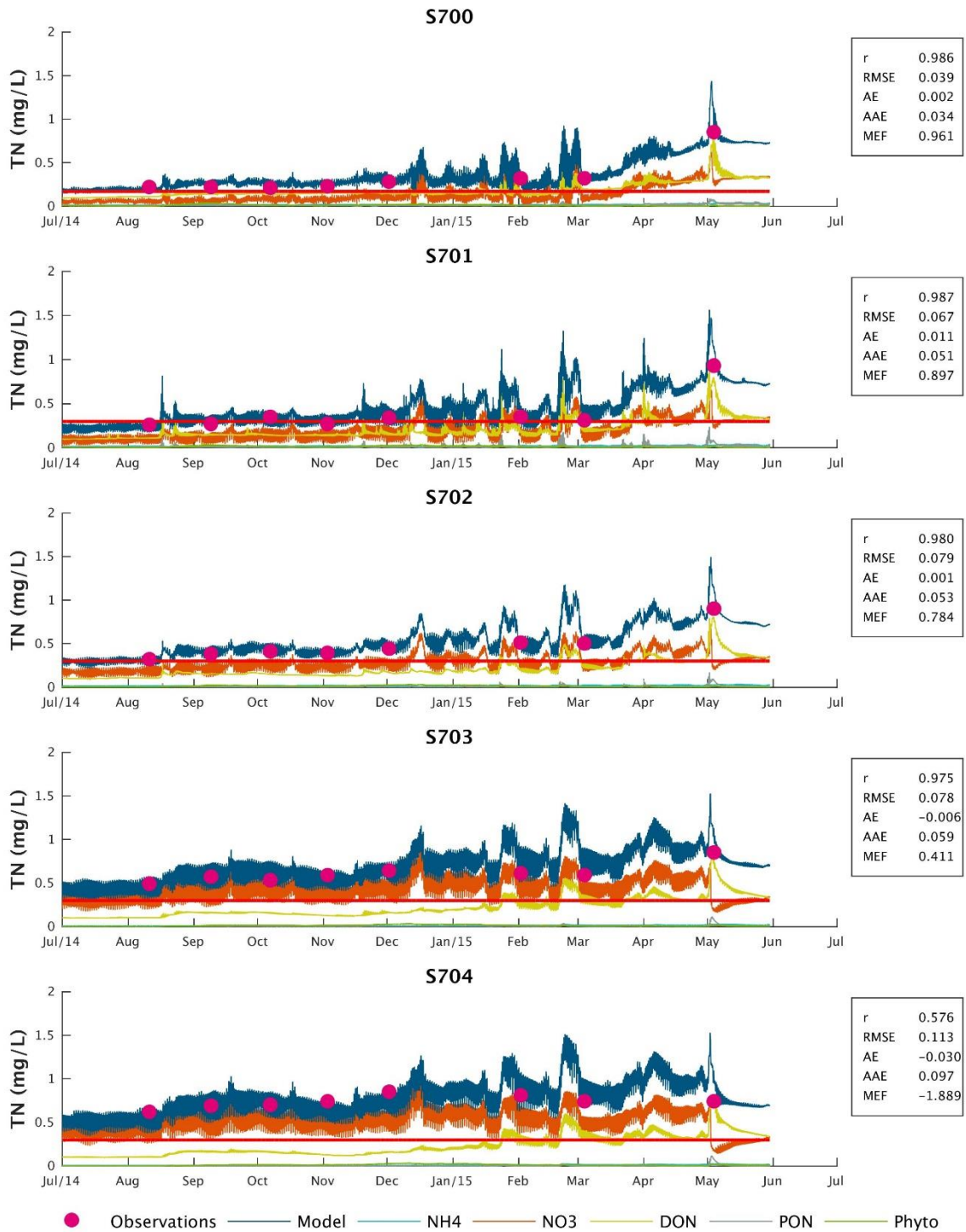


Figure A-86 Total Nitrogen timeseries plot for Brisbane D/s

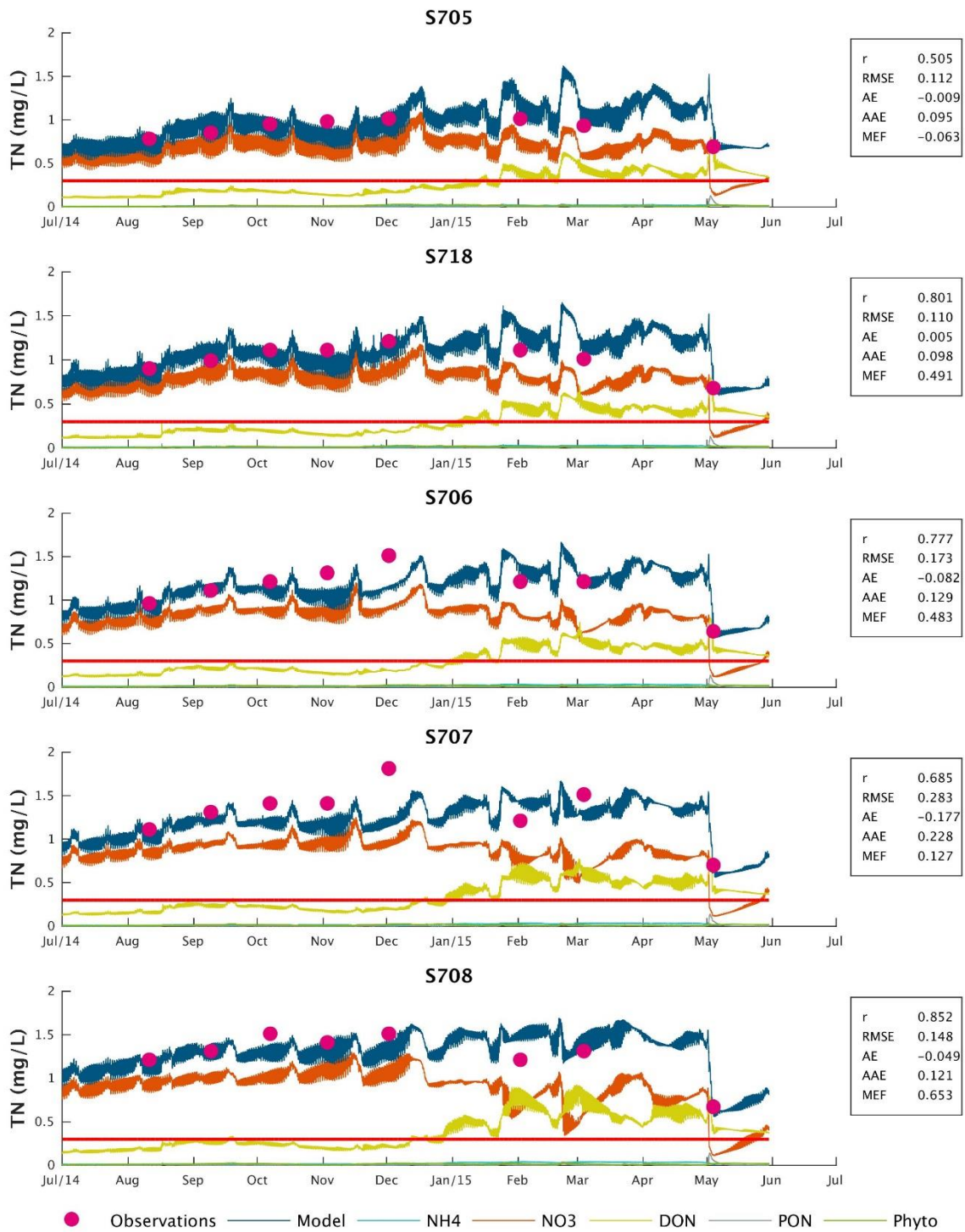


Figure A-87 Total Nitrogen timeseries plot for Brisbane Mid

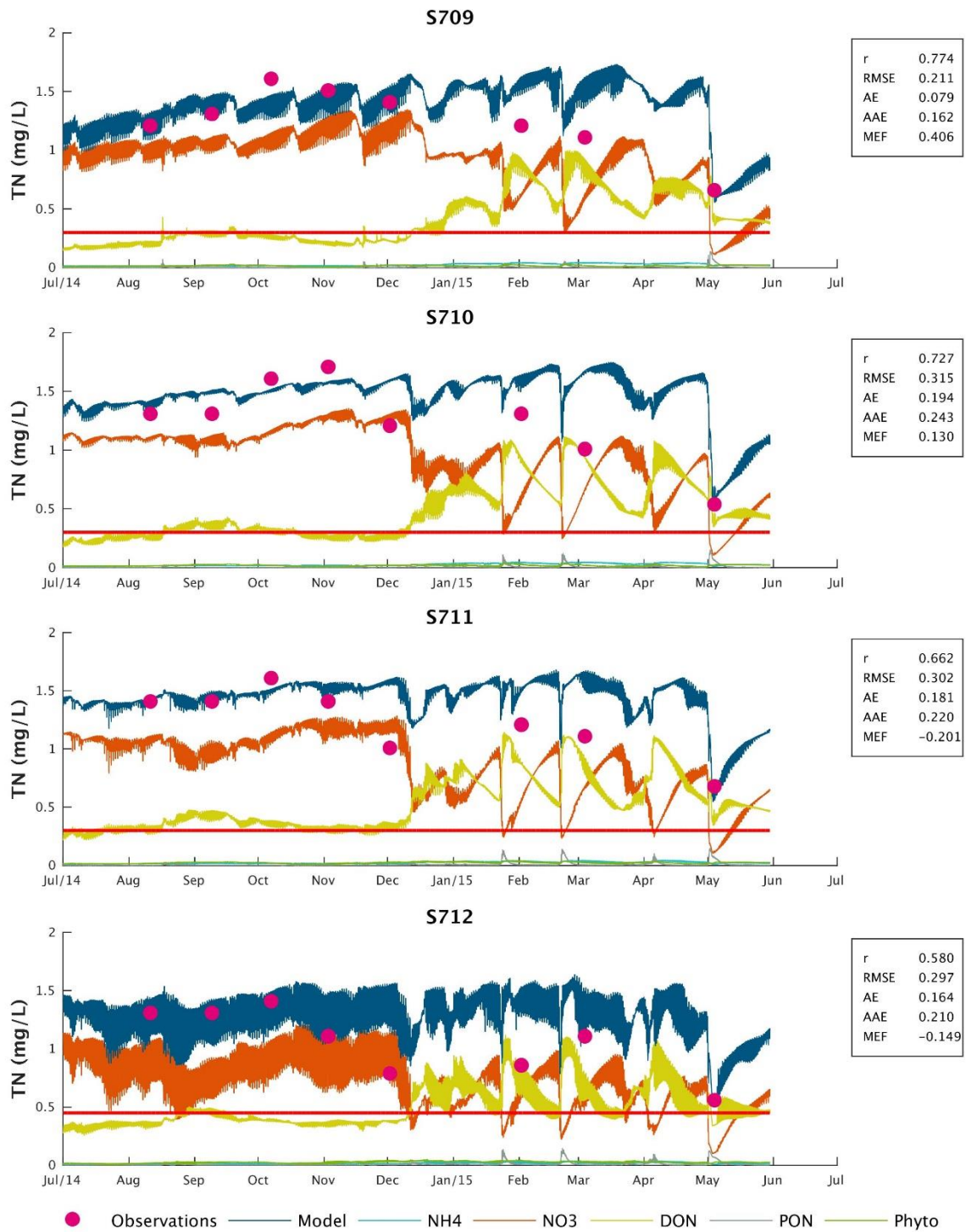


Figure A-88 Total Nitrogen timeseries plot for Brisbane U/s

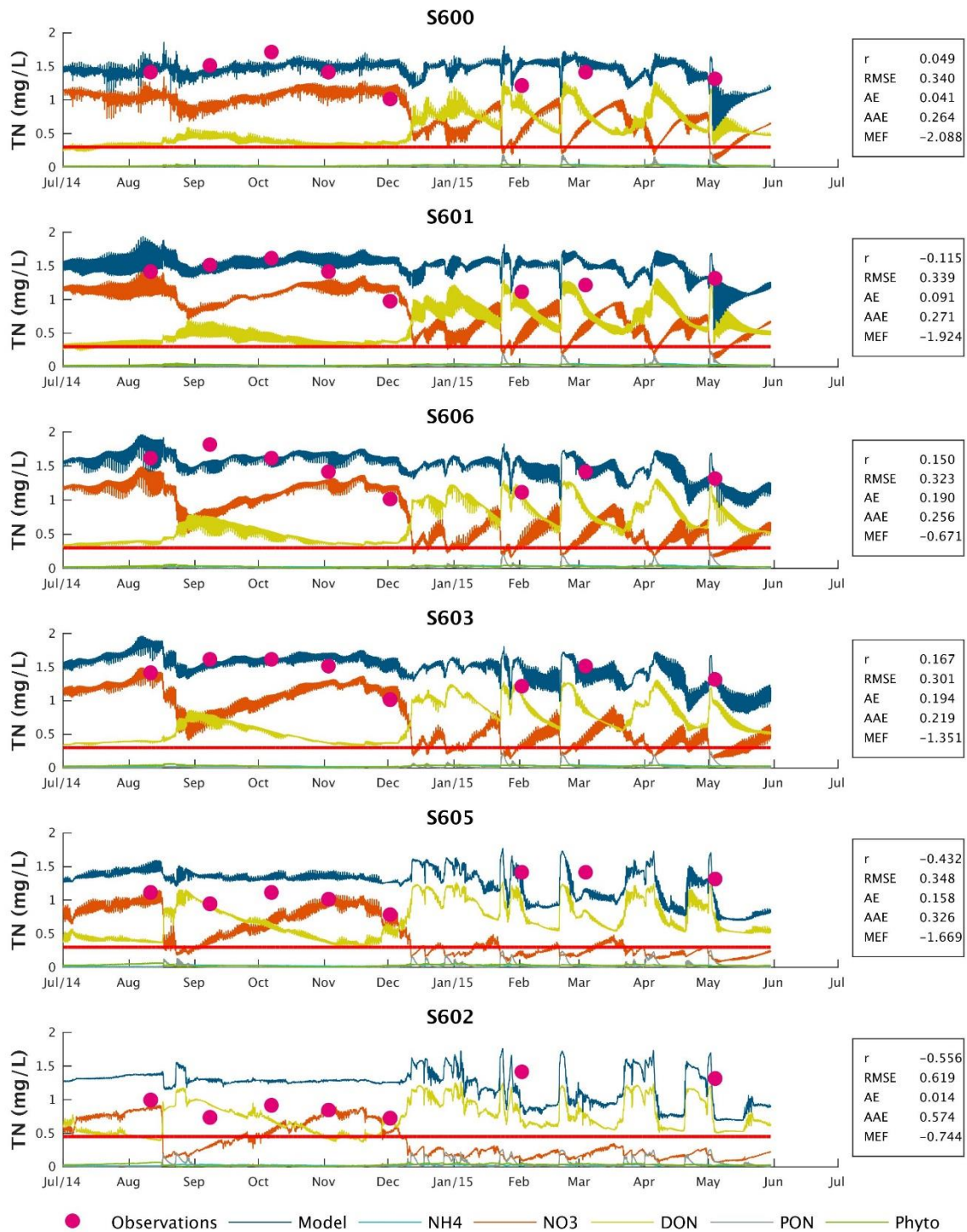


Figure A-89 Total Nitrogen timeseries plot for Bremer

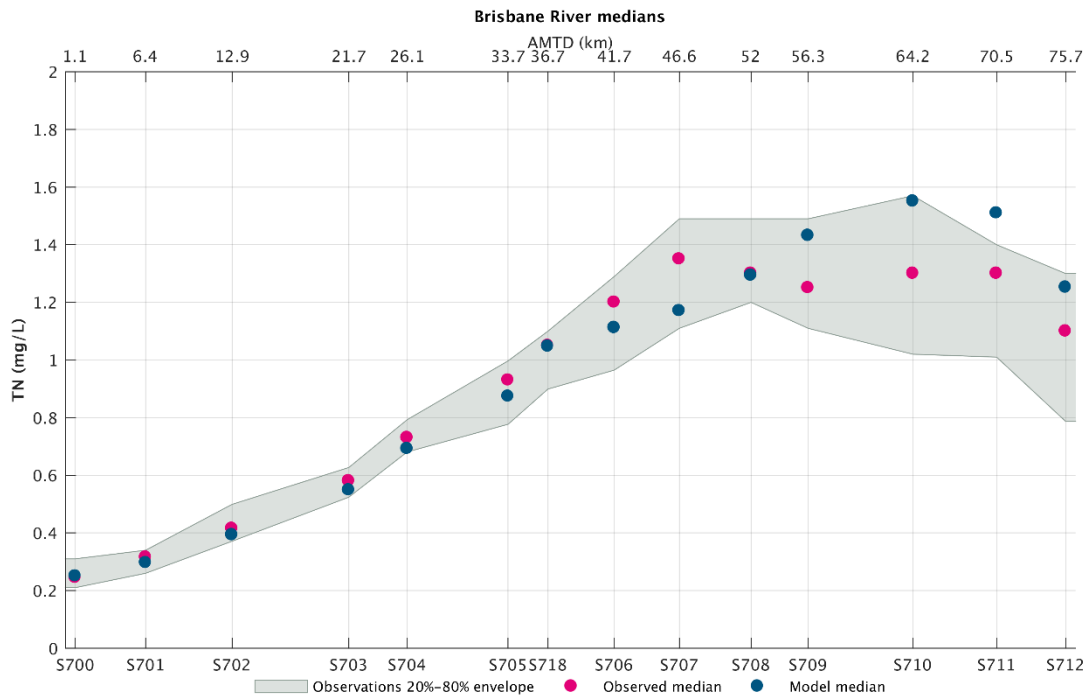


Figure A-90 Total Nitrogen thalweg comparison for Brisbane

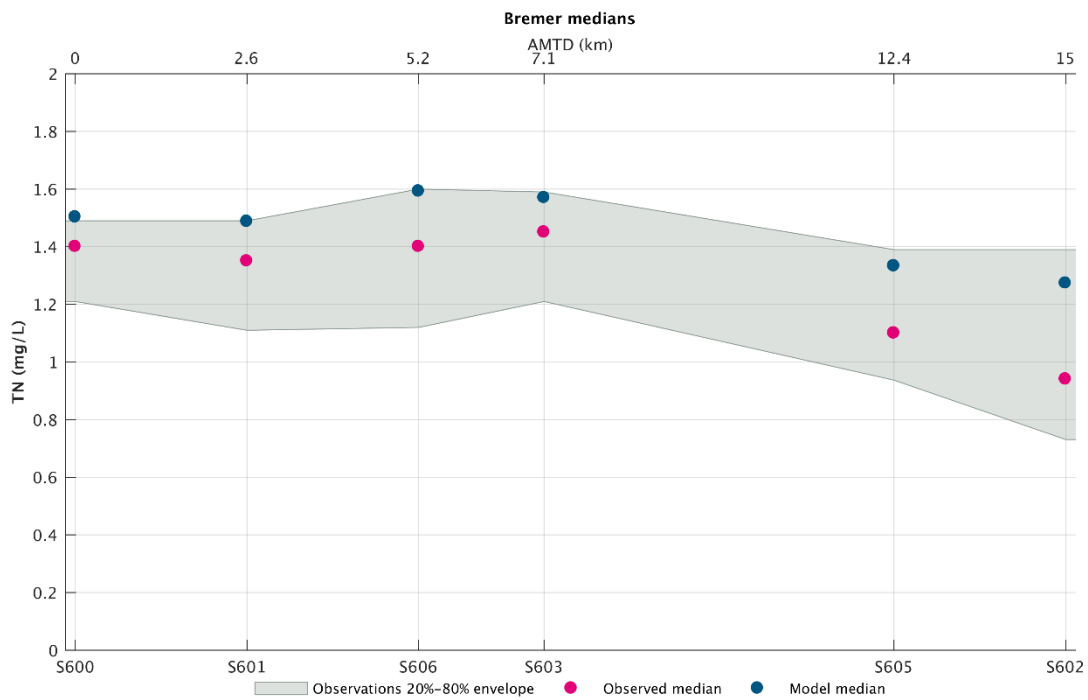


Figure A-91 Total Nitrogen thalweg comparison for Bremer

### A.6.4 Total phosphorus

Total phosphorous calibration information is presented below.

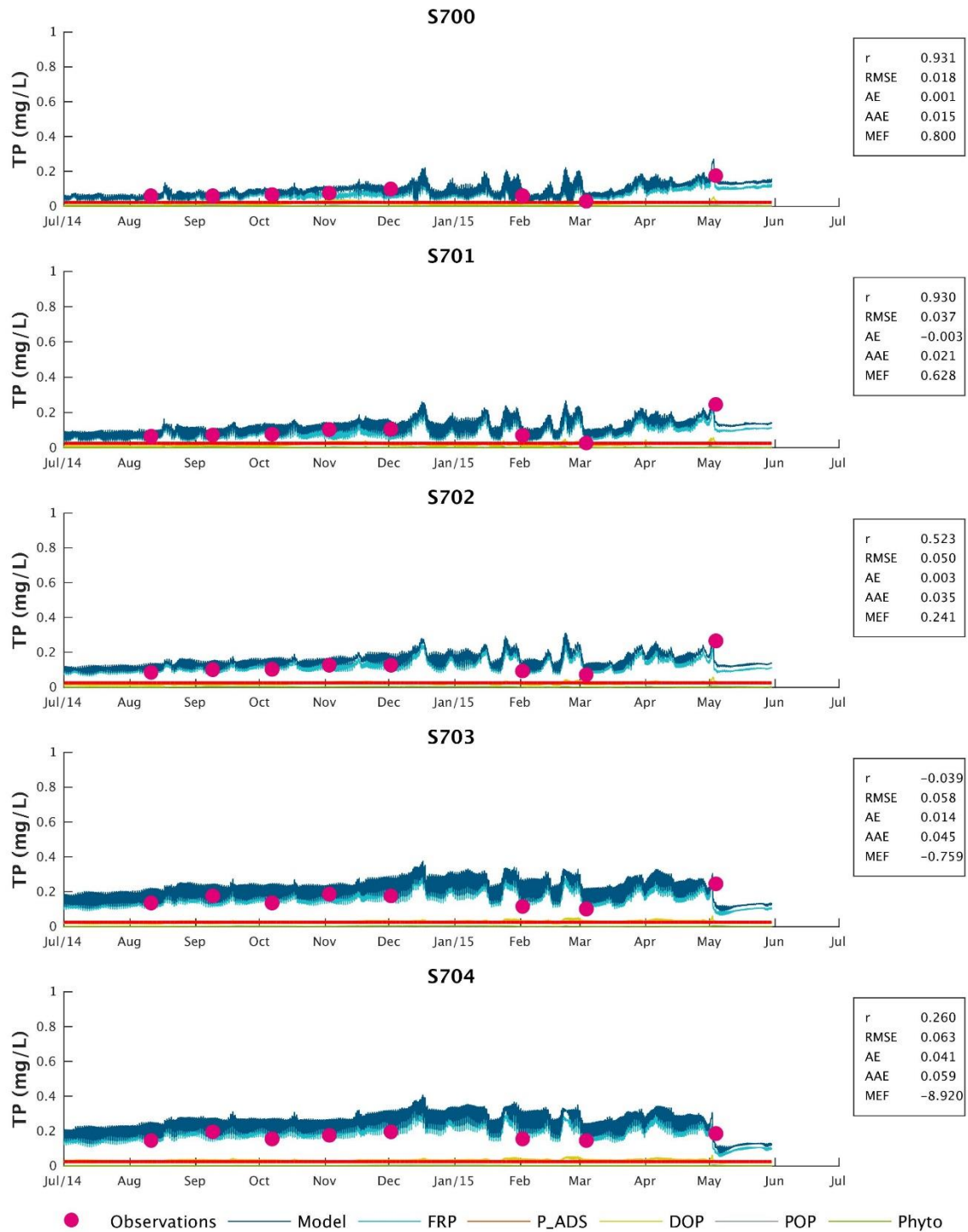


Figure A-92 Total phosphorus timeseries plot for Brisbane D/s

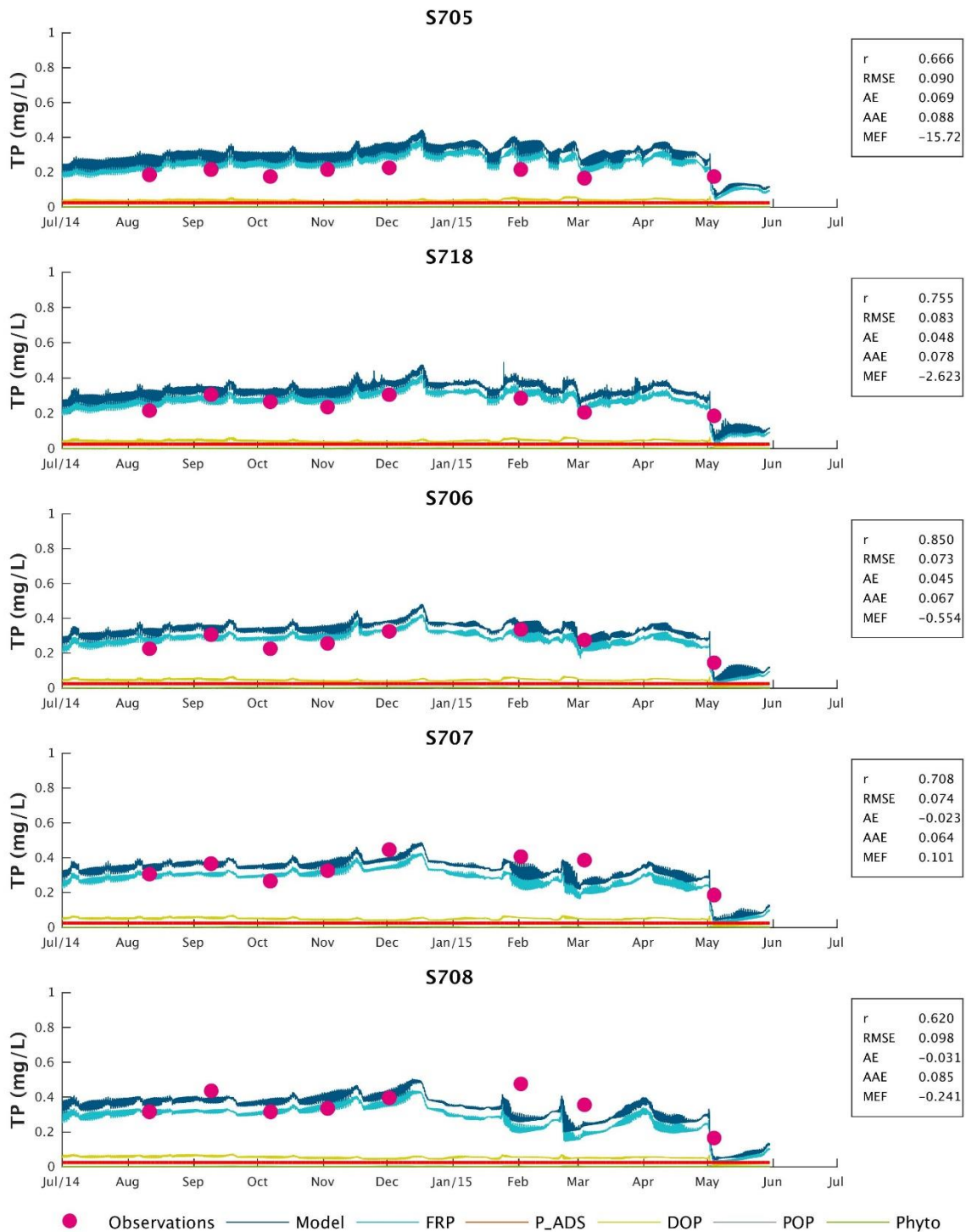


Figure A-93 Total phosphorus timeseries plot for Brisbane Mid

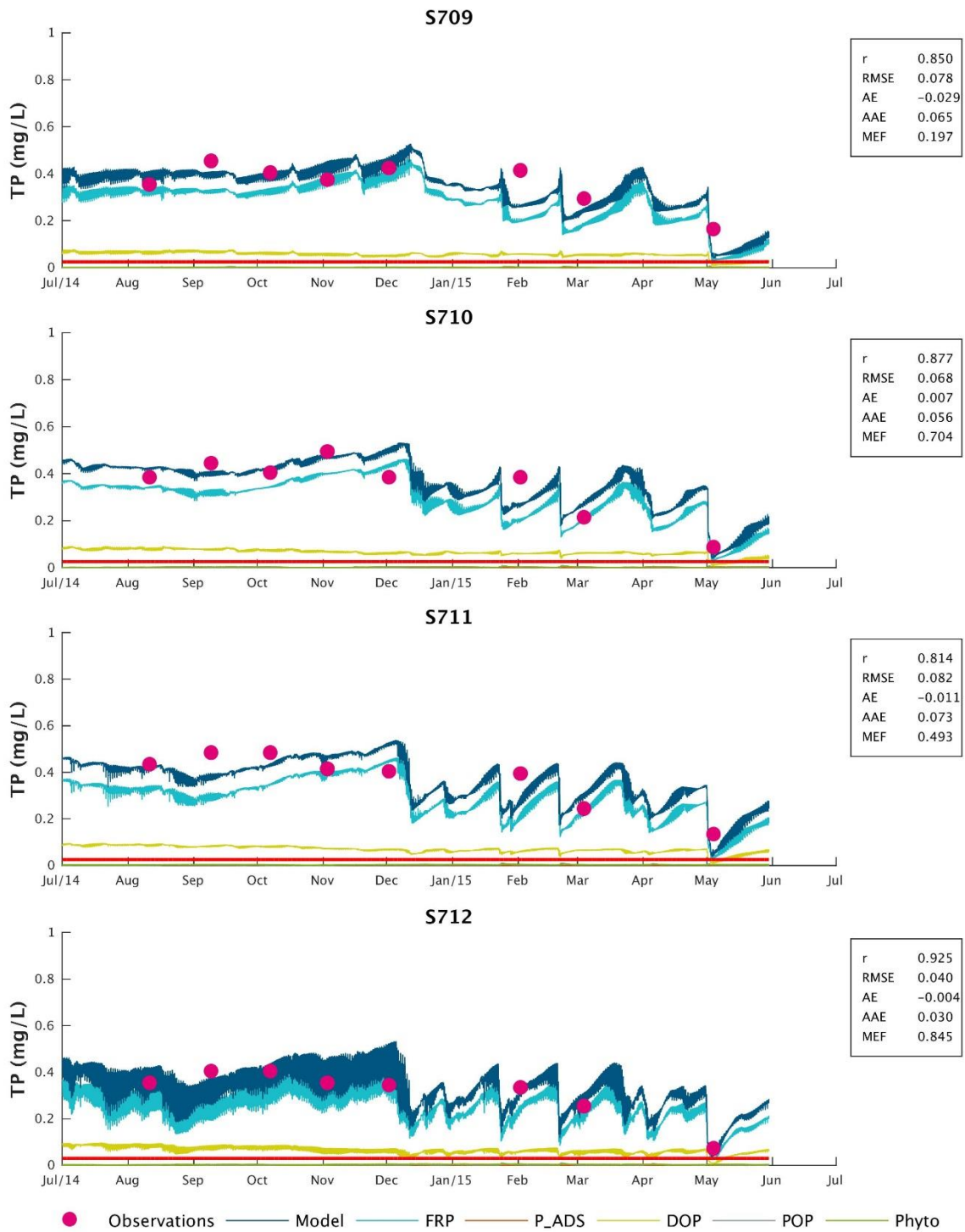


Figure A-94 Total phosphorus timeseries plot for Brisbane U/s

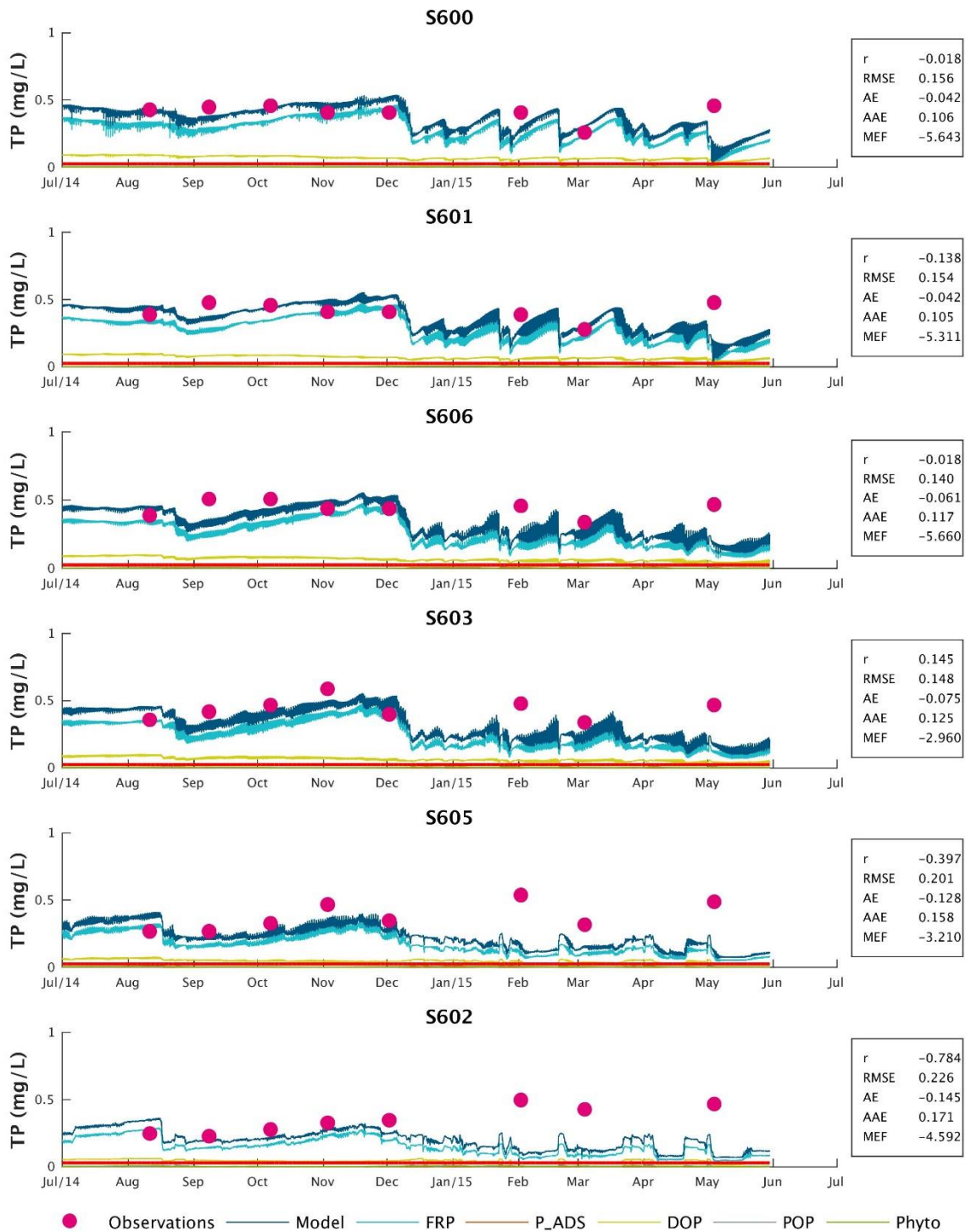


Figure A-95 Total phosphorus timeseries plot for Bremer

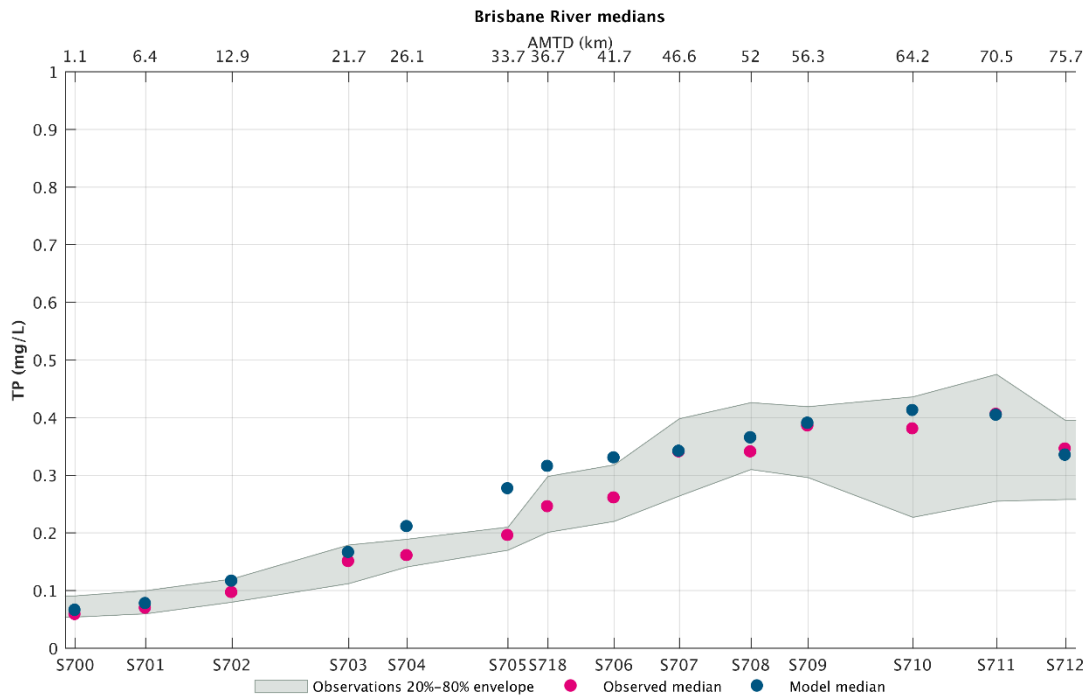


Figure A-96 Total phosphorus thalweg comparison for Brisbane

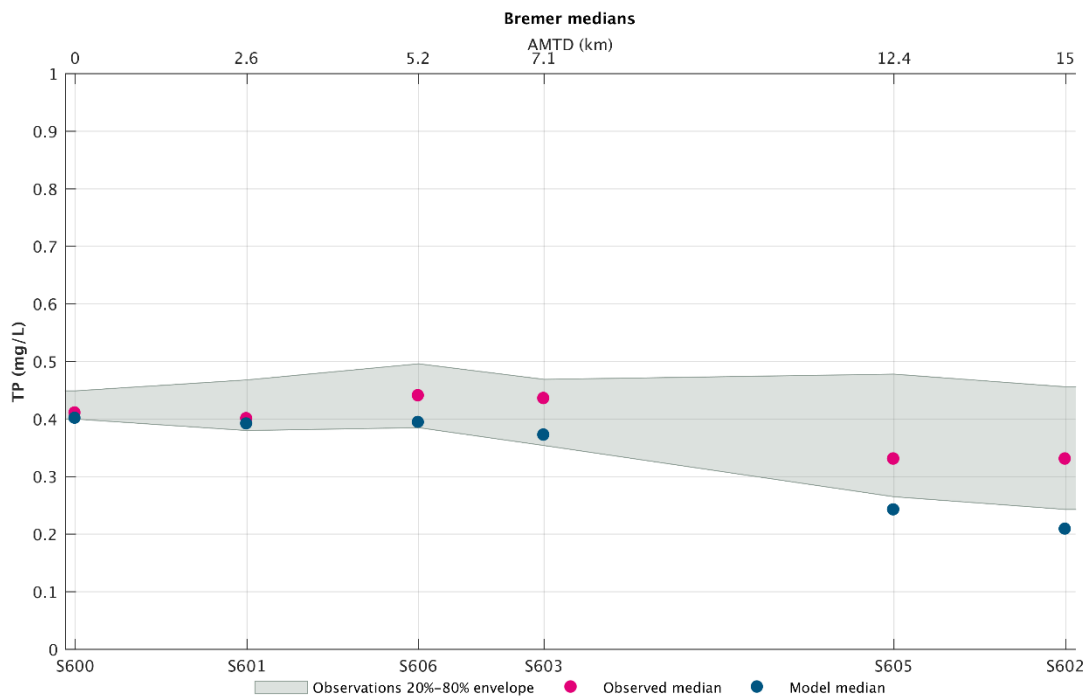


Figure A-97 Total phosphorus thalweg comparison for Bremer

### A.6.5 Chlorophyll-a

Chlorophyll-a calibration information is presented below.

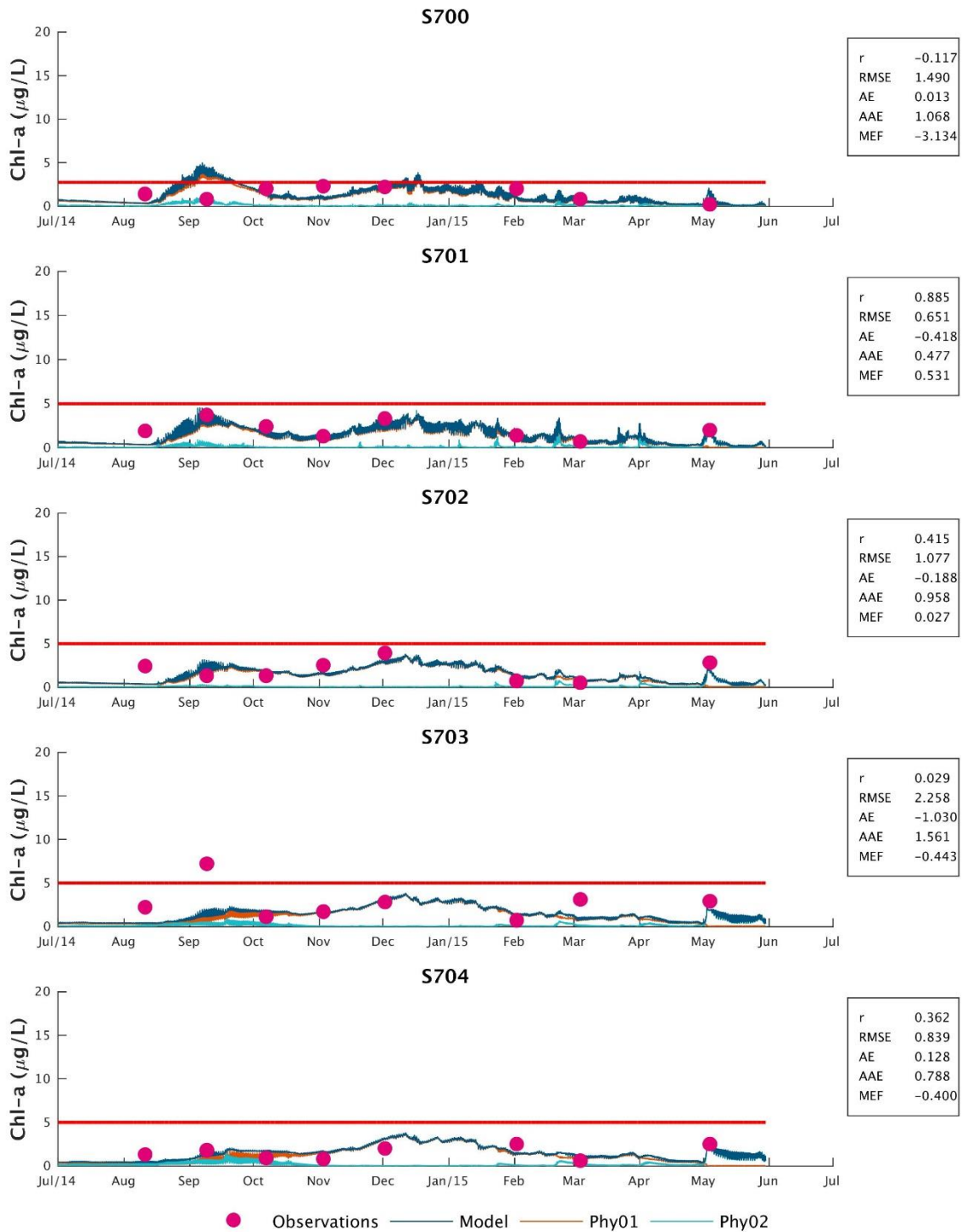


Figure A-98 Chlorophyll-a timeseries plot for Brisbane D/s

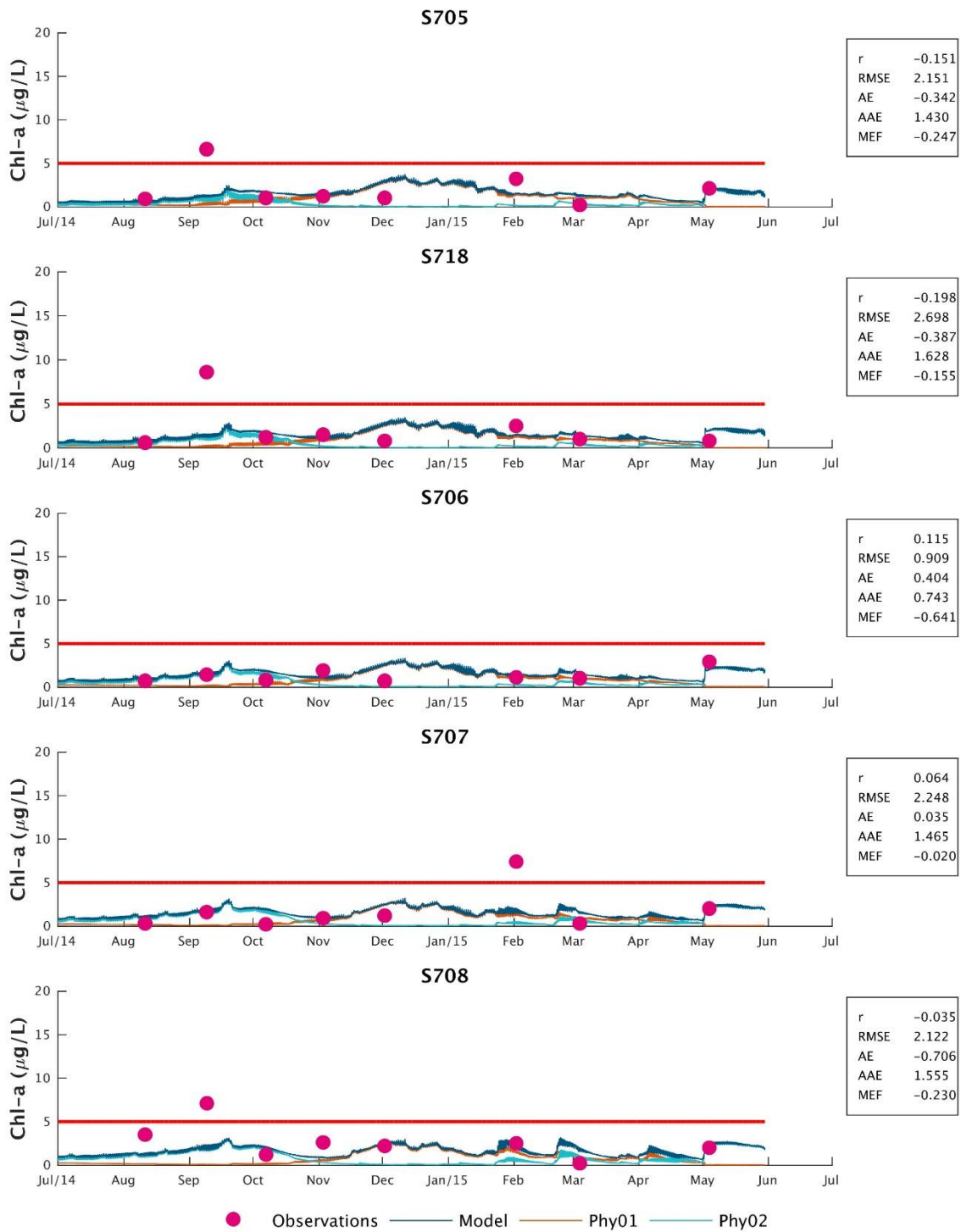


Figure A-99 Chlorophyll-a timeseries plot for Brisbane Mid

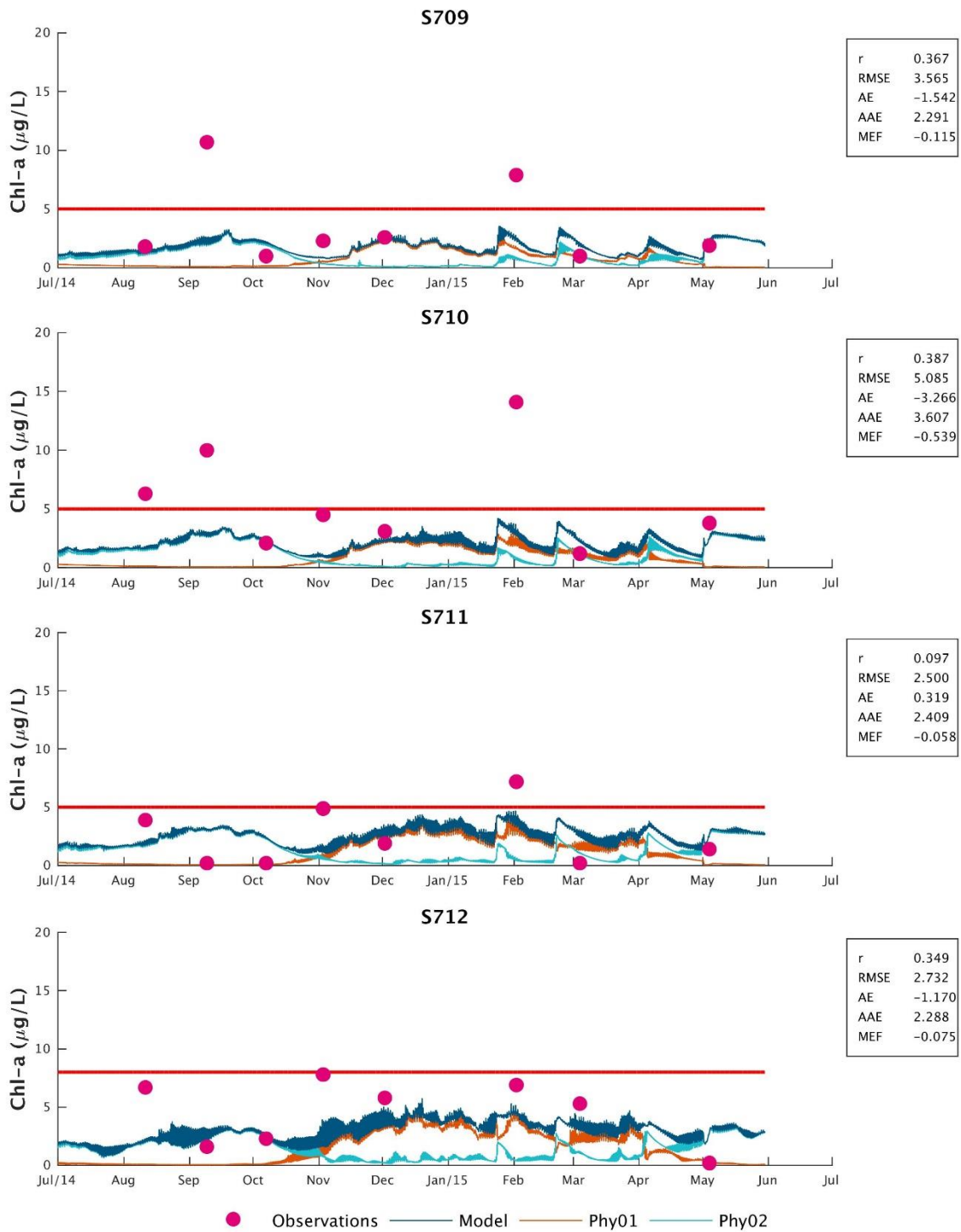


Figure A-100 Chlorophyll-a timeseries plot for Brisbane U/s

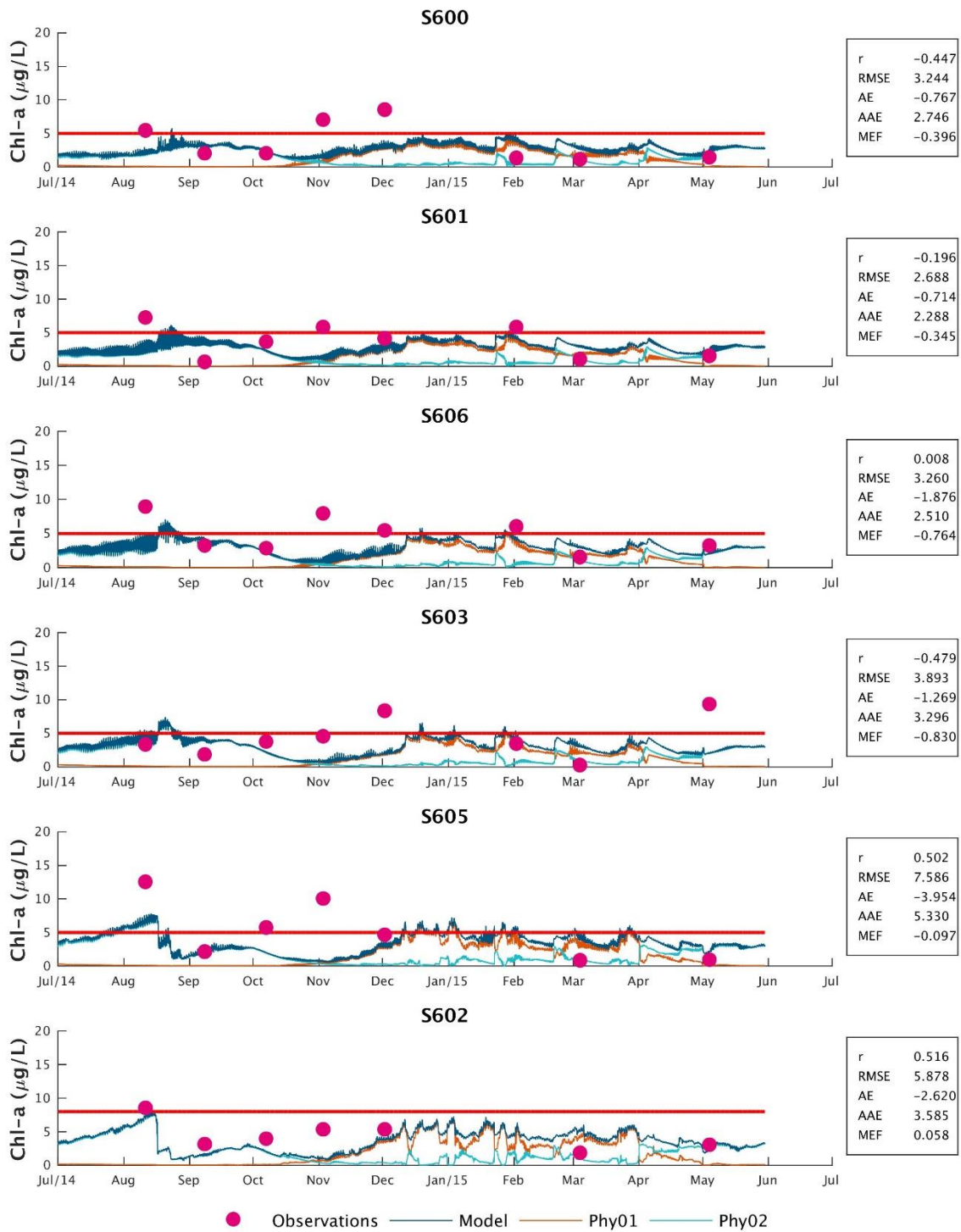


Figure A-101 Chlorophyll-a timeseries plot for Bremer

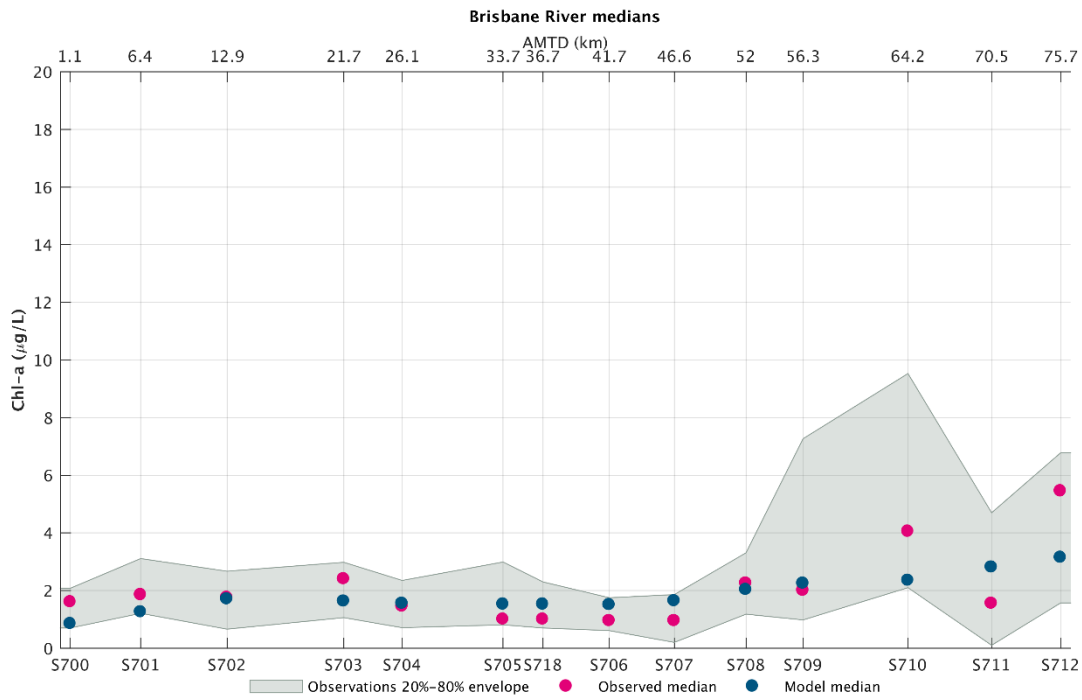


Figure A-102 Chlorophyll-a thalweg comparison for Brisbane

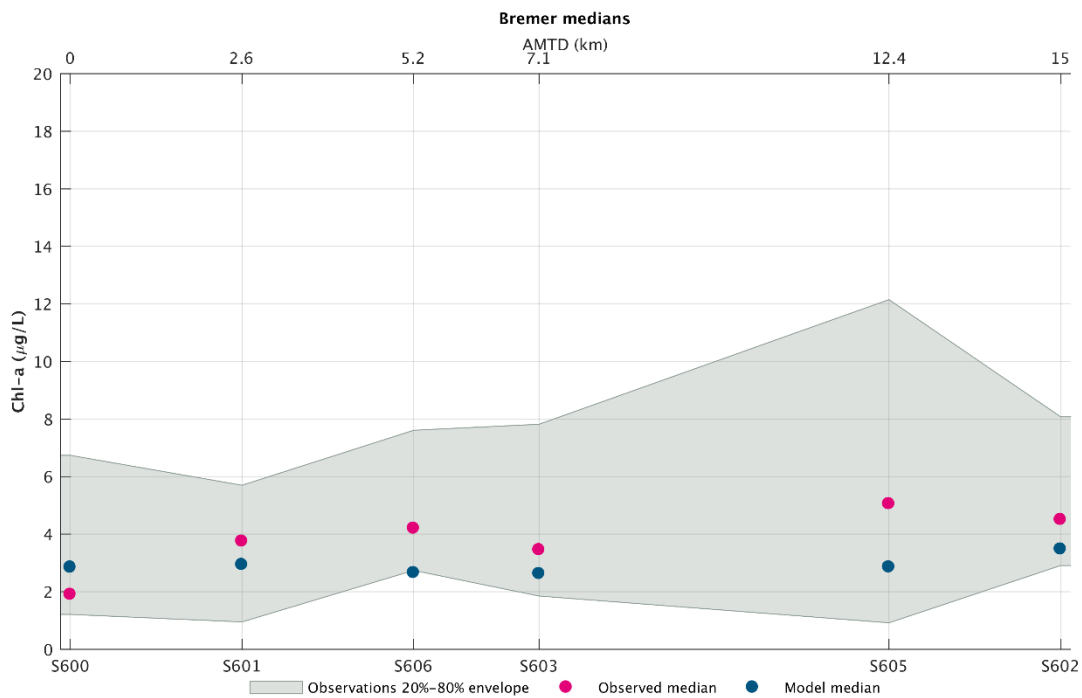


Figure A-103 Chlorophyll-a thalweg comparison for Bremer

## A.7 Logan and Albert

### A.7.1 Turbidity

Turbidity calibration information is presented below.

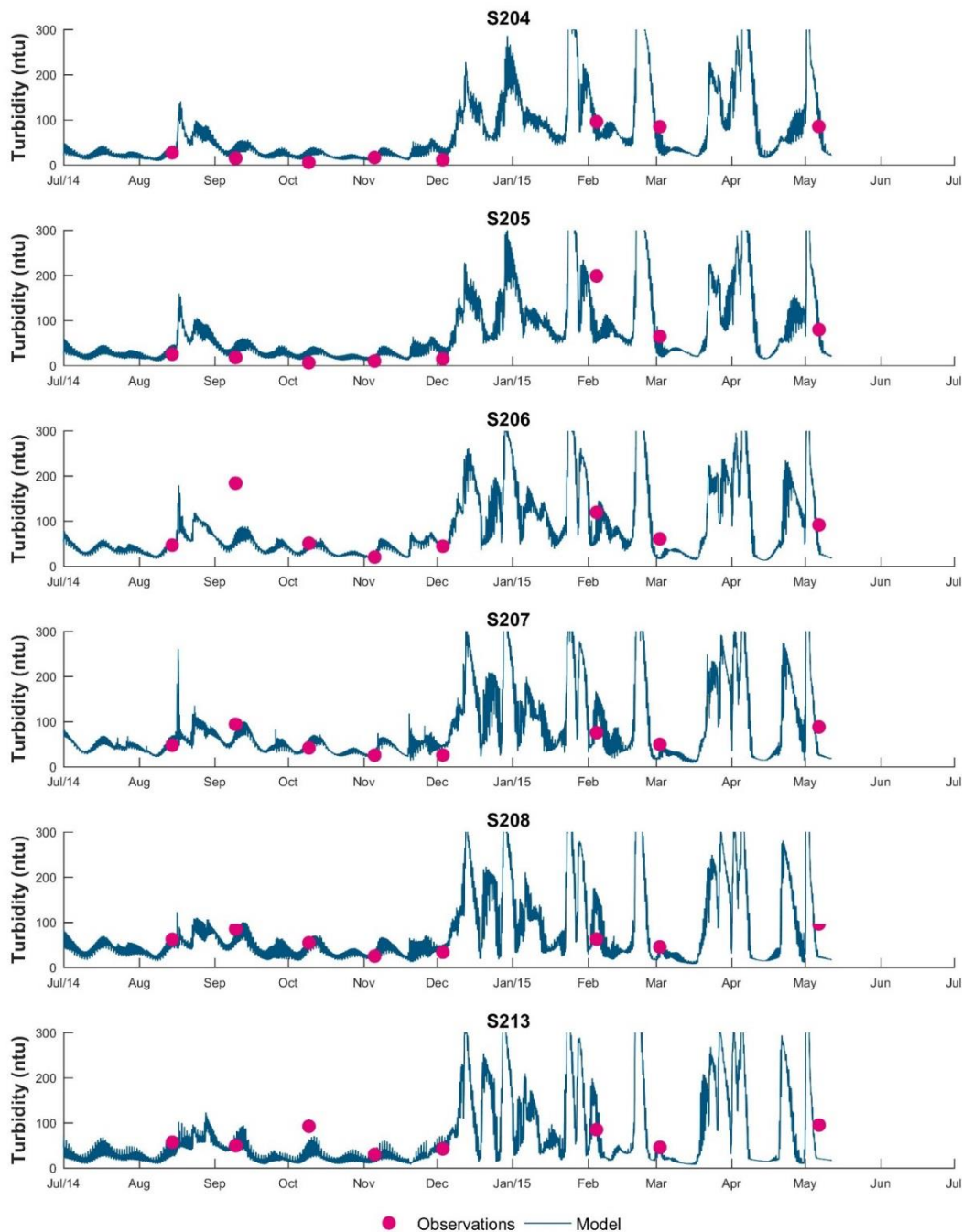


Figure A-104 Turbidity timeseries plot for Logan D/s

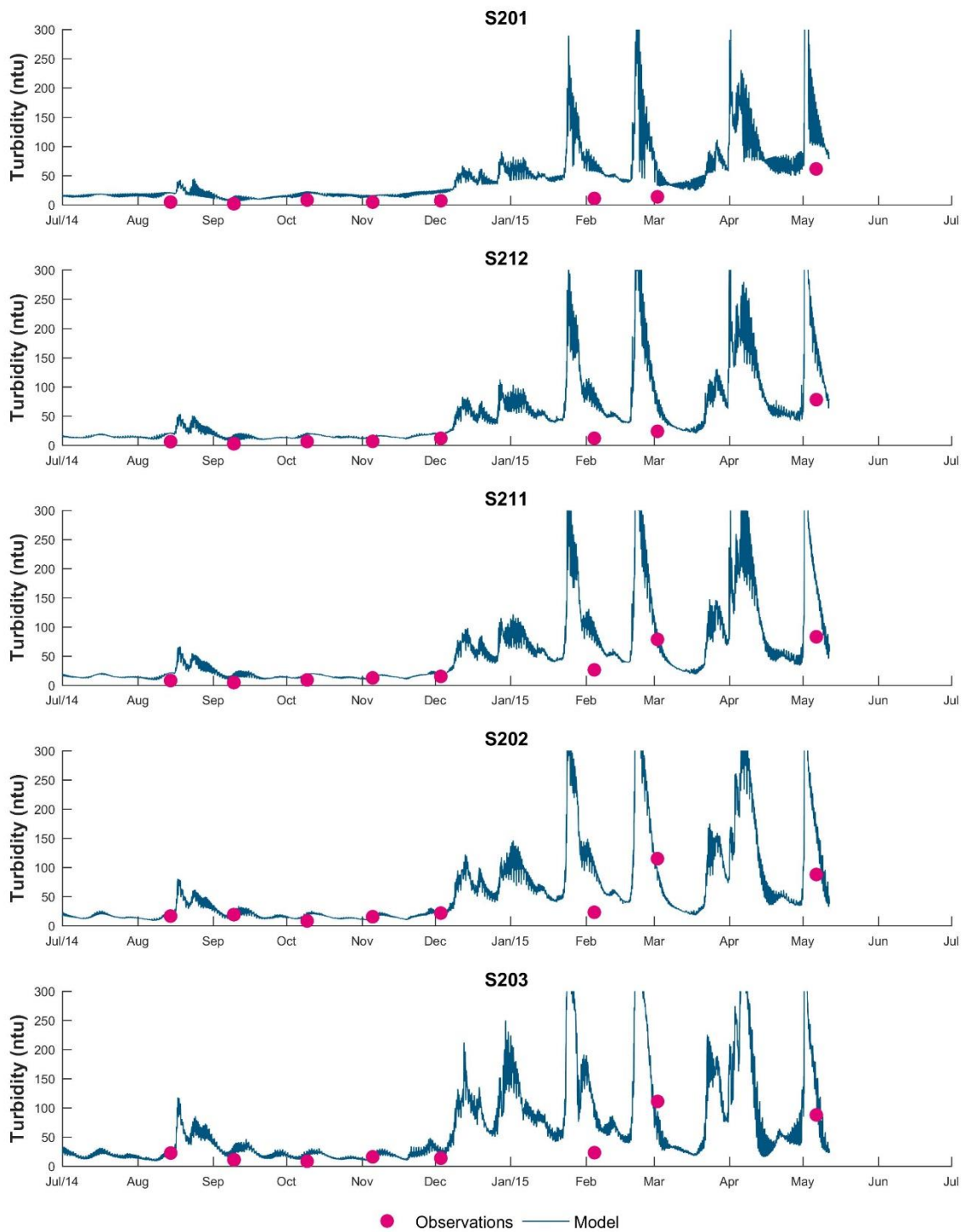


Figure A-105 Turbidity timeseries plot for Logan U/s

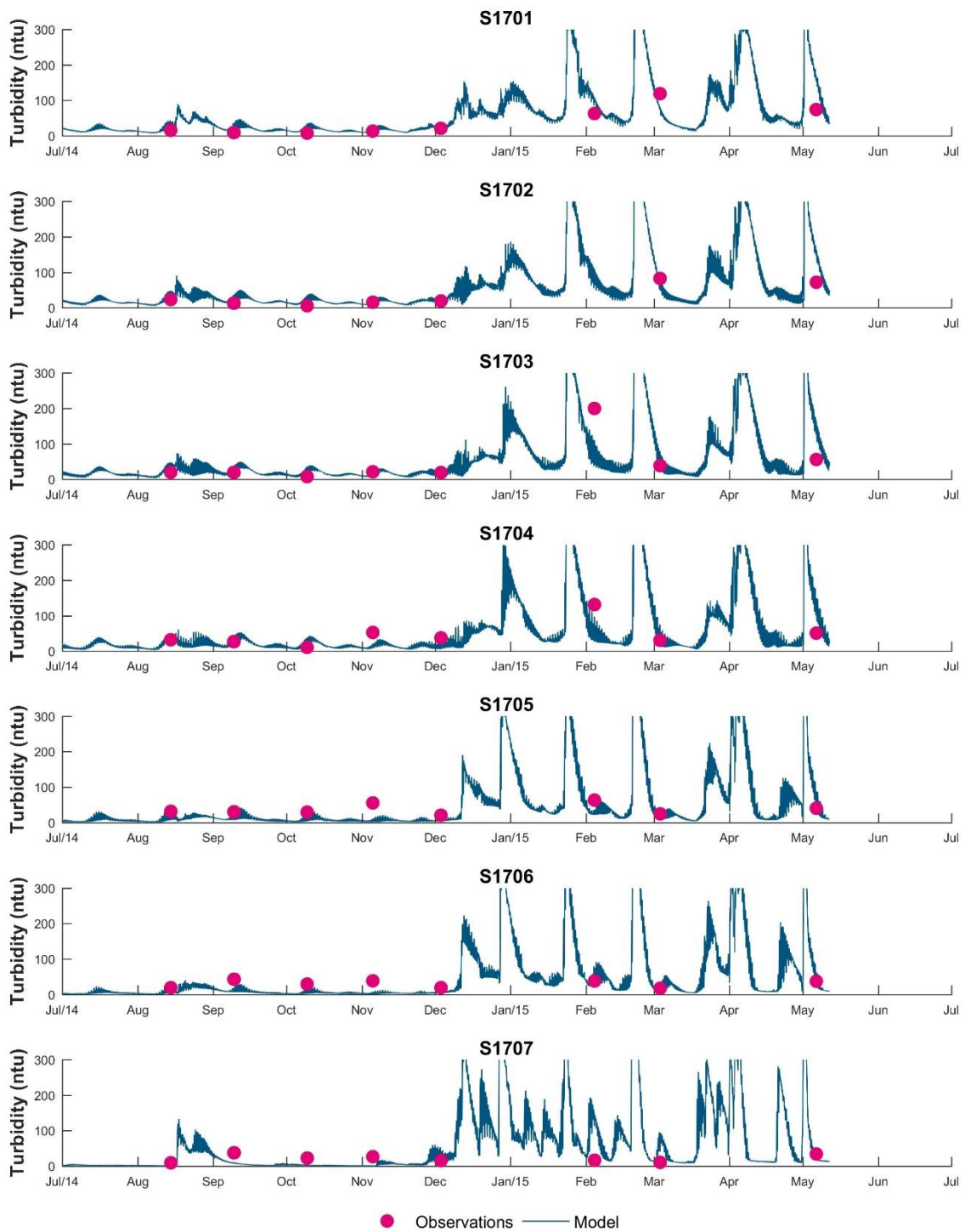


Figure A-106 Turbidity timeseries plot for Albert

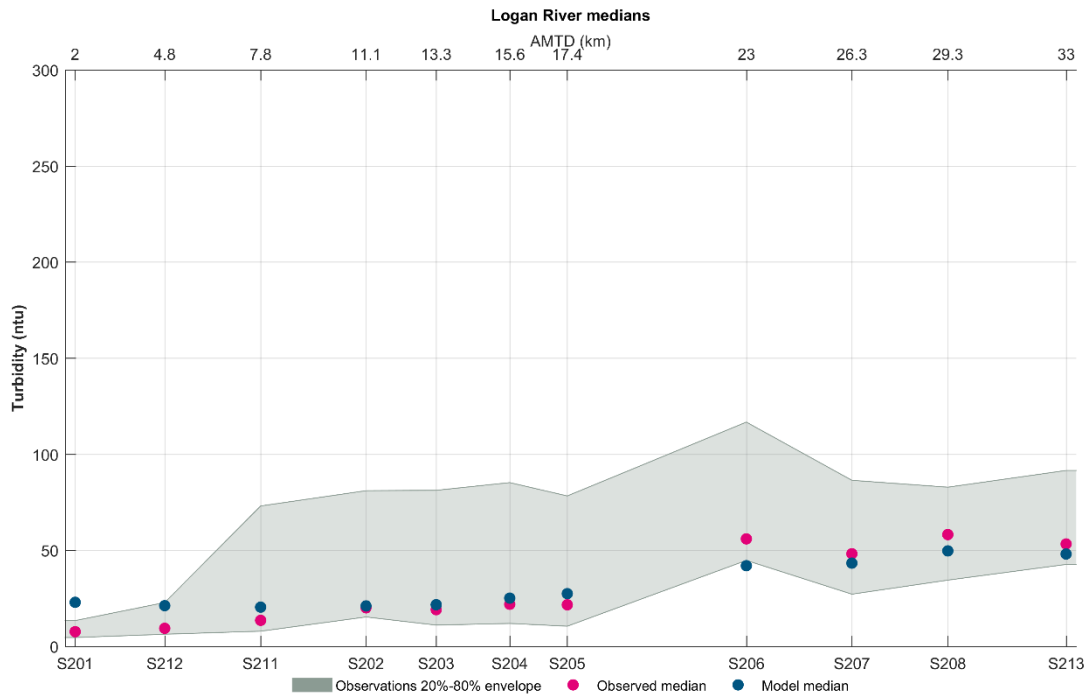


Figure A-107 Turbidity thalweg comparison Logan

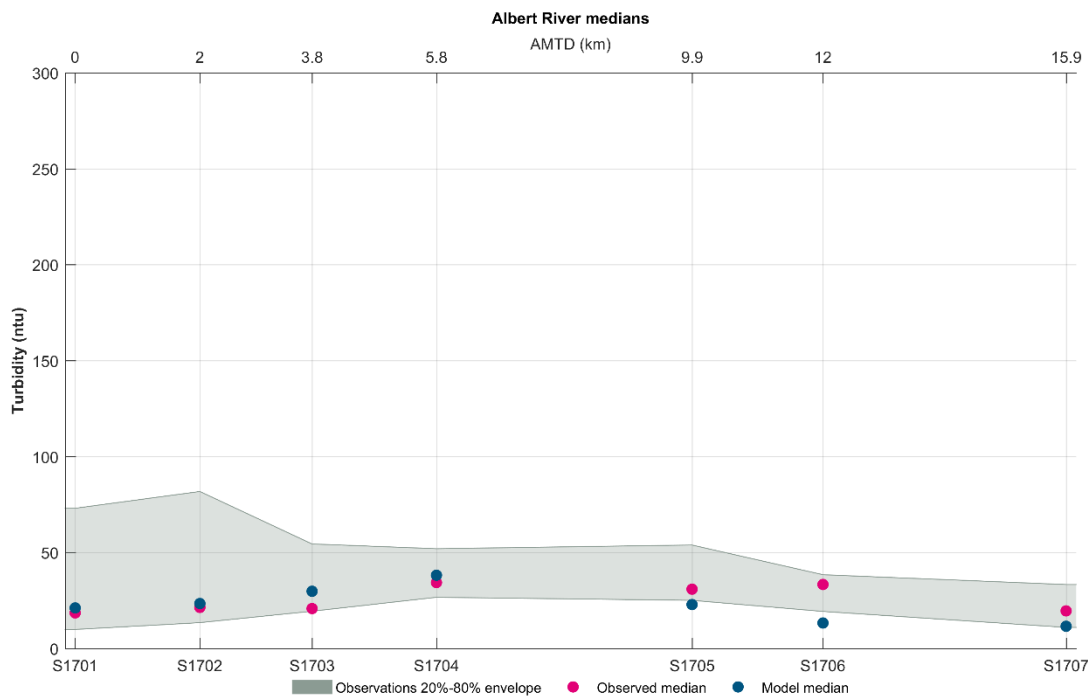


Figure A-108 Turbidity thalweg comparison Albert

### A.7.2 Dissolved oxygen deficit

Dissolved oxygen deficit calibration information is presented below.

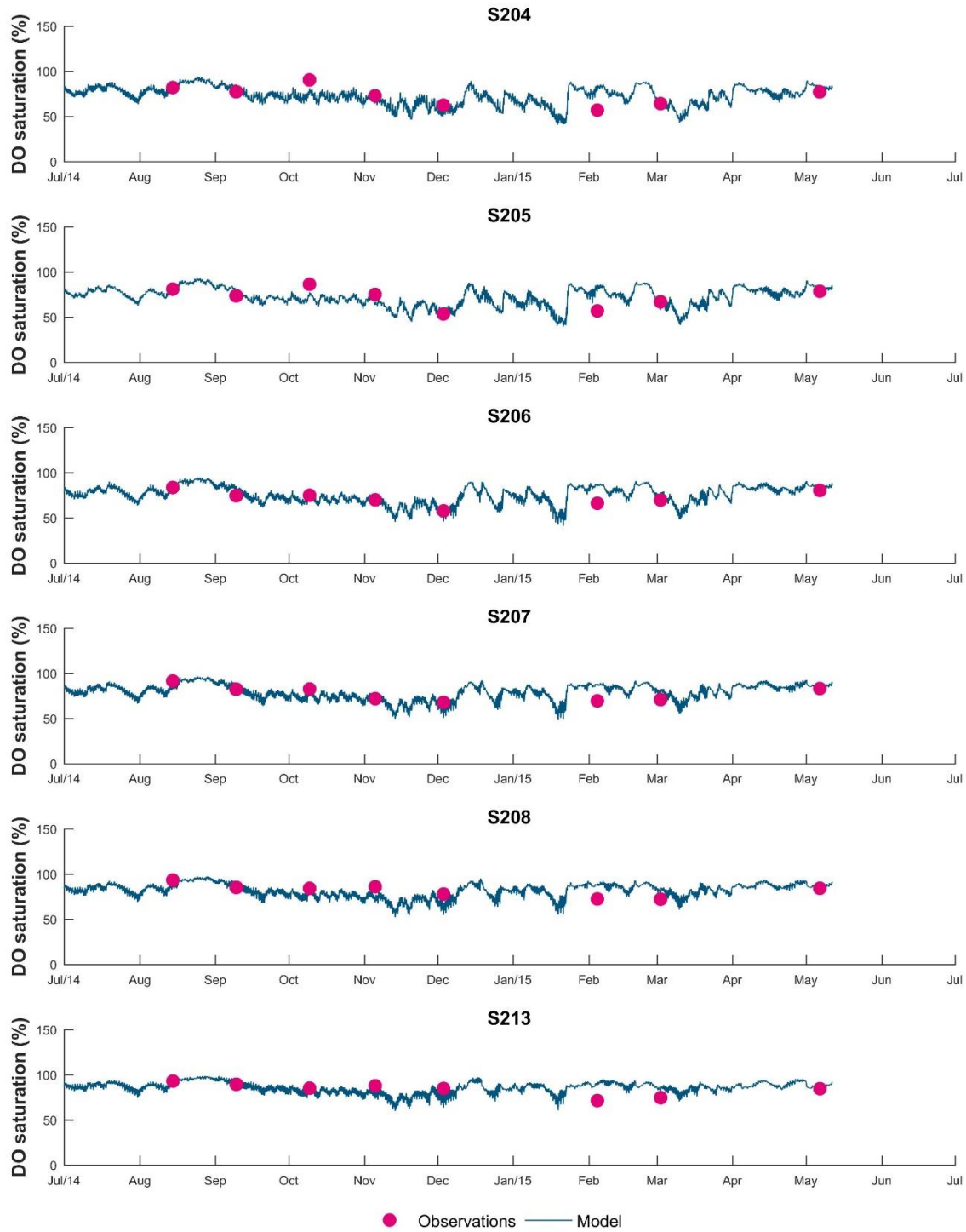


Figure A-109 Dissolved oxygen deficit timeseries plot for Logan D/s

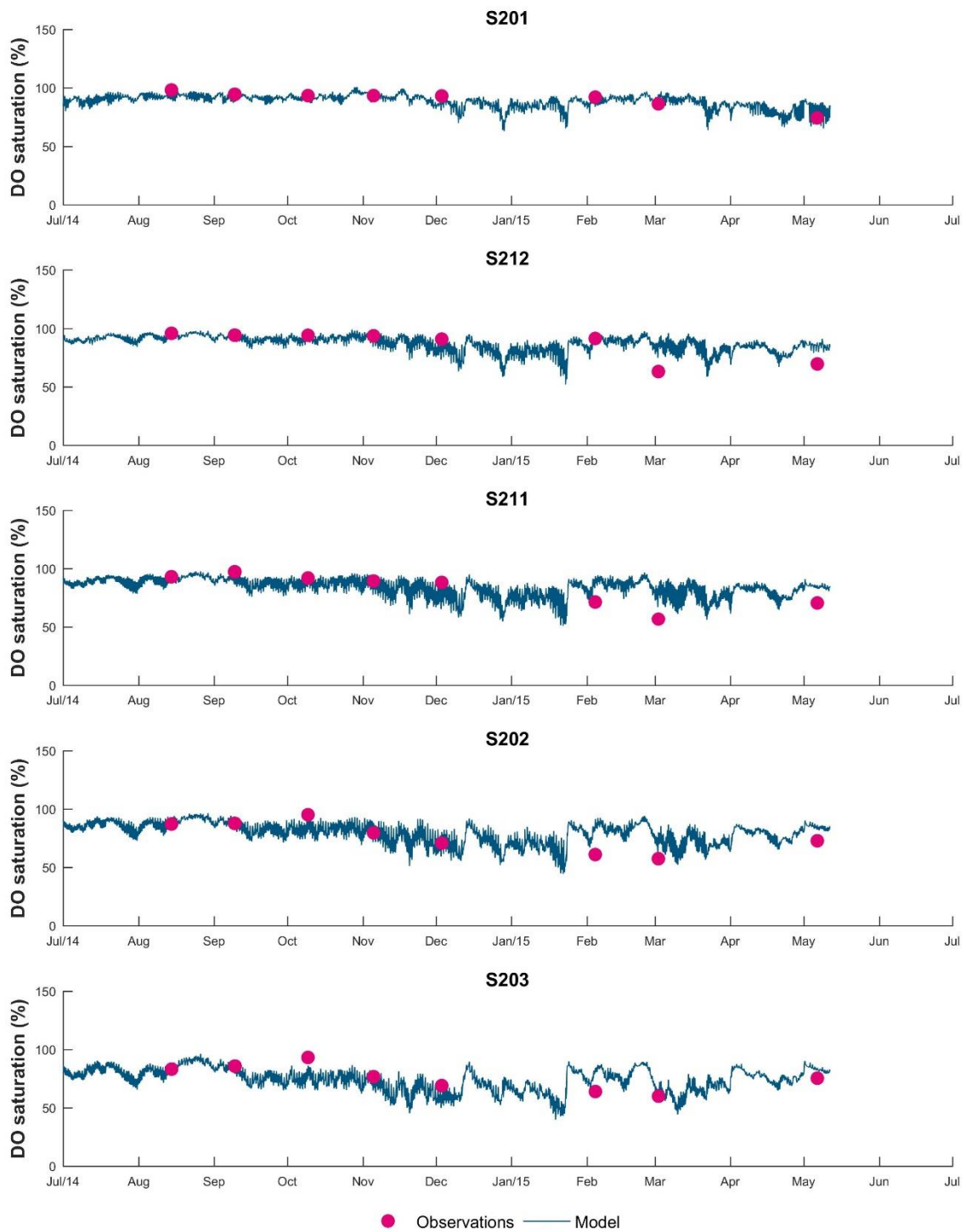


Figure A-110 Dissolved oxygen deficit timeseries plot for Logan U/s

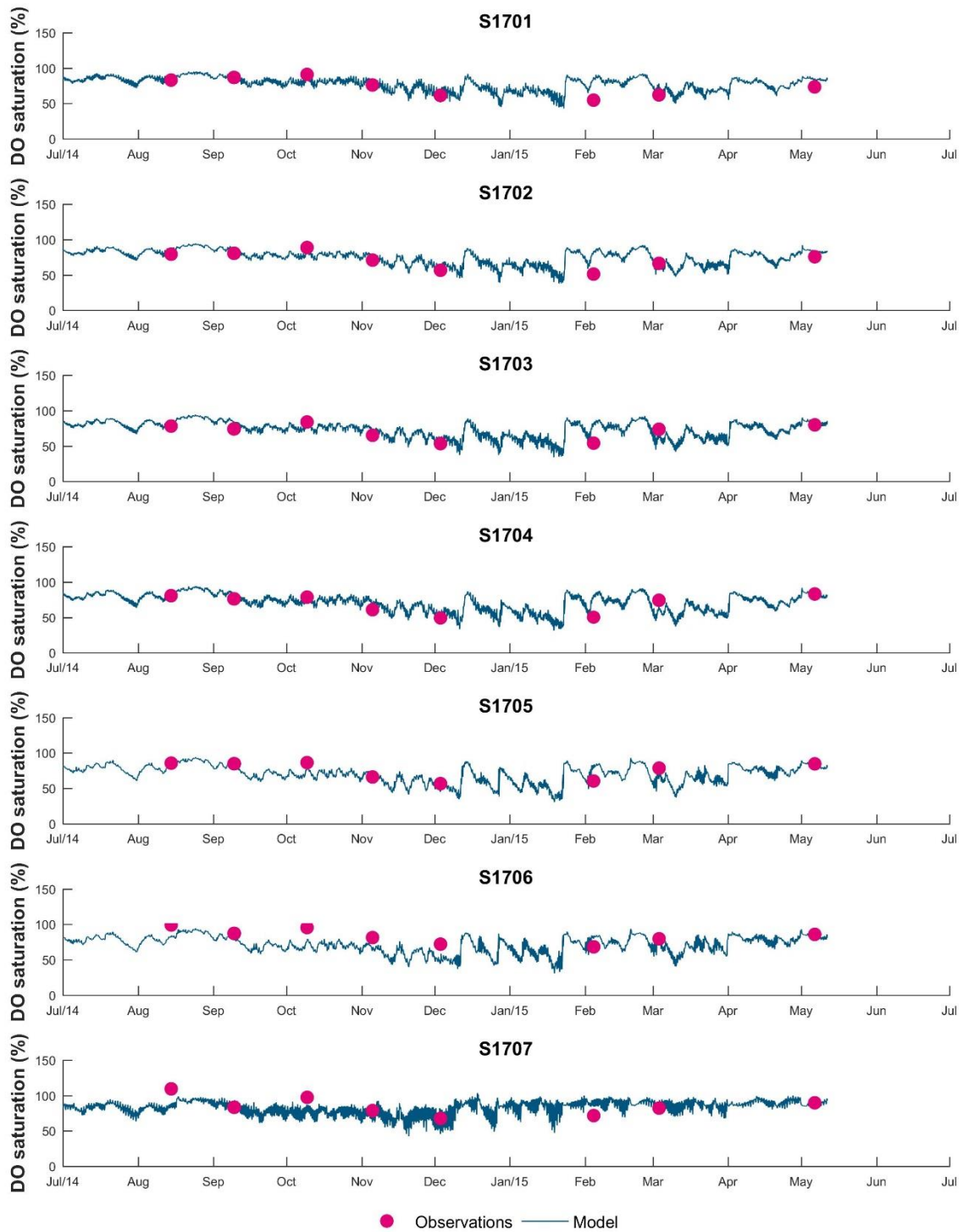


Figure A-111 Dissolved oxygen deficit timeseries plot for Albert

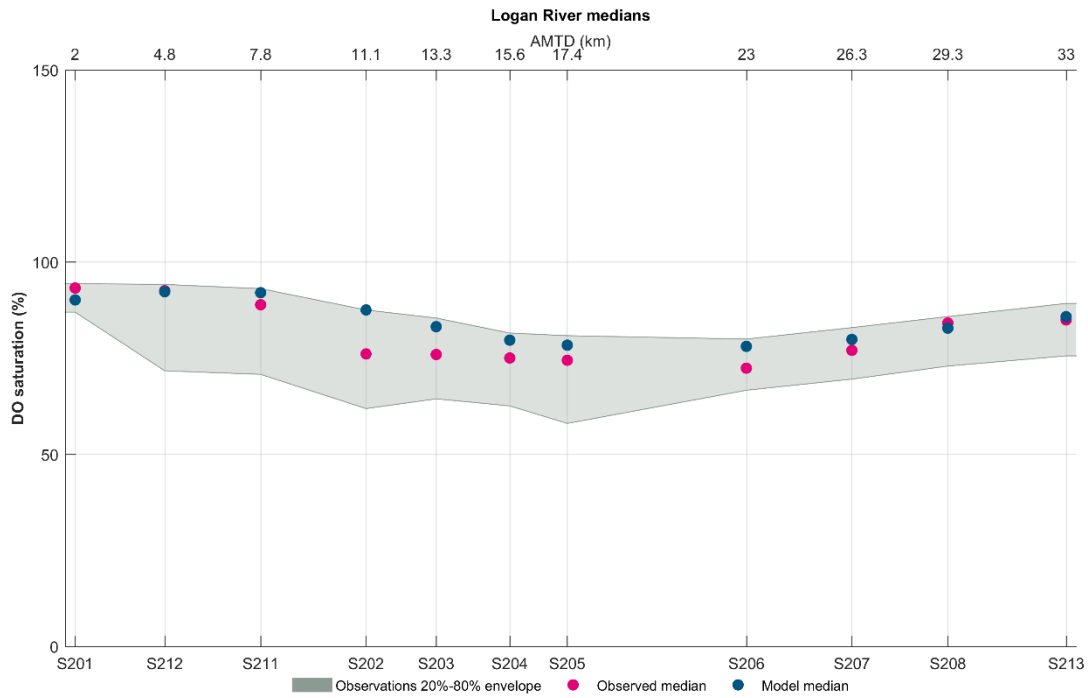


Figure A-112 Dissolved oxygen deficit thalweg comparison Logan

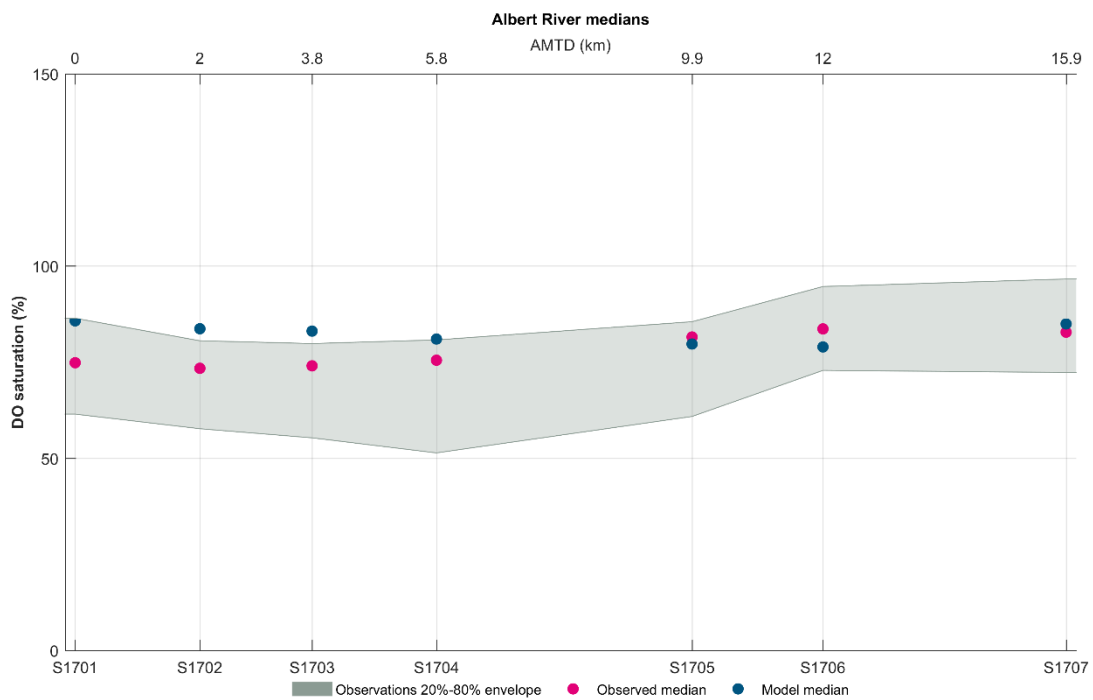


Figure A-113 Dissolved oxygen deficit thalweg comparison Albert

### A.7.3 Total Nitrogen

Total Nitrogen calibration information is presented below.

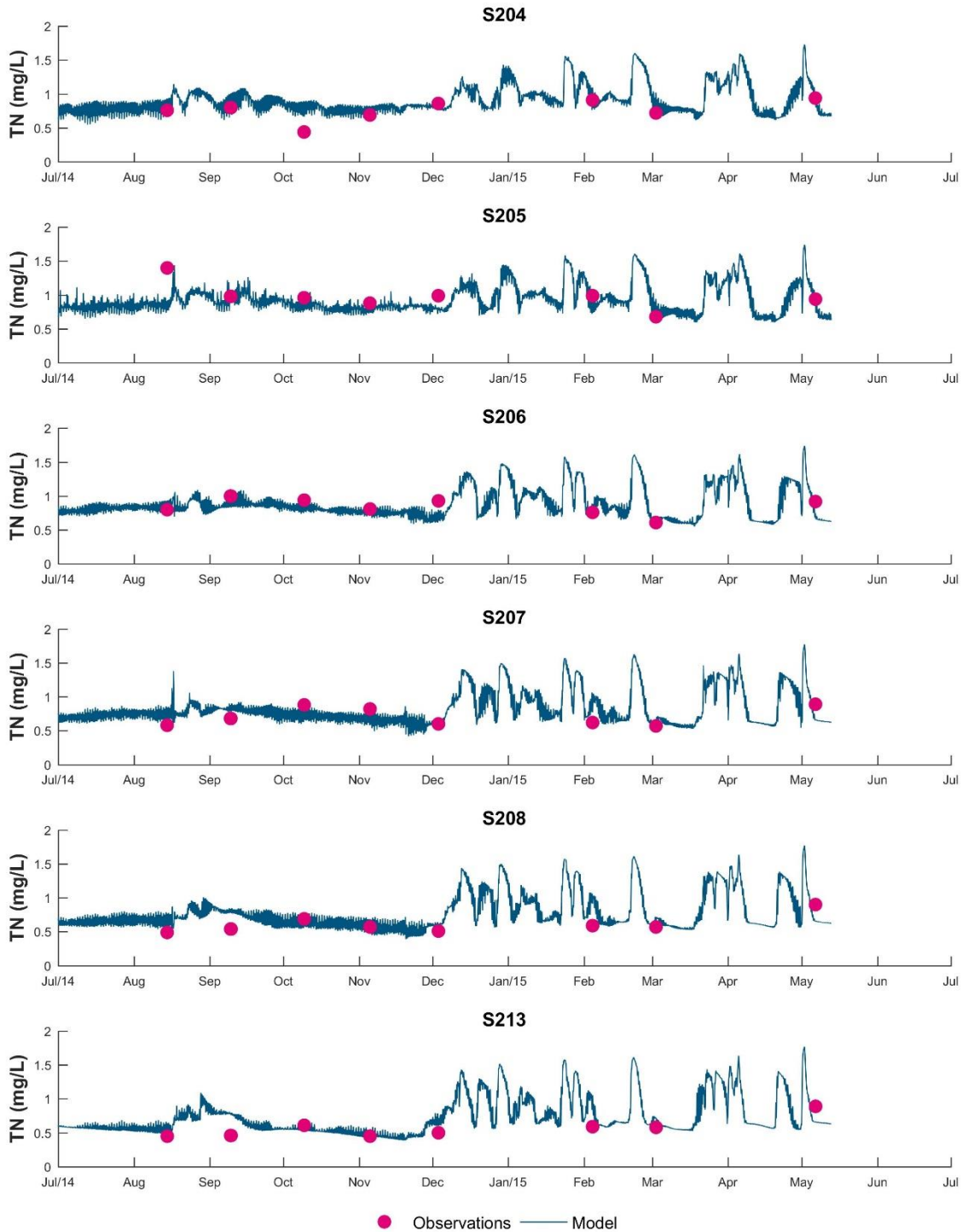


Figure A-114 Total Nitrogen timeseries plot for Logan D/s

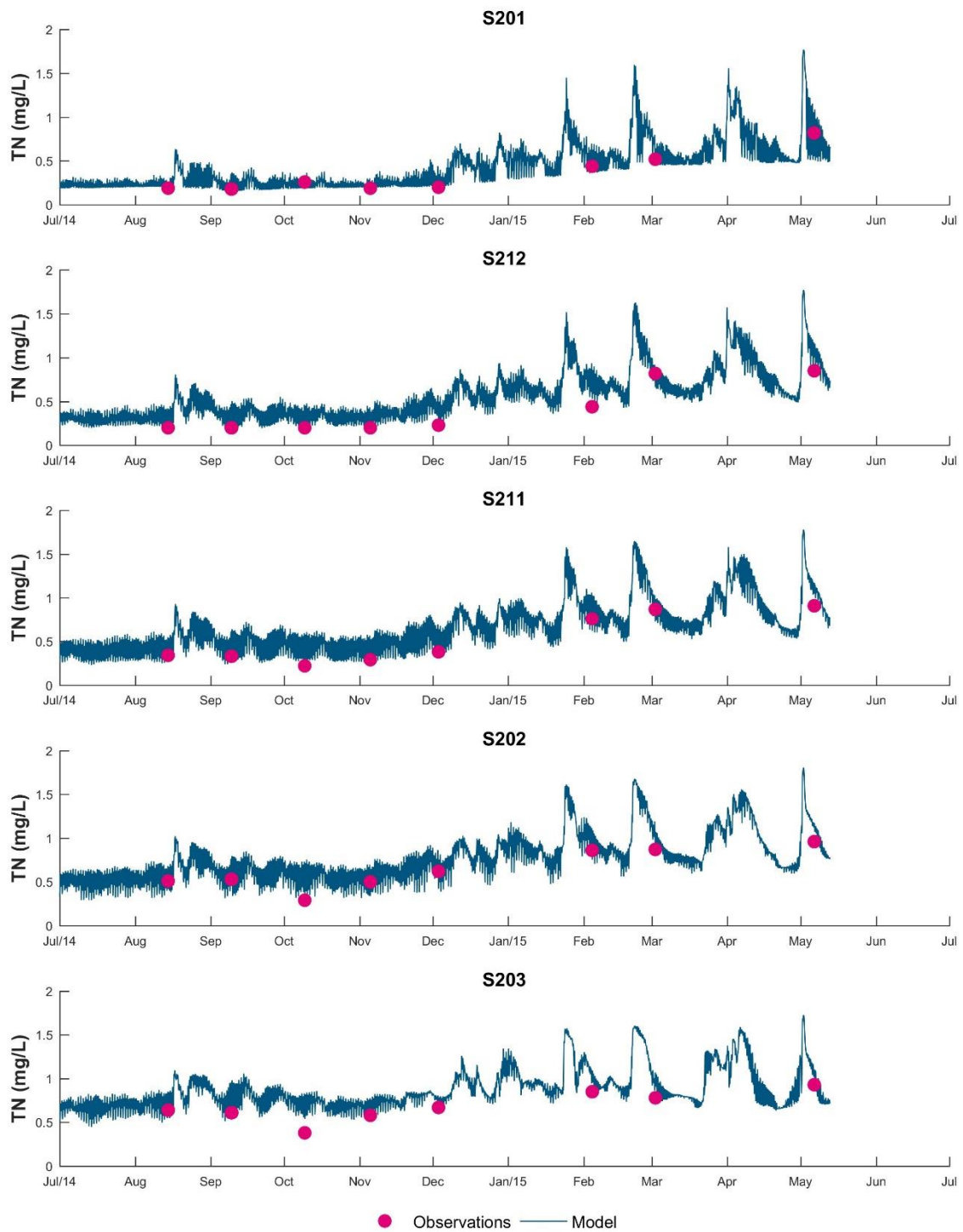


Figure A-115 Total Nitrogen timeseries plot for Logan U/s

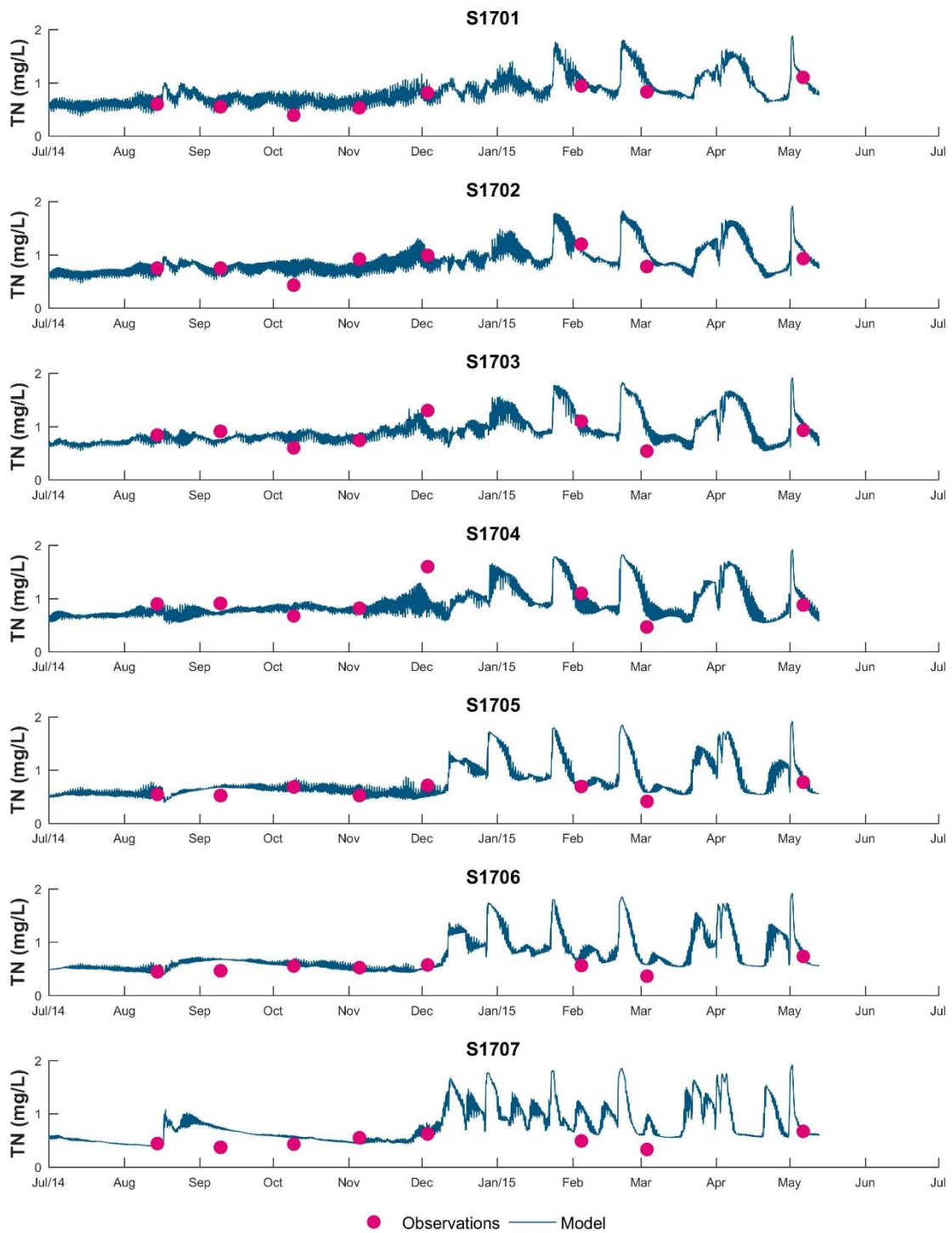


Figure A-116 Total Nitrogen timeseries plot for Albert

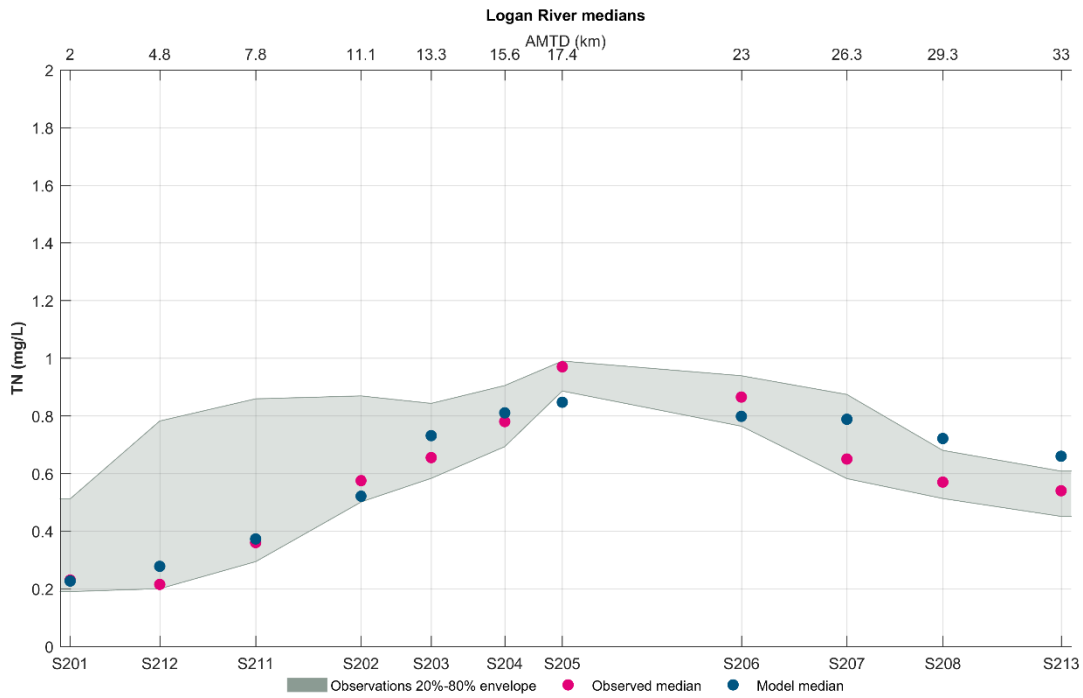


Figure A-117 Total Nitrogen thalweg comparison Logan

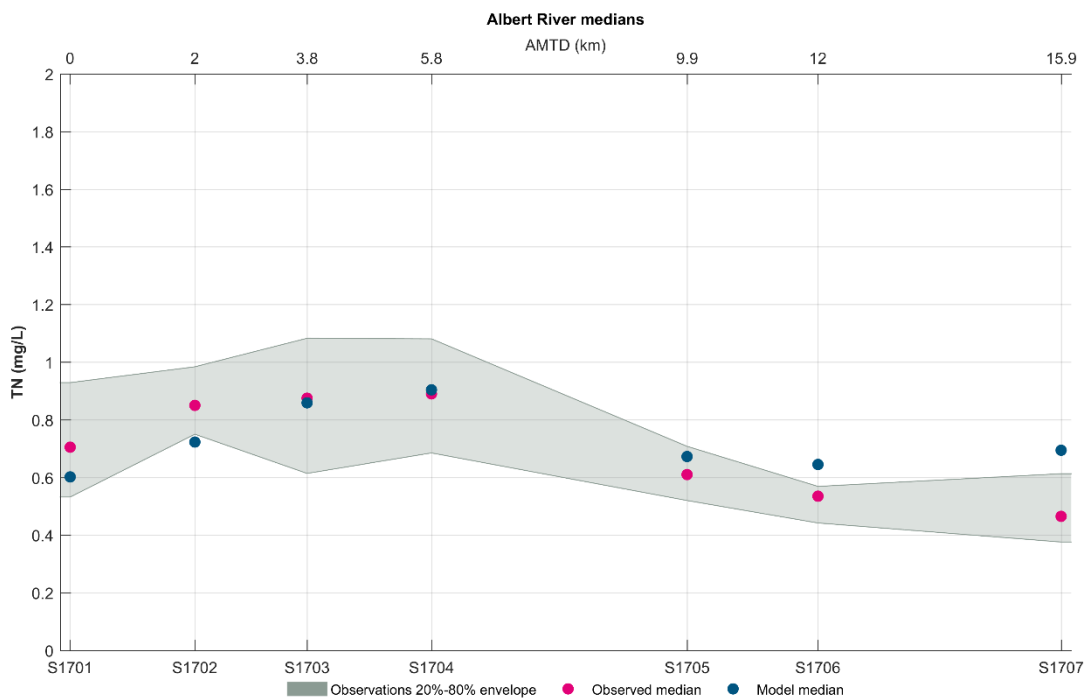


Figure A-118 Total Nitrogen thalweg comparison Albert

### A.7.4 Total phosphorus

Total phosphorous calibration information is presented below.

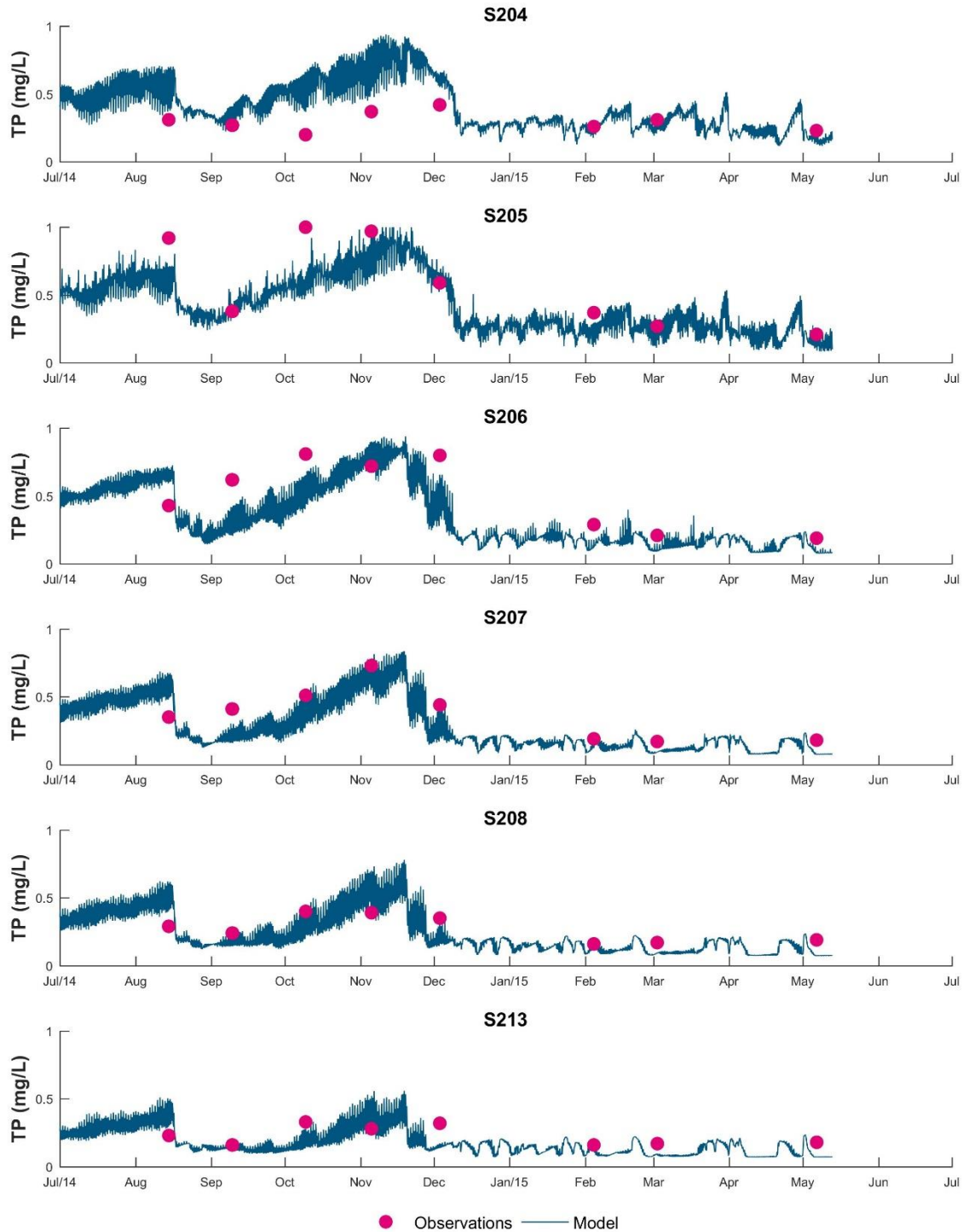


Figure A-119 Total phosphorus timeseries plot for Logan D/s

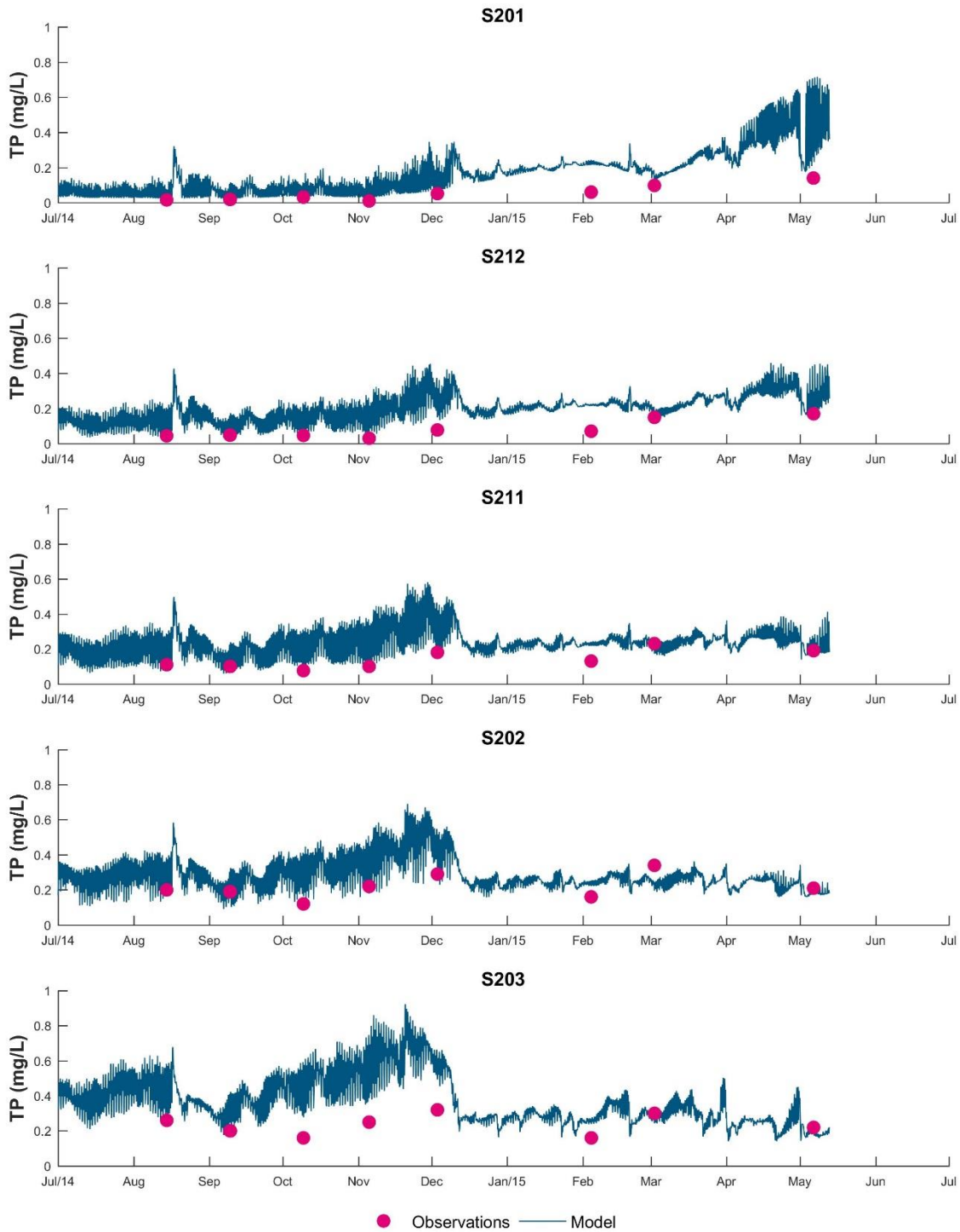


Figure A-120 Total phosphorus timeseries plot for Logan U/s

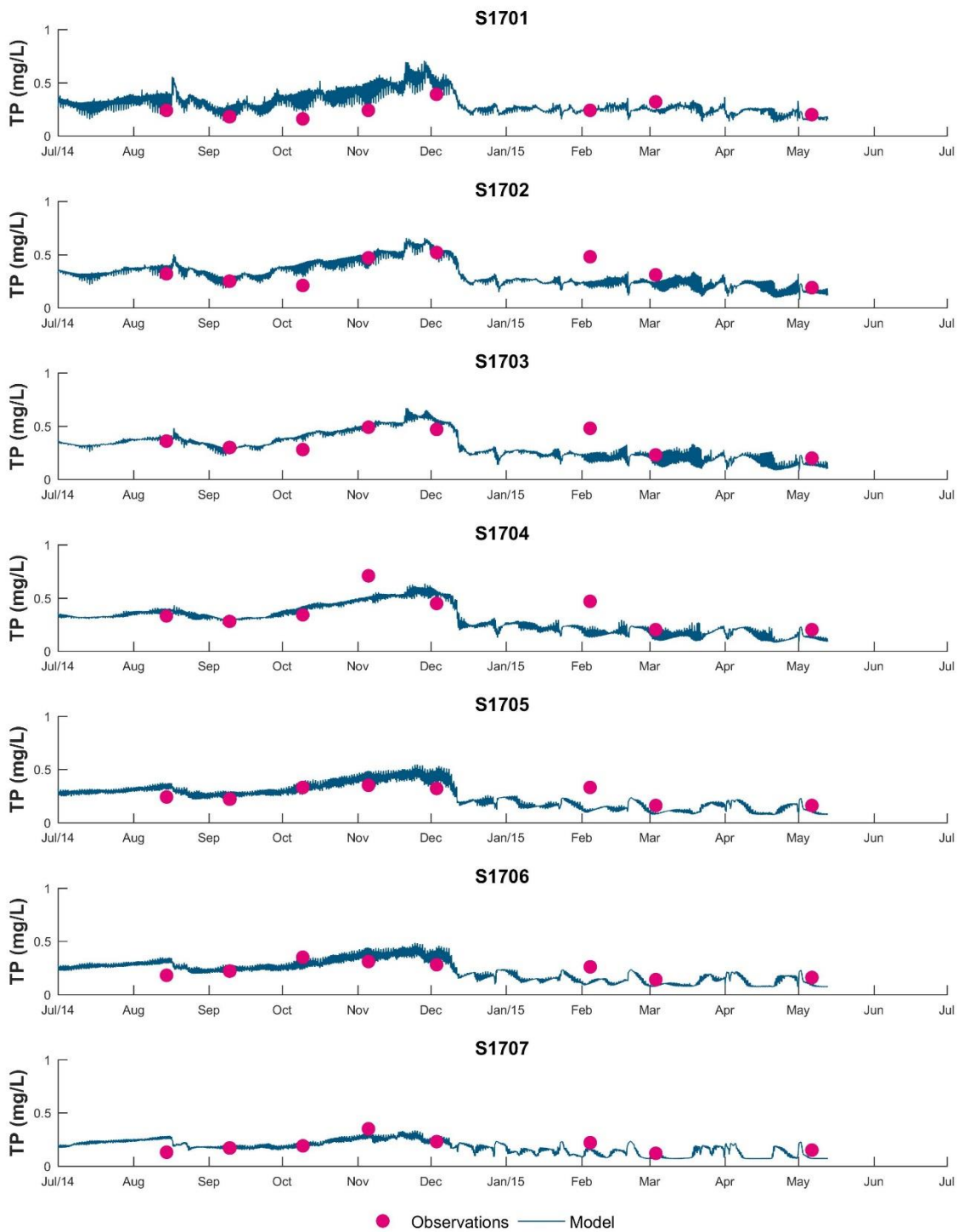


Figure A-121 Total phosphorus timeseries plot for Albert

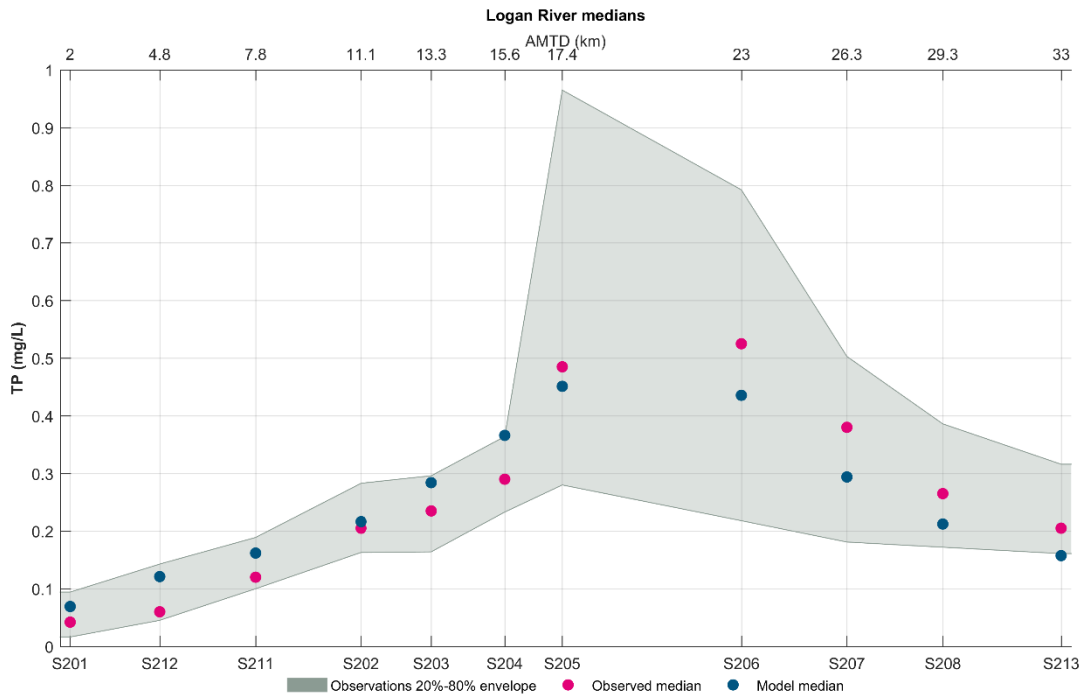


Figure A-122 Total phosphorus thalweg comparison Logan

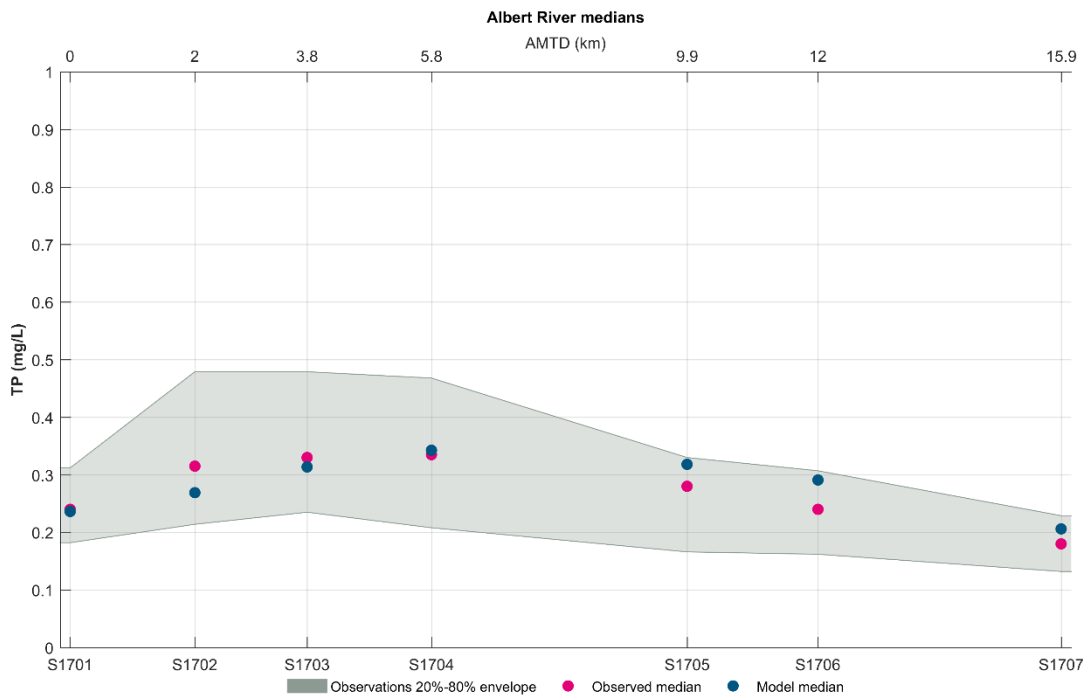


Figure A-123 Total phosphorus thalweg comparison Albert

### A.7.5 Chlorophyll-a

Chlorophyll-a calibration information is presented below.

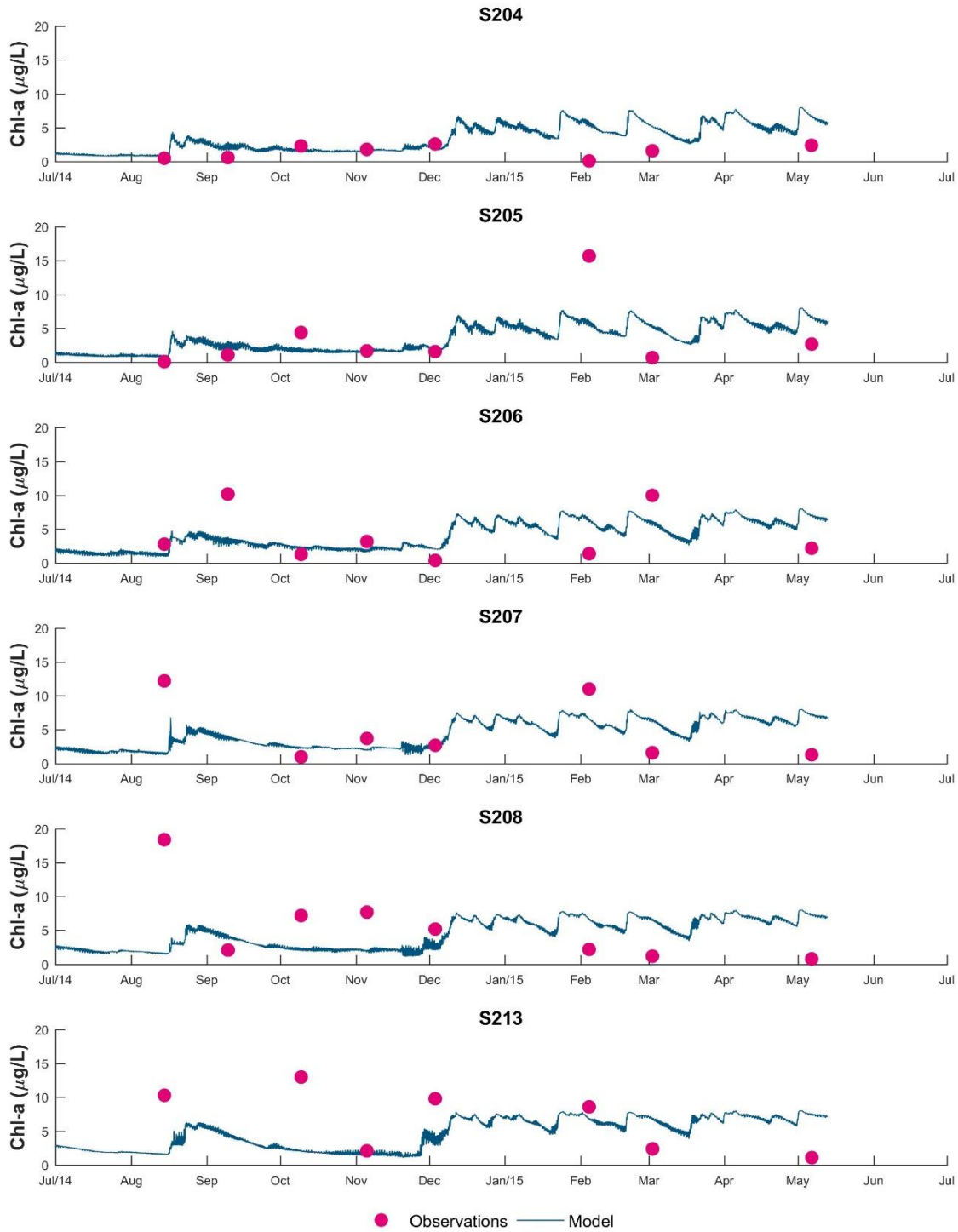


Figure A-124 Chlorophyll-a timeseries plot for Logan D/s

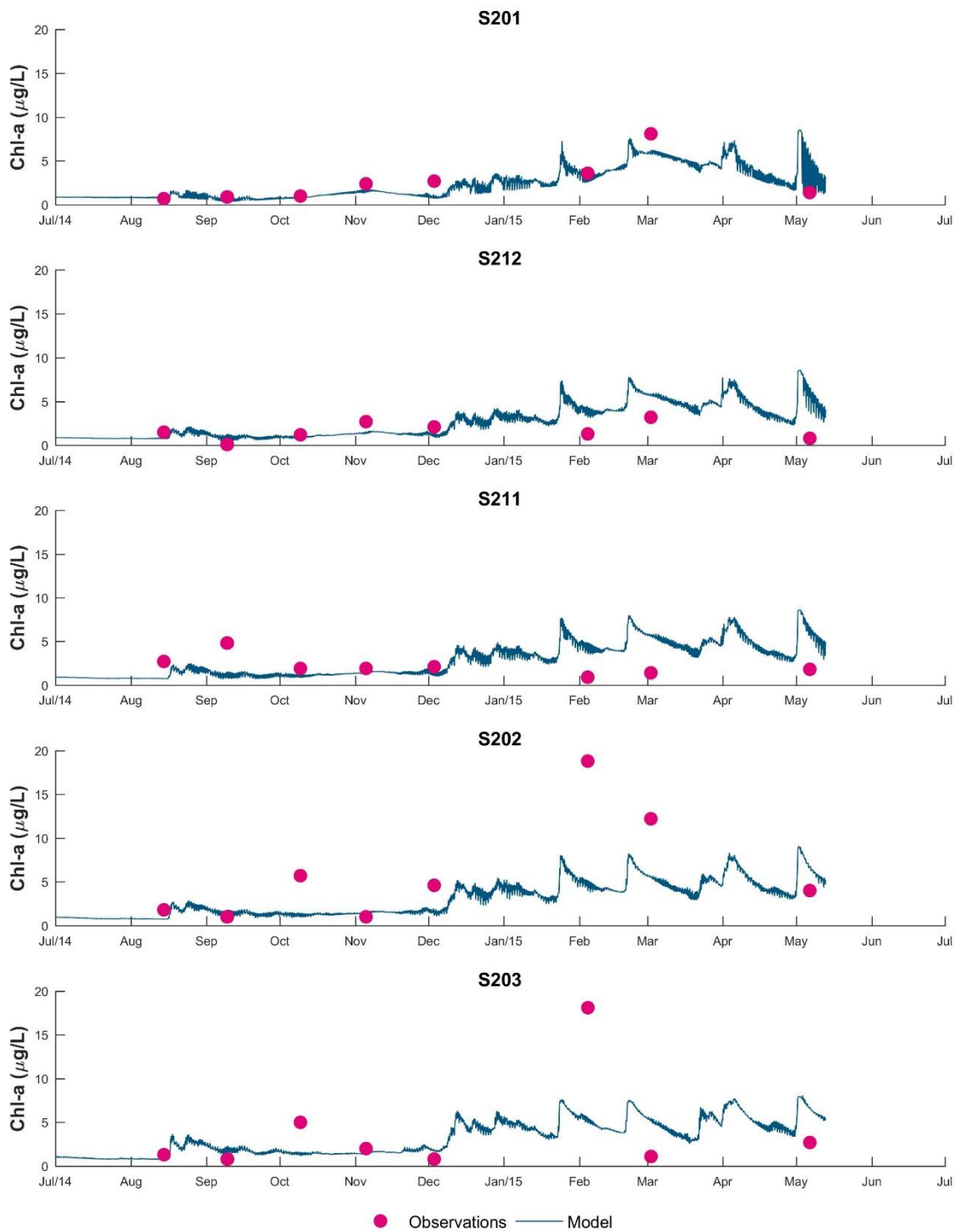


Figure A-125 Chlorophyll-a timeseries plot for Logan U/s

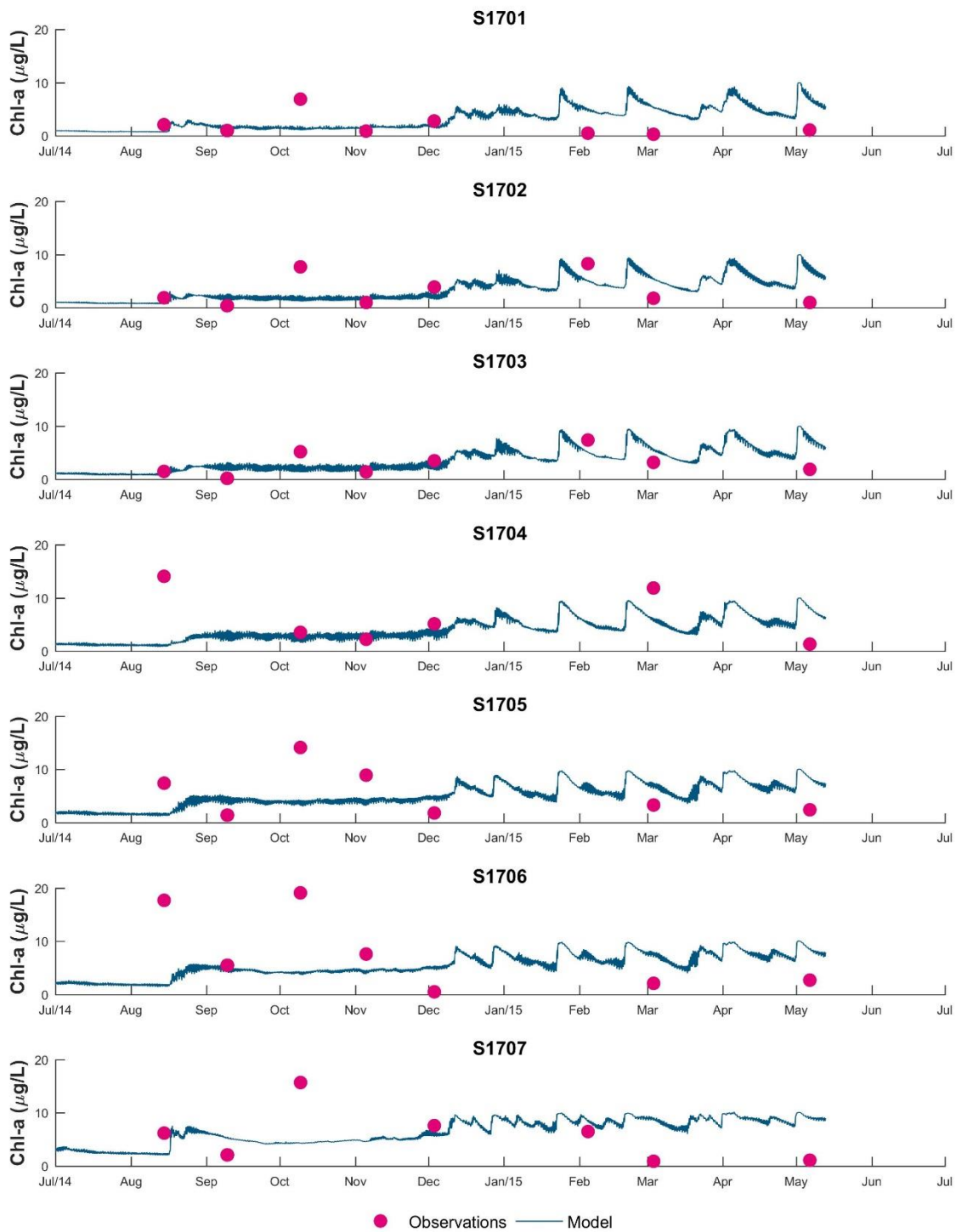


Figure A-126 Chlorophyll-a timeseries plot for Albert

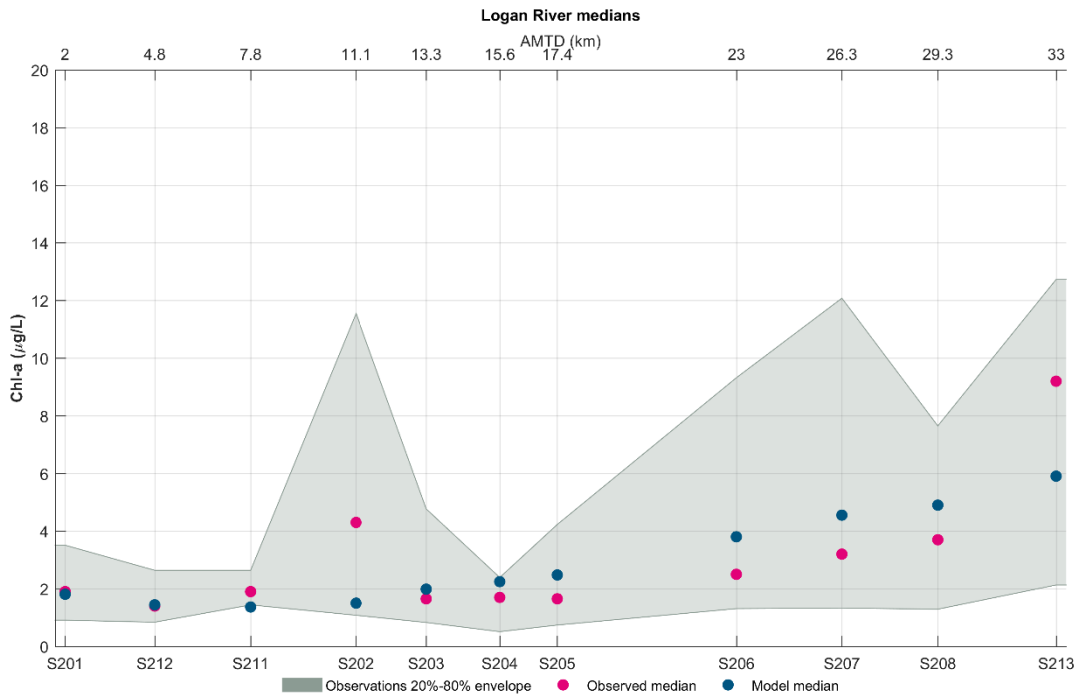


Figure A-127 Chlorophyll-a thalweg comparison Logan

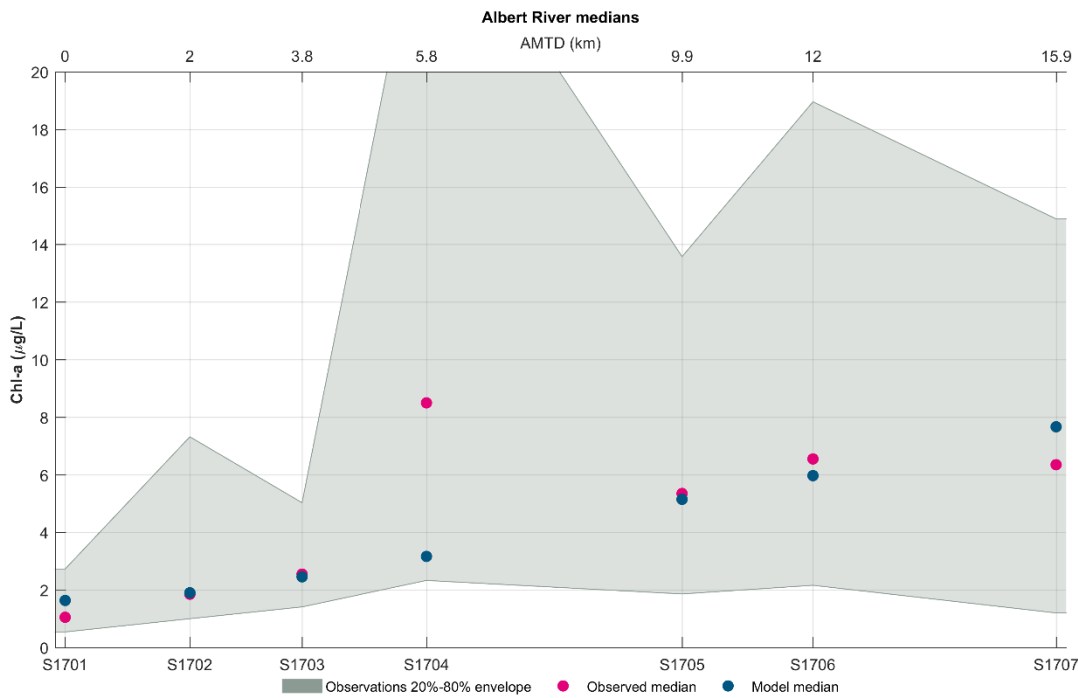


Figure A-128 Chlorophyll-a thalweg comparison Albert

## A.8 Moreton Bay

### A.8.1 Turbidity

Turbidity calibration information is presented below.

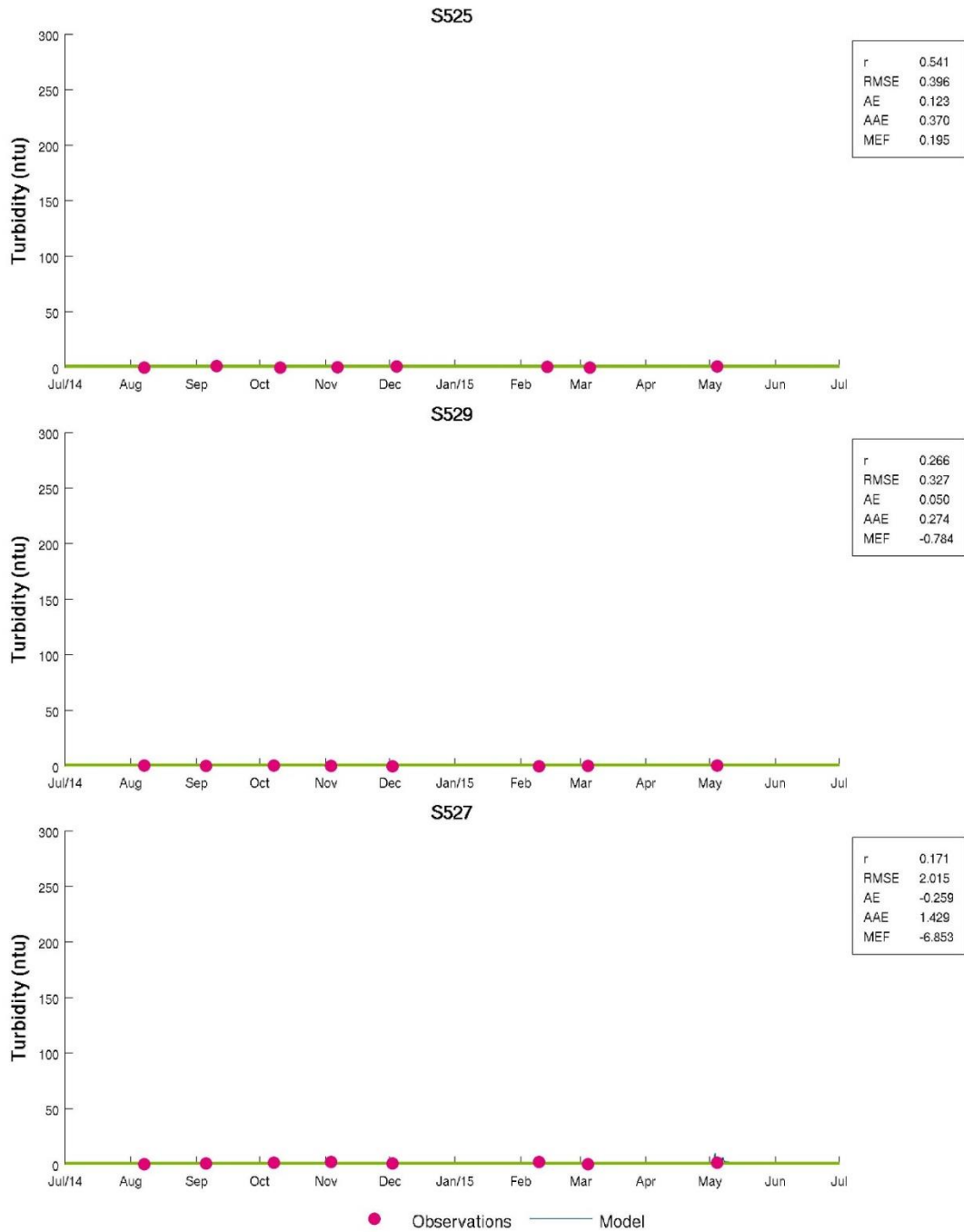


Figure A-129 Turbidity timeseries plot for Moreton Bay - Eastern

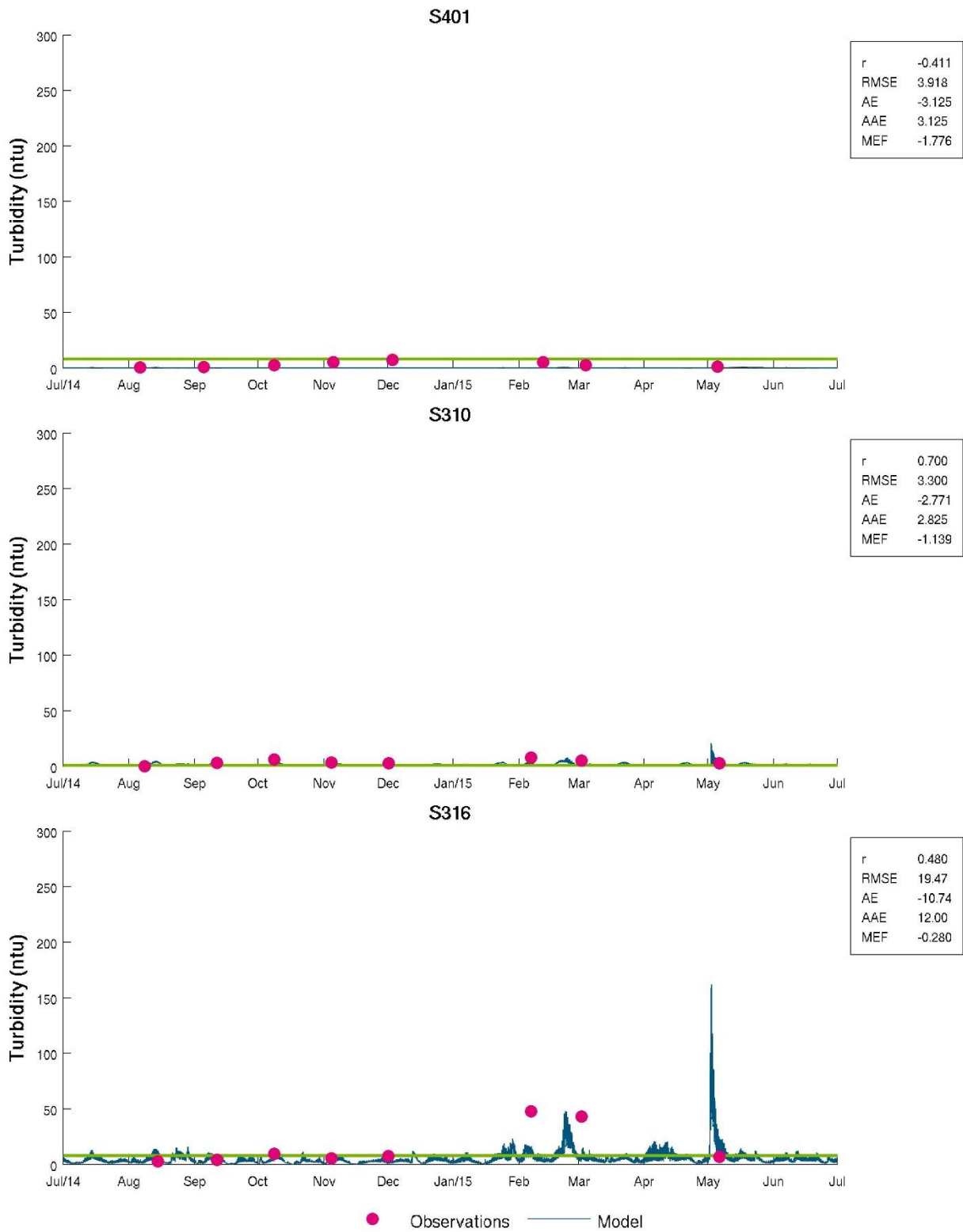


Figure A-130 Turbidity timeseries plot for Moreton Bay - Southern

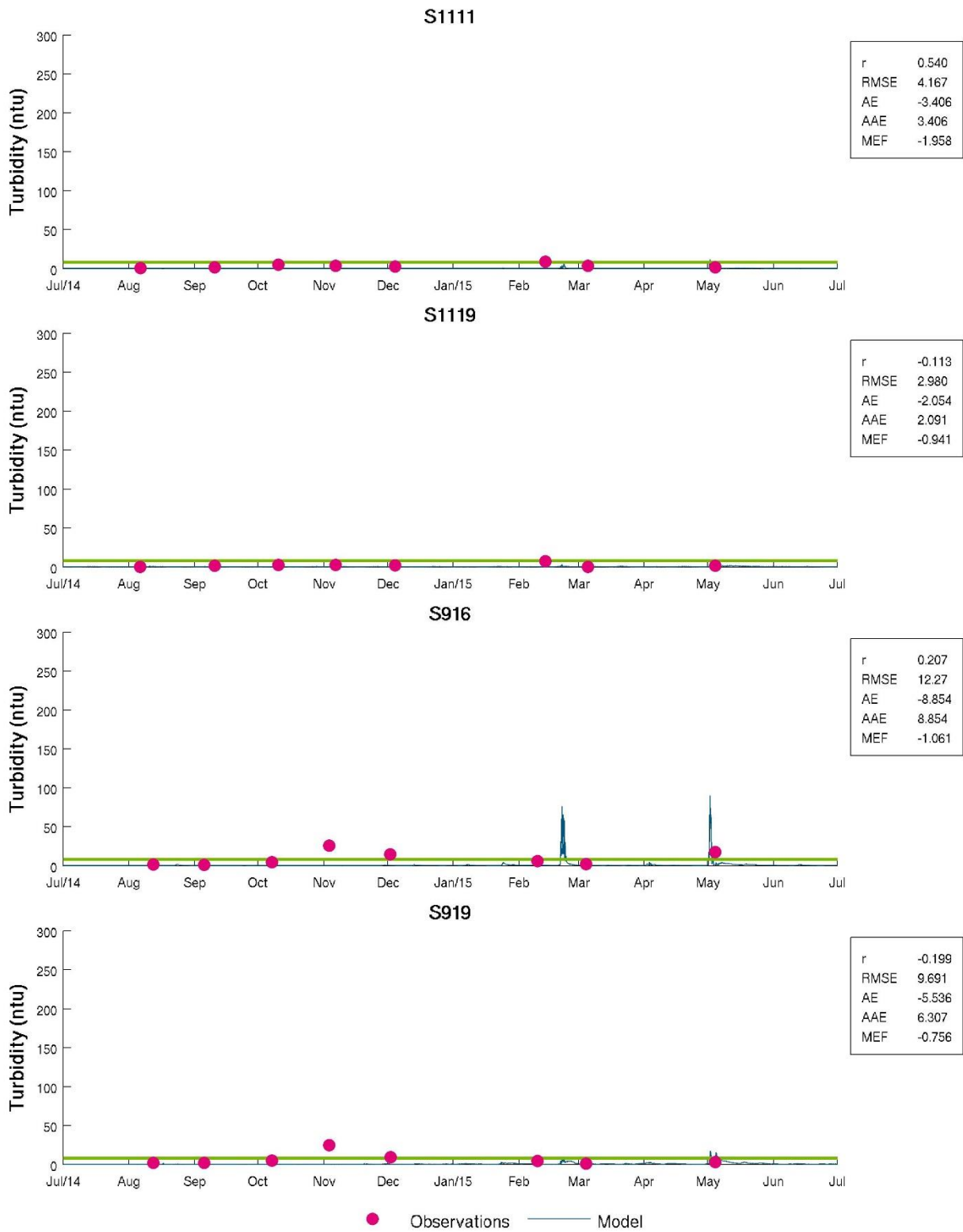
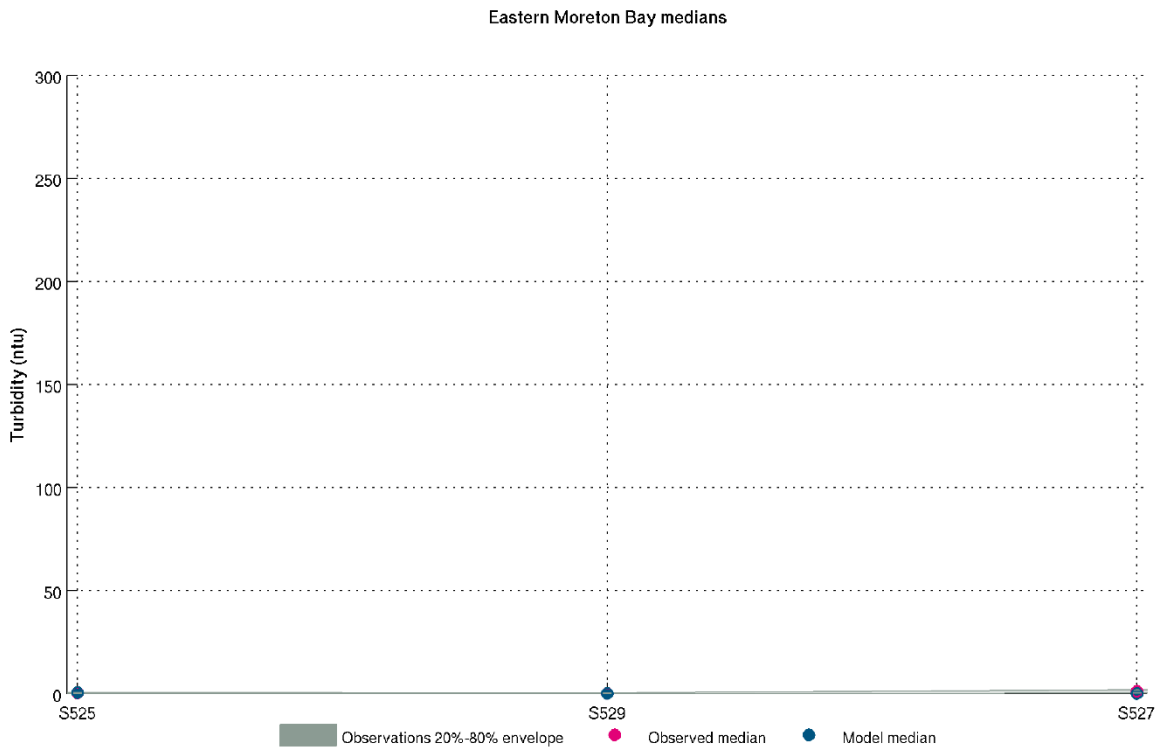
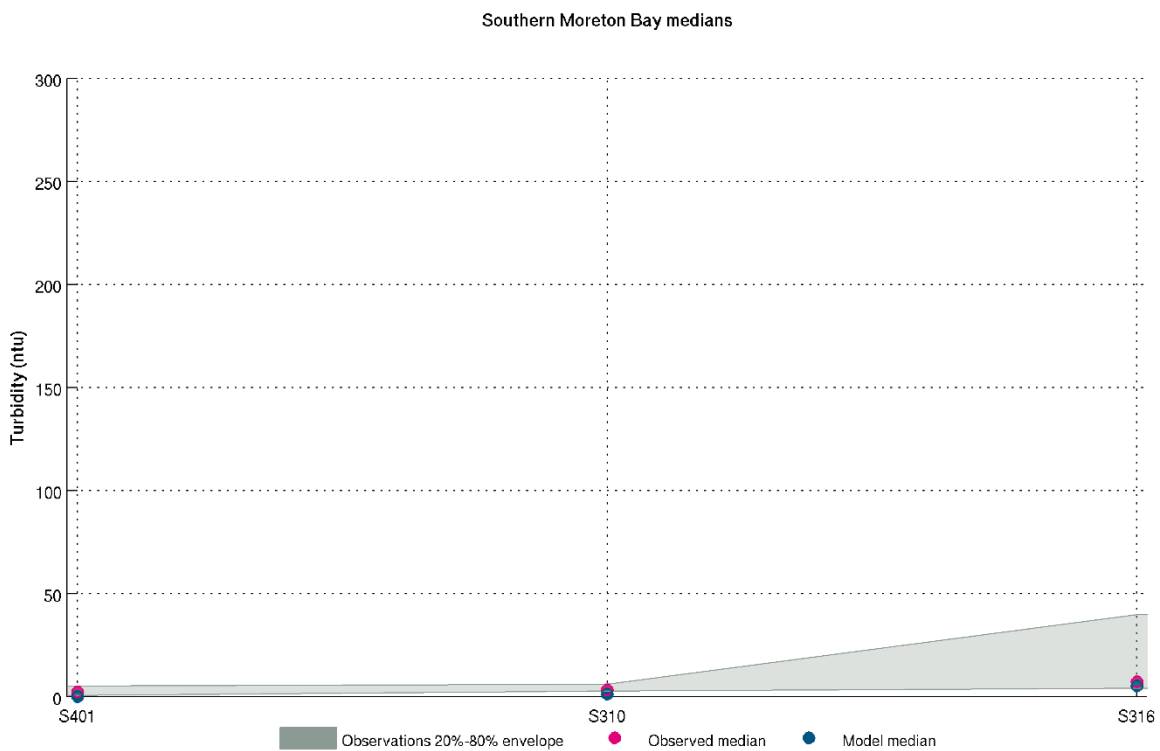


Figure A-131 Turbidity timeseries plot for Moreton Bay - Western



**Figure A-132 Turbidity thalweg comparison Moreton Bay – Eastern**



**Figure A-133 Turbidity thalweg comparison Moreton Bay - Southern**

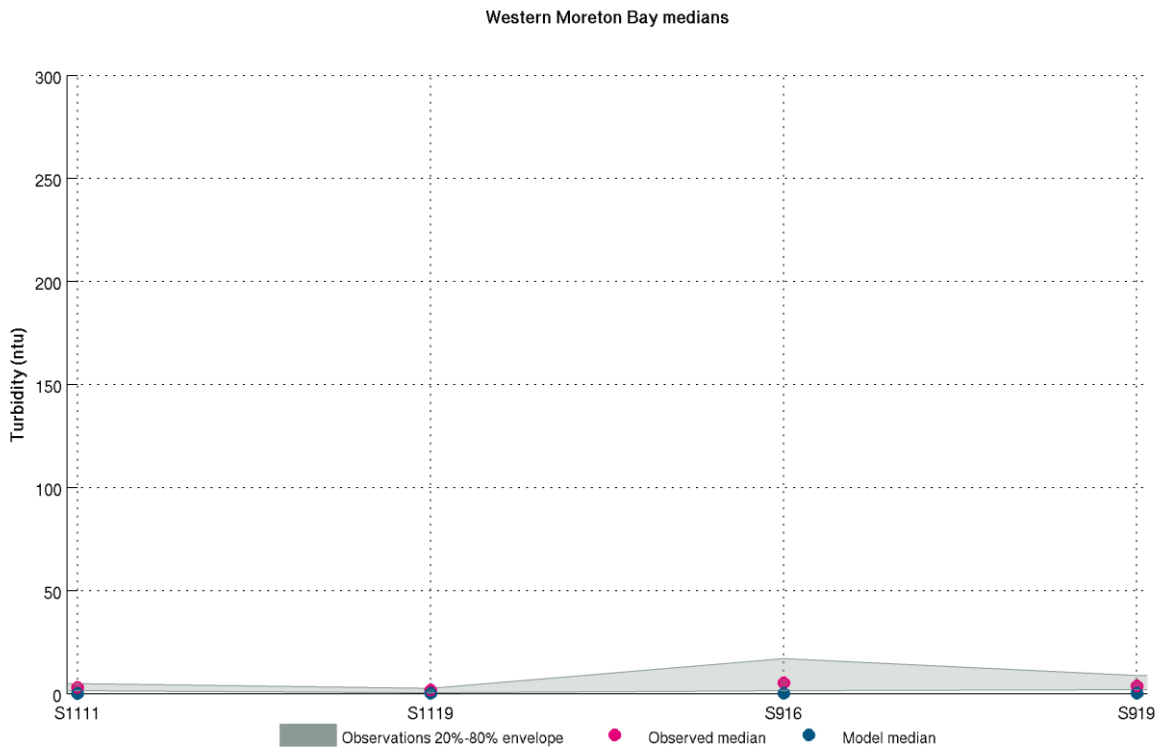


Figure A-134 Turbidity thalweg comparison Moreton Bay – Western

### A.8.2 Dissolved oxygen deficit

Dissolved oxygen deficit calibration information is presented below.

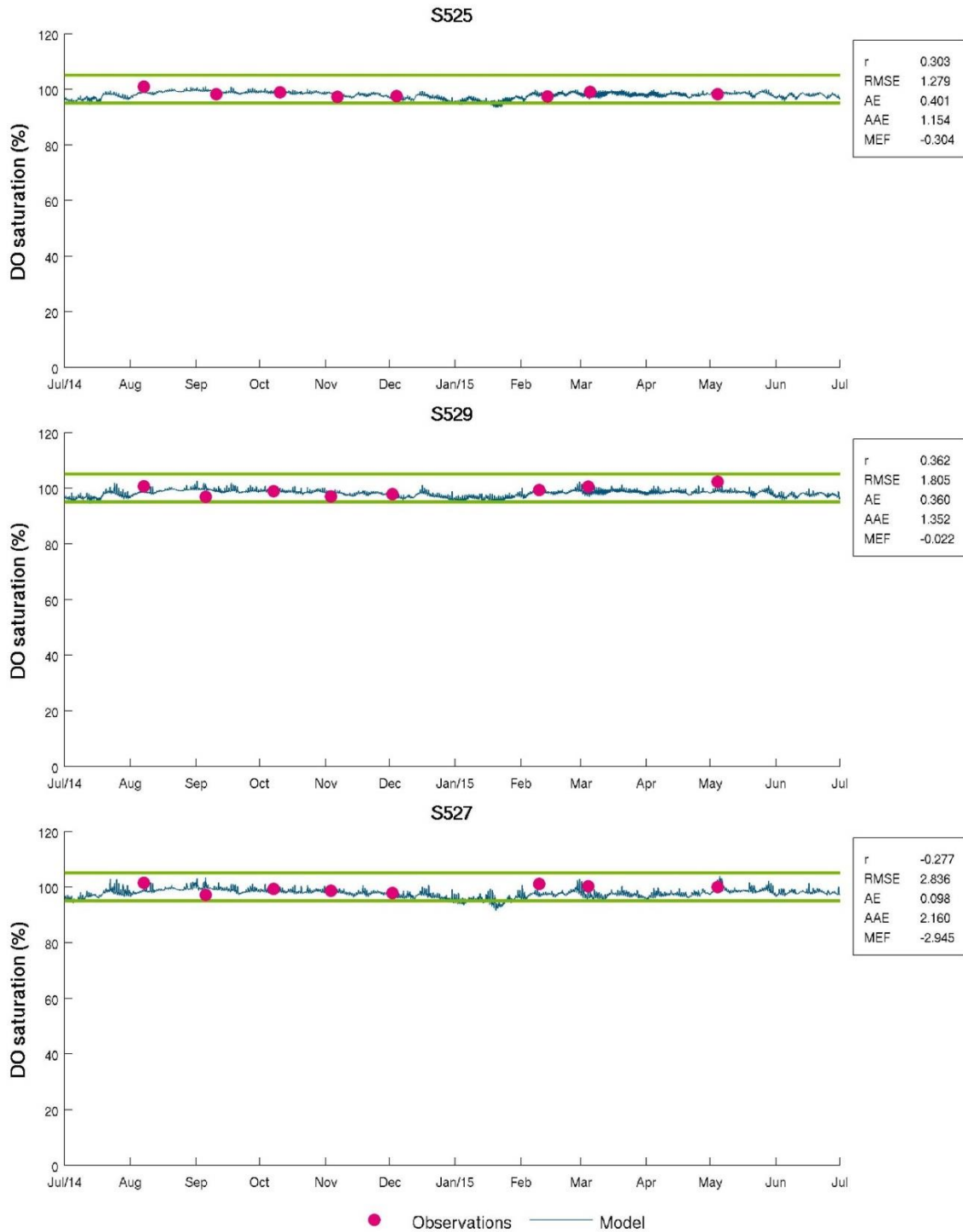


Figure A-135 Dissolved oxygen deficit timeseries plot for Moreton Bay - Eastern

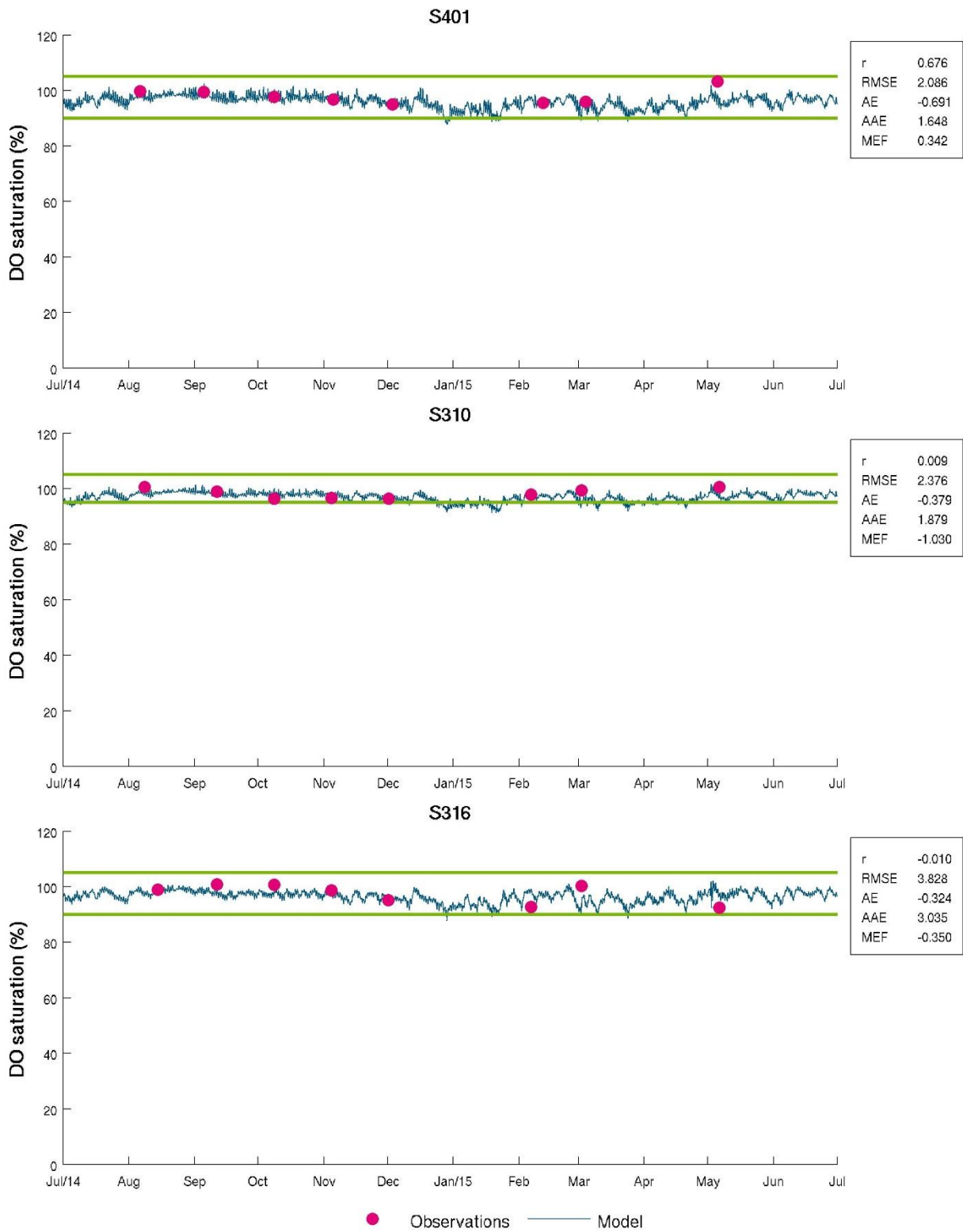


Figure A-136 Dissolved oxygen deficit timeseries plot for Moreton Bay - Southern

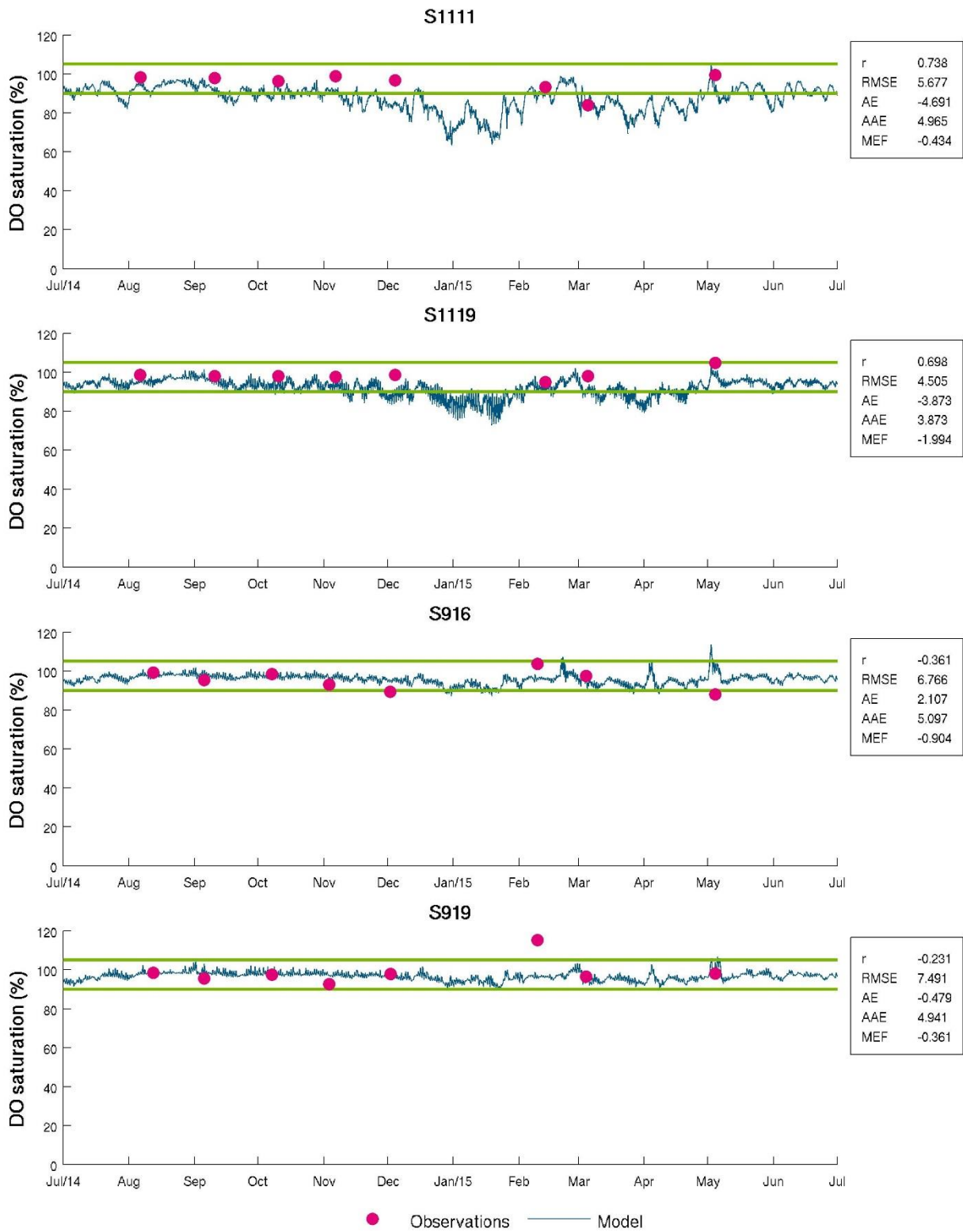
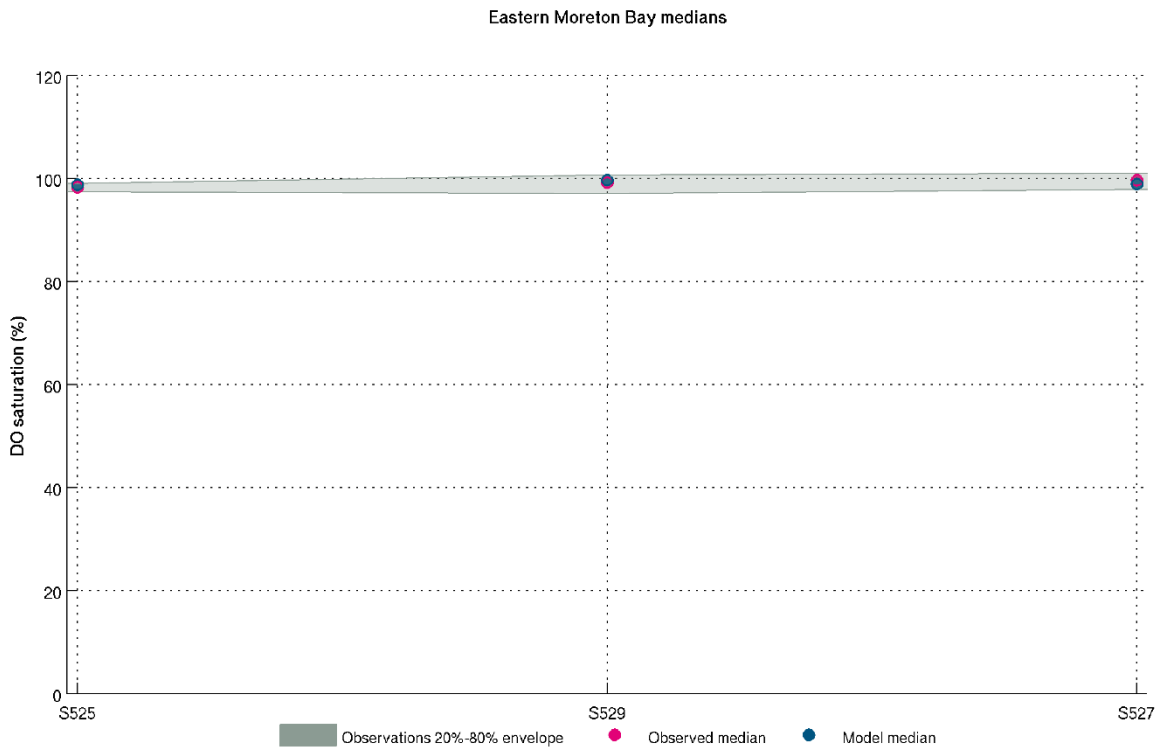
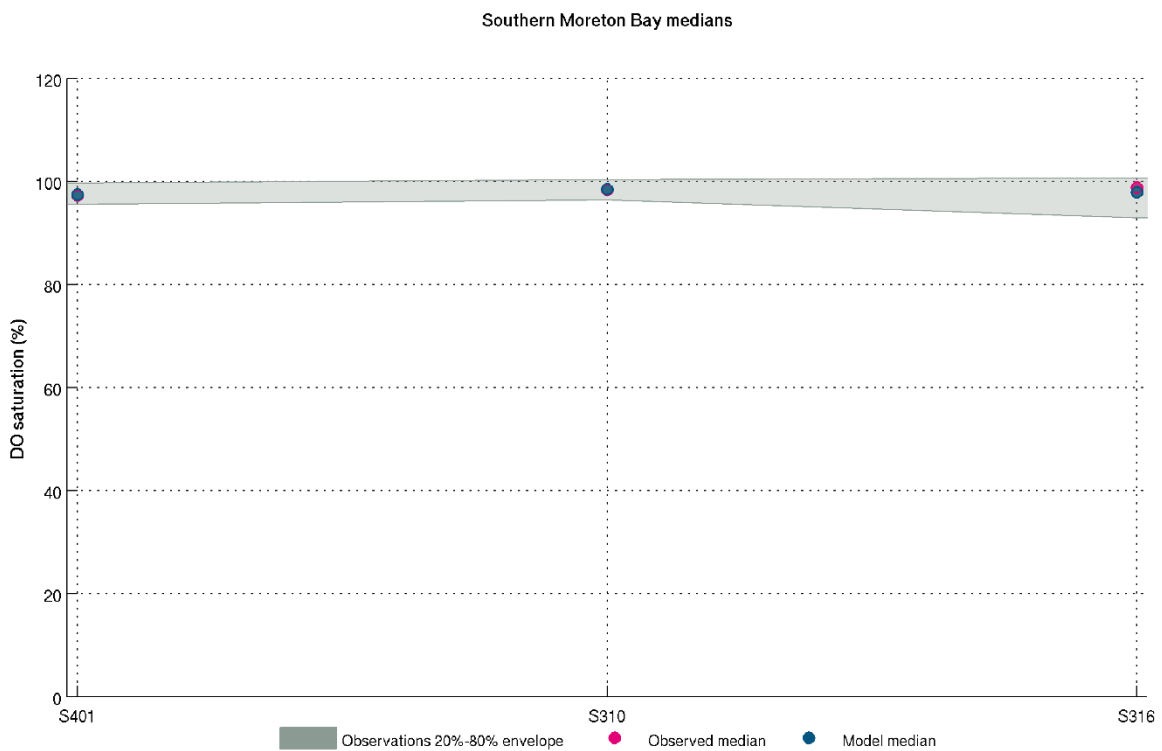


Figure A-137 Dissolved oxygen deficit timeseries plot for Moreton Bay - Western



**Figure A-138 Dissolved oxygen deficit thalweg comparison Moreton Bay – Eastern**



**Figure A-139 Dissolved oxygen deficit thalweg comparison Moreton Bay - Southern**

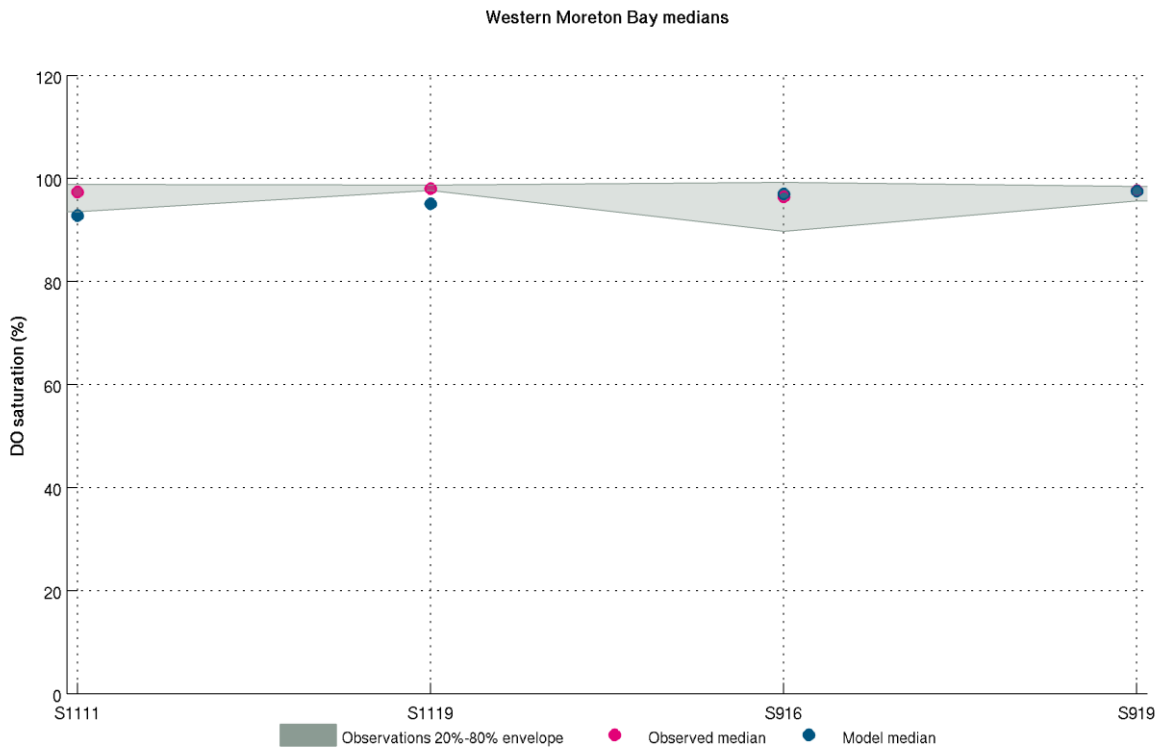


Figure A-140 Dissolved oxygen deficit thalweg comparison Moreton Bay - Western

### A.8.3 Total Nitrogen

Total Nitrogen calibration information is presented below.

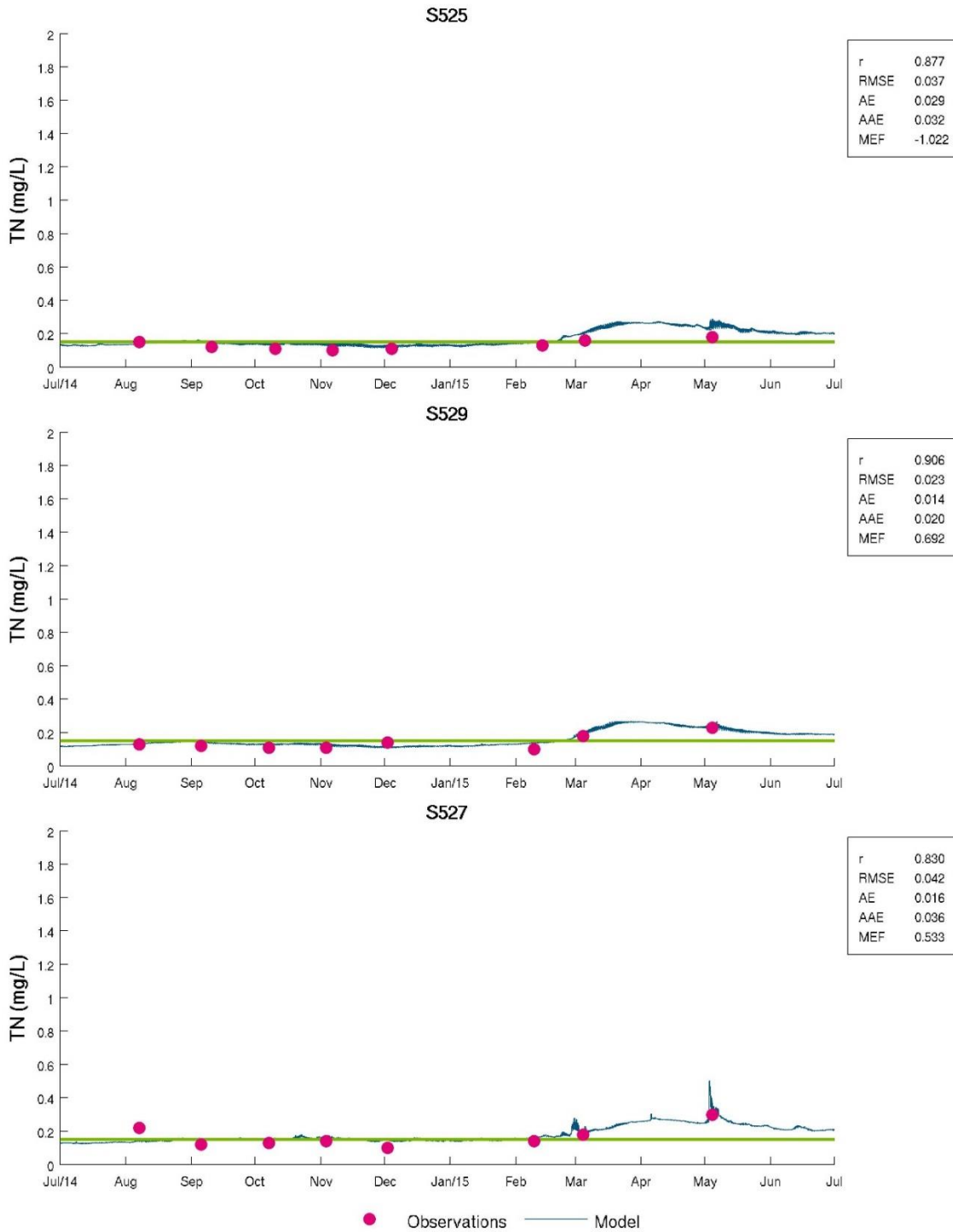


Figure A-141 Total Nitrogen timeseries plot for Moreton Bay - Eastern

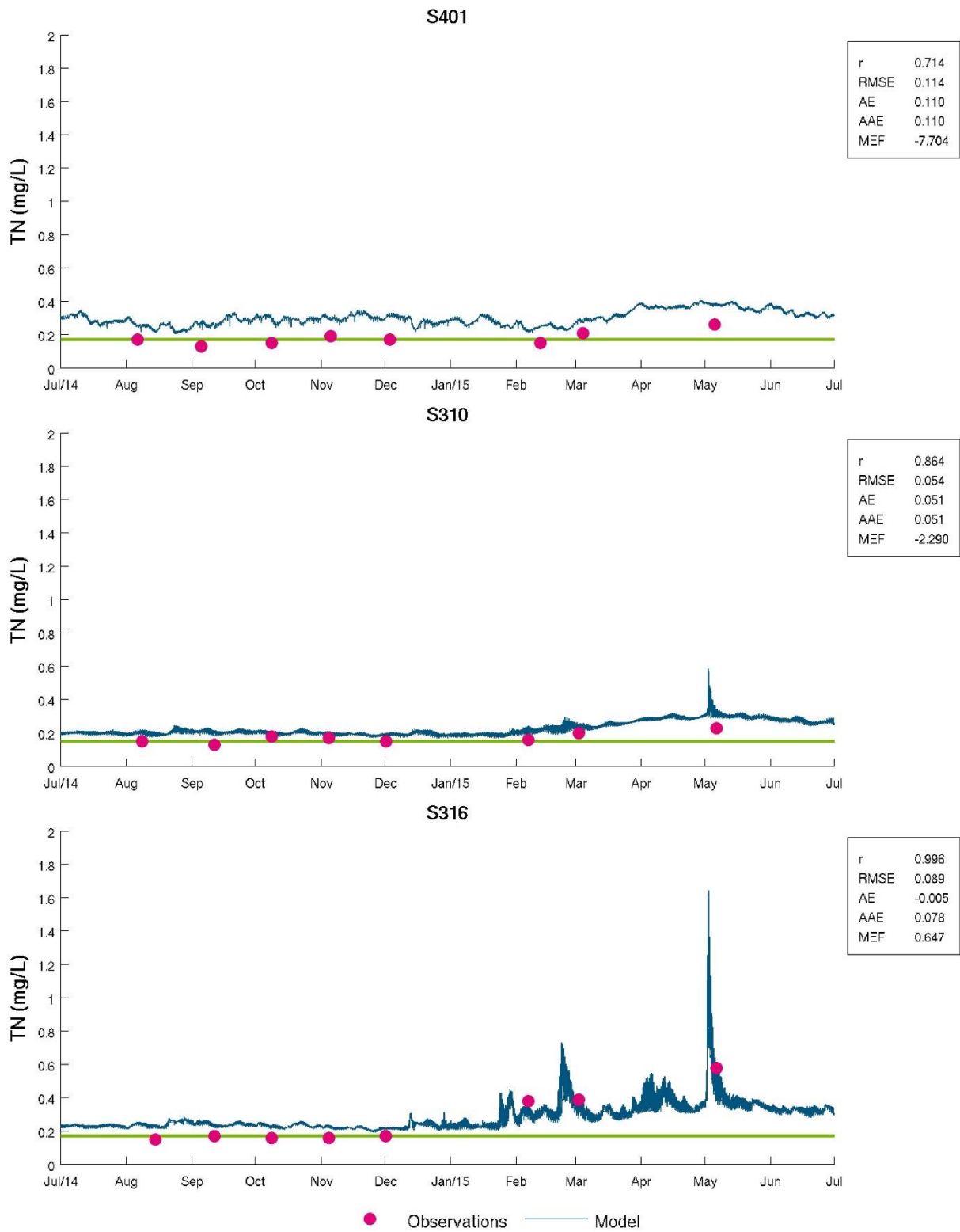


Figure A-142 Total Nitrogen timeseries plot for Moreton Bay - Southern

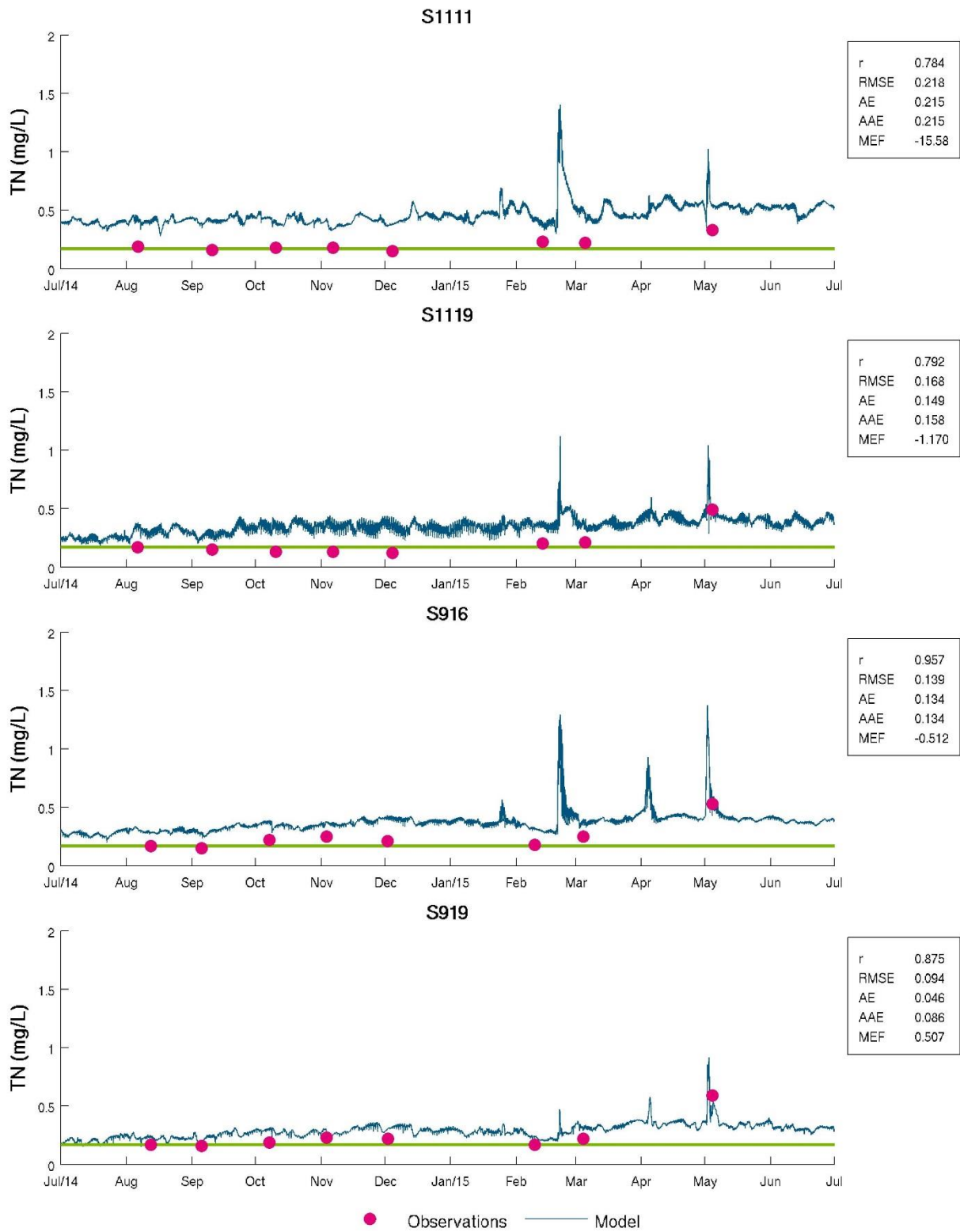
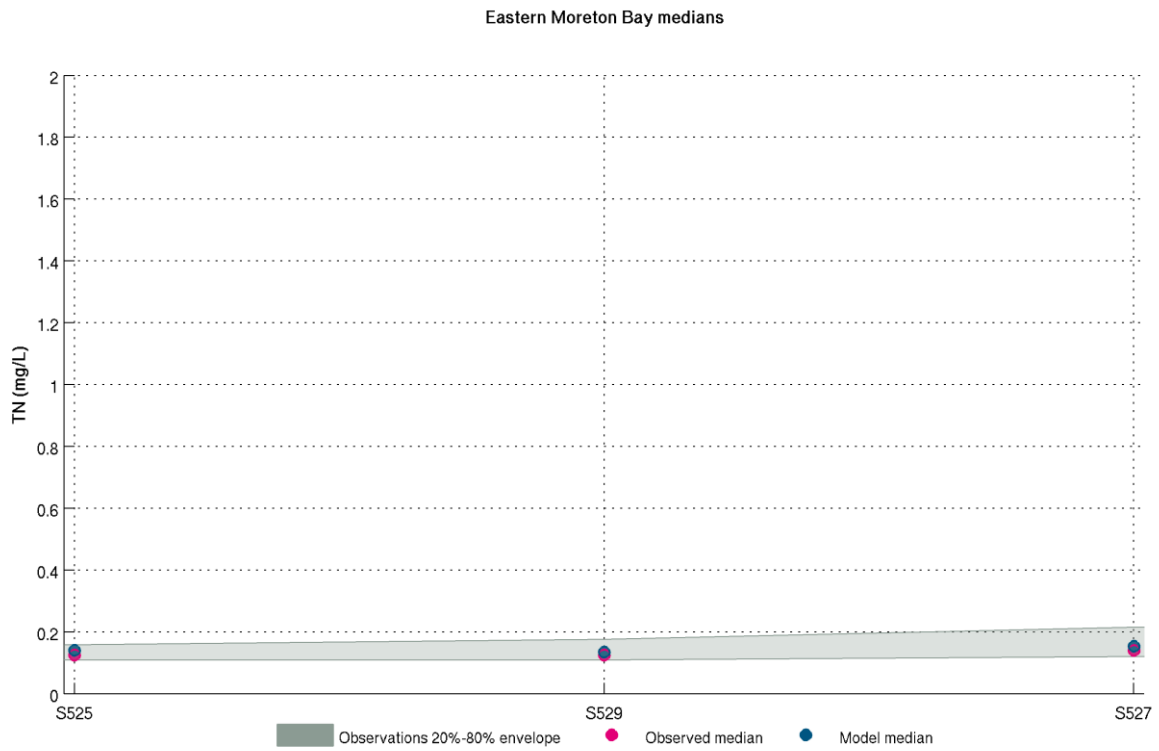
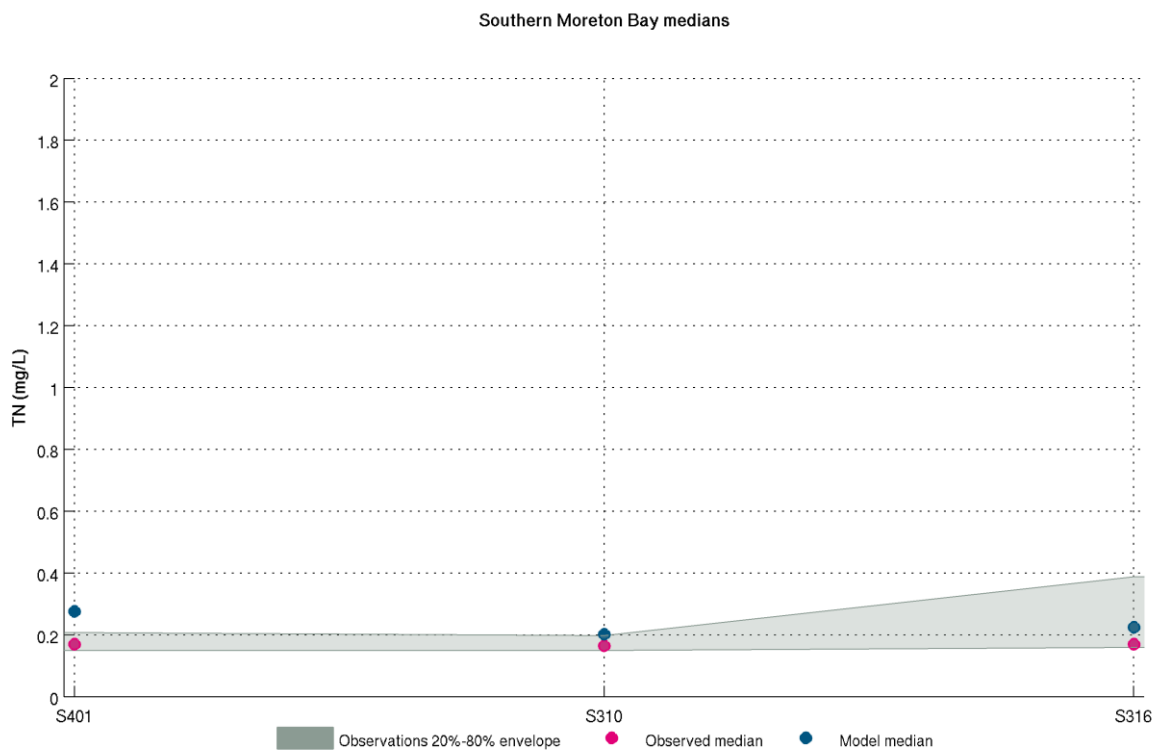


Figure A-143 Total Nitrogen timeseries plot for Moreton Bay - Western



**Figure A-144 Total Nitrogen thalweg comparison Moreton Bay – Eastern**



**Figure A-145 Total Nitrogen thalweg comparison Moreton Bay - Southern**

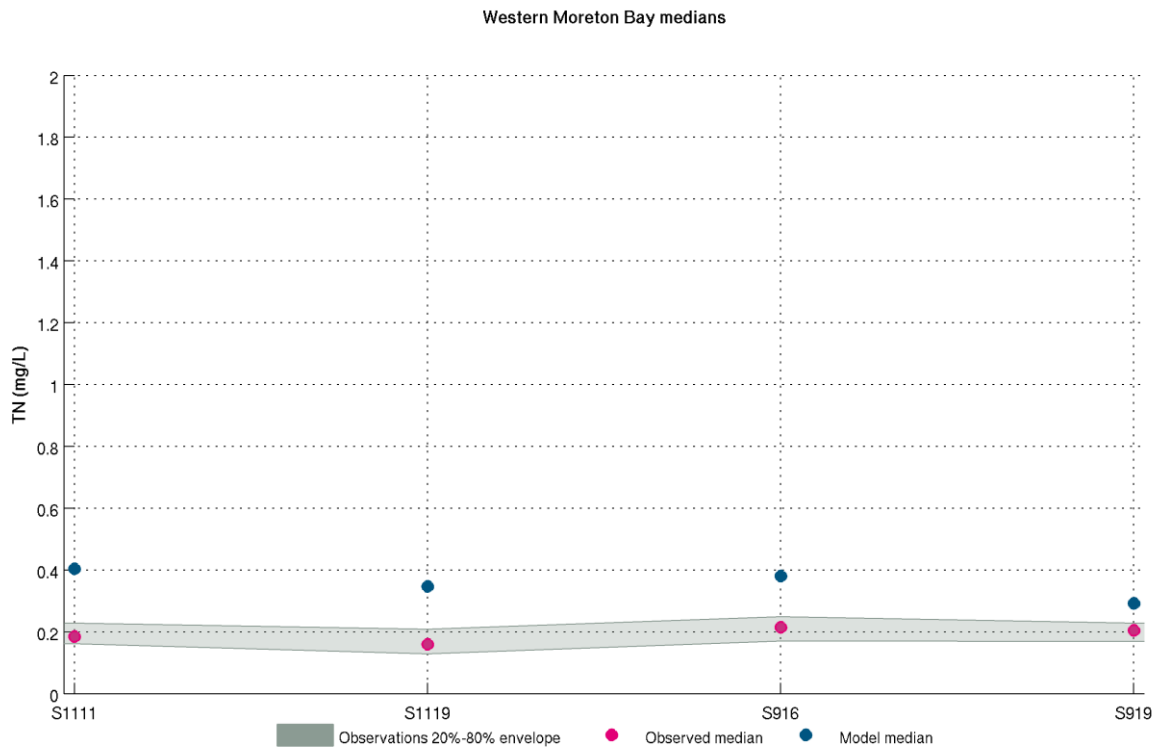


Figure A-146 Total Nitrogen thalweg comparison Moreton Bay - Western

### A.8.4 Total phosphorus

Total phosphorous calibration information is presented below.

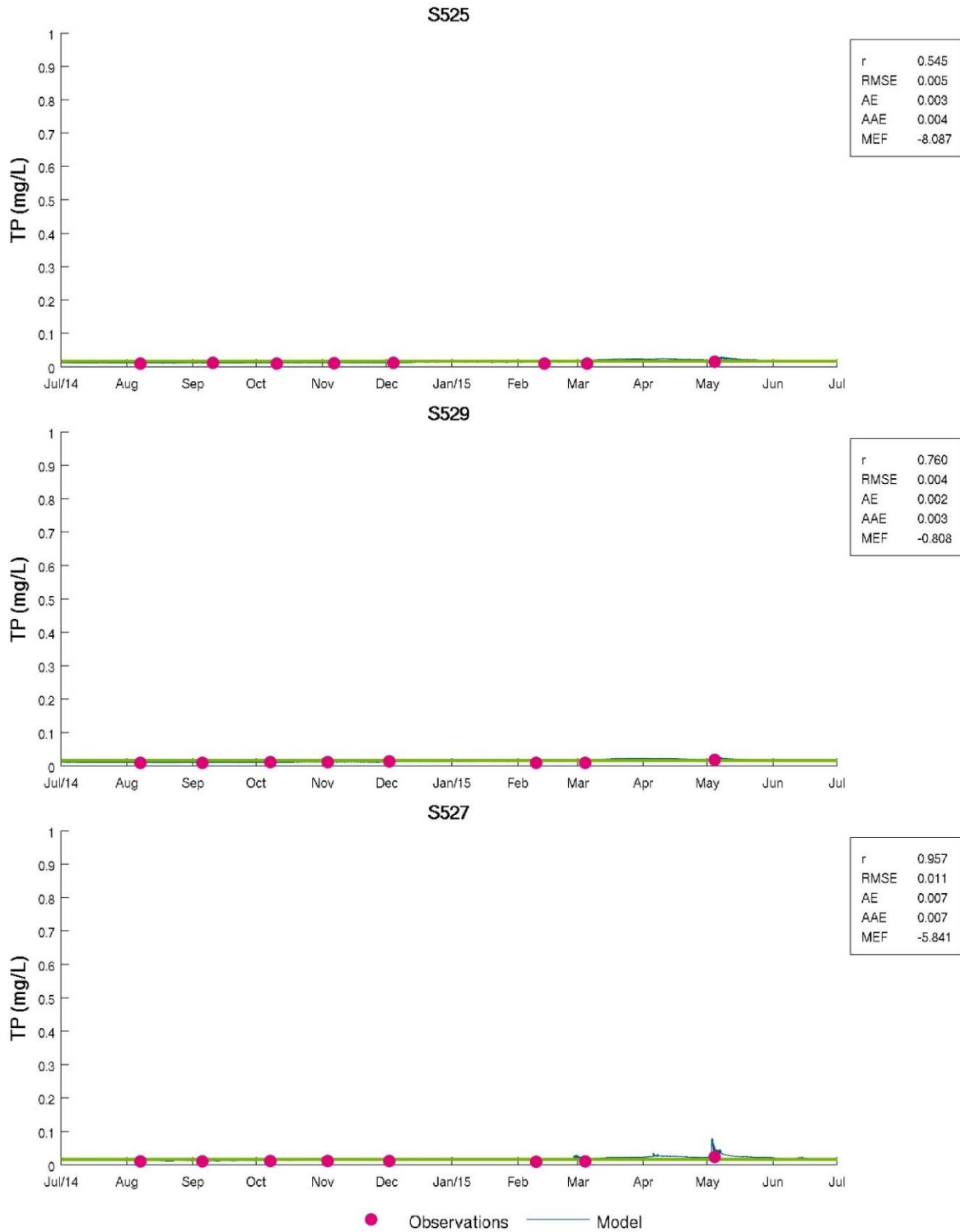


Figure A-147 Total phosphorus timeseries plot for Moreton Bay - Eastern

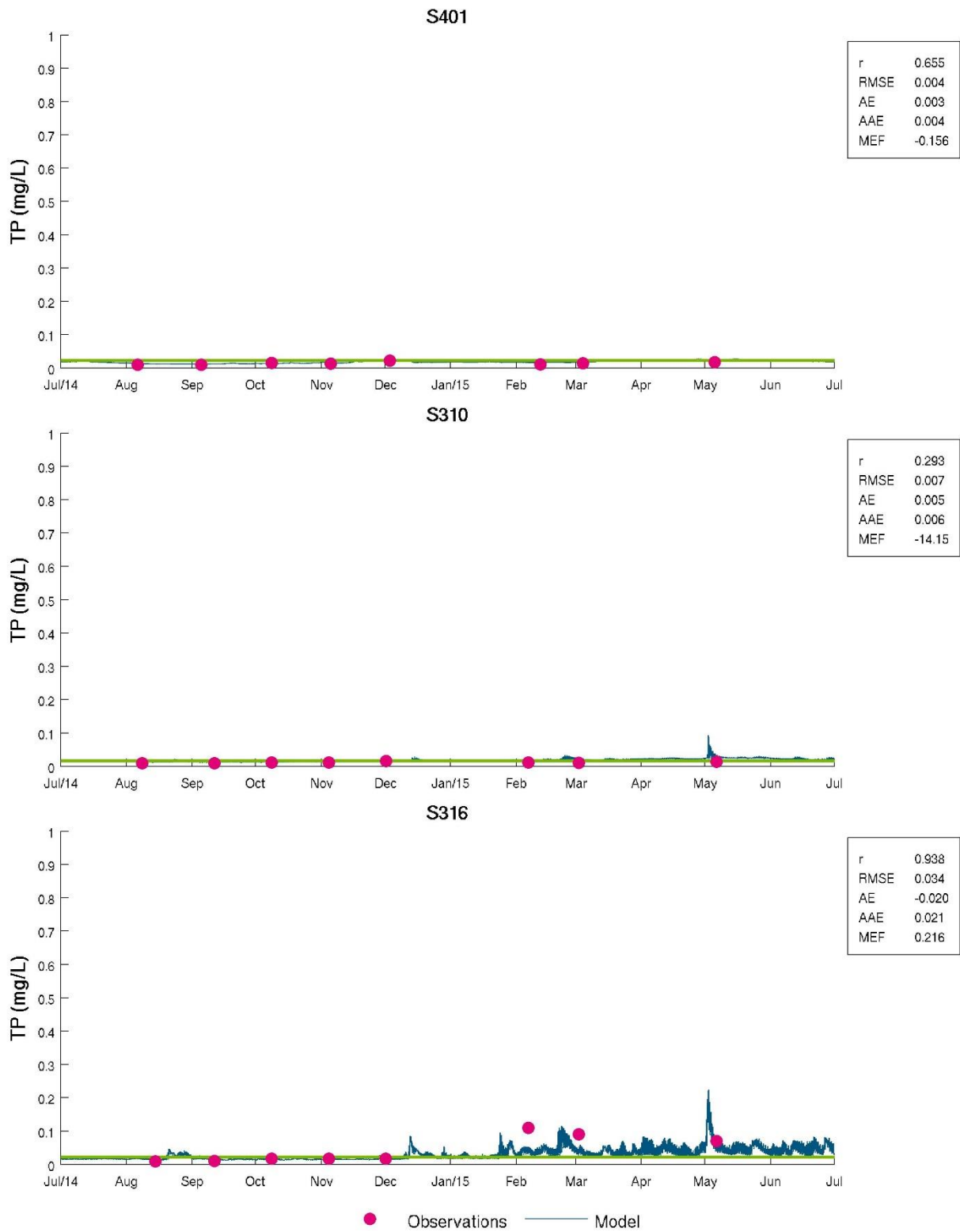


Figure A-148 Total phosphorus timeseries plot for Moreton Bay - Southern

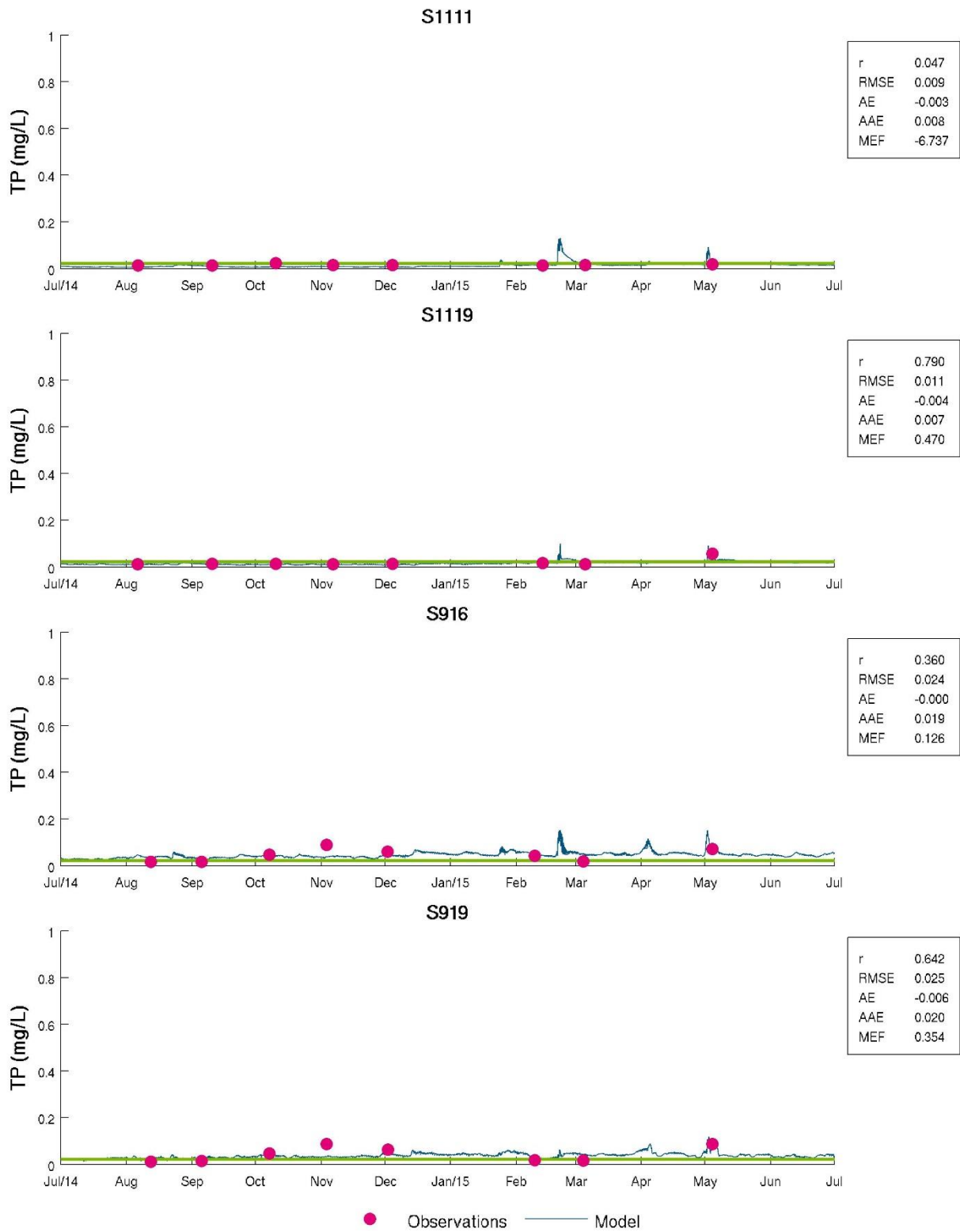
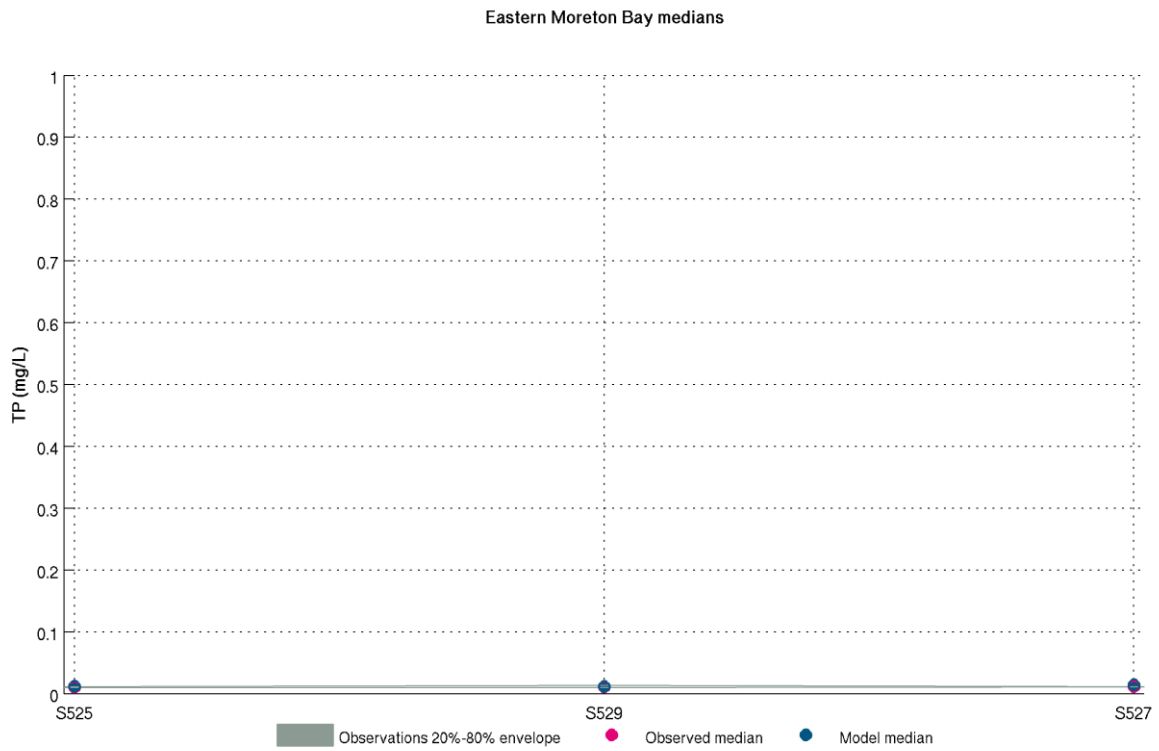
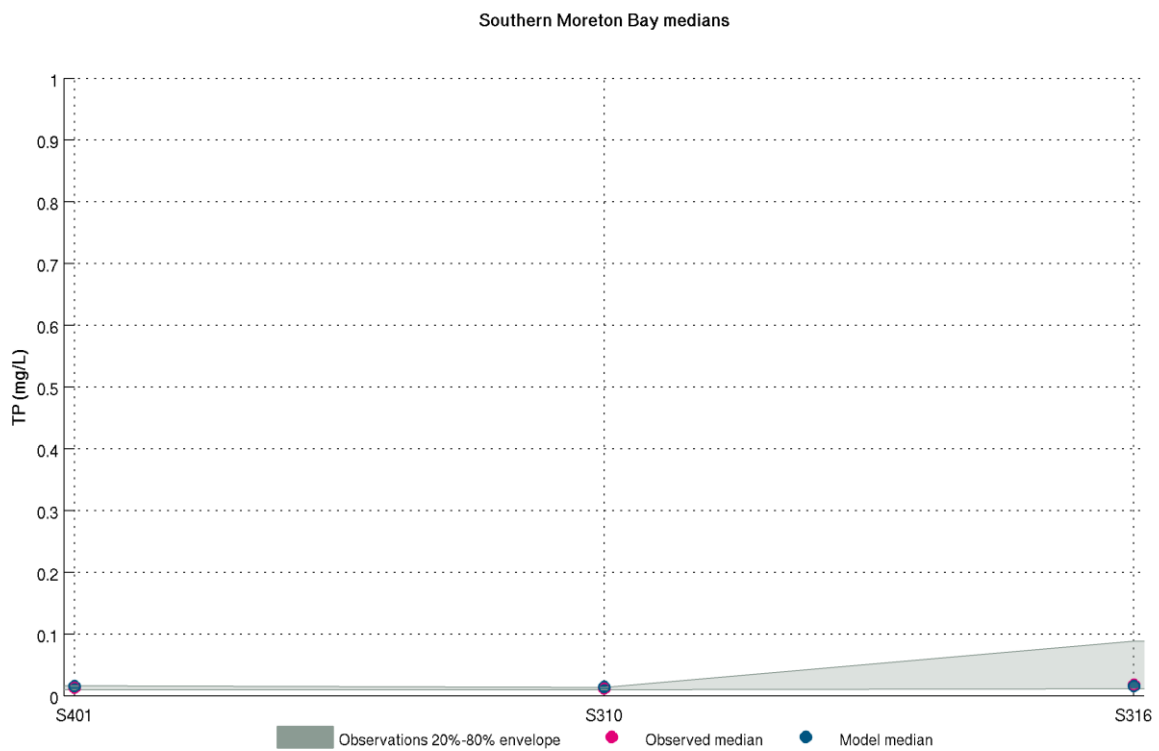


Figure A-149 Total phosphorus timeseries plot for Moreton Bay - Western



**Figure A-150 Total phosphorus thalweg comparison Moreton Bay – Eastern**



**Figure A-151 Total phosphorus thalweg comparison Moreton Bay - Southern**

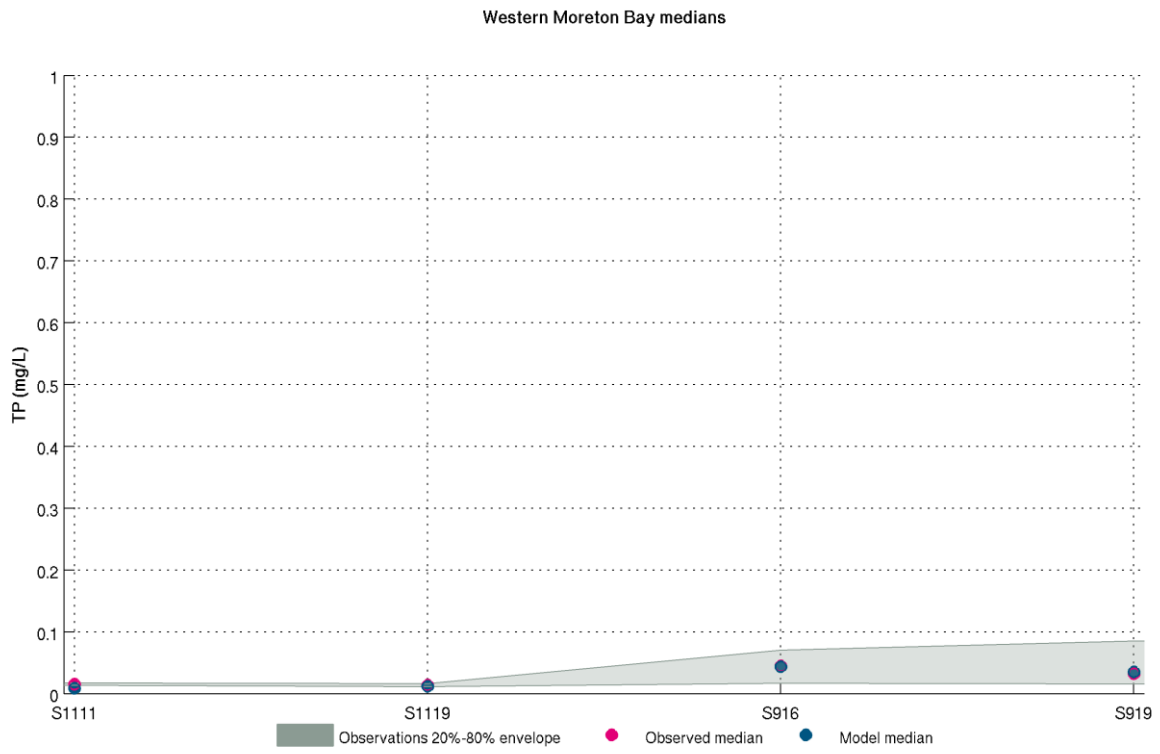


Figure A-152 Total phosphorus thalweg comparison Moreton Bay – Western

### A.8.5 Chlorophyll-a

Chlorophyll-a calibration information is presented below.

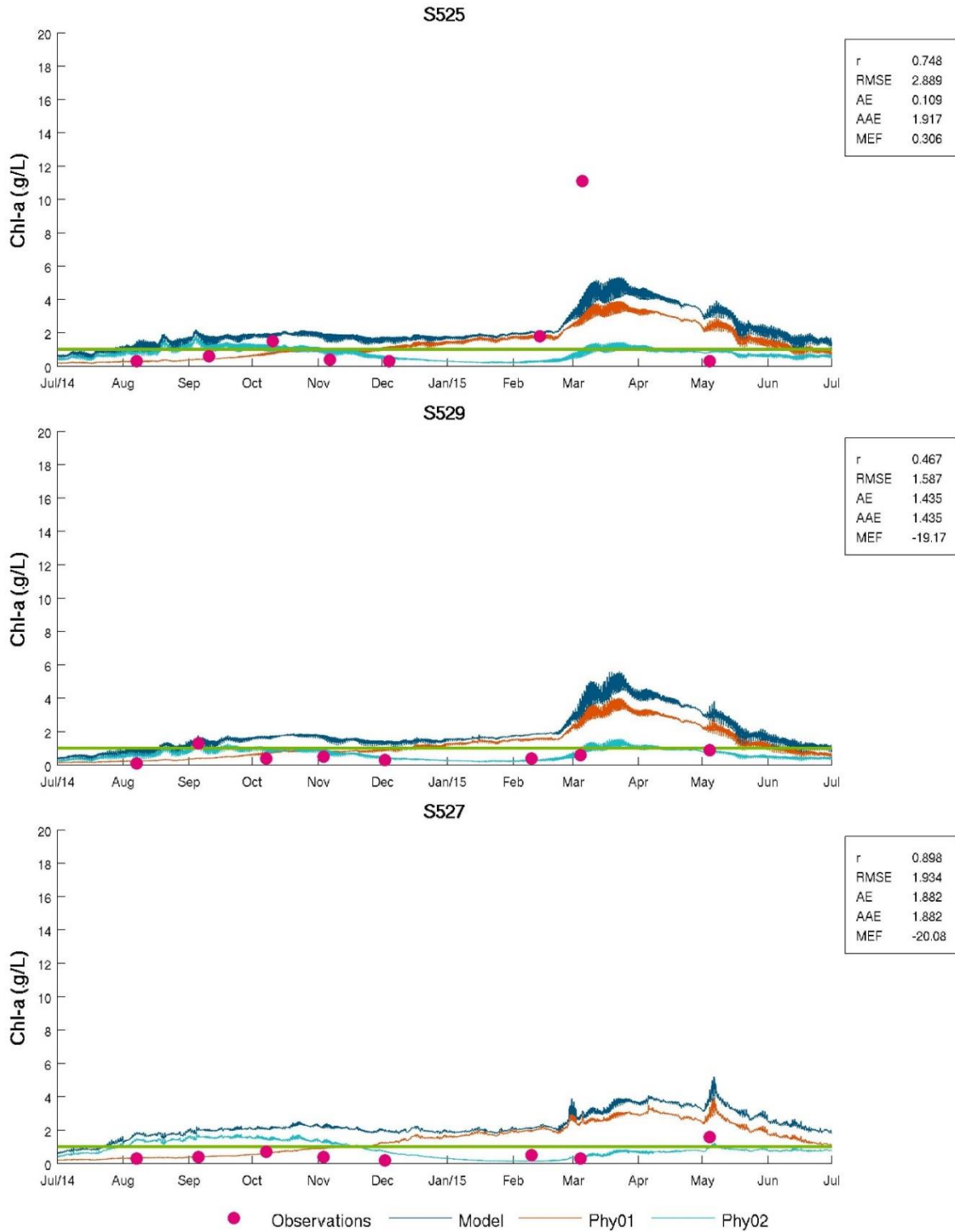


Figure A-153 Chlorophyll-a timeseries plot for Moreton Bay - Eastern

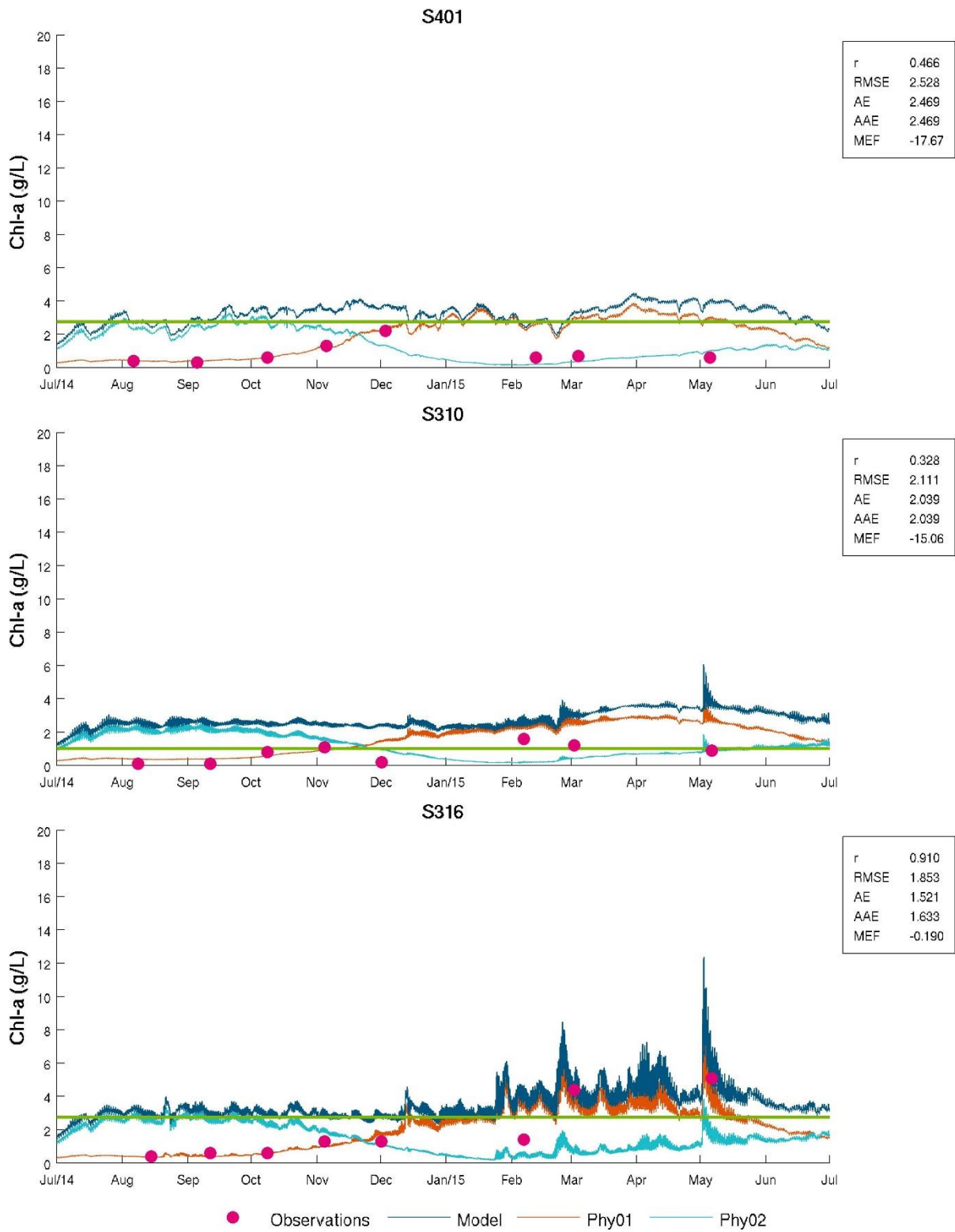


Figure A-154 Chlorophyll-a timeseries plot for Moreton Bay - Southern

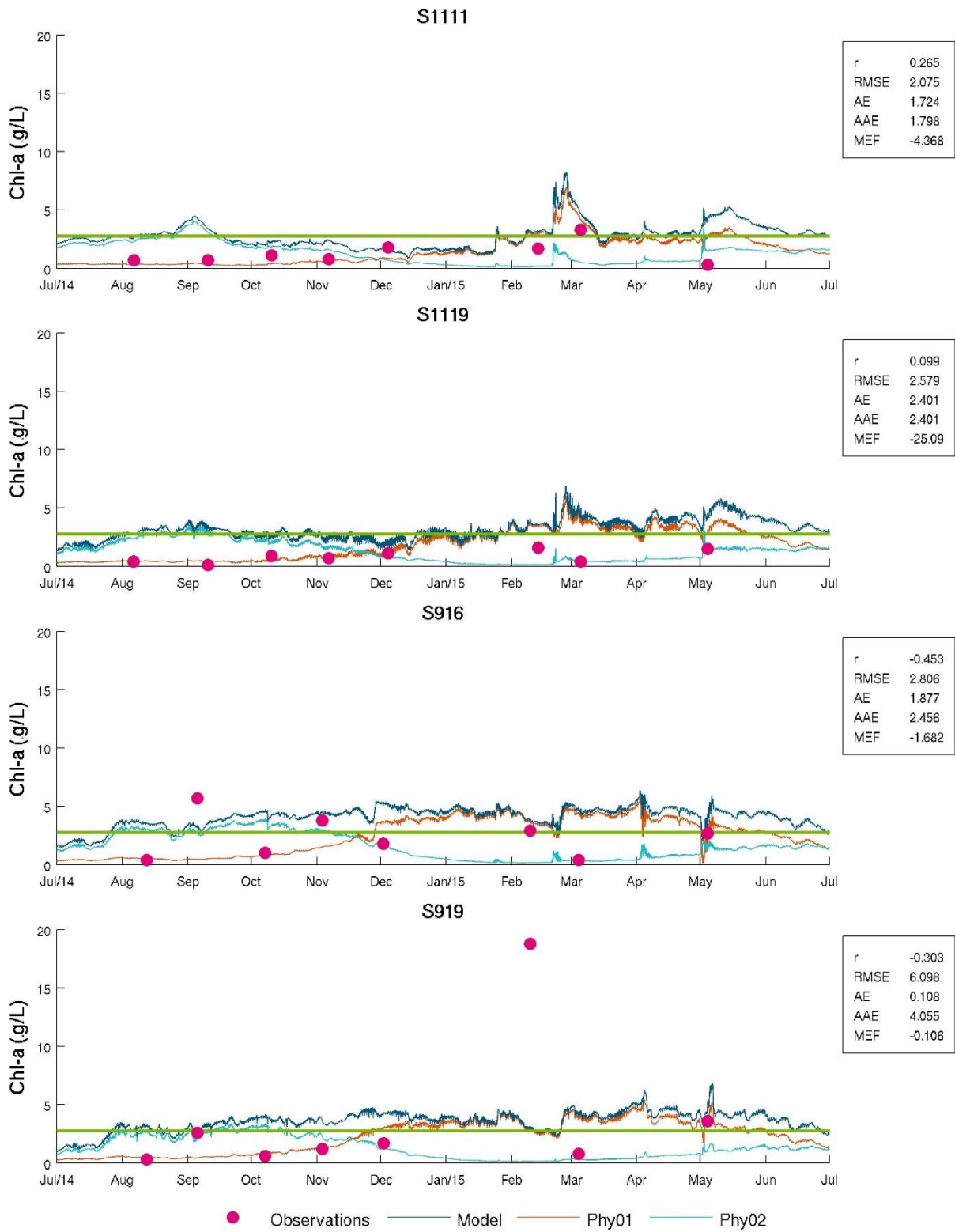
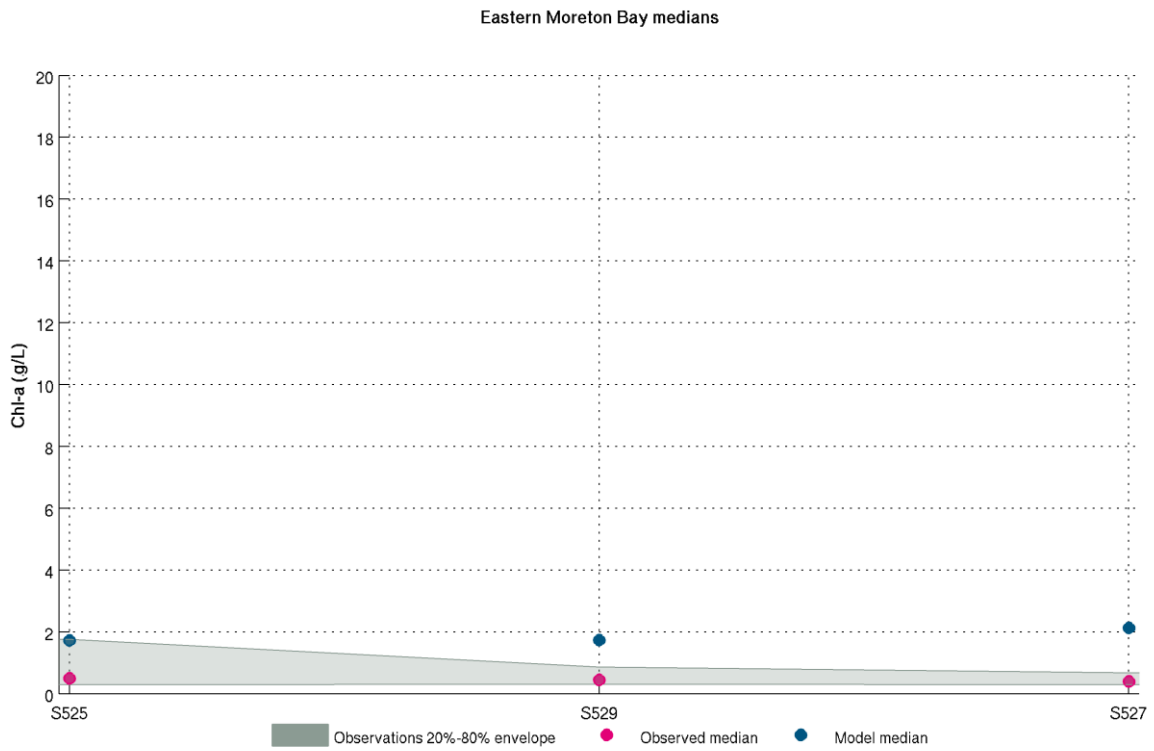
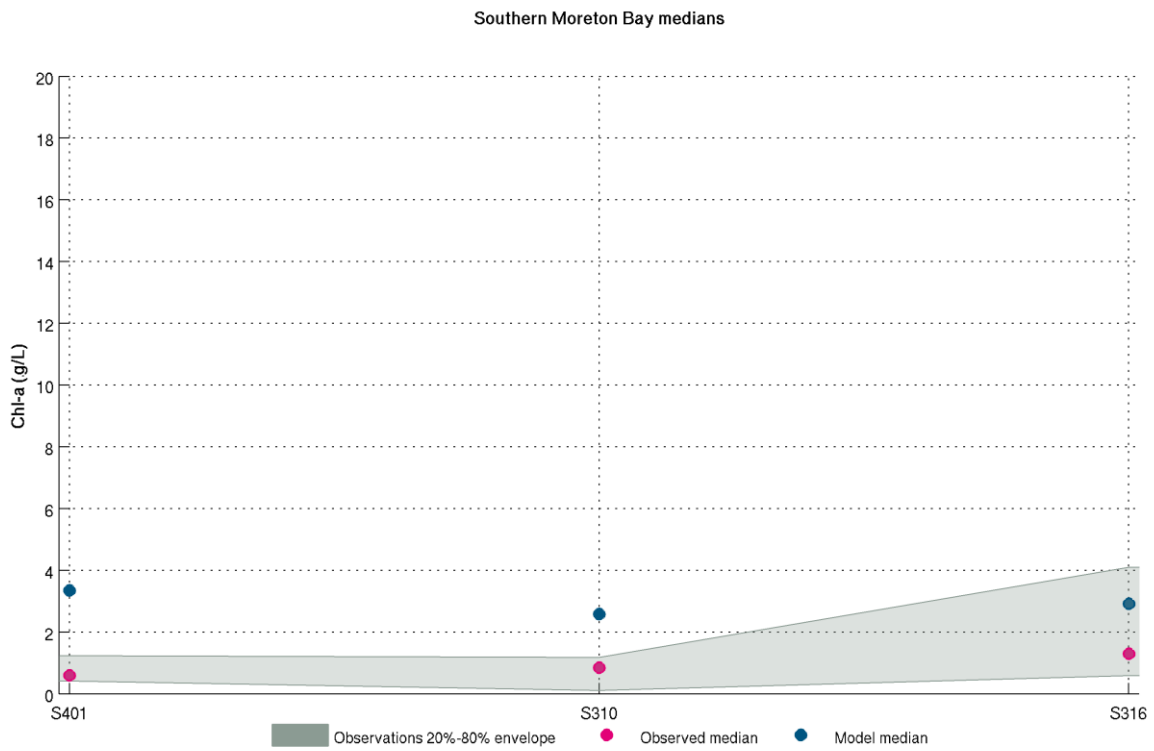


Figure A-155 Chlorophyll-a timeseries plot for Moreton Bay - Western



**Figure A-156 Chlorophyll-a thalweg comparison Moreton Bay – Eastern**



**Figure A-157 Chlorophyll-a thalweg comparison Moreton Bay - Southern**

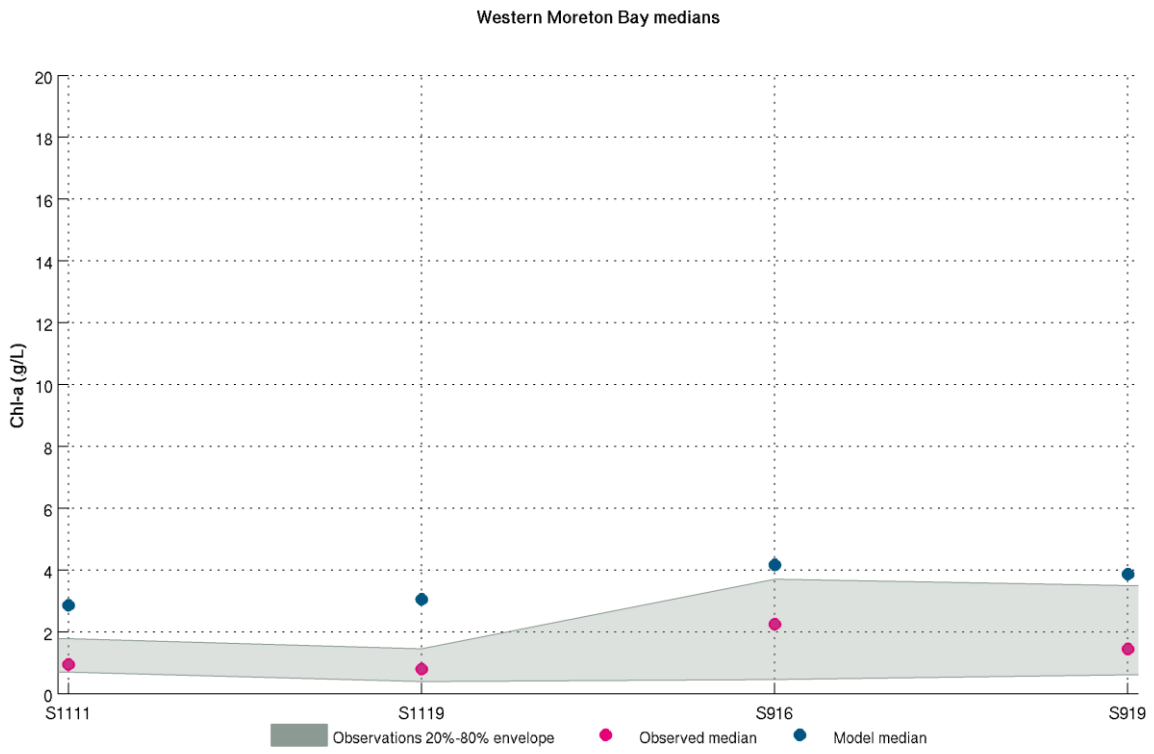


Figure A-158 Chlorophyll-a thalweg comparison Moreton Bay - Western



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