Transport for NSW

M1 Pacific Motorway extension to Raymond Terrace

Submissions Report - Appendix H

June 2022

Australian Government

BUILDING OUR FUTURE

NSW GOVERNMENT

M1 Pacific Motorway extension to Raymond Terrace

Appendix H

Supplementary report - surface water and groundwater quality

June 2022

Executive summary

Transport for New South Wales (Transport) proposes to construct the M1 Pacific Motorway extension to Raymond Terrace (the project). Approval is sought under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979* and Part 9, Division 1 of the *Environment Protection and Biodiversity Conservation Act 1999*.

In accordance with the Secretary's Environmental Assessment Requirements (SEARs), an environmental impact statement (EIS) was prepared by Transport in July 2021 (*M1 Pacific Motorway extension to Raymond Terrace Environmental Impact Statement* (Transport for NSW 2021)) to assess the potential impacts of the project. The EIS was exhibited by the Department of Planning, Industry and Environment (DPIE) for 28 days from 28 July 2021 to 24 August 2021.

The *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) was prepared in support of the EIS for the project. The purpose of the assessment was to assess potential surface water and groundwater quality impacts from construction and operation of the project, and where required, identify mitigation measures. The assessment was prepared to address the SEARs issued by DPIE for the project.

Following exhibition of the EIS, receipt of submissions and further consultation with stakeholders, a number of refinements have been made to the publicly exhibited project. The main design refinements that potentially influence surface water and groundwater quality include:

- Amendments to the drainage design at Heatherbrae at two locations
- Lining temporary sediment basins and permanent water quality basins that intercept groundwater.

This supplementary surface water and groundwater quality report has been prepared to respond to the submissions received and to assess the potential impacts of the refinements made to the project following public exhibition of the EIS. The following points summarise the outcomes of this supplementary report:

- Additional water quality monitoring data collected since the exhibition of the EIS supports previous findings that the water quality of waterways in the project area is poor and generally does not achieve nominated water quality objectives (WQOs) and environmental values
- The refinements to enable works at the Heatherbrae drain, while resulting in a minor increase to the construction footprint, would have minimal impact to surface water quality with the implementation of erosion and sediment controls
- The lining of sediment basins and permanent water quality basins that intercept groundwater provides an improvement to surface water and groundwater quality than reported in the EIS. This refinement increases opportunities during construction to reuse water collected in sediment basins by avoiding risks associated with the mixing of groundwater and surface water
- While it is proposed to reuse more water on site than reported in the EIS there would still be discharges from sediment basins during construction and permanent water quality basins during operation. A revised water quality discharge assessment was undertaken which confirmed that:
    - Controlled releases from temporary sediment basins would meet the ambient total suspended solids (TSS) concentrations at the discharge point for most waterways. Where ambient TSS concentrations are not met at the point of discharge the mixing zone is small and ambient water quality is met within about 3.5 metres
    - Existing nutrient concentrations are notably higher than the default guideline value (DGV) in all waterways. Discharges from permanent water quality basins are better than the ambient water quality but do not comply with the DGV for total nitrogen (TN) and total phosphorus (TP) and therefore do not achieve the WQOs. TSS concentrations were converted to turbidity at five of the seven waterways, of which discharge to all waterways met ambient

turbidity concentrations. However, only Glenrowan Creek had the WQO met at discharge from each basin and under worst-case. Under worst-case Viney creek had a mixing zone of about two metres until the WQO was met. Mixing zones for the other waterways (Hunter River, Hunter River Drain and Purgatory Creek) could not be determined due to existing poor upstream water quality conditions.

- The reshaping and relocation of sediment basins near the Hunter River Drains provides the same water quality outcome as reported in the EIS. Mitigation measures such as scour protection at culvert outlets would be provided during detailed design. This amendment does not present any additional risk to water quality than reported in the EIS.

The refinements outlined in this supplementary surface water and groundwater quality report are expected to produce outcomes for the project that are consistent or better than those presented in the EIS. The construction and operation impacts of the refinements have been assessed, and several additional environmental management measures have been identified including measures to manage displaced water from soft soils and intercepted groundwater, the development of a trigger action response plan (TARP) and dredge management plan.

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Glossary of terms and abbreviations

Term/ Acronym	Description
AEP	Annual Exceedance Probability
ANZG	Australian and New Zealand guidelines for fresh and marine water quality
ARI	Annual Recurrence Interval
ARTC	Australian Rail Track Corporation
ASS	Acid Sulfate Soils
BAR	Biodiversity Assessment Report
CEMP	Construction Environmental Management Plan
CFU	Colony Forming Units
CSWMP	Construction Soils and Water Management Plan
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
DGV	Default Guideline Value
DO	Dissolved Oxygen
DPE	Department of Planning and Environment (formerly DPIE)
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment (now DPE)
EC	Electrical Conductivity
EES	The Environment, Energy and Sciences Group of the DPIE
EIS	Environment Impact Statement
EMM	Environmental Management Measure
EPA	Environment Protection Authority
EPL	Environment Protection License
ESCP	Erosion and Sedimentation Control Plan
MER	A state-wide estuary monitoring program, carried out by the DPIE
NTU	Nephelometric Turbidity Units
SEPP	State Environmental Planning Policy
TARP	Trigger Action Response Plan
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
WMP	Waste Management Plan
WQO	Water Quality Objective
WWTP	Waste Water Treatment Plant

1 Introduction and background

1.1 The project

Transport for New South Wales (Transport) proposes to construct the M1 Pacific Motorway extension to Raymond Terrace (the project). The project would connect the existing M1 Pacific Motorway at Black Hill and the Pacific Highway at Raymond Terrace within the City of Newcastle and Port Stephens Council local government areas (LGAs). The project location is shown in **Figure 1-1**.

The project would include the following key features (see **Figure 1-2**):

- A 15 kilometre motorway comprised of a four lane divided road (two lanes in each direction)
- Motorway access from the existing road network via four new interchanges at:
  - Black Hill: connection to the M1 Pacific Motorway
  - Tarro: connection and upgrade (six lanes) to the New England Highway between John Renshaw Drive and the existing Tarro interchange at Anderson Drive
  - Tomago: connection to the Pacific Highway and Old Punt Road
  - Raymond Terrace: connection to the Pacific Highway.
- A 2.6 kilometre viaduct over the Hunter River flood plain including new bridge crossings over the Hunter River, the Main North Rail Line, and the New England Highway
- Bridge structures over local waterways at Tarro and Raymond Terrace, and an overpass for Masonite Road in Heatherbrae
- Connections and modifications to the adjoining local road network
- Traffic management facilities and features
- Roadside furniture including safety barriers, signage, fauna fencing and crossings and street lighting
- Adjustment of waterways, including Purgatory Creek at Tarro and a tributary of Viney Creek
- Environmental management measures including surface water quality control measures
- Adjustment, protection and/or relocation of existing utilities
- Walking and cycling considerations, allowing for existing and proposed cycleway route access
- Permanent and temporary property adjustments and property access refinements
- Construction activities, including establishment and use of temporary ancillary facilities, temporary access tracks, haul roads, batching plants, temporary wharves, soil treatment and environmental controls.

A more detailed description of the project incorporating the refinements identified in **Section 1.2** is presented in Appendix A of the *M1 Pacific Motorway extension to Raymond Terrace Submissions Report* (Transport for NSW, 2022).

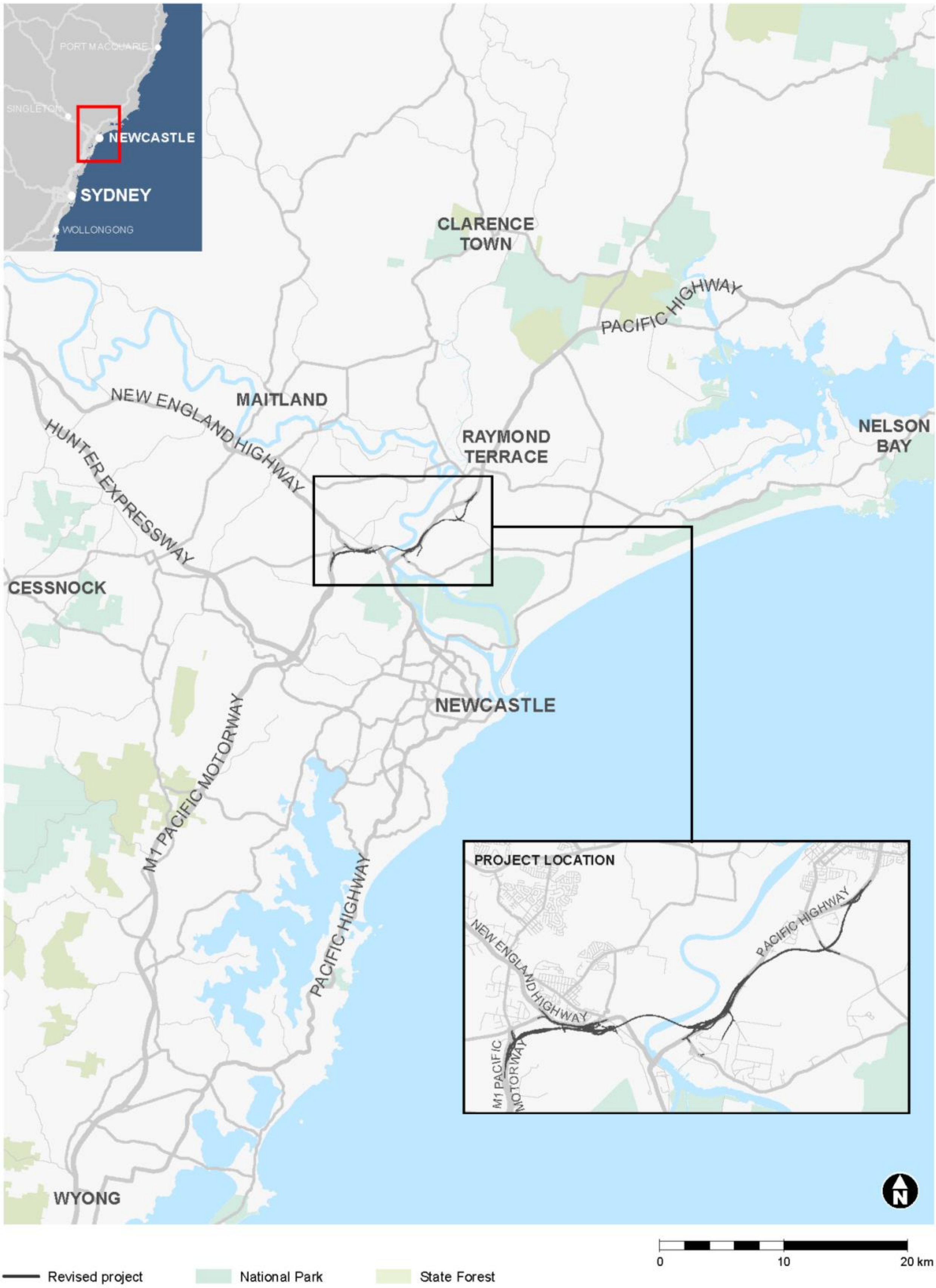


Figure 1-1 Regional context of the project

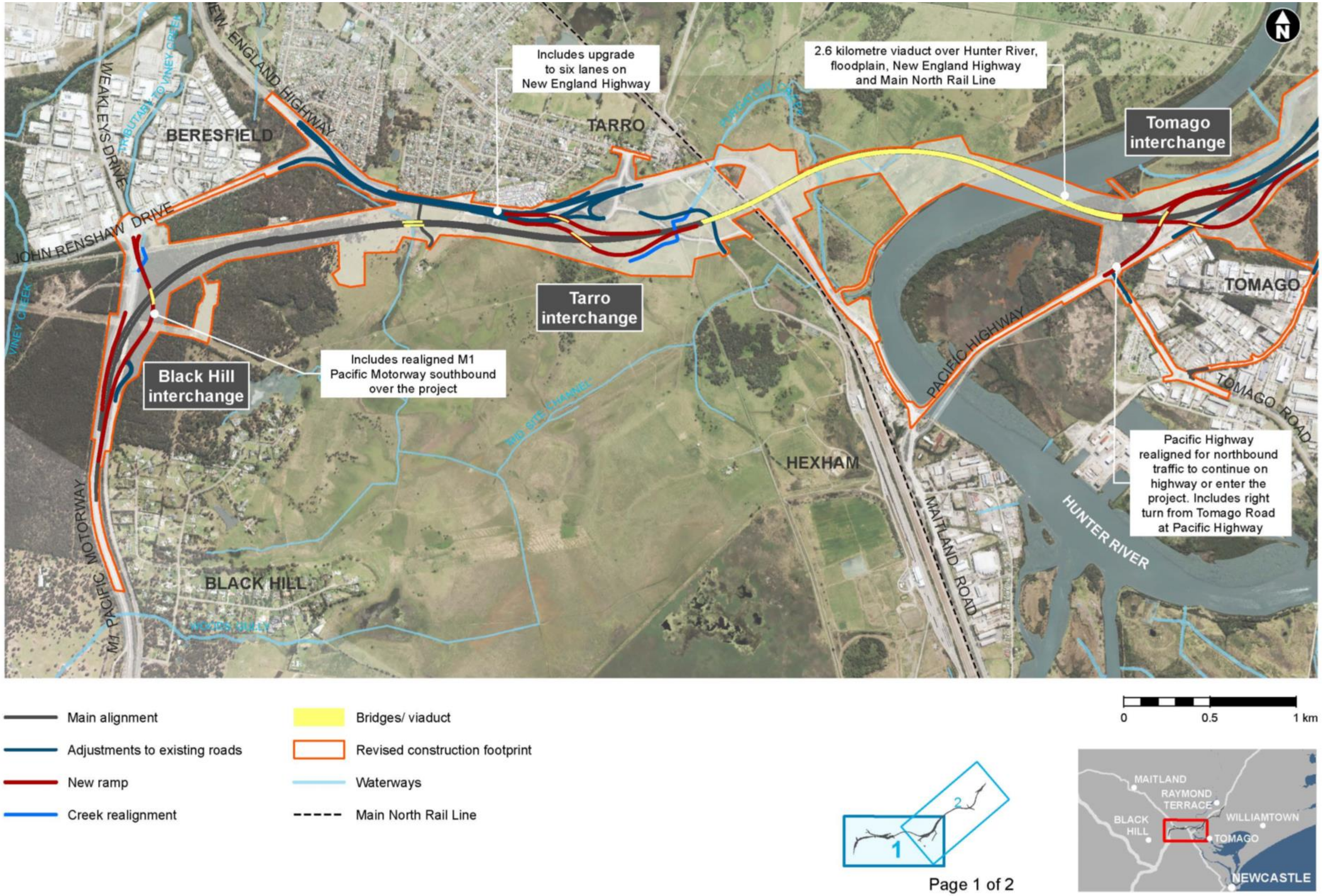
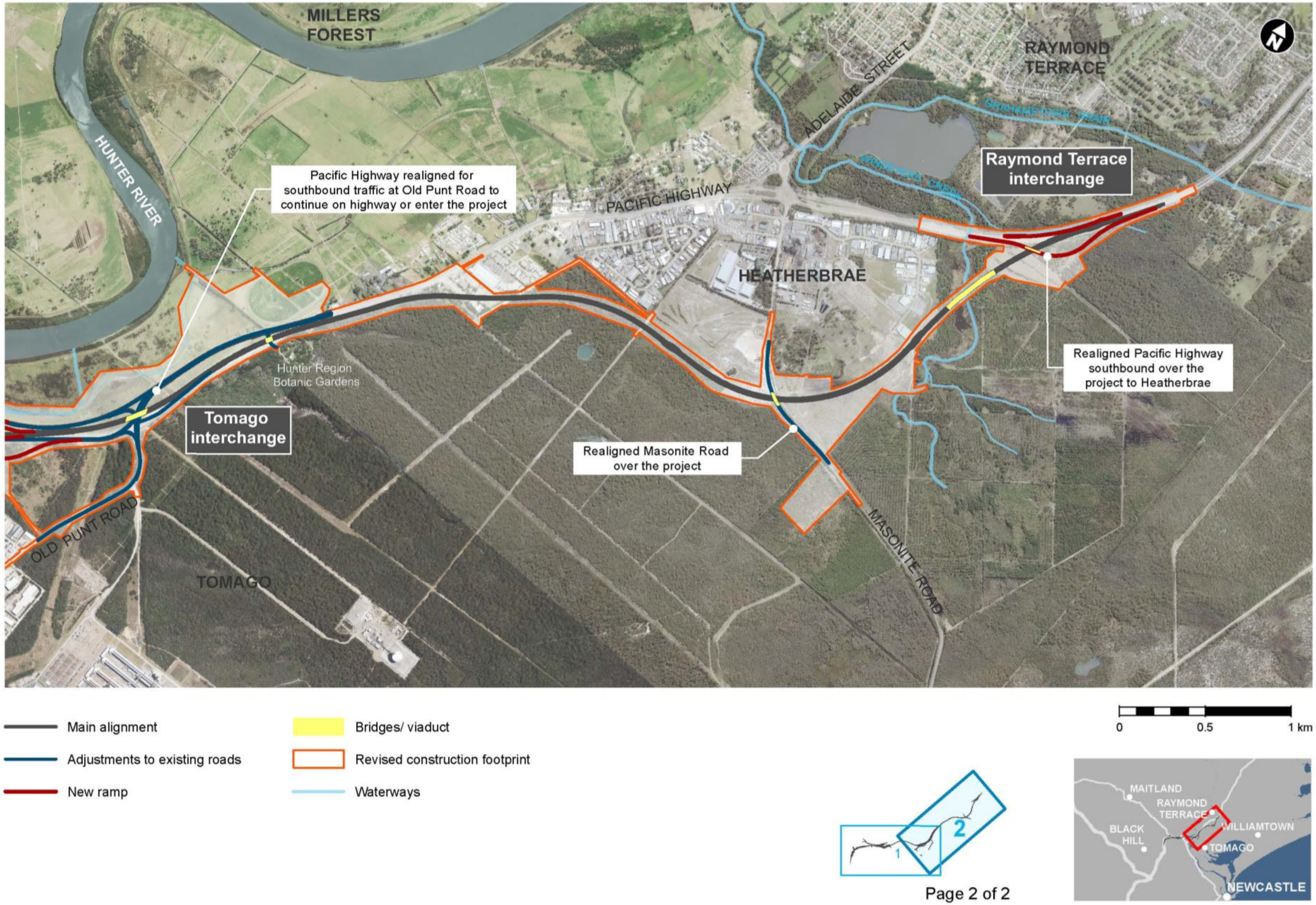


Figure 1-2 Project key features


MILLERS FOREST
RAYMOND TERRACE
HUNTER RIVER
ADELAIDE STREET
GRAHAMSTOWN DRAIN
PACIFIC HIGHWAY
Raymond Terrace interchange
Pacific Highway realigned for southbound traffic at Old Punt Road to continue on highway or enter the project
HEATHERBRAE
Hunter Region Botanic Gardens
Tomago interchange
Realigned Masonite Road over the project
Realigned Pacific Highway southbound over the project to Heatherbrae
MASONITE ROAD
OLD PUNT ROAD
TOMAGO
Main alignment
Adjustments to existing roads
New ramp
Bridges/ viaduct
Revised construction footprint
Waterways
0
0.5
1 km
1
2
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MAITLAND
RAYMOND TERRACE
WILLIAMTOWN
BLACK HILL
TOMAGO
NEWCASTLE

1.2 Project refinements

Transport has refined a number of aspects of the project as exhibited in the environmental impact statement (EIS). These refinements have arisen through the ongoing review of the concept design and construction methodology, identification of opportunities to reduce environmental impact, consultation with landowners and government agencies, and in response to issues raised during the EIS exhibition period. The project refinements are described below.

Design refinements

- Southbound M1 Pacific Motorway merge – a 200 metre extension of the merge lane for southbound traffic from the John Renshaw Drive/Weakleys Drive intersection to allow for improved capacity and safety
- Utilities strategy – key changes include grouping of utilities at Tarro and Tomago into utility corridors and extension of the construction footprint at Beresfield and Hexham to accommodate utility relocations
- Cycleway strategy – improvements to facilitate incorporation with the Richmond Vale Rail Trail and removal of shared use path on the new Masonite Road bridge (bridge at Heatherbrae
- Drainage design at Heatherbrae – minor changes to basin locations and extension of drainage lines to minimise property and drainage impacts on adjacent properties
- Water quality basins – lining of temporary and permanent water quality basins which interface with ground water.

Construction refinements

- Ancillary facilities and site access – minor changes to the size, location and access arrangements of some ancillary facilities
- Earthworks management – identification of a borrow pit and sites for beneficial reuse of materials within the construction footprint.

Construction staging

- Staged project opening - the project would be delivered via two packages of work, the Southern (Black Hill to Tomago) and Northern (Heatherbrae bypass) works. The Northern section would likely have a shorter construction duration and could potentially be opened to traffic before the Southern section.

Project footprint refinements

- Consultation with landowners, and the design and construction refinements to reduce property and biodiversity impacts, have resulted in minor changes to the construction and operational project footprints.

1.3 Purpose of the document

The *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) was prepared in support of the EIS for the project. The purpose of the working paper was to provide a detailed assessment of the potential impacts from the construction and operation of the project on water quality with reference to the ANZG (2018) Water Quality Guidelines and with regard to the relevant water quality objectives (WQOs) and environmental values as identified in the NSW Water Quality and River Flow Objectives (DECCW, 2006).

The assessment was prepared to address the Secretary's Environmental Assessment Requirements (SEARs) and Supplementary SEARs as described in Section 1.4 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a).

During the exhibition of the EIS, four submissions were made in relation to surface water and groundwater quality matters. These submissions have been addressed in the *M1 Pacific Motorway extension to Raymond Terrace Submissions Report* (Transport for NSW, 2022).

This surface water and groundwater supplementary report has been prepared to clarify detail presented in the EIS and provide additional information on some project elements relevant to surface water and groundwater (refer **Chapter 3**). This supplementary report also assesses potential impacts from project refinements identified in **Section 1.2**. The project refinements affecting surface water and groundwater quality are presented in **Chapter 4** (assessment of construction impacts) and **Chapter 5** (assessment of operational impacts).

This supplementary report only includes additional detail or information that has changed since submission of the EIS and should be read in conjunction with the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) included in the EIS.

2 Existing Environment

2.1 Overview

A detailed description of the existing environment is provided in Chapter 4 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a). This included:

- Catchment overview which provided discussion on the land-use, topography, climate and Hunter Valley Flood Mitigation Schemes
- Waterway and wetlands which discusses the key waterways, wetlands and drains within the surface water study area
- Soil landscapes and characteristics which provided discussion on acid sulfate soils (ASS) and salinity
- Hydrogeology which provided discussion on the main geological units and groundwater systems in the project area
- Groundwater and surface water interactions
- Existing surface water quality with respect to the ANZG (2018) water quality guidelines and DECCW (2006) NSW WQOs
- Existing groundwater quality within the study area that has the potential to be impacted by the project
- Sensitive receiving environments within the study are which included the Tomago Sandbeds, Groundwater users, Hunter River, Hunter Estuary Wetland Ramsar site, Important wetlands, Groundwater Dependent Ecosystems (GDEs) and Key Fish Habitat.

2.2 Surface water quality monitoring

Surface water quality data was collected from all available sources during development of the EIS. Since submission of the EIS, additional surface water quality monitoring was available to include in the assessment, at locations nominated in the EIS (refer to **Figure 2-1**).**Table 2-1** provides a summary of all Transport monitoring events.

Table 2-1 Additional monitoring events by Transport

Monitoring dates	Location	Dry or wet sampling	Rainfall (millimetres)
25-26 June 2018	All monitoring sites across project area	Dry	0
5-6 February 2019	All monitoring sites across project area	Dry	0
25-25 February 2020	All monitoring sites across project area	Dry	0
7-8 May 2020	All monitoring sites across project area	Dry	0
26-27 May 2020	All monitoring sites across project area	Wet	33.2
24-25 June 2020	All monitoring sites across project area	Dry	2
15-16 July 2020	All monitoring sites across project area	Wet	29
29-30 September 2020[1]	All monitoring sites across project area	Dry	0
26-27 October 2020[1]	All monitoring sites across project area	Wet	83.5
25-26 November 2020[1]	All monitoring sites across project area	Dry	0

1 Additional water quality monitoring included since EIS.

The Department of Planning, Industry and Environment (Environment, Energy and Science Group (EES Group)) also carried out additional monitoring as part of the state-wide estuary monitoring program (MER) comprising monitoring at various points along the Hunter River on six occasions between 2019 and 2020.

The combination of Transport and EES Group monitoring data has been used to update the summary of existing water quality with reference to WQO or environmental value and is presented in **Table 2-5** and **Table 2-6**. A summary of available data used in this assessment is provided in **Table 2-2**.

Water quality data used in the assessment is considered comprehensive and provides a good basis for characterisation of the existing environment.

Table 2-2 Summary of water quality data monitoring events

Stakeholder	Monitoring site	Number of samples	Date range
Hunter Water Corporation	Hunter River at Sandgate	63	Jan 2011 – Mar 2016
	Windeyers Creek	184	Jan 2011 – Mar 2016
EES Group/ DPIE	Hunter River (various locations)	109	Aug 2014 – Mar 2020
ARTC	Mid Site Channel	16	Aug 2012 - May 2018
DPIE	Various (pre flood nutrient data)	Single sampling event at 36 sites	Mar 2018
Transport	Project specific (various locations)	10	Jun 2018 – November 2020

(Shaded cells denotes additional data included in this assessment)

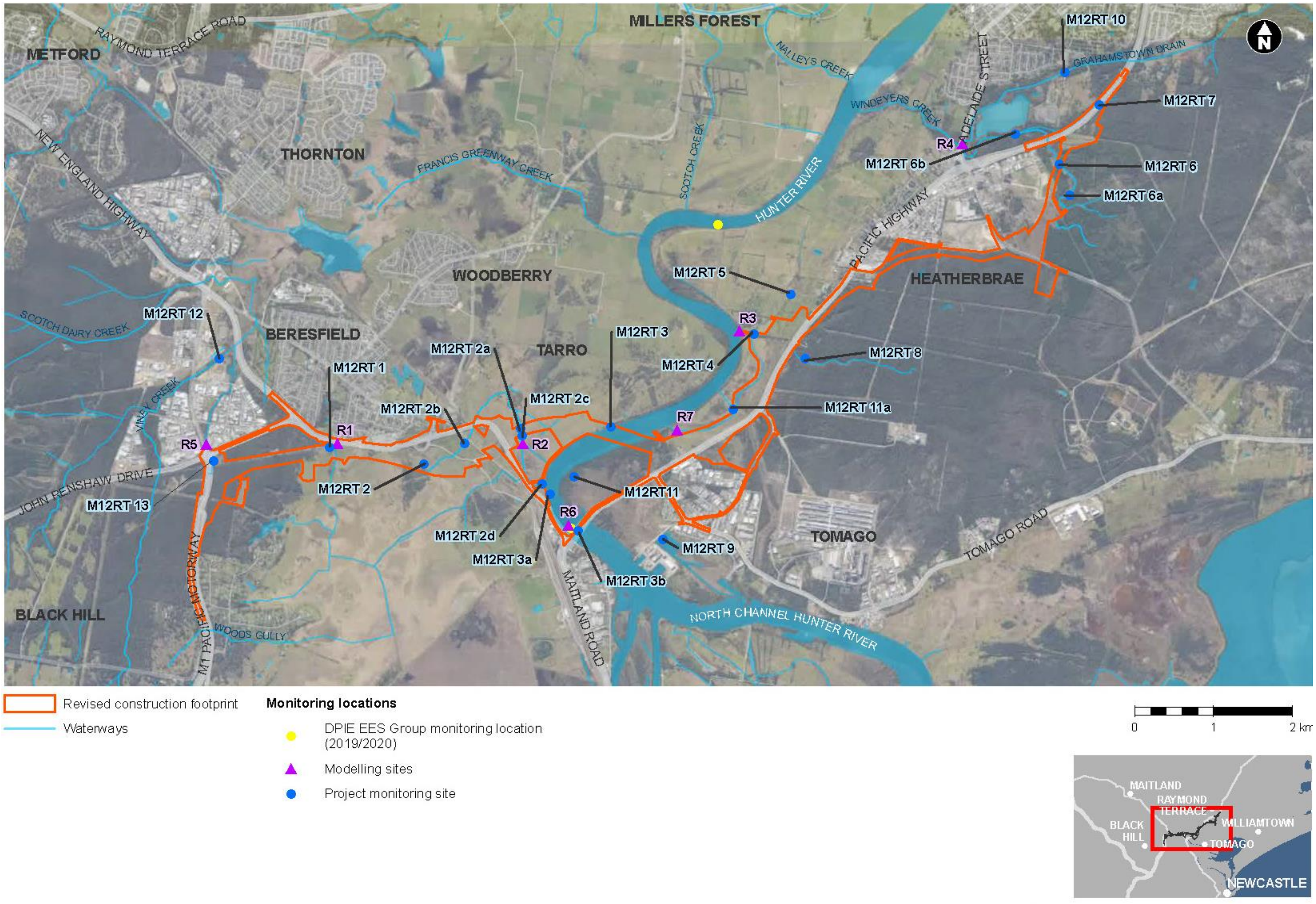

Figure 2-1 Surface water monitoring locations

2.3 Water quality assessment criteria

As outlined in Section 3.3.4 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a), WQOs have been assigned to waterways within the study area. Existing water quality has been compared to applicable ANZG (2018) Water Quality Guidelines default guideline value (DGVs) to determine whether waterways are meeting relevant WQOs.

For the purpose of understanding ambient water quality related to aquatic ecosystem health, the ANZG (2018) DGVs for the protection of aquatic ecosystems have been applied. Due to the disturbed and modified nature of the Hunter River and waterways on the floodplains, waterways have been classified as "slightly to moderately disturbed ecosystems". Therefore a 95 per cent level of species protection has been adopted for relevant metals and toxicants, except for chemicals that have the potential to bioaccumulate in which the 99 per cent level of species protection has been adopted (refer to **Table 2-3**)

Since exhibition of the EIS, the default guideline value (DGV) for zinc in marine/estuarine waters has changed from 0.015mg/L to 0.008mg/L for 95 percent species protection. This amended guideline value has also been applied in the summary of existing water quality.

Table 2-3 Water quality indicators and associated default guideline values for water quality objectives nominated to waterways within the surface and groundwater study area

Water Quality Objective	Indicator	Default guideline value	
		Lowland rivers	Estuaries
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	Total phosphorus	0.025mg/L	0.030mg/L
	Filterable reactive phosphorus	0.02mg/L	0.005mg/L
	Total nitrogen	0.35mg/L	0.3mg/L
	Ammonium	0.02mg/L	0.015mg/L
	Oxidised nitrogen	0.04mg/L	0.015mg/L
	Chlorophyll-a	0.003mg/L	0.004mg/L
	pH	6.5 – 8.5	7 – 8.5
	Turbidity	6 – 50 NTU	0.5 – 10 NTU
	Dissolved oxygen	85 – 110%	80 – 110%
	Electrical conductivity (EC)	200 – 300µS/cm	N/A
	Chemical contaminants or toxicants^*	As per ANZG (2018): Arsenic – 0.013mg/L Cadmium – 0.0002mg/L Chromium (VI) –0.001mg/L Copper – 0.0014mg/L Nickel – 0.011mg/L Lead – 0.0034mg/L Mercury – 0.00006mg/L Zinc – 0.008mg/L Benzo(a) pyrene – 0.0001mg/L TPH – N/A	As per ANZG (2018): Arsenic – N/A Cadmium – 0.0007mg/L Chromium (VI) – 0.0044mg/L Copper – 0.0013mg/L Nickel – 0.007mg/L Lead – 0.004mg/L Mercury – 0.0001mg/L Zinc – 0.008mg/L Benzo(a) pyrene – 0.0001mg/L TPH – N/A

Water Quality Objective	Indicator	Default guideline value	
		Lowland rivers	Estuaries
		Benzene – 0.95mg/L Ethylbenzene – 0.08mg/L Toluene – 0.18mg/L	Benzene – 0.0005mg/L Ethylbenzene – 0.08mg/L Toluene – 0.18mg/L
Visual amenity – aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.	
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and matter.	
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.	
Secondary contact recreation – maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	Median over bathing season of <230 enterococci per 100mL (maximum number in any one sample: 450-700 organisms/100mL) Median over bathing season of < 1000 faecal coliforms per 100mL, with 4 out of 5 samples < 4000/10mL Algae – <15000 cells/mL	
	Nuisance organisms	As per the visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.	
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed values in Table 9.3 of NHMRC (2008) Guidelines.	
	Visual clarity and colour	As per the visual amenity guidelines.	
	Surface films	As per the visual amenity guidelines.	
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	Median over bathing season of < 35 enterococci per 100mL (maximum number in any one sample: 60 – 100 organisms/100mL) Median over bathing season of < 150 faecal coliforms per 100mL, with 4 out of 5 samples < 600/100mL Algae – <15000 cells/mL.	
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water.	
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed values in Table 9.2 of NHMRC (2008) guidelines.	
	Visual clarity and colour	As per the visual amenity guidelines.	
	Temperature	15°– 35°C for prolonged exposure	
Aquatic foods (cooked) – refers	Algae and blue-green algae	No guidelines is directly applicable, but toxins present in blue-green algae may accumulated in other aquatic organisms.	

Water Quality Objective	Indicator	Default guideline value	
		Lowland rivers	Estuaries
to protecting water quality so that it is suitable for production of aquatic foods for human consumption and aquaculture activities	Faecal coliforms	Guideline in water for shellfish: The median faecal coliform concentration should not exceed 14MPN/100mL; with no more than 10 per cent of the samples exceeding 43MPN/100mL. Standard in edible tissue: Fish destined for human consumption should not exceed a limit of 2.3MPN E Coli/g of flesh with a standard plate count of 100,000 organisms/g.	
	Toxicants (as applied to aquaculture activities)	Metals: Copper – less than 0.005mg/L Mercury – less than 0.001mg/L Zinc – less than 0.005mg/L. Organochlorines: Chlordane – less than 0.004mg/L (saltwater production) PCBs – less than 0.002mg/L.	
	Physico-chemical indicators (as applied to aquaculture activities)	Suspended solids: less than 40mg/L (freshwater); 10mg/L (marine) Temperature: less than 2°C change over one hour.	

^ only those indicators where data is available have been reported.
* DGVs for slightly to moderately disturbed ecosystems (95% level of species protection) have been adopted, except for cases where there is a potential for bioaccumulation (i.e. mercury for freshwater and estuarine and cadmium for estuarine) in which the 99% level of species protection have been used.

2.4 Existing surface water quality

Section 4.6 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) provided a summary of existing water quality compliance with recommended ANZG (2018) thresholds for aquatic ecosystems.

Based on the additional water sampling by Transport and EES Group, a revised summary of existing surface water quality is provided in **Table 2-6**. **Appendix A** and **Appendix B** provide updated median values for water quality parameters following the inclusion of results from monitoring by Transport. An explanation of the colour and compliance rating is provided in **Table 2-4**. Failure to achieve the WQO is determined as soon as any single indicator does not comply with the nominated DGV. **Table 2-5** summarises the existing water quality compliance with the ANZG (2018) Water Quality Guidelines default guideline values for the protection of aquatic ecosystems for slightly to moderately disturbed ecosystems.

Table 2-4 Compliance against water quality objectives

Per cent compliance	Colour and rating
75.1% - 100%	Good
50.1% - 75%	Fair
25.1% - 50%	Poor
0 - 25%	Very poor
Insufficient data	N/A

Table 2-5 Summary of existing water quality compliance with recommended ANZG (2018) DGVs for protection of aquatic ecosystems

Waterway / wetland	Description of existing water quality (with reference to aquatic ecosystem values)	
	Wet	Dry
Viney Creek	Very poor	Very poor
Glenrowan Creek	Very poor	Very poor
Purgatory Creek	Very poor	Very poor
Hunter River main stream	Poor	Very poor
Hunter River Drain and Tributary to Hunter River Drain	Very poor	Very poor
Hunter River wetland	N/A – no wet weather samples	Very poor
Unnamed Coastal Wetland (Tomago)	Very poor	Very poor
Windeyers Creek	Very poor	Very poor
Grahamstown Drain	Very poor	Very poor

Table 2-6 Updated summary of existing water quality against compliance with recommended ANZG (2018) thresholds for other relevant values

Waterway / wetland	Compliance with ANZG (2018) guideline values				
	Aquatic ecosystems	**Visual amenity**	**Primary contact recreation**	**Secondary contact recreation**	**Aquatic foods (cooked)**
Viney Creek	Currently not being achieved due to: • Dissolved oxygen saturation is very low and fails to meet the DGV • Median turbidity not achieving the DGV in wet weather • Nutrient concentrations are elevated with median TN more than double the DGV and TP four times the DGV during dry weather sampling. Medan concentrations during wet weather were also very high • Median concentrations of metals in samples from dry weather generally complied with the DGV except for zinc which exceeded the recommended limit of 0.008mg/L. Following wet weather sampling concentrations of copper and zinc increased to exceed the recommended DGV.	Currently not being achieved due to: • Murky brown water and presence of odour, algae and aquatic weeds.	Currently not being achieved due to: • Enterococci numbers during dry weather are slightly elevated and unsuitable for primary contact recreation. Following wet weather median numbers increased significantly and exceeded the recommended guidelines for both primary and secondary recreation.	Currently achieved in dry weather. Currently not being achieved in wet weather due to median enterococci numbers exceeding the recommended guidelines.	-
Glenrowan Creek	Currently not being achieved due to: • Dissolved oxygen concentrations are low and do not comply with the DGV during dry and wet weather. Turbidity and pH comply with the DGV during dry and wet weather • Median nutrient concentrations (TN and TP) are very high and do not comply with DGVs for protection of aquatic ecosystems. Concentrations of TN are more than 4 times the DGV during dry weather and almost 10 times the DGV during wet weather sampling. Total phosphorus concentrations are more than 10 times and five times the DGV during dry weather and wet weather respectively. • Median metal concentrations are generally low and comply with the respective DGVs for 95% protection of species (ANZG, 2018) except for zinc and copper. Zinc concentrations do not comply with the DGV during dry and wet weather and copper concentrations do not comply during wet weather.	Currently not being achieved due to: • Turbid brown water, oily films, odour and infestations of weeds.	Currently not being achieved due to: • Enterococci numbers during dry weather are slightly elevated and unsuitable for primary contact recreation. Following wet weather median numbers increased significantly and exceeded the recommended guidelines.	Currently achieved in dry weather. Currently not being achieved in wet weather due to median enterococci numbers increasing significantly and exceeding the recommended guidelines.	-

<table>
<tr><th rowspan="2">Waterway / wetland</th><th colspan="5">Compliance with ANZG (2018) guideline values</th></tr>
<tr><th>Aquatic ecosystems</th><th>Visual amenity</th><th>Primary contact recreation</th><th>Secondary contact recreation</th><th>Aquatic foods (cooked)</th></tr>
<tr><td>Purgatory Creek</td><td>Currently not being achieved due to:
• Low dissolved oxygen concentrations, particularly at the upstream sites (M12RT2, M12RT2b and M12RT2a) that do not comply with the DGV during dry weather. Following rainfall, dissolved oxygen increases slightly but concentrations at M12RT2 and M12RT2b still do not comply
• pH levels comply at all sites except for during dry weather at M12RT2
• Turbidity is elevated at all sites during dry and wet weather and does not comply with the DGV of 10NTU
• Median nutrient concentrations of TN and TP are elevated and significantly higher than the recommended DGVs at all sites on Purgatory Creek during dry and wet weather
• Median metal concentrations vary between the sites. Only arsenic, cadmium, nickel and mercury comply with the respective DGVs at all sites during dry and wet weather, whereas copper and zinc did not comply with the DGV during wet weather at half the sites. Chromium and lead were elevated at times and did not comply at M12RT2d and M12RT2a respectively during wet weather. M12RT2a generally had the highest concentrations failing to comply with the DGV for a number of metals.</td><td>Currently not being achieved due to:
• Exhibiting turbid brown water and presence of algae.</td><td>Currently not being achieved due to:
• Enterococci numbers varied between sites during dry weather with mixed compliance, however following rainfall increased significantly and did not comply with the recommended DGVs.</td><td>Currently not being achieved due to:
• Enterococci numbers varied between sites during dry weather with mixed compliance, however following rainfall increased significantly and did not comply with the recommended DGVs.</td><td>Currently not being achieved due to:
• Elevated concentrations of metals (zinc and copper)
• TSS and dissolved oxygen that did not comply with the DGVs.</td></tr>
<tr><td>Hunter River mainstream</td><td>Currently not being achieved due to:
• Dissolved oxygen concentrations generally complied except for at M12RT3 during wet weather and M12RT3b during dry weather
• Turbidity concentrations that do not comply with the DGV of 10NTU at any site during dry or wet weather
• Elevated nutrient concentrations, TN and TP that do not comply with the respective DGVs at any sites during dry weather sampling. Following rainfall, median</td><td>Currently not being achieved due to:
• Elevated turbidity levels
• Brown turbid water.</td><td>Currently not achieved during dry weather due to median enterococci numbers exceeding the recommend limit at M12RT3b.
Currently not achieved during wet weather due to elevated enterococci numbers following rainfall.</td><td>Currently achieved during dry weather.
Currently not achieved during wet weather due to elevated enterococci numbers following rainfall.</td><td>Currently not being achieved due to:
• Elevated TSS and zinc concentrations.</td></tr>
</table>

Waterway / wetland	Compliance with ANZG (2018) guideline values				
	Aquatic ecosystems	Visual amenity	Primary contact recreation	Secondary contact recreation	Aquatic foods (cooked)
	TN complies with the DGV at M12RT3a and M12RT3b and median TP is equal to the DGV at M12RT3b • Median chlorophyll-a concentrations that do not comply with the DGV of 4µg/L at the MER monitoring sites. Nutrient concentrations at these sites also do not comply with the recommended DGVs • Metal concentrations (copper and zinc) at M12RT3 that did not comply with the DGV during dry weather.				
Hunter River Drain and Tributary to Hunter River Drain	Currently not being achieved due to: • pH during wet weather at M12RT4 which fell below the lower DGV of 7 • Dissolved oxygen levels below the lower DGV of 80 percent saturation at all sites during both dry and wet weather • Turbidity that did not comply with the DGV of 10NTU at all sites during dry and wet weather sampling • Very high nutrient concentrations during both dry and wet weather that do not comply with the respective DGVs. During wet weather concentrations increase significantly and the recommended DGVs for TN is exceeded by between 9 and 11 times and TP is exceeded by 23 to 36 times • Median metal concentrations for arsenic, cadmium, chromium, lead and mercury at all sites complied with the respective DGV during dry and wet weather at all sites. Copper, nickel and zinc whilst recorded in low concentration during dry weather, increased and did not comply during wet weather at both sites.	Currently not being achieved due to: • Presence of turbid brown water, oily films and algae.	-	-	-
Unnamed coastal wetland	Currently not being achieved due to: • Dissolved oxygen below the lower limit of 80% saturation and turbidity exceeding the upper limit of 10NTU during both dry and wert weather sampling • Median nutrient concentrations (TN and TP) that are notably higher than the recommended DGV during dry	Currently partially achieved due to turbid brown water and presence of algae on occasion.	-	-	-

<table>
<tr><th rowspan="2">Waterway / wetland</th><th colspan="5">Compliance with ANZG (2018) guideline values</th></tr>
<tr><th>Aquatic ecosystems</th><th>Visual amenity</th><th>Primary contact recreation</th><th>Secondary contact recreation</th><th>Aquatic foods (cooked)</th></tr>
<tr><td></td><td>and wet weather sampling events and therefore do not comply
• Metal concentrations are generally low and comply with the DGV during dry and wet weather except for copper and zinc. Copper does not comply with the DGV during wet weather and zinc does not comply during dry or wet weather.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Windeyers Creek</td><td>Currently not being achieved due to:
• pH levels at M12RT6a which fell just below the lower limit of 6.5
• Low dissolved oxygen concentrations during dry and wet weather and did not comply with the DGV falling below the lower limit of 85 per cent saturation
• Elevated nutrient concentrations with median TN and TP not complying with the respective DGVs
• Zinc and chromium concentrations at M2RT6a do not comply with the DGV during dry and wet weather but do comply at M12RT6b. Copper concentrations whilst compliant at M12RT6a, do not comply with the DGV at M12RT6b for dry and wet weather sampling.</td><td>Currently not being achieved due to:
• Presence of oily films, turbid water, duckweed and algae.</td><td>Currently not achieved due to slightly elevated enterococci numbers at both sites during dry weather, which increase significantly following rainfall.</td><td>Currently achieved during dry weather.
Currently not achieved during wet weather due to elevated enterococci numbers following rainfall.</td><td>Currently not protected due to:
• Elevated copper and zinc concentration s
• Dissolved oxygen outside DGV.</td></tr>
<tr><td>Grahamstown drain</td><td>Currently not being achieved due to:
• Low pH and dissolved oxygen that do not comply with the respective DGVs
• Elevated nutrient concentrations (TN and TP) during wet weather that do not comply with the respective DGVs
• Elevated nickel and zinc concentrations. Nickel concentrations during dry weather exceeded the DGV of 0.013mg/L but was lower following rainfall and complied with the DGV. Zinc was elevated in Grahamstown Drain and recorded in similar concentrations during dry and wet weather sampling and did not comply with the DGV of 0.008mg/L.</td><td>Currently not being achieved due to:
• Turbid brown water and presence of iron bacteria.</td><td>Currently achieved during dry weather.
Currently not achieved during wet weather due to elevated enterococci numbers following rainfall.</td><td>Currently achieved during dry weather.
Currently not achieved during wet weather due to elevated enterococci numbers following rainfall.</td><td>-</td></tr>
</table>

3 Clarification and additional information

3.1 Submissions

Two submissions received during exhibition of the EIS required review of surface water quality and groundwater quality matters. A summary of those issues requiring additional information or assessment is presented in **Table 3-1**.

Table 3-1 Response to EIS submission

Stakeholder	Issue	How addressed in this report
NSW EPA	**Intercepted groundwater** Concerns raised with the interception of groundwater and the associated management and interaction with surface water.	Design changes to temporary construction sediment and operational water quality basins have been made to line all basins with potential to intercept groundwater. Refer to **Section 4.2** and **Section 5.1** for further detail. **Chapter 6** includes updated environmental management measure to address this issue.
NSW EPA	**Assessment of discharges from the project** Concerns were raised with the appropriateness of the assessment provided in the EIS particularly in relation to dilution / mixing zone assessment in waterways from discharge points, characterization of the potential discharge and the assessment of turbidity.	An updated water quality discharge assessment including discharge mixing zone/dilution assessment for all receiving waterways is included in **Section 3.2.1**. An updated linear regression analysis for TSS and turbidity was undertaken to convert the MUSIC modelling results for TSS to turbidity for inclusion in the water quality discharge assessment. Further information on the linear regression analysis is provided in **Appendix F**.
NSW EPA	**Practical measures for discharges and intercepted groundwater** Concerns were raised regarding the detail provided in management of potentially polluted discharges or intercepted groundwater. Improved methodology was recommended to address matters such as reuse of water and the management of extracted groundwater.	Provision of lined basins for potentially intercepted groundwater provides a strategy to minimise extraction of groundwater. As described in **Section 3.1.1**, a number of options would be implemented so that wherever possible surface water and groundwater would be reused on site.
NSW EPA	**In stream works / dredging** Concerns raised on the existing quality of river sediment, and practical measures to control / monitor dredging.	Further information on the scope of potential dredging and the existing river conditions is included in **Section 3.2.2**. Additional environmental management measures via a dredge management plan have been included in **Section 3.2.2** and **Chapter 6**.
NSW EPA and DPIE Water	**Management plans** Prepare management plans that include Trigger Action Response Plans (TARP)	A Construction Soil and Water Management Plan would be prepared for the project, as per environmental management measure WQ01. A commitment to prepare a trigger action response plan has been included in WQ01 to address this issue. Refer to **Chapter 6**.
NSW EPA and DPIE Water	**Sampling and monitoring** Clarification of monitoring data utilised and the commitment to continued groundwater monitoring	Groundwater monitoring has been undertaken over a suitable timeframe to adequately characterise groundwater quality. Additional pre-construction and construction monitoring would be undertaken as committed in environmental management measure WQ06. TARP sites would be nominated with the updated water monitoring program. Refer to **Appendix I** for the proposed water monitoring program.

3.1.1 Construction and operation water quality strategy

Section 5.1.1 and Section 5.2.1 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) provided a summary of the water quality strategy for the project.

The strategy sought to minimise impacts to water quality during construction via the following hierarchy:

- Avoidance and minimisation erosion and sedimentation through project design development
- Design and implementation of erosion control and sediment control
- Sediment capture and treatment using temporary sediment basins, including reusing water for construction activities where possible.

During operation, the main strategy to minimise impacts to water quality include the provision of a water quality treatment sequence consisting of providing vegetation cover for all unsealed surfaces, grassed drainage swales and permanent water quality basins. Rainfall runoff and accidental spills (such as petroleum hydrocarbons) within the footprint of the road would be captured and treated through these vegetated swales and basins.

Since exhibition of the EIS, the project design has been revised to minimise risks associated with the potential interaction between surface and groundwater. Surface water and groundwater monitoring undertaken during development of the EIS has shown groundwater to exhibit physical and chemical parameters at levels above those recorded in surface water. The interaction of groundwater with surface water collected in temporary sediment basins and operational water quality basins was considered to limit opportunities for reuse during construction or to meet / work toward meeting WQOs during operation. To achieve this, it is now proposed for all temporary sediment basins and permanent water quality basins that are anticipated to intercept groundwater to be lined. This design change is detailed further in **Section 4.2** and **Section 5.1**.

While it is proposed to re-use more of the surface water captured on site during construction, some water captured in sediment basins would need to be discharged to downstream waterways. In response, a revised water quality discharge assessment which includes a mixing zone analysis has been undertaken to determine the potential impact to downstream water quality from basin discharges. Further detail on the assessment and associated results are provided in **Section 3.2.1** and **Appendix E**.

Wherever possible, surface water captured in temporary sediment basins that does not prevent compliance with designed rain event capacity requirements, would be reused on site. Practical reuse options might include:

- Application across exposed surfaces including access tracks, haul routes and stockpiles for dust suppression
- Placement on the formation during earthworks to achieve compaction compliance with road design standards
- Application to stockpiles or imported material to condition during earthworks prior to placement
- Temporary storage for reuse in landscaping and ongoing maintenance work
- Application to open areas within the project footprint not required for construction to facilitate evaporation and infiltration.

Similarly, intercepted groundwater encountered during excavation or soft soil loading would be contained on site and assessed for reuse. Options for reuse, subject to physical and chemical properties, would be similar to those for surface water, but also include re-injection where possible. Any discharge of groundwater from site attributable to construction work would be subject to assessment, testing and demonstrated compliance with approved surface water discharge requirements.

Transport would continue to investigate all feasible and reasonable opportunities during construction to reuse surface water and groundwater.

3.2 Additional information

3.2.1 Revised water quality discharge assessment

Section 6.2.6 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) included a water quality discharge assessment to estimate Total Suspended Solids (TSS) and turbidity in temporary sediment basin discharges into a number of waterways and to determine whether the discharges complied with the relevant DGVs for achieving the nominated WQO or not. The estimated dilution factor that would be required to comply with the DGV in order to achieve the WQO was provided if the turbidity concentration did not comply with the DGV at discharge. This same approach was also adopted for the permanent water quality basins and is outlined in section 6.3.4 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a). However, the operational discharge assessment also included the indicators of total nitrogen (TN) and total phosphorus (TP) in addition to TSS and turbidity.

Basin discharges in the EIS were assessed by determining if basin water quality was better or worse than existing water quality and the DGV. The assessment did not account for dilution or mixing in the receiving waterway. A dilution model was applied to gain an understanding of the impact construction and operation of the project could have on the Hunter Estuary Wetlands.

Since public exhibition of the EIS, a revised water quality discharge impact assessment has been undertaken. The assessment is based on modelled water quality of the waterways after discharge of water occurs and a calculation of the mixing zone required should the WQO not be achieved at discharge. Additionally, the assessment determined if ambient water quality was achieved at discharge and, if not, the required mixing zone to achieve ambient water quality. Ambient water quality was defined as the 80th percentile of existing water quality data (dry and wet) for the named waterway the basins discharge to. As the WQO are currently not being achieved the 80th percentile was calculated to define ambient water quality within the mixing zone. This approach is recommended by ANZG (2018) when defining sites specific DGVs for WQO and despite the absence of suitable reference site data, was considered appropriate in this discharge impact assessment.

Dilution/mixing zone modelling has been performed for the seven waterways that would receive basin discharges. The location of these representative waterways is shown on **Figure 2-1**.

TSS and turbidity have been used as indicators for assessing water quality impacts from temporary sediment basin discharges. As noted previously, TSS, turbidity, TN and TP has been used for permanent water quality basins.

A summary of the water quality impact assessment due to discharges from temporary sediment and permanent water quality basins is discussed below. Further details on the methodology and the results of the water quality discharge impact assessment are provided in **Appendix D** and **Appendix E**.

The method and results of the mixing zone modelling at waterways where discharges would not meet the nominated WQO DGVs are described below.

Revised water quality impact assessment of temporary sediment basin discharges

Water quality indicators generally do not comply with the respective DGVs and therefore WQOs are not currently achieved for most waterways. A revised water quality discharge impact assessment of controlled and overflow discharges was undertaken for temporary sediment basins that would discharge into a receiving waterway.

Controlled discharges are the controlled release of water from temporary sediment basins following a rainfall event when the TSS concentration is less than 50mg/L. For the purposes of the revised assessment, the scenarios of all basins within the catchment being released at the same time and one basin at a time has been considered. The worst-case scenario is not consistent with industry practice where controlled basin releases occur sequentially by optimising the availability of resources. Overflow discharges are overflows from the basin that occur when the design capacity of the basins (developed in accordance with the “Blue Book”) is reached during or following an over criteria rain event. Overflow discharges were calculated for the assumed 50% AEP which would occur approximately every 1.44

years. As a 4-year construction period is proposed, this event may occur during the construction period. A range of velocities were determined along the waterways with the most upstream velocity (m/s) being applied to the revised water quality discharge impact assessment.

As there is no DGV for TSS for protection of aquatic ecosystems, the revised water quality discharge impact assessment determined the mixing zone required for discharge of TSS of 50mg/L from temporary sediment basins to meet ambient concentrations (80th percentile). The results for this are presented in **Table 3-2**. Temporary sediment basins where controlled and overflows discharge into Glenrowan Creek, Purgatory Creek, Hunter River and Hunter River Drains all meet ambient water quality within one metre of the discharge. If all basins discharged at the same time (worst-case) to these waterways, ambient water quality would again be met at the point of discharge (i.e. within one metre). The location of sediment basins is shown in **Appendix G**.

For controlled sediment basin releases into Hunter River and the Unnamed Coastal wetland, ambient water quality is met at the discharge point for each basin and under the worst-case. For Windeyers Creek and Viney Creek, while controlled discharges from each basin meet ambient water quality (TSS of 19.6mg/L and 29mg/L respectively at discharge) under worst-case, ambient water quality is not met in Windeyers Creek until 3.51 metres downstream of discharge and for Viney Creek 2.25 metres downstream of discharge. TSS concentrations following rainfall in Windeyers Creek and Viney Creek have been recorded as high as 64mg/L and 40mg/L respectively.

Overflow discharge releases from over criteria rain events from sediment basins do not meet ambient water quality under worst-case for Unnamed Coastal Wetland, Viney Creek and Windeyers Creek, despite some individual basins meeting ambient water quality at discharge. Under worst-case overflow discharges into the Unnamed Coastal Wetland, ambient water quality (21mg/L) would be met at 5.07 metres, at Viney Creek ambient water quality (29mg/L) would be met 16.68 metres downstream and at Windeyers Creek ambient water quality (19.6mg/L) would be met 26.2 metres downstream of discharge. As mentioned previously the likelihood of this occurring is once every 1.44 years. Due to the infrequency of overflow discharges occurring and water quality meeting ambient levels close to the source, impacts from overflow sediment basin releases is not likely to deteriorate the long-term water quality of these waterways.

Table 3-2 TSS concentrations and mixing zone from controlled (c) and overflows (o) temporary sediment basin discharges

Location	Relevant basins	TSS mixed range (mg/L)	TSS mixed worst-case	Ambient WQ (80th percentile) met	Mixing zone range for ambient WQ (m) [1]	Mixing zone for ambient worst-case[1,2]	80th percentile (wet and dry)
Glenrowan Creek	TPB06, TPB07, TPB08, TB03	26.79 – 43.07mg/L (o) 19.15 – 29.21mg/L (c)	44.96mg/L (o) 31.53mg/L (c)	Yes	0	0	61.4mg/L
Purgatory Creek	TPB09, TPB10, TPB11, TB04, TB05, TB06	26.0 – 40.3mg/L (o) 15.88 – 24.83mg/L (c)	45.23mg/L (o) 32.31mg/L (c)	Yes	0	0	60.6mg/L
Hunter River Drain	TPB19, TPB18, TPB20, TPB22	39.15 – 45.29mg/L (o) 36.37 – 38.63mg/L (c)	46.90mg/L (o) 42.08mg/L (c)	Yes	0	0	71.4mg/L
Windeyers Creek	TPB27, TPB28, TPB30 TPB29, TPB31, TPB32, TPB33	14.12 – 33.6mg/L (o) 14.76 – 18.00mg/L (c)	44.47mg/L (o) 29.01mg/L (c)	All basins meet ambient WQ during controlled release except worst- case. Only one basin (TPB29) meets ambient WQ during overflow discharges).	0.14 – 5.79m (o) 0.23 – 0.72m (c)	26.2m (o) 3.51m (c)	19.6mg/L
Viney Creek	TPB01, TPB02, TPB03, TPB04, TPB05, TB01	29.10 – 34.03mg/L (o) 27.67 – 28.89mg/L (c)	39.73mg/L (o) 30.61mg/L (c)	No basins meet ambient WQ during overflow discharge release 5 basins meet ambient WQ during controlled (TPB01, TPB02, TPB03, TPB05, TB01).	1.07 – 5.72m (o) 0.10 – 0.92m (c)	16.68m (o) 2.25m (c)	29mg/L
Hunter River	TPB12, TPB13, TPB16, TPB17, TB07, TB10	28.49 – 38.77mg/L (o) 16.04 – 23.27mg/L (c)	46.25mg/L (o) 33.78mg/L (c)	Yes	0	0	48.2mg/L

Location	Relevant basins	TSS mixed range (mg/L)	TSS mixed worst-case	Ambient WQ (80th percentile) met	Mixing zone range for ambient WQ (m) [1]	Mixing zone for ambient worst-case[1,2]	80th percentile (wet and dry)
Unnamed Coastal wetland	TPB14, TPB15, TPB16, TPPB17, TB10	15.80 – 25.14mg/L (o) 10.44 – 13.36mg/L (c)	36.55mg/L (o) 18.59mg/L (c)	All basins meet ambient WQ during controlled. 3 basins meet ambient WQ for overflow discharges (TB10, TPB14, TPB15). Worst-case overflow does not meet ambient WQ.	0.46 – 1.59m (o) 0 (c)	5.07m (o) 0 (c)	21mg/L

[1]A mixing zone of 0 metres means that the TSS concentrations from temporary sediment basins meet ambient WQ at the discharge point.

[2]Worst-case is all basins discharging at the same time. Assumed velocity is the most upstream velocity.

(o) refers to overflow discharges from over design criteria events and (c) refers to controlled discharges.

Project impact on water quality during construction

The discharge of temporary sediment basins under controlled and overflow events generally meet ambient TSS levels in most waterways under a range of scenarios. Where ambient water quality is not met, particularly for controlled discharges, only a very small mixing zone is required to meet ambient concentration levels which suggests minimal change to water quality in these waterways.

Similar to the above, it is assumed that as TSS generally meets ambient concentrations that the WQO visual amenity, which is currently not achieved or only partially achieved in these waterways, would not be further impacted during these controlled and overflow events. Where TSS exceeds ambient concentrations, such as in Windeyers Creek and Viney Creek, visual amenity may be temporarily worse than existing until localised mixing has occurred.

The WQO aquatic foods (cooked) is nominated for protection in Purgatory Creek, Hunter River mainstream and Windeyers Creek and is currently not achieved in any of these waterways. TSS is one of the indicators nominated for protection of this WQO, with a DGV of less than 10mg/L for estuarine and less than 40mg/L in freshwater waterways. TSS in basin discharges would not meet the DGV for aquatic foods in either Purgatory Creek or Hunter River mainstream, but would meet the DGV in Windeyers Creek (except under worst-case overflow discharge events).

Revised water quality impact assessment for permanent water quality basin discharges

During operation, basin discharges generally do not comply with the DGVs, including the parameters of TSS, turbidity, TN and TP and therefore WQOs are not being achieved for most waterways. A revised water quality discharge impact assessment of discharges from operational water quality basins for 50% AEP was undertaken for the key indicators of TSS, TN and TP.

A range of velocities were determined along the waterways with the most upstream velocity (m/s) being applied to the revised water quality discharge impact assessment. Turbidity values were calculated based on a correlation of sampled TSS/turbidity values. Where correlation was weak (R^2 <0.3), the revised water quality discharge impact assessment on turbidity was not undertaken. Results of the assessment are displayed in **Table 3-3, Table 3-4**, **Table 3-5** and **Table 3-6**. The updated turbidity/TSS correlation plots which incorporated additional water quality data since submission of the EIS and methodology are provided in **Appendix F**.

The location of permanent water quality basins is shown in **Appendix H**.

Total suspended solids

As mentioned previously, there is no DGV for TSS for the protection of aquatic ecosystems. Therefore, discharges of TSS from operational water quality basins has only been compared to ambient (80^{th} percentile) water quality results. TSS in discharges from individual basins and under worst-case meet ambient TSS concentrations at the discharge for Glenrowan Creek, Purgatory Creek, Hunter River drain and Hunter River. Therefore, discharges from these basins would not impact on existing TSS concentrations. While some basins that discharge into Windeyers Creek, Viney Creek and the unnamed coastal wetland at Tomago meet ambient concentrations at the discharge, under the worst-case ambient water quality is not met. In Windeyers Creek, TSS concentrations do not meet ambient water quality until 13.14 metres downstream. In Viney Creek and the unnamed coastal wetland, ambient water quality under worst-case is met 2.6 metres and 5.76 metres downstream, respectively. Results for TSS are provided in **Table 3-3**.

Table 3-3 TSS concentrations and mixing zone from operational water quality basin discharges

Location	Relevant basins	TSS mixed range (mg/L)	TSS mixed worst-case	Ambient WQ (80th percentile) met	Mixing zone range for ambient WQ (m)[1]	Mixing zone for ambient worst-case[1,2]	80th percentile (wet and dry)
Glenrowan Creek	PB07, PB08, PB09	21.55 – 40.05mg/L	28.64mg/L	Yes	0	0	61.4mg/L
Purgatory Creek	PB10, PB12, PB13, PB11, PB14	17.39 – 38.23mg/L	35.49mg/L	Yes	0	0	60.6mg/L
Hunter River Drain	PB25, PB24, PB26, PB28	26.72 – 33.62mg/L	25.86mg/L	Yes	0	0	71.4mg/L
Windeyers Creek	PB33, PB34, PB36, PB35, PB37, PB38, PB39	15.4 – 26.29mg/L	29.56mg/L	Three basins meet ambient WQ (PB36, PB37, PB39)	0.08 – 3.87m	13.14m	19.6mg/L
Viney Creek	PB01, PB02, PB03, PB04, PB05, PB06	27.46 – 29.62mg/L	30.31mg/L	Four basins meet ambient WQ (PB02, PB03, PB04, PB05)	0.46 – 1.44m	2.6m	29mg/L
Hunter River	PB15, PB16, PB17, PB18, TB19	15.09 – 26.94mg/L	22.38mg/L	Yes	0	0	48.2mg/L
Unnamed Coastal wetland	PB20, PB22, PB23, PB21	10.64 – 34.74mg/L	36.54mg/L	Two basins meet ambient WQ (PB20, PB23)	0.68 – 4.04m	5.76m	21mg/L

[1]A mixing zone of 0 metres means that the TSS concentrations from sediment basins meet ambient WQ at the discharge point.

[2]Worst case is all basins discharging at the same time. Assumed velocity is the most upstream velocity.

Turbidity

The impact of high turbidity being discharged from operational water quality basins was assessed performing a linear regression analysis to convert modelled TSS loads to turbidity (Kusari et al, 2013). The regression analysis undertaken as part of the EIS was updated to incorporate additional monitoring data, however due to a weak correlation at two sites, TSS was not converted to turbidity in Windeyers Creek and the unnamed coastal wetland (refer to **Appendix F**). The need for the regression analysis was due to the absence of a DGV for TSS for protection of aquatic ecosystems.

Ambient turbidity was met at the discharge point for each waterway assessed. Discharges from operational water quality basins and under worst-case comply with the DGV for the protection of aquatic ecosystems in Glenrowan Creek only. While some basins comply with the DGV at discharge, under worst-case the DGV is not met in Viney Creek and Hunter River. In Viney Creek compliance with the DGV occurs within 2.2 metres of the discharge. However, in the Hunter River, upstream ambient turbidity is too high compared to the DGV to determine the length of the mixing zone despite better water quality being discharged. No basin discharges comply with the DGV in Purgatory Creek and Hunter River drain and under worst-case the existing water quality upstream is too poor to determine the mixing zone required to meet the DGV. Ambient water quality is met under worst-case at the discharge. Overall, discharges only achieve the WQO for protection of aquatic ecosystems in Glenrowan Creek. Some basins in Viney Creek and Hunter River do achieve the WQO but under worst-case, the WQO for protection of aquatic ecosystem is not achieved. Results for turbidity are provided in **Table 3-4**.

Table 3-4 Turbidity concentrations and mixing zone from operational water quality basin discharges

Location	Relevant basins	Turbidity mixed range[1]	Turbidity mixed worst-case	WQO met	Ambient WQ (80th percentile) met	Mixing zone range for WQO (m)	ANZG (2018) DGV	80th percentile (wet and dry)
Glenrowan Creek	PB07, PB08, PB09	16.03 – 19.45 NTU	13.76 NTU	Yes	Yes	0	50NTU	26.9NTU
Purgatory Creek	PB10, PB12, PB13, PB11, PB14	21.84 – 36.90 NTU	28.55 NTU	No	Yes	Existing WQ too poor to determine mixing zone	10NTU	47.9NTU
Hunter River Drain	PB25, PB24, PB26, PB28	14.35 – 28.47 NTU	25.65 NTU	No	Yes	Existing WQ too poor to determine mixing zone	10NTU	71.24NTU
Windeyers Creek	PB33, PB34, PB36, PB35, PB37, PB38, PB39	N/A	N/A	N/A	N/A	N/A	50NTU	18NTU
Viney Creek	PB01, PB02, PB03, PB04, PB05, PB06	39.32– 41.38 NTU	56.91 NTU	Yes at each basin. No for worst-case.	Yes	2.2m for worst case	50NTU	66.88NTU
Hunter River	PB15, PB16, PB17, PB18, TB19	6.56 – 30.68 NTU	23.18 NTU	Yes for one basin (PB17). No for all others and worst-case.	Yes	Existing WQ too poor to determine mixing zone	10NTU	48.56NTU
Unnamed Coastal wetland	PB20, PB22, PB23, PB21	N/A	N/A	N/A	N/A	N/A	10NTU	29.68NTU

[1] N/A turbidity could not be reported as no correlation could be determined due to a very weak linear regression (refer **Appendix F**)

Total nitrogen

The DGV for TN for protection of aquatic ecosystems is 0.35mg/L in lowland rivers and 0.3mg/L in estuarine systems. Total nitrogen concentrations in basin discharges during operation currently do not comply with the DGV, however they meet ambient water quality at discharge for each basin and under worst-case. Due to notably elevated concentrations of TN currently recorded in the waterways the mixing zone required to meet the DGV cannot be determined. These results are similar to the EIS where TN in basin discharges were determined to be similar or better than ambient TN concentrations but did not comply with the DGV in at most waterways. The EIS reported that TN in basins discharging to Hunter River Drain complied with the DGV however the results of this revised water quality discharge impact assessment approach and use of additional water quality data suggests that basin discharges would not comply with the DGV. Overall, while basin discharges are better than ambient water quality, the WQO for protection of aquatic ecosystems is not achieved. Results for TN are provided in **Table 3-5**.

Total phosphorous

The DGV for TP for protection of aquatic ecosystems is 0.025mg/L in lowland river and 0.03mg/L in estuarine systems. Total phosphorus concentrations in basin discharges currently do not comply with the DGV, however meet ambient water quality at discharge for each basin and under worst-case. Due to notably elevated concentrations of TP in the waterways the mixing zone required to comply with the DGV and therefore achieve the WQO cannot be determined. These results are similar to the EIS where TP in basin discharges were determined to be similar or better than ambient TP concentrations for all waterways except the unnamed coastal wetland. Results for TP are provided in **Table 3-6**.

Table 3-5 Total nitrogen concentrations and mixing zone from operational water quality basin discharges

Location	Relevant basins	TN mixed range (mg/L)	TN mixed worst-case	WQO met	Ambient WQ (80th percentile) met	ANZG (2018) DGV	80th percentile (wet and dry)
Glenrowan Creek	PB07, PB08, PB09	0.54 – 1.27mg/L	0.58mg/L	No	Yes	0.35 mg/L	4.22 mg/L
Purgatory Creek	PB10, PB12, PB13, PB11, PB14	0.65 – 0.90mg/L	0.64mg/L	No	Yes	0.3 mg/L	2.54 mg/L
Hunter River Drain	PB25, PB24, PB26, PB28	0.74 – 1.75mg/L	0.50mg/L	No	Yes	0.3 mg/L	3.56 mg/L
Windeyers Creek	PB33, PB34, PB36, PB35, PB37, PB38, PB39	0.84 – 1.19mg/L	0.7mg/L	No	Yes	0.35 mg/L	2.4 mg/L
Viney Creek	PB01, PB02, PB03, PB04, PB05, PB06	0.70 – 0.75mg/L	0.67mg/L	No	Yes	0.35 mg/L	0.9 mg/L
Hunter River	PB15, PB16, PB17, PB18, TB19	0.41 – 0.97mg/L	0.88mg/L	No	Yes	0.3 mg/L	1.06 mg/L
Unnamed Coastal wetland	PB20, PB22, PB23, PB21	1.02 – 1.34mg/L	0.92mg/L	No	Yes	0.3 mg/L	2.2 mg/L

Note. No mixing zone value for WQO as existing water quality in the waterways is already too poor to determine a mixing zone. Initial mixing is considered to be one metre from discharge, therefore ambient water quality is met within one metre.

Table 3-6 Total phosphorus concentrations and mixing zone from operational water quality basin discharges

Location	Relevant basins	TP mixed range (mg/L)	TP mixed worst-case	WQO met	Ambient WQ (80th percentile) met	ANZG (2018) DGV	80th percentile (wet and dry)
Glenrowan Creek	PB07, PB08, PB09	0.06 – 0.12mg/L	0.07mg/L	No	Yes	0.025 mg/L	0.282 mg/L
Purgatory Creek	PB10, PB12, PB13, PB11, PB14	0.11 – 0.19mg/L	0.10mg/L	No	Yes	0.03 mg/L	0.474 mg/L
Hunter River Drain	PB25, PB24, PB26, PB28	0.18 – 0.47mg/L	0.12mg/L	No	Yes	0.03 mg/L	1.082 mg/L
Windeyers Creek	PB33, PB34, PB36, PB35, PB37, PB38, PB39	0.07 – 0.09mg/L	0.08mg/L	No	Yes	0.025 mg/L	0.246 mg/L
Viney Creek	PB01, PB02, PB03, PB04, PB05, PB06	0.09 – 0.10mg/L	0.09mg/L	No	Yes	0.025 mg/L	0.14 mg/L
Hunter River	PB15, PB16, PB17, PB18, TB19	0.06 – 0.14mg/L	0.12mg/L	No	Yes	0.03 mg/L	0.186 mg/L
Unnamed Coastal wetland	PB20, PB22, PB23, PB21	0.09 – 0.10mg/L	0.10mg/L	No	Yes	0.03 mg/L	0.144 mg/L

Note. No mixing zone value for WQO as existing water quality in the waterways is already too poor to determine a mixing zone. Initial mixing is considered to be one metre from discharge, therefore ambient water quality is met within one metre.

Project impact on water quality objectives during operation

While an improvement to existing water quality is anticipated for some indicators at modelled locations, water quality remains unlikely to comply with the ANZG (2018) Water Quality Guidelines and not likely to achieve nominated objectives in the short term.

The findings of this revised water quality discharge assessment are similar to the findings of the EIS, which is that generally, existing water quality is too poor to achieve nominated WQOs despite basin discharges at times complying with DGVs, and that basin discharges are generally of better quality than the receiving environment. Similar to the EIS, the likelihood of pollutants being present in basin discharges at a level that poses a risk to human health is minimal as it is expected that pollutants would be bound to sediments that would be retained in the basins.

A summary of the water quality impact assessment results with respect to nominated WQOs is provided in **Table 3-7**.

Table 3-7 Revised project impact on water quality objectives during operation

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
R1 – Glenrowan Creek (Lowland river)	✓	✓	✓	✓	NA	Median water quality at this waterway complies with the DGV for turbidity for the protection of aquatic ecosystems. Median water quality does not comply with the DGV for TN or TP for protection of aquatic ecosystems. Each basin individually and cumulatively (worst-case) would discharge water that has turbidity that is lower than the DGV. TN and TP concentrations in basin discharges (individually and cumulatively) would not meet the DGV, but concentrations are lower than existing. Other pollutants such as heavy metals which pose a risk to the environment and human health are generally sediment bound. As TSS and turbidity in basin discharges are better than existing and often comply with the DGV, it is expected that these pollutants would also be reduced and not pose a risk to downstream water quality. A brief discussion on the WQO is provided below. Aquatic ecosystems – Basin discharge water quality has lower levels of contaminants than either the DGV or the existing environment and are unlikely to have a significant impact on the receiving aquatic ecosystem. Visual amenity - The project would achieve the WQO for visual amenity with turbidity levels expected to comply with the DGV. Visual clarity is therefore not expected to be reduced. Primary and secondary contact – Secondary contact may be possible for public access and maintenance of assets however primary contact is unlikely due to shallow water and degraded water quality. The project would meet the WQO for secondary contact (i.e. recreation) as operation of the project is not expected to increase bacterial counts that would result in the deterioration of recreational water quality. Additionally, metal and toxicant concentrations are expected to be captured by sediment and therefore are unlikely to be in concentrations that are hazardous to human health.
R2 – Purgatory Creek (Estuarine)	✓	✓	✓	✓	NA	Median water quality at this waterway does not comply with the DGVs for turbidity, TN or TP. Each basin discharge individually and cumulatively has turbidity that exceeds the DGV of 10NTU and TN and TP that exceeds the DGV of 0.3mg/L and 0.025mg/L respectively. Basin discharges however are lower than existing ambient conditions and hence would contribute to achieving the WQO over time. Existing water quality is too poor to determine a mixing zone for turbidity, TN and TP. As basins would discharge lower TSS and turbidity than existing it is expected that other pollutants that are sediment bound would also be reduced and not pose a risk to downstream water quality. A brief discussion on the WQOs is provided below. Aquatic ecosystems – As stated in the EIS this WQO is currently not met and while discharge water quality also exceeds the DGV, the concentrations are better than existing and therefore would work to achieve the WQO over time.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						Visual amenity – Existing turbidity levels do not achieve the WQO. The sporadic addition of discharge water during rainfall events that is generally comparable with the existing turbidity range during rain fall events is unlikely to significantly impact on the visual amenity of the water. Primary and secondary contact - Secondary contact is possible due to landowner access and ongoing asset maintenance, however primary contact recreation is considered highly unlikely as it is a shallow modified drainage channel that is situated within private farmland. Construction discharges shall not generate or consolidate enterococci and as the turbidity of the discharges would be consistent with existing conditions, increased algal blooms are not anticipated. The project would be unlikely to significantly impact on secondary contact values.
R3 – Hunter River Drain (Estuarine)	✓	✓	✓	✓	NA	Median water quality at this waterway does not comply with the DGVs for turbidity, TN or TP. Each basin discharge individually and cumulatively has turbidity that exceeds the DGV of 10NTU and TN and TP that exceeds the DGV of 0.3mg/L and 0.025mg/L respectively. Basin discharges however are lower than existing and hence contribute to achieving the WQO over time. Existing water quality is too poor to determine a mixing zone for turbidity, TN and TP. As basin would discharge lower TSS and turbidity than existing it is expected that other pollutants that are sediment bound would also be reduced and not pose a risk to downstream water quality. A brief discussion on the WQO is provided below. Aquatic ecosystems – As stated in the EIS this WQO is currently not met and while discharge water quality also exceeds the DGV, the concentrations are better than existing and therefore would work to achieve the WQO over time. Visual amenity - The proposed water quality generally consistent with the existing ambient condition and is unlikely to significantly impact on visual amenity. Primary and secondary contact – Secondary contact is possible due to landowner access for flood conveyance management and ongoing asset maintenance, however primary contact recreation is considered highly unlikely as it is a shallow modified drainage channel that is situated within private farmland. Construction discharges would not generate or consolidate enterococci and as the turbidity of the discharges would be consistent with existing conditions, increased algal blooms are not anticipated. The project would be unlikely to significantly impact on secondary contact values.
R4 – Windeyers Creek (Lowland river)	✓	✓	✓	✓	NA	Median water quality at this waterway complies with the DGV for turbidity for the protection of aquatic ecosystems. Median water quality does not comply with the DGV for TN or TP for protection of aquatic ecosystems. Turbidity of basin discharge could not be accurately calculated however TSS in basin discharge meets ambient TSS in three of seven basins. Cumulatively basin discharges do not meet ambient TSS until about 13 metres downstream of discharge. TN and TP in basin

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						discharges do not meet the DGVs but do meet ambient water quality. TSS of discharge from some basins slightly exceed the ambient TSS of Windeyers Creek and may result in temporary increase of other pollutants. A brief discussion on the WQO is provided below. Aquatic ecosystems – Existing water quality it too poor to achieve the WQO at the discharge point however discharge water quality is better than existing for TN and TP and TSS generally meets ambient within three metres of discharge except under worst-case. As such the operation of the project is unlikely to significantly impact on the receiving aquatic ecosystems. Visual amenity – TSS is similar to existing at most discharge points and unlikely to significantly impact on visual amenity. If all basins overflowed together visual amenity may be temporarily impacted for up to 13 metres downstream. Primary and secondary contact - Secondary contact is possible due to public access to surrounding open spaces and access for maintenance for drainage from WWTP, however primary contact recreation is considered highly unlikely due to shallow water and poor water quality. Operational discharges would not generate or consolidate enterococci and as the turbidity of the discharges would be consistent with existing conditions, increased algal blooms are not anticipated. The project would be unlikely to significantly impact on secondary contact values.
R5 – Viney Creek (Lowland river)	✓	✓	✓	✓	✓	Median turbidity only complies with the DGV under dry weather conditions in Viney Creek and TN and TP exceed the DGV under wet and dry conditions. Each basin individually would discharge water that has turbidity lower than the DGV, however cumulatively, the DGV would not be met until 2.6 metres downstream. TN and TP concentrations in basin discharges (individually and cumulatively) would not meet the DGV, but concentrations are lower than existing. Other pollutants such as heavy metals which pose a risk to the environment and human health are generally sediment bound. As TSS and turbidity in basin discharges are better than existing and often meet the DGV, it is expected that these pollutants would also be reduced and not pose a risk to downstream water quality. A brief discussion on the WQOs is provided below. Aquatic ecosystems - Basin discharge water quality has lower levels of contaminants than either the WQO or the existing environment and are unlikely to have a significant impact on the receiving aquatic ecosystem. Visual amenity – The project would meet the WQO for visual amenity with turbidity levels expected to be below the DGV. Visual clarity is therefore not expected to be reduced. If all basins overflowed together visual amenity may be temporarily impacted for up to 2.6 metres downstream.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
						Primary and secondary contact - Secondary contact with the water is possible due to its accessibility by the public and its ongoing of maintenance for flood conveyance through the industrial area, however primary contact is unlikely due to shallow water and access limitation due to dense reed growth. Operational discharges would not generate or consolidate enterococci, and as the modelled turbidity output is lower than the existing range, the project would be unlikely to have a significant impact to secondary contact values.
R6 – Hunter River (Estuarine)	✓	✓	✓	✓	✓	Median water quality at this waterway does not comply with the DGVs for turbidity, TN or TP, although TN does fall below the DGV during wet weather at some sites. Only one of the five basins that discharge into the Hunter River would have turbidity that complies with the DGV at the discharge point. Cumulatively, the discharge turbidity would not comply with the DGV at discharge. TN and TP in basin discharge exceeds the DGV of 0.3mg/L and 0.025mg/L respectively however are lower than existing and hence contribute to achieving the WQO over time. Existing water quality is too poor to determine a mixing zone for turbidity, TN and TP. As basins would discharge lower TSS and turbidity than existing it is expected that other pollutants that are sediment bound would also be reduced and not pose a risk to downstream water quality. A brief discussion on the WQOs is provided below. Aquatic ecosystems - As stated in the EIS this WQO is currently not met and while discharge water quality also exceeds the DGV, the concentrations are better than existing and therefore would work to achieve the WQO over time. Visual amenity - The proposed ambient water quality are generally better than the existing ambient quality and would be unlikely to significantly impact on visual amenity. Primary and secondary contact - The most probable primary recreational contact with water across the project would be in the Hunter River as it is infrequently used for water sports (skiing, paddling etc). Secondary contact is highly probable due to activities such as shore and boat fishing. The WQOs of primary and secondary contact recreation are currently not being met due to high turbidity and nutrient levels and suspended sediments may contain elevated concentrations of metals and toxicants that are hazardous to human health. Permanent operational discharges would not contribute to conditions favouring the growth of or introducing bacteria (i.e. enterococci) to the waterway. Discharges therefore would work toward achieving these WQOs and would be unlikely to have a significant impact to primary and secondary contact values. Aquatic foods (cooked) - The WQO of aquatic foods (cooked) is currently not being achieved due to elevated NTU and other contaminates levels above the DGV. The discharges from the permanent water quality basins would improve the background water quality. Additionally, with the large volume of dilution available, the basin discharges are unlikely to hinder the long-term achievement of this WQO and would be unlikely to have a significant impact on aquatic food values.

Waterway	Relevant site specific WQO applied to the assessment					Assessment of project impact during operation
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Aquatic foods (cooked)	
R7 – Unnamed coastal wetland (Estuarine)	✓	✓	✓	✓	✓	Median water quality does not comply with the DGV for turbidity, TN or TP for protection of aquatic ecosystems. Turbidity of basin discharge could not be accurately calculated, however TSS in basin discharge meets ambient TSS in two of four basins. Cumulatively basin discharges do not meet ambient TSS until about 5.7 metres downstream of discharge. TN and TP in basin discharges do not comply with the DGVs but do meet ambient water quality. TSS of discharge from some basins slightly exceed the ambient TSS of Windeyers Creek and may result in temporary increase of other pollutants. A brief discussion on the WQOs is provided below. Aquatic ecosystems - Existing water quality is too poor to achieve the WQO at the discharge point however discharge water quality is better than existing for TN and TP and TSS generally meets ambient within four metres of discharge except under worst case. As such the operation of the project would be unlikely to significantly impact on the receiving aquatic ecosystems. Visual amenity - TSS is similar to existing at most discharge points and unlikely to significantly impact on visual amenity. If all basins overflowed together visual amenity may be temporarily impacted for a up to 5.7 metres downstream. Primary and secondary contact – Secondary contact with surface water is possible due to access of the site for asset maintenance. Primary contact is unlikely due to shallow water at the site. Permanent operational discharges would not contribute to conditions favouring the growth of or introducing bacteria (i.e. enterococci) to the waterway. Discharges therefore would work toward meeting these WQOs and would be unlikely to have a significant impact to secondary contact values.

3.2.2 Dredging in the Hunter River

Background

The *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) identified potential impacts to Hunter River water quality from dredging activities. Further detail was provided in Chapter 5 of the EIS and the *M1 Pacific Motorway extension to Raymond Terrace Biodiversity Assessment Report* (BAR) (Jacobs, 2021c).

Construction of the overwater viaduct elements would require dredging of a limited area of the Hunter River riverbed within the construction footprint to allow shallow water access for barges during construction. Dredging is a relatively common activity undertaken within NSW ports and coastal waters, including in the Hunter River Estuary, for capital and maintenance projects. Dredging activities in NSW use specialised contractors and equipment designed to meet project and environmental requirements in a variety of conditions. An example of dredging in operation in the Hunter River is provided in **Figure 3-1**.

It is anticipated that dredging via excavator on the project would be over an area of about 1,500 square metres, generate up to about 2000 cubic metres of spoil and require up to five days of in-water work.

Figure 3-1 Example of dredging the Hunter River

Impacts

Impacts from dredging without management would be limited to a potential reduction in local water quality associated with elevated suspended sediment concentrations in the water column and the potential mobilisation of contaminants bounds within riverbed sediment disturbed by the proposed activities. Based on sediment quality data provided in the *M1 Pacific Motorway extension to Raymond Terrace Soils and Contamination Working Paper* (Jacobs, 2021c) and four sediment samples collected at overwater bores, metals are largely within acceptable ANZG (2018) guidelines limits with the exception of nickel which marginally exceeded the DGV in two samples (refer Appendix J of submissions report). Elevated nickel has also been recorded in existing soil and groundwater samples across the site and therefore likely a result of the naturally occurring geology and not an isolated anthropogenic contaminant associated with previous land use. Overall, Hunter River sediments do not pose a risk to human health or the environment and do not require further special consideration or management.

Investigations found that there are no gravel beds, snags or significant areas of instream vegetation in the deep section of the channel at the location where the proposed viaduct crosses the Hunter River. Impacts to instream habitat features are not anticipated.

It is proposed to install silt curtains to the full water column depth during dredging operations apart from a small portion of the water column immediately above the streambed. This is considered sufficient for mitigating dispersion of sediment as most suspended sediment is light-weight and would disperse toward the top of the water column when disturbed. Furthermore, in a natural, tidally influenced ecosystem, a small portion of the water column should be unobstructed below the silt curtain to provide opportunity for fauna to escape if trapped by the curtain and to minimise disruption due to tidal flow. As the dredging area in the construction footprint is relatively shallow, a two to three metre deep weighted floating silt curtain would be suitable to minimise dispersion of suspended sediment.

Further to installation of silt curtains around the dredging areas, a shallow silt curtain may also be installed next to ecologically sensitive areas to provide additional protection. Dredging material would be either transported to an ancillary facility for assessment, treatment and potential reuse on site, or disposed off-site to a licensed facility.

Mitigation

Transport would prepare a Dredge Management Plan (DMP) prior to the commencement of any dredging operations. The DMP would include:

- Sampling to classify material that would be intercepted by the dredging activities
- Dredging management objectives
- Dredging management implementation including contamination management and contingency measures
- Dredging mitigation including:
  - Dredging operations would be completed within a double silt curtain to contain disturbed sediments
  - No overflow would be permitted from transport barges taking material for unloading and land disposal
  - Work would be completed under a full-time supervision and inspection regime.

In addition to proposed mitigation measures listed above, the water quality monitoring program would incorporate visual turbidity plume monitoring immediately outside the silt curtain during dredging operations as detailed in **Appendix I**. Adaptive management responses contained within the DMP would be implemented if deficiencies were identified.

4 Construction Impacts

This chapter contains an assessment of impacts on surface and groundwater quality from proposed project refinements during construction.

4.1 Heatherbrae waterway construction footprint adjustment

4.1.1 Refinement description

Transport proposes a minor adjustment to the project footprint to the west of the alignment at Heatherbrae (refer **Figure 4-1**). The proposed design refinement includes a minor increase (0.1 hectares) to the construction footprint at Heatherbrae to enable works at the existing headwall near the horse racing facility. The footprint adjustment would facilitate access along an existing drainage line to the point of discharge with the Hunter River. Access to this area would facilitate drainage channel maintenance or flow-pathway improvements where determined necessary during development of the detailed design.

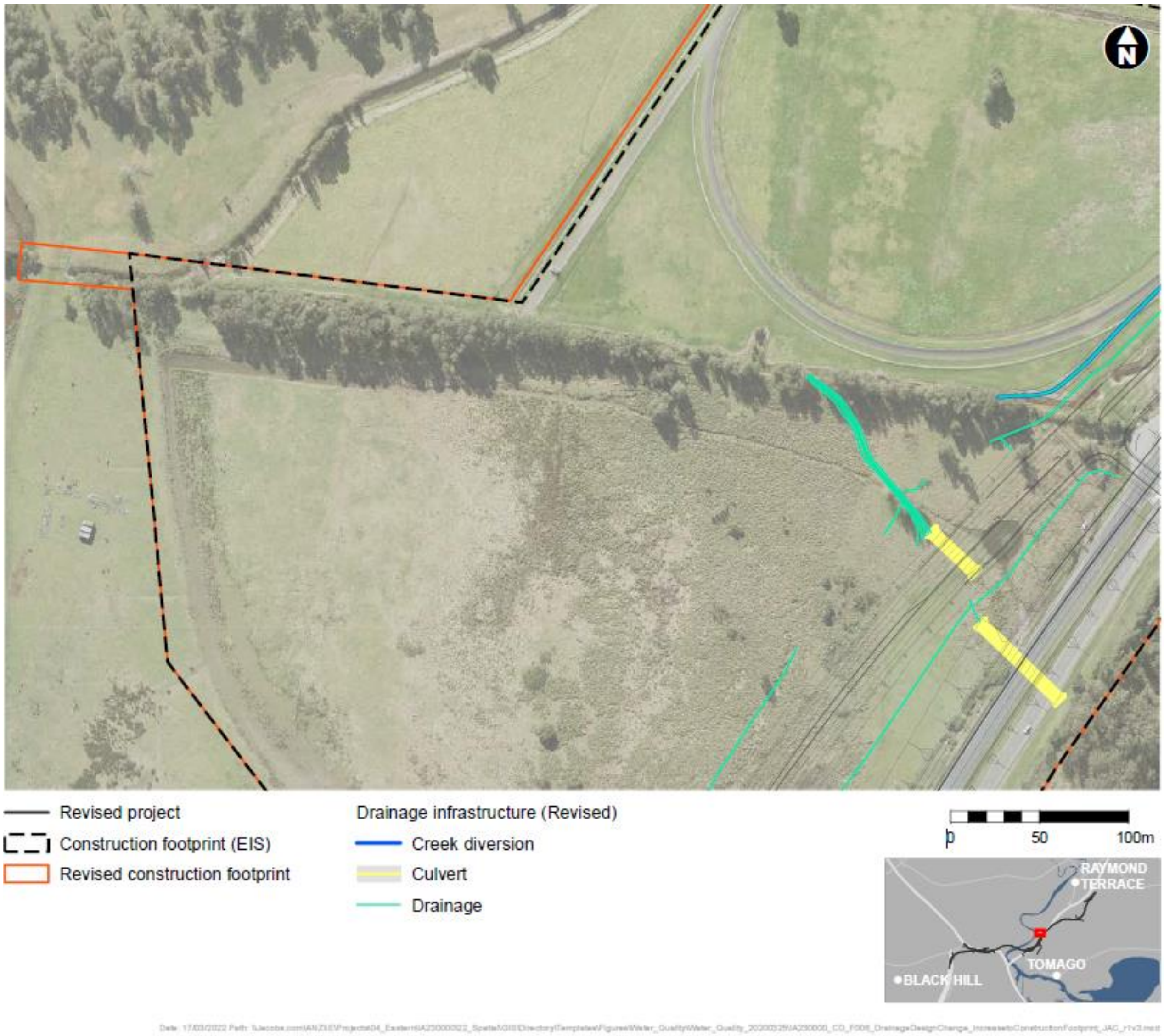

Figure 4-1 Minor increase to construction footprint at existing headwall, Heatherbrae

4.1.2 Impacts from refinement

The proposed design refinement would increase the construction footprint by about 0.1 hectares. The area is proximate to the Hunter River and would have the potential to expose an additional small area of land and surface water to erosion and sedimentation impacts consistent with those outlined in Section 11.4.2 of the *M1 Pacific Motorway extension to Raymond Terrace Environmental Impact Statement* (Transport for NSW 2021).

The additional area is also located on land mapped as Coastal Wetland under the State Environmental Planning Policy (Resilience and Hazards) 2021. The EIS noted much of this area to be in poor condition and cleared for agricultural purposes. Therefore, the additional increase in cleared area of 0.1 hectares is not likely to impact on the ecological function of the area.

4.1.3 Additional mitigation

Mitigation measures documented in **Chapter 6** of this report would be implemented to avoid or minimise the potential for surface water and groundwater impacts from this proposed refinement.

4.2 Temporary sediment basin lining

4.2.1 Refinement description

Section 5.1.4 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) identified several temporary sediment basins that would either interact with groundwater that had naturally occurring elevated salinity or were located within the Tomago Sandbeds Catchment. On this basis, these were proposed for lining. Following exhibition of the EIS and in response to submissions Transport now propose to line a greater proportion of temporary sediment basins, specifically those that would be expected to intercept groundwater.

Temporary sediment basins proposed for lining are listed in **Table 4-1**. Cells shaded blue are those that had previously been nominated for lining. The location of sediment basins is shown in **Appendix G**.

Table 4-1 Temporary sediment basins proposed to be lined during construction

Basin name	Basin code	Type
TB01	B00950L	Construction only
TPB04	B01000L	Construction and operation
TPB05	B01120L	Construction and operation
TPB06	B02460L	Construction and operation
TPB09	B03340M	Construction and operation
TB05	B03350L	Construction only
TB04	B03480R	Construction only
TPB10	B03750L	Construction only
TPB11	B03800M	Construction and operation
TB06	B04300L	Construction only
TPB12	B07150L	Construction and operation
TPB13	B07300R	Construction and operation
TPB14	B07500L	Construction and operation
TPB15	B07800R	Construction and operation
TPB16	B08000L	Construction and operation

Basin name	Basin code	Type
TPB17	B08150L	Construction and operation
TB10	B08360R	Construction only
TPB19	B08980M	Construction and operation
TPB18	B09120M	Construction and operation
TPB22	B09440L	Construction and operation
TB13	B11550L	Construction only
TB12	B11950R	Construction only
TPB26	B12460R	Construction and operation
TPB27	B12650R	Construction and operation
TPB28	B13450L	Construction and operation
TPB30	B13850L	Construction and operation
TPB29	B13900L	Construction and operation
TPB31	B14160M	Construction and operation
TPB32	B14400M	Construction and operation

Cells shaded blue are those that had previously been nominated for lining.

4.2.2 Impacts from refinement

The key risks to surface water quality identified in the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) with respect to unlined basins was the potential to intercept and discharge groundwater with elevated salinity and other contaminants from those basins that are below the water table. The risk to surface water quality would be that water containing elevated salinity and other contaminants than would otherwise be the case could be discharged and not meet the nominated WQO. As those sediment basins below the water table are now proposed to be lined the risk to surface water quality from groundwater interception would be minimal.

Additionally, surface water captured in sediment basins would now be reused on site wherever possible. As discussed in **Section 3.1.1**, reuse options include application across exposed surfaces and application to stockpiles and imported materials; placement on the formation during earthworks, temporary storage for reuse in landscaping and ongoing maintenance works and application to open areas within the project footprint not required for construction.

The key risks to groundwater identified in the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) with respect to unlined basins that intercept the water table, is that they would have the potential to introduce contaminants into the groundwater table via a new migration pathway. Potential contaminants include hydrocarbons from leaks and spills that are substantial enough to make it to a water quality basin and suspended sediment (with particulate bound pollutants) from runoff. As the sediment basins are now proposed to be lined the risk of contamination to groundwater is minimal.

4.2.3 Additional mitigation

Mitigation measures documented in **Chapter 6** of this report would be implemented to avoid or minimise the potential for surface and groundwater impacts from this proposed refinement.

5 Operational Impacts

This chapter includes an assessment of the operational impacts from refinements on the project.

5.1 Permanent water quality basin lining

5.1.1 Refinement description

Section 5.2.5 of the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) identified several permanent water quality basins that would interact with groundwater.

As discussed in **Section 1.2**, the project design has been refined and includes the lining of all permanent water quality basins that are anticipated to intercept groundwater. Previously only five basins were recommended for lining due to naturally occurring elevated salinity or their location within Tomago Sandbeds Catchment. The permanent water quality basins proposed for lining are listed in **Table 5-1**. Cells shaded blue are those that had previously been nominated for lining in the EIS. The location of the permanent water quality basins is shown in **Appendix H**.

Table 5-1 Permanent water quality basins proposed to be lined during operation

Basin name	Basin code	Basin type
PB05	B01000L	Construction and operation
PB06	B01120L	Construction and operation
PB07	B02460L	Construction and operation
PB10	B03340M	Construction and operation
PB12	B03750L	Construction and operation
PB13	B03800M	Construction and operation
PB14	B05700L	Operation only
PB15	B06100L	Operation only
PB17	B07150L	Construction and operation
PB19	B07300R	Construction and operation
PB20	B07500L	Construction and operation
PB21	B07800R	Construction and operation
PB22	B08000L	Construction and operation
PB23	B08150L	Construction and operation
PB25	B08980M	Construction and operation
PB24	B09120M	Construction and operation
PB28	B09440L	Construction and operation
PB32	B12460R	Construction and operation
PB33	B12650R	Construction and operation
PB34	B13450L	Construction and operation
PB36	B13850L	Construction and operation

Basin name	Basin code	Basin type
PB35	B13900L	Construction and operation
PB37	B14160M	Construction and operation
PB38	B14400M	Construction and operation

Cells shaded blue are those that had previously been nominated for lining in the EIS

5.1.2 Impacts from refinement

The key risk to surface water quality identified in the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) with respect to unlined basins was that dewatering or overflows from unlined basins with groundwater interaction could result in water with elevated salinity and other contaminants being discharged to receiving waterways. Over the operation of the project this could have resulted in the receiving waterway becoming more impacted and not able to achieve the nominated WQO and impacting instream biota. All water quality basins that potentially intercept the water table would now be lined and therefore the risk to surface water quality from groundwater interception would be minimal.

The key risk to water quality identified in the *M1 Pacific Motorway extension to Raymond Terrace Surface Water and Groundwater Quality Working Paper* (Jacobs, 2021a) with respect to unlined basins was that runoff from the operational footprint that might contain hydrocarbons and other contaminants (e.g. nutrients, metals) could migrate to groundwater potentially impacting on groundwater quality. Lining of the water quality basins would minimise the interaction and risk to groundwater quality.

5.1.3 Additional mitigation

Mitigation measures documented in **Chapter 6** of this report would be implemented to avoid or minimise the potential for surface water and groundwater impacts from this proposed refinement.

5.2 Drainage design refinements, Heatherbrae

5.2.1 Refinement description

Drainage design refinements have occurred near the horse training facility to reduce the impacts to the horse track and the Hunter River Botanic Gardens. Design refinements that may impact on surface water quality during the operation of the project relevant to surface water quality include (refer to **Figure** 5-1):

- Relocation and reshaping of the permanent water quality basin PB28 (B09440L) such that it is five metres from the open channel that discharges to Hunter River drain
- Modification of the road pavement drainage so that runoff from two catchments draining to two separate basins; PB26 (B09160M) and PB27 (B09360L), was optimised so that all discharge is now into a combined new basin PB26 (B09200L) resized accordingly to maintain previous water quality treatment levels
- A new clean water channel within the horse track property to replace an existing channel that is impacted by realignment of Pacific Highway. The realigned clean water channel conveys flows from the outlet of transverse drainage culvert C9380 along the western side of realigned Pacific Highway connecting to the existing channel at southeast corner of horse track. To limit the footprint of the new channel a trapezoidal profile with concrete lining was adopted.

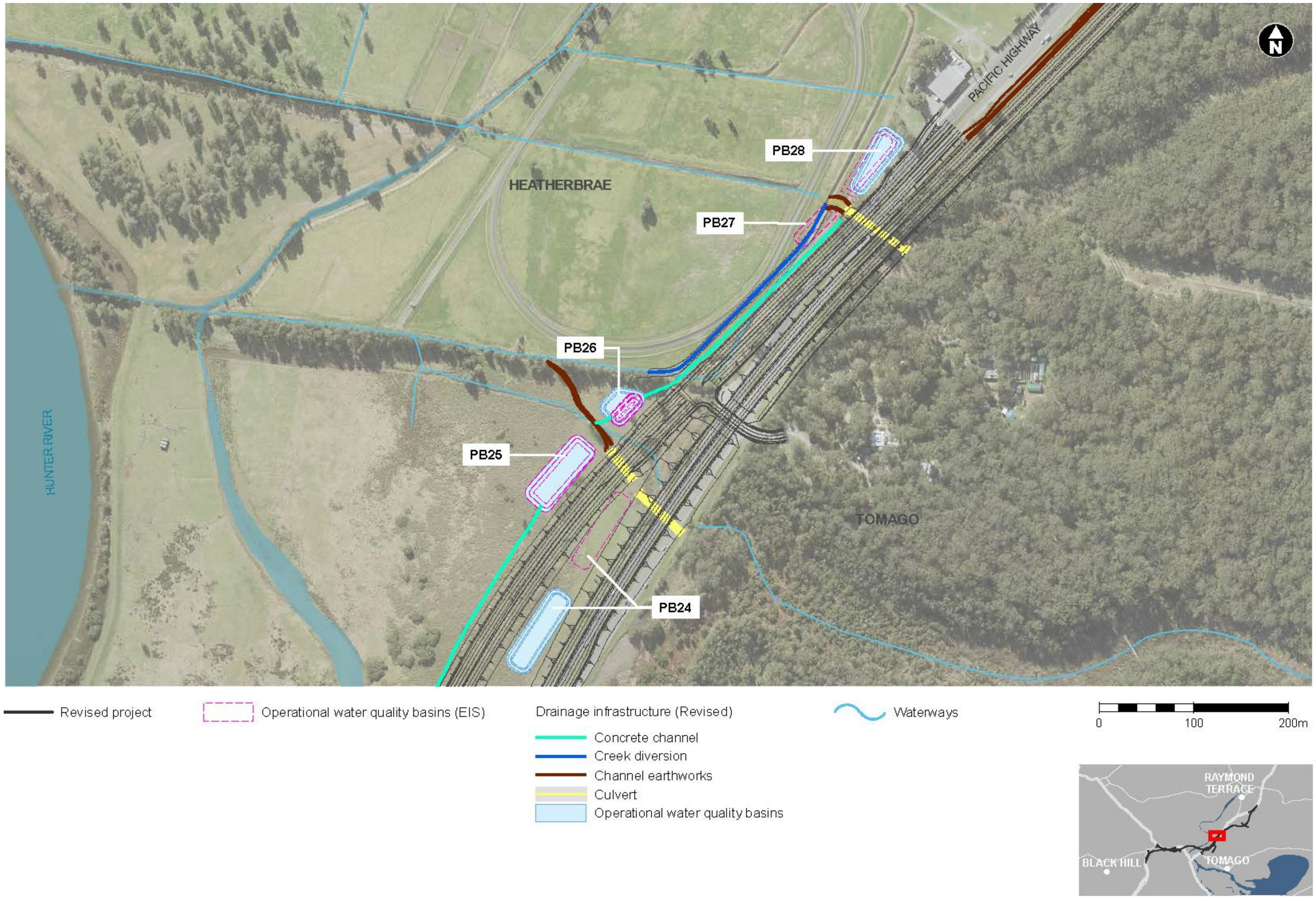

Figure 5-1 Drainage design change near horse training facility, Heatherbrae

5.2.2 Impacts from refinement

The combined basins have been resized such that there would be no decrease in the previous water quality treatment performance. This work continues to be compliant with the water quality design criteria.

The increased flow velocity in the concrete channel would result in small increases to water velocity. During detailed design, the drainage design at this location would be optimised to ensure that there is an adequate transition between the concrete and grassed lined sections to minimise potential for scouring or higher TSS and sediment export at this location. Impacts to downstream water quality would not be expected.

5.2.3 Additional mitigation

No additional mitigation measures are required to address this proposed design refinement.

6 Revised environmental management measures

The *M1 Pacific Motorway extension to Raymond Terrace Environmental Impact Statement* (Transport for NSW 2021) identified a range of environmental outcomes and management measures that would be required to avoid or reduce the environmental impacts.

After consideration of the issues raised in the public submissions and the changes to the project, the environmental management measures for the project (refer to Chapter 24 of the EIS) have been revised.

Additional and/or modified environmental management measures to those presented in the environmental impact statement are in ***italics*** and deleted measures, or parts of measures, have been struck out.

Table 6-1 presents the proposed changes to the surface water and groundwater quality environmental mitigation measures.

Table 6-1 Summary of revised environmental management measures – Surface water and groundwater quality

Impact	Reference	Management measure	Responsibility	Timing
General	WQ01	A Construction Soils and Water Management Plan (CSWMP) would be developed as a sub plan of the CEMP and will outline measures to manage soil and water quality impacts associated with the construction work, including contaminated land. The CSWMP would include but not be limited to: • Measures to minimise/manage erosion and sediment transport both within the construction footprint and offsite including requirements for the preparation of erosion and sediment control plans (ESCP) for all progressive stages of construction and the implementation of erosion and sediment control measures • Erosion and sediment control measures, which will be implemented and maintained in accordance with Managing Urban Stormwater – Soils and Construction, Volume 1 (Landcom 2004) and Volume 2D (DECC, 2008) • Measures to manage stockpiles including locations, separation of waste types, sediment controls and stabilisation in accordance with the Stockpile Site Management Guideline (Roads and Maritime, 2015). • Procedures for dewatering (including waterways, wetlands and excavations and temporary sediment basins) including relevant discharge criteria. • ***Assessment and management measures for displaced water from soft soils treatment and intercepted groundwater*** • Concrete waste management procedures • Measures to manage accidental spills including the requirement to maintain materials such as spill kits, an emergency spill response procedure and regular visual water quality checks when working near waterways • Measures to manage tannin leachate and potential saline soils • Controls for sensitive receiving environments which may include but not be limited to designation of ‘no go’ zones for construction plant and equipment (where applicable) • ***A Trigger Action Response Plan (TARP) for water quality impacts related to the project will be developed and detailed in this CSWMP.***	Contractor	Prior to construction/ construction/ operation
	WQ02	A soil conservation specialist will be engaged for the duration of construction of the project to provide advice on the planning and implementation of erosion and sediment control including review of the CSWMP and ESCP.	Transport / Contractor	Prior to construction/ construction/ operation

Impact	Reference	Management measure	Responsibility	Timing
Water reuse	WQ03	A water reuse strategy will be developed as part of the CEMP for both construction and operational phases of the project to reduce reliance on potable water. Any water from sediment basins will be checked to ensure compliance with ANZG (2018) Water Quality Guidelines prior to reuse.	Contractor	Detailed design/ prior to construction/ construction
Discharge of saline groundwater to drinking catchment	WQ04	Basins and swales within the Tomago Sandbeds drawdown area will be lined during construction and operation. ***The final basin lining design will be provided to Hunter Water Corporation prior to the construction of these structures.***	Contractor	Detailed design
Discharge of saline groundwater to surface waterways	WQ05	~~Basins TB04, TB06, TPB10 (PB12), TPB18 (PB24), PB14 and PB15 shall be further investigated to confirm requirement for lining to avoid discharge of saline groundwater to surface waterways during construction and operation.~~ ***All temporary sediment basins and permanent water quality basins at risk of intercepting groundwater will be lined to avoid mixing of surface water and groundwater.***	Transport	Detailed design
Surface water and groundwater quality impacts	WQ06	A water quality monitoring program will be developed in accordance with the Guidelines for Construction Water Quality Monitoring (RTA, 2003b). The program will monitor surface water and groundwater during construction and during operation. ***The monitoring program will include TARP sites.***	Transport / Contractor	Prior to construction/ construction/ operation
Dredging impacts on surface water	***WQ07***	***A Dredge Management Plan (DMP) will be prepared prior to the commencement of any dredging operations. The DMP will include:*** • ***Sampling to classify material that will be intercepted by the dredging activities*** • ***Dredging management objectives*** • ***Dredging management implementation including contamination management and contingency measures*** • ***Dredging mitigation including:*** - ***Dredging operations would be completed within a double silt curtain to contain disturbed sediments*** - ***No overflow would be permitted from transport barges taking material for unloading and land disposal*** - ***Work would be completed under a full-time supervision and inspection regime.***		

Impact	Reference	Management measure	Responsibility	Timing
Surface water quality impacts	***WQ08***	***Double silt curtains, booms or similar will be deployed in waterways where it is determined that work would present a risk of mobilising sediment. Appropriate controls will remain in place until that work has been completed or the risk effectively managed.***	***Contractor***	***Construction***

7 Conclusion

This surface water and groundwater supplementary report has been prepared to clarify detail presented in the EIS and provide additional information on some project elements relevant to surface water and groundwater. It also assesses potential impacts from project refinements following public exhibition of the EIS. Through a review of both the construction and operational refinements considered in this supplementary surface water and groundwater quality report, the project would be expected to produce surface water and groundwater quality outcomes that are consistent with or better than those presented in the EIS.

Since submission of the EIS, Transport has carried out additional water quality sampling at the 12 surface water monitoring locations nominated in the EIS. Additional monitoring results were combined with previous water quality data to determine existing surface water quality and if nominated WQOs or environmental values are being achieved. Additional water quality data were also provided by relevant agencies and were incorporated into the revised summary of existing water quality. Changes to DGVs since submission of the EIS have also been applied to this assessment. With consideration of the additional data and changes to the DGVs, it was determined that WQOs and environmental values continue to generally not be achieved.

During construction and operation, refinements to the project are expected to produce surface water and groundwater quality outcomes that are consistent or better than those presented in the EIS. The proposed extension to the existing headwall at Heatherbrae, while increasing the construction footprint by approximately 0.1 hectares, is not likely to impact on the ecological functioning of the area or substantially impact surface water quality. As a result of design refinements, all temporary sediment basins and permanent water quality basins that are anticipated to intercept groundwater would now be lined. This refinement is expected to have an overall positive impact on the construction and operation surface water and groundwater quality outcomes by reducing the potential for mixing. The separation of surface and groundwater would also increase beneficial reuse opportunities for surface water during construction.

Drainage design refinements including relocation and reshaping of basins and refinements to the clean water channel have occurred near the horse training facility to reduce impacts to the horse track and Hunter River Botanic Gardens. The reshaping of the basins provides the same water quality outcome as presented in the EIS. Detailed design would ensure the amended clean water channel would not result in scouring or impact downstream water quality.

Following consideration of the project refinements, along with the public submissions received during exhibition of the EIS, the environmental management measures relating to surface water and groundwater quality have been revised. Through implementation of the proposed management measures, the proposed refinements assessed in this report are expected to produce surface water and groundwater quality outcomes that are consistent with or better than those presented in the EIS.

8 References

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Appendix A. Revised median water quality results – summary stats

Table A-1 Revised Median Water Quality Results Viney Creek (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS, with EIS result provided in brackets)

Analyte	M12RT12 (EIS result)		Aquatic Ecosystem guideline (lowland river)
	Dry (n=5)	Wet (n=3)	
pH	7.11	7.30 (7.29)	6.5-8.5
Dissolved oxygen (% saturation)	**13.03 (8.2)**	**82.13 (64)**	85-110
Turbidity (NTU)	29.73 (31.53)	**68.1 (63.8)**	6-50
Total Suspended solids (mg/L)	14	29 (28)	No guideline
Electrical conductivity (µS/cm)	**1010 (855)**	**310 (610)**	200-300
Oxidised Nitrogen (mg/L)	**0.07 (0.12)**	**0.11**	0.04
Total nitrogen (mg/L)	**0.9**	**0.6 (0.95)**	0.35
Total phosphorus (mg/L)	**0.1**	**0.09 (0.13)**	0.025
Arsenic (mg/L)	0.0005	0.0005	0.013
Cadmium (mg/L)	0.00005	0.00005 (0.00013)	0.0002
Chromium (mg/L)	0.0005	0.0005	0.001
Copper (mg/L)	0.0005	**0.002** (0.0013)	0.0014
Nickel (mg/L)	0.004	0.002 (0.0035)	0.011
Lead (mg/L)	0.0005	0.0005	0.0034
Zinc (mg/L)	**0.01 (0.012)**	**0.02**	0.008
Mercury (mg/L)	0.00005	0.00005	0.00006
Enterococci (CFU/100mL)*	**50**	**2700 (1640)**	<35 primary contact <230 secondary contact

*DECCW (2006)

Table A-2 Revised Median Water Quality Results Glenrowan Creek (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS, with EIS result provided in brackets)

Analyte	M12RT1 (EIS result)		Aquatic ecosystem guideline (lowland river)
	Dry (n=6)	Wet (n=2)	
pH	6.9	7.04	6.5-8.5
Dissolved oxygen (% saturation)	**17.8**	**67.05**	85-110
Turbidity (NTU)	17	17	6-50
Total suspended solids (mg/L)	17	12	No guideline
Electrical conductivity (µs/cm)	**336** (266)	285	200-300
Oxidised Nitrogen (mg/L)	**0.09**	**2**	0.04
Total nitrogen (mg/L)	**1.6**	**3.35**	0.35
Total phosphorus (mg/L)	**0.25 (0.13)**	**0.12**	0.025
Arsenic (mg/L)	0.0005	0.0013	0.013
Cadmium (mg/L)	0.00005	0.00013	0.0002
Chromium (mg/L)	0.0005	0.0005	0.001
Copper (mg/L)	0.001 **(0.002)**	**0.0025**	0.0014
Nickel (mg/L)	0.001 (0.002)	0.0023	0.011
Lead (mg/L)	0.0005	0.0005	0.0034
Zinc (mg/L)	**0.016**	**0.049**	0.008
Mercury (mg/L)	0.00005	0.00005	0.00006
Enterococci (CFU/100mL)*	**60**	**2650**	<35 primary contact <230 secondary contact

*DECCW (2006)

Table A-3 Revised Median Water Quality Results Purgatory Creek (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS, with EIS result provided in brackets)

Analyte	M12RT2 (EIS result)		M12RT2b (EIS result)		M12RT2a (EIS result)		M12RT2c (EIS result)		M12RT2d (EIS result)		Aquatic ecosystem guideline (estuarine)
	Dry (n=6)	Wet (n=3)	Dry (n=5)	Wet (n=3)	Dry (n=7)	Wet (n=3)	Dry (n=7)	Wet (n=3)	Dry (n=3)	Wet (n=2)	
pH	**6.53 (6.65)**	7.3 (7.17)	7.16	7.67 (7.58)	7.8 (7.34)	7.09 (7.02)	8.24	7.62 (7.4)	7.42 (nd)	7.84 (7.9)	7-8.5
Dissolved oxygen (% saturation)	**42.03 (63.15)**	**51.6 (45.2)**	**67.2 (79.23)**	**79.67 (76.28)**	**72.87**	87.53 (22.7)	97.07	90.77 (80.43_	82.07 (nd)	95.75 (101.1)	80-110
Turbidity (NTU)	**41.65**	**20.43 (22.13)**	**30.57 (14.81)**	**59.53 (35.10)**	**14.19 (21.93)**	**17.43 (29)**	**10.15 (15.27)**	**34.73 (29.5)**	**17.53** (nd)	**129.47 (23.6)**	**0.5-10**
Total Suspended solids (mg/L)	176	14 (42.5)	12 (8)	24 (26.5)	7 (23)	17 (20)	6 (14)	9 (19.5)	10 (nd)	45.75 (2.5)	No guideline
Electrical conductivity (µs/cm)	641 (760)	700 (370)	4263 (3183)	5890 (4080)	13031 (7623)	1693 (1611)	19940 (6133)	6160 (5370)	25576 (nd)	25010 (15643)	No guideline
Oxidised Nitrogen (mg/L)	**0.09**	**0.03 (0.02)**	**0.03**	**0.07 (0.06)**	**0.095 (0.13)**	0.01 **(0.04)**	**0.03 (0.05)**	**0.02 (0.06)**	**0.24** (nd)	**0.11 (0.2)**	**0.015**
Total nitrogen (mg/L)	**5.1**	**1.3 (2.4)**	**2.6**	**1.90 (1.95)**	**0.5**	**0.7 (1.4)**	**0.5 (0.6)**	0.25 **(1.13)**	**0.7** (nd)	**0.75 (0.8)**	**0.3**
Total phosphorus (mg/L)	**0.58**	**0.12 (0.25)**	**0.42**	**0.49**	**0.15 (0.38)**	**0.14 (0.42)**	**0.16 (0.27)**	**0.19 (0.48)**	**0.09** (nd)	**0.225 (0.15)**	**0.03**
Arsenic (mg/L)	0.001 (0.0015)	0.0005 (0.0013)	0.002	0.002	0.001 (0.002)	0.001 (0.003)	0.001	0.001 (0.003)	0.0005 (nd)	0.00125 (0.002)	No guideline
Cadmium (mg/L)	0.00005	0.00005 (0.00013)	0.00005	0.00005 (0.00013)	0.00005	0.0005 (0.0004)	0.00005	0.0002 (0.0004)	0.00005 (nd)	0.000125 (0.0002)	0.0007
Chromium (mg/L)	0.0005 (0.00125)	0.0005	0.0005	0.0005	0.0005	**0.005** (0.0008)	0.0005	0.0005 (0.003)	0.0005 (nd)	**0.0075** (0.001)	0.0044
Copper (mg/L)	0.00075 (0.0025)	**0.002 (0.0018)**	0.001 **(0.002)**	**0.003**	0.001	**0.002 (0.004)**	0.001	**0.002 (0.004)**	0.001 (nd)	0.00125 (0.0005)	0.0013
Nickel (mg/L)	0.006 (0.0095)	0.002 (0.005)	0.007 (0.006)	0.006 (0.009)	0.003 (0.005)	0.005 (0.007)	0.004 (0.005)	0.005 (0.007)	0.002 (nd)	0.003 (0.007)	0.007

Analyte	M12RT2 (EIS result)		M12RT2b (EIS result)		M12RT2a (EIS result)		M12RT2c (EIS result)		M12RT2d (EIS result)		Aquatic ecosystem guideline (estuarine)
	Dry (n=6)	Wet (n=3)	Dry (n=5)	Wet (n=3)	Dry (n=7)	Wet (n=3)	Dry (n=7)	Wet (n=3)	Dry (n=3)	Wet (n=2)	
Lead (mg/L)	0.0005 (0.00075)	0.0005	0.0005	0.0005	0.0005	**0.005** (0.003)	0.0005	0.0005 (0.003)	0.0005 (nd)	0.0005	0.004
Zinc (mg/L)	0.007 (0.009)	**0.012 (0.008)**	0.007 **(0.01)**	**0.011 (0.018)**	0.0025 (0.048)	0.0025 (0.0098)	0.0025 (0.031)	0.0025 (0.008)	0.0025 (nd)	0.0025 (0.00025)	0.008
Mercury (mg/L)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005 (nd)	0.00005	0.0001
Enterococci (CFU/100mL)*	**48** (16)	**3000 (1595)**	**138 (33)**	**3300 (2150)**	25 **(47)**	**800 (2200)**	7 (13)	**130 (1615)**	28 (nd)	**800 (600)**	<35 primary contact <230 secondary contact

*DECCW (2006)
(nd) no data/not previously sampled

Table A-4 Revised Median Water Quality Results Hunter River Mainstream (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS, with EIS result provided in brackets)

Analyte	**M12RT3 (EIS result)**		**M12RT3a (EIS result)**		**M12RT3b (EIS result)**		**Aquatic Ecosystem guideline (estuarine)**
	Dry (n=7)	**Wet (n=3)**	**Dry (n=3)**	**Wet (n=2)**	**Dry (n=7)**	**Wet (n=3)**	
pH	7.69	7.87 (7.88)	7.83 (7.78)	7.89 (7.9)	7.34 (7.29)	7.71 (7.99)	7-8.5
Dissolved oxygen (% saturation)	88.77	**153.43** (107.2)	91.7 (91.37)	98.63 (86.8)	**77.33**	86.8 (83.5)	80-110
Turbidity (NTU)	**26.02 (37.3)**	**25.7 (17.03)**	**11.47 (16.3)**	**30.91 (86.8)**	**37.4 (66.03)**	**13.53 (22.35)**	0.5-10
Total Suspended solids (mg/L)	26 (32)	16 (9.25)	7	49.75 (2.5)	16 (24)	8 (19.25)	No guideline
Electrical conductivity (µs/cm)	18710 (3990)	24280 (24070)	25540 (25786)	27780 (22807)	11810 (3356)	19680 (26140)	No guideline
Oxidised Nitrogen (mg/L)	**0.31 (0.37)**	**0.2 (0.29)**	**0.26**	**0.1 (0.2)**	**0.33 (0.6)**	**0.18 (0.29)**	0.015
Total nitrogen (mg/L)	**0.5 (1)**	**0.5 (0.58)**	**0.5**	0.25	**0.9 (1.6)**	0.25 **(0.63)**	0.3
Total phosphorus (mg/L)	**0.16**	**0.08 (0.07)**	**0.11**	**0.06** (0.025)	**0.18 (0.21)**	0.03 **(0.05)**	0.03
Arsenic (mg/L)	0.001	0.001 (0.0015)	0.0005	0.002	0.0005	0.001 (0.0015)	No guideline
Cadmium (mg/L)	0.00005	0.00005 (0.00013)	0.00005	0.0002	0.00005	0.00005 (0.00023)	0.0007
Chromium (mg/L)	0.001 (0.003)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0044
Copper (mg/L)	**0.003 (0.0065)**	0.001 (0.00125)	0.001	0.0005	0.001	0.0005	0.0013
Nickel (mg/L)	0.004 (0.007)	0.003	0.002 (0.001)	0.004	0.002 (0.003)	0.002 (0.0025)	0.007
Lead (mg/L)	0.0005 (0.0023)	0.0005	0.0005	0.0005	0.0005	0.0005	0.004
Zinc (mg/L)	**0.025 (0.049)**	0.00025	0.0025 (0.0003)	0.00025	0.005 (0.0009)	0.00025	0.008
Mercury (mg/L)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.0001
Enterococci (CFU/100mL)*	29 **(36)**	**110 (88)**	6 (16)	**155 (170)**	**45**	**350 (197)**	<35 primary contact <230 secondary contact

* DECCW (2006)

Table A-5 Revised Median Water Quality Results Hunter River Drains (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS, with EIS result provided in brackets)

Analyte	M12RT4 (EIS result)		M12RT5 (EIS result)		Aquatic Ecosystem guideline (estuarine)
	Dry (n=6)	Wet (n=2)	Dry (n=7)	Wet (n=3)	
pH	7.53 (7.14)	**6.47 (6.65)**	7.6	7.55 (7.44)	7-8.5
Dissolved oxygen (% saturation)	**71.03 (58.65)**	**49.02 (44.9)**	**21.73 (16.6)**	**61.3 (45.3)**	80-110
Turbidity (NTU)	**13.95 (20.82)**	**42.43 (63.2)**	**55.63**	**68.3 (72.15)**	0.5-10
Total Suspended solids (mg/L)	12.5 (15)	26.5 (38)	51 (36)	42 (44)	No guideline
Electrical conductivity (µS/cm)	13750 (7235)	3200 (4697)	4160 (4163)	750 (1050)	No guideline
Oxidised Nitrogen (mg/L)	**0.06 (0.15)**	**0.68 (0.77)**	**0.07 (0.1)**	**0.25 (0.61)**	0.015
Total nitrogen (mg/L)	**0.75 (1.15)**	**2.95 (3.4)**	**3**	**3.5 (3.75)**	0.3
Total phosphorus (mg/L)	**0.24 (0.43)**	**0.73 (0.68)**	**0.77 (1.04)**	**1.11 (0.91)**	0.03
Arsenic (mg/L)	0.0005	0.00075 (0.001)	0.002	0.001	No guideline
Cadmium (mg/L)	0.00005	0.00005	0.00005	0.00005	0.0007
Chromium (mg/L)	0.0005	0.0005	0.0005	0.001 (0.00125)	0.0044
Copper (mg/L)	0.0005 (0.0008)	**0.007 (0.008)**	0.0005 **(0.002)**	**0.005 (0.0035)**	0.0013
Nickel (mg/L)	0.0025 (0.0045)	**0.0085 (0.009)**	0.006 (	**0.01 (0.009)**	0.007
Lead (mg/L)	0.0005	0.0005	0.0005	0.0005	0.004
Zinc (mg/L)	0.0025 **(0.036)**	**0.021 (0.023)**	0.005 (0.006)	**0.017**	0.008
Mercury (mg/L)	0.00005	0.00005	0.00005	0.00005	0.0001
Enterococci (CFU/100mL)*	**38 (44)**	**6000 (8000)**	**530 (965)**	**1200 (4600)**	<35 primary contact <230 secondary contact

* DECCW (2006)

Table A-6 Revised Median Water Quality Results Hunter River wetland (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS, with EIS result provided in brackets)

Analyte	**M12RT9 (EIS result)**		**Aquatic Ecosystem guideline (estuarine)**
	Dry (n=7)	**Wet (n=3)**	
pH	7.72 (7.66)	7.29 (7.34)	7-8.5
Dissolved oxygen (% saturation)	**75.4 (75.8)**	87.77 (86.7)	80-110
Turbidity (NTU)	**30.17 (36.5)**	9.2 **(19.58)**	0.5-10
Total Suspended solids (mg/L)	19 (20)	8 (10)	No guideline
Electrical conductivity (µs/cm)	21020 (5043)	20580 (13370)	No guideline
Oxidised Nitrogen (mg/L)	**0.25 (0.32)**	**0.15 (0.21)**	0.015
Total nitrogen (mg/L)	**0.5 (1.2)**	0.25	0.3
Total phosphorus (mg/L)	**0.09 (0.18)**	**0.07 (0.14)**	0.03
Arsenic (mg/L)	0.005 (0.001)	0.0005 (0.00275)	No guideline
Cadmium (mg/L)	0.00005	0.00005	0.0007
Chromium (mg/L)	0.005 (0.001)	0.0005	0.0044
Copper (mg/L)	**0.002**	0.001 **(0.003)**	0.0013
Nickel (mg/L)	0.002 (0.004)	0.002 (0.0035)	0.007
Lead (mg/L)	0.0005	0.0005 (0.00275)	0.004
Zinc (mg/L)	0.005 (0.009)	0.0025	0.008
Mercury (mg/L)	0.00005	0.00005	0.00006
Enterococci (CFU/100mL)*	22	**90 (60)**	<35 primary contact <230 secondary contact

* DECCW (2006)

Table A-7 Revised Median Water Quality Results Unnamed Coastal wetland (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS, with EIS result provided in brackets)

Analyte	M12RT11 (EIS result)		Aquatic Ecosystem guideline (estuarine)
	Dry (n=5)	Wet (n=3)	
pH	7.17 (7.58)	7.23 (7.52)	7-8.5
Dissolved oxygen (% saturation)	**75.00 (50.98)**	**58.53 (54.9)**	80-110
Turbidity (NTU)	**19.57 (25.75)**	**12.87 (21.92)**	0.5-10
Total Suspended solids (mg/L)	13 (12.75)	6 (14.25)	No guideline
Electrical conductivity (µs/cm)	15660 (10378)	6250 (13060)	No guideline
Oxidised Nitrogen (mg/L)	**0.03**	**0.14 (0.09)**	0.015
Total nitrogen (mg/L)	**1.8 (1.2)**	**1.2 (1.7)**	0.3
Total phosphorus (mg/L)	**0.08 (0.07)**	**0.12 (0.14)**	0.03
Arsenic (mg/L)	0.001 (0.00075)	0.0005 (0.00075_	No guideline
Cadmium (mg/L)	0.00005	0.00005 (0.00023)	0.0007
Chromium (mg/L)	0.0005	0.0005	0.0044
Copper (mg/L)	0.0005 (0.0015)	**0.002 (0.0015)**	0.0013
Nickel (mg/L)	0.002 (0.006)	0.004 (0.006)	0.007
Lead (mg/L)	0.0005 (0.00075)	0.0005	0.004
Zinc (mg/L)	**0.029 (0.2025)**	**0.048 (0.034)**	0.008
Mercury (mg/L)	0.00005	0.00005	0.0001
Enterococci (CFU/100mL)*	**79 (39)**	**2950**	<35 primary contact <230 secondary contact

* DECCW (2006) guideline

Table A-8 Revised Median Water Quality Results Windeyers Creek (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS with EIS result provided in brackets)

Analyte	M12RT6a (EIS result)		M12RT6b (EIS result)		Aquatic Ecosystem guideline (lowland river)
	Dry (n=6)	Wet (n=3)	Dry (n=6)	Wet (n=3)	
pH	**6.4** (6.6)	6.67 (6.76)	6.52	6.7 (6.9)	6.5-8.5
Dissolved oxygen (% saturation)	**11.03 (15.03)**	**17.4 (23.28)**	**11.2**	**40.20 (42.57)**	85-110
Turbidity (NTU)	13.7	13.27 (11.58)	6.57	19.9 (18.5)	6-50
Total Suspended solids (mg/L)	15.5 (22)	6 (4)	15	6 (2.5)	No guideline
Electrical conductivity (µs/cm)	490 (489)	520 (550)	130 (133)	70	200-300
Oxidised Nitrogen (mg/L)	0.01	0.01 (0.02)	0.01	**0.14 (0.16)**	0.04
Total nitrogen (mg/L)	**1.7 (2.7)**	**1.4**	**1.4 (1.3)**	**0.6 (0.5)**	0.35
Total phosphorus (mg/L)	**0.09 (0.2)**	**0.08 (0.07)**	**0.18 (0.16)**	**0.04**	0.025
Arsenic (mg/L)	0.0005 (0.0013)	0.0005	0.0005	0.0005	0.013
Cadmium (mg/L)	0.00005	0.00005	0.00005	0.00005	0.0002
Chromium (mg/L)	**0.0035 (0.004)**	0.002	0.0005	0.0005	0.001
Copper (mg/L)	0.0005 (0.0008)	0.0005	**0.002 (0.003)**	**0.003 (0.0025)**	0.0014
Nickel (mg/L)	0.00075 (0.002)	0.001	0.002	0.0005	0.011
Lead (mg/L)	0.0005	0.0005	0.0005	0.0005	0.0034
Zinc (mg/L)	**0.012** (0.002)	**0.017 (0.0115)**	0.0034	**0.069**	0.008
Mercury (mg/L)	0.00005	0.00005	0.00005	0.00005	0.00006
Enterococci (CFU/100mL)*	**62**	**800 (627)**	**105 (78)**	**700 (2705)**	<35 primary contact <230 secondary contact

* DECCW (2006)

Table A-9 Revised Median Water Quality Results Grahamstown Drain (bolded text denotes an exceedance of guideline, shaded cells denotes change to median since EIS with EIS result provided in brackets)

Analyte	M12RT10 (EIS result)		Aquatic Ecosystem guideline (lowland river)
	Dry (n=7)	Wet (n=3)	
pH	**4.88**	**6.29 (5.57)**	6.5-8.5
Dissolved oxygen (% saturation)	**14.1 (16.63)**	**40.17 (37.9)**	85-110
Turbidity (NTU)	7.71 (47.4)	11.93 (12.8)	6-50
Total Suspended solids (mg/L)	10	6 (9.25)	No guideline
Electrical conductivity (µs/cm)	**630 (553)**	**320** (260)	200-300
Oxidised Nitrogen (mg/L)	0.02	**0.43 (0.32)**	0.04
Total nitrogen (mg/L)	0.3	**0.9 (0.75)**	0.35
Total phosphorus (mg/L)	0.005	**0.07 (0.04)**	0.025
Arsenic (mg/L)	0.0005	0.0005	0.013
Cadmium (mg/L)	0.00005	0.00005	0.0002
Chromium (mg/L)	0.0005	0.0005	0.001
Copper (mg/L)	0.0005	0.0005	0.0014
Nickel (mg/L)	**0.013 (0.016)**	0.003 (0.006)	0.011
Lead (mg/L)	0.0005	0.0005	0.0034
Zinc (mg/L)	**0.025 (0.018)**	**0.022 (0.045)**	0.008
Mercury (mg/L)	0.00005	0.00005	0.00006
Enterococci (CFU/100mL)*	8 (15)	**1500 (1140)**	<35 primary contact <230 secondary contact

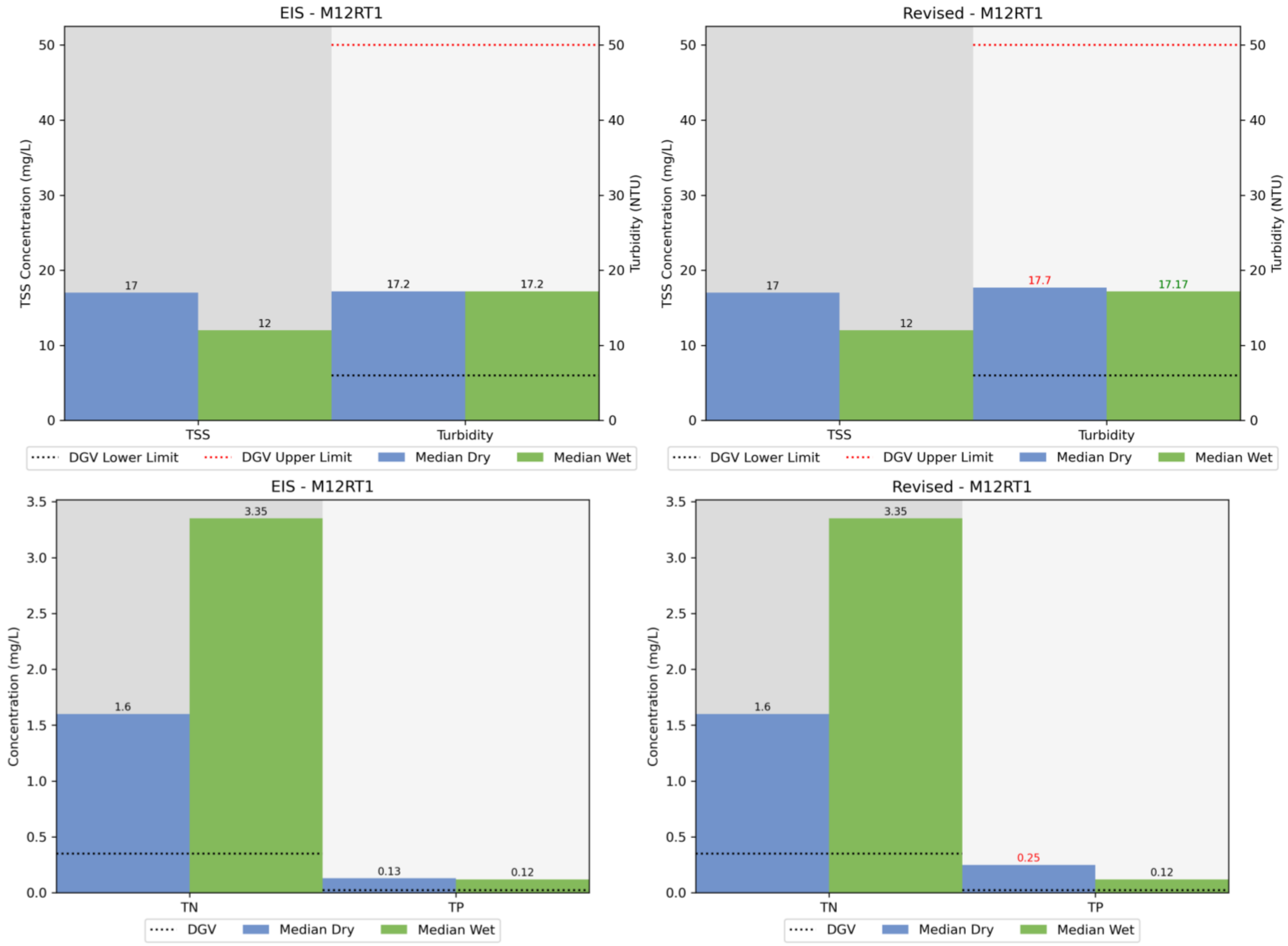
* DECCW (2006)

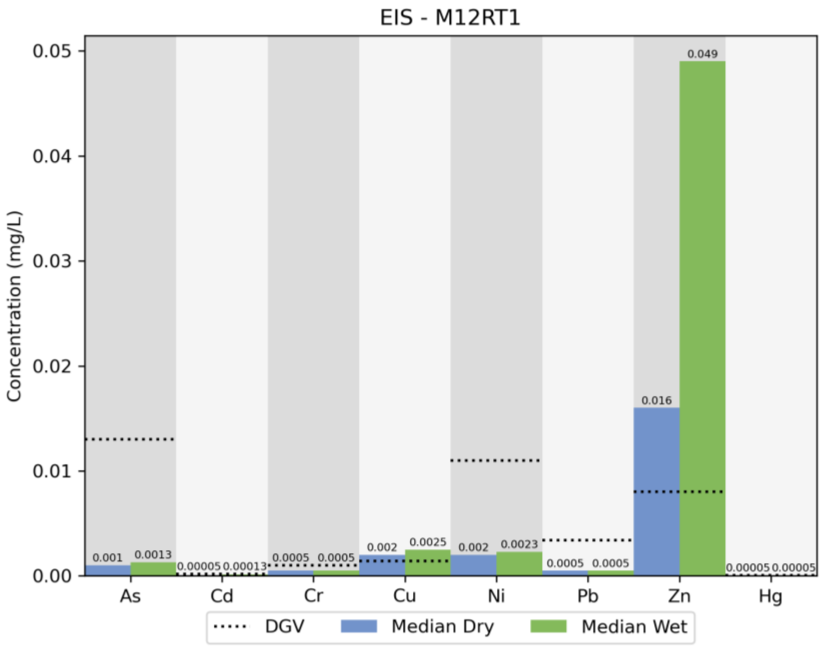
Appendix B. Revised median water quality results – plots

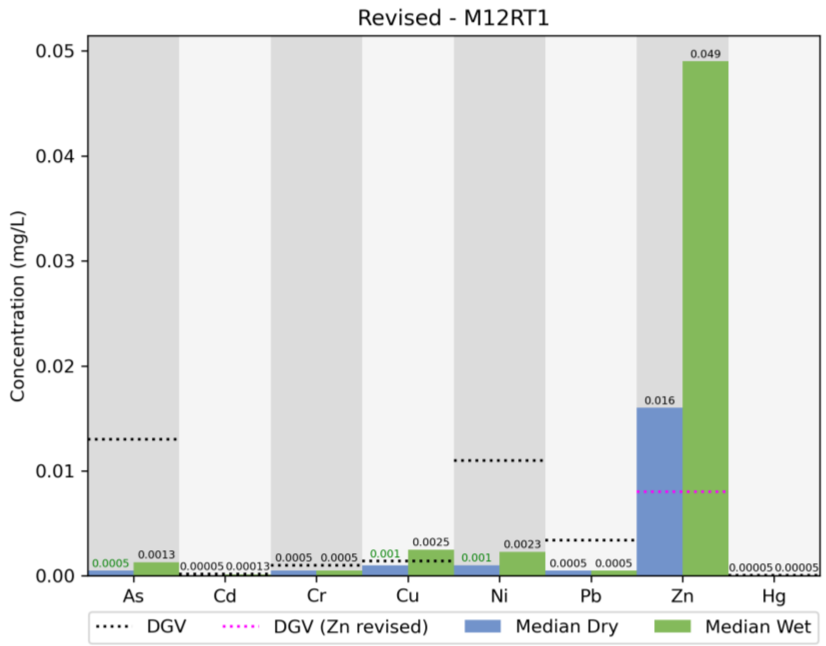
The graphs below display the median water quality results that were presented in the EIS and the revised median water quality results that incorporate water quality data collected since submission of the EIS. The median values are displayed at the top of each column/bar. Median value that is coloured black indicates no change to median result for that indicator since the EIS.

Median values coloured red, indicate a decline in that indicator since submission of the EIS (i.e. median value is higher than reported in the EIS). Median values coloured green indicates an improvement in that indicator since the EIS (i.e. median value is lower than reported in the EIS).

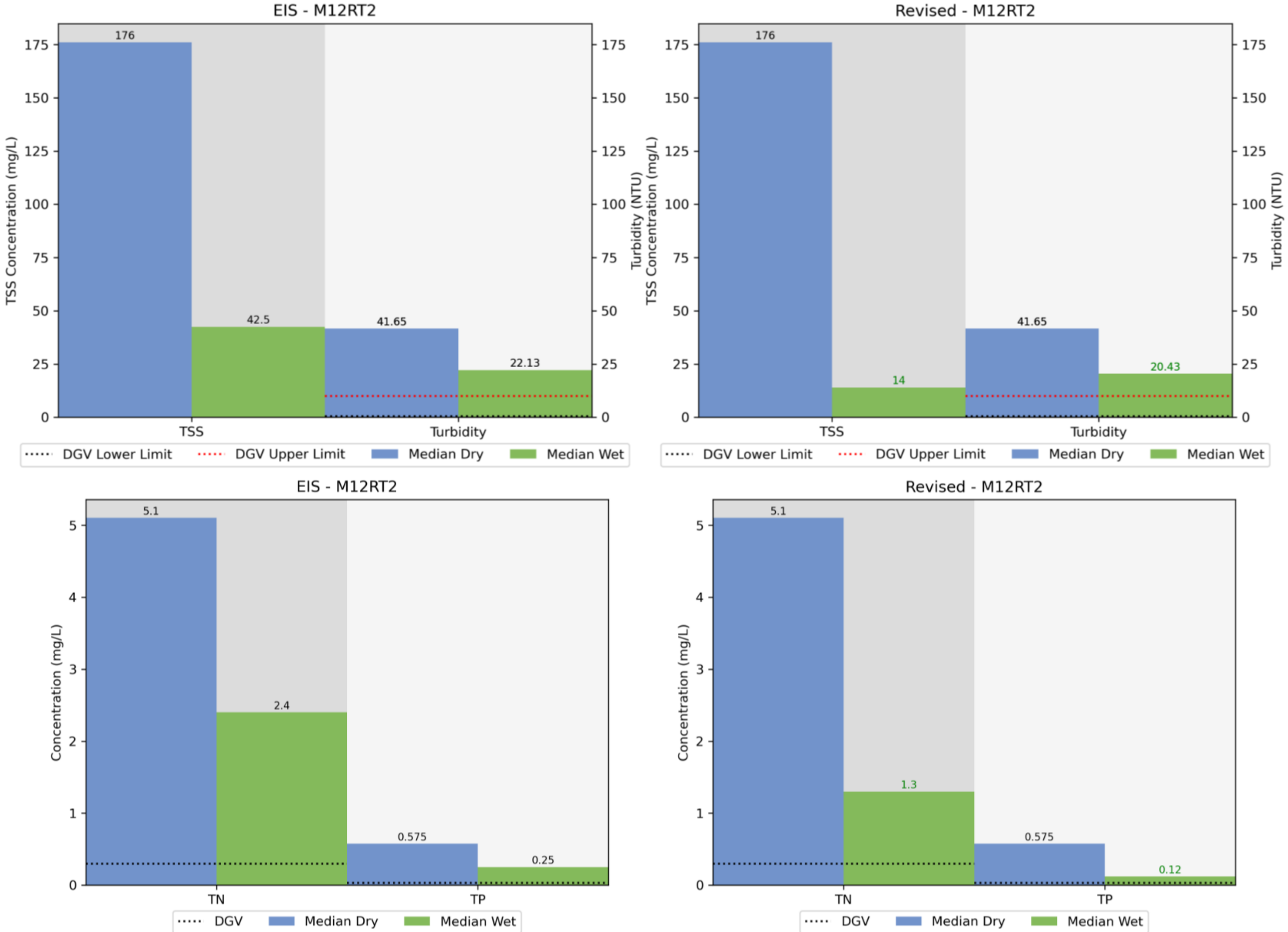
Glenrowan Creek (M12RT1)

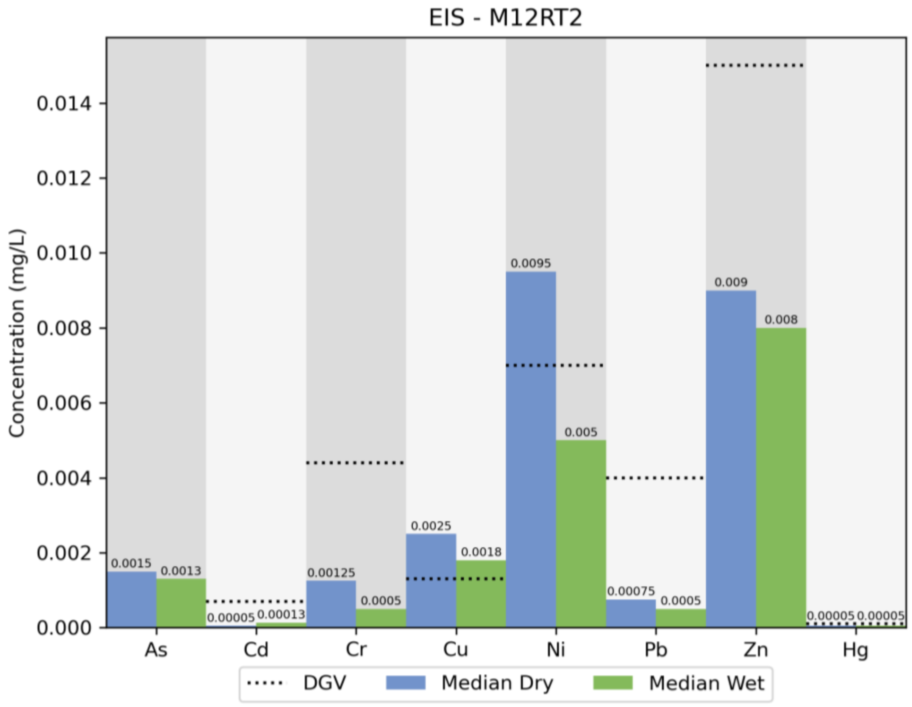



EIS - M12RT1
Concentration (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0.001
0.0013
0.00005
0.00013
0.0005
0.0005
0.002
0.0025
0.002
0.0023
0.0005
0.0005
0.016
0.049
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet

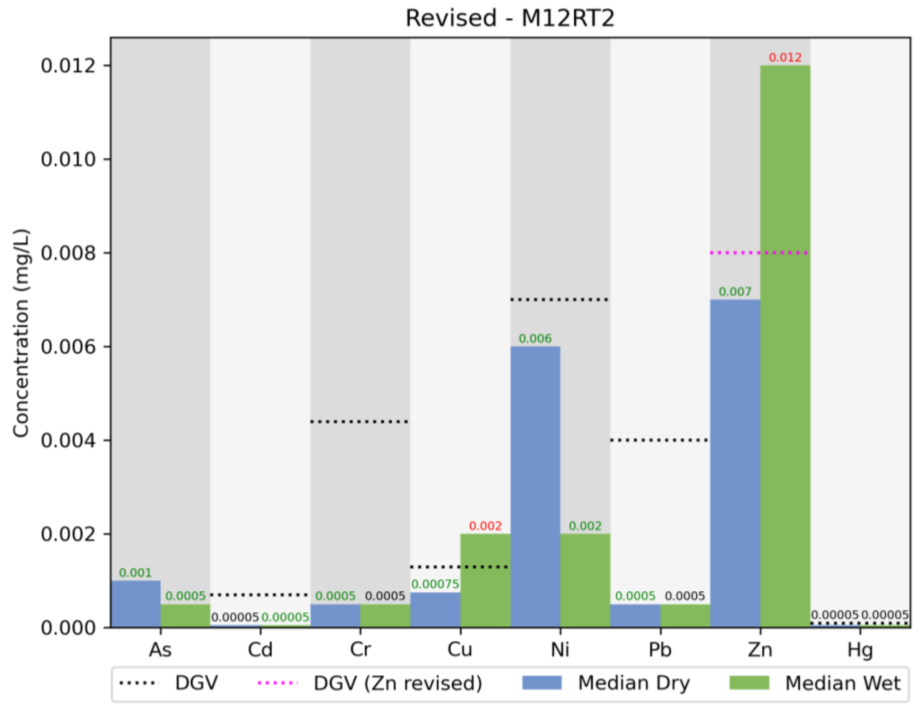

Revised - M12RT1
Concentration (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0.0005
0.0013
0.00005
0.00013
0.0005
0.0005
0.001
0.0025
0.001
0.0023
0.0005
0.0005
0.016
0.049
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

Purgatory Creek (M12RT2)



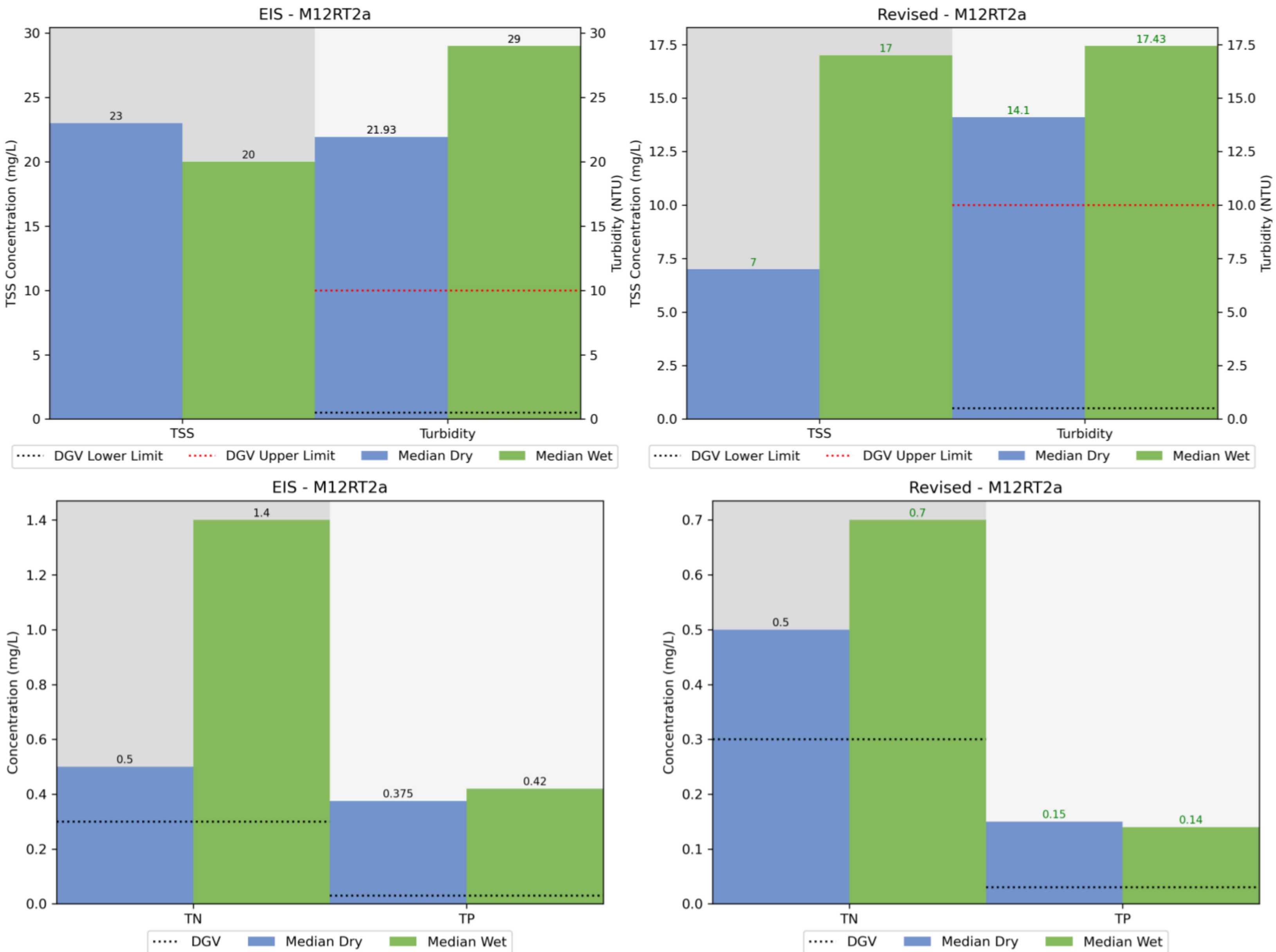


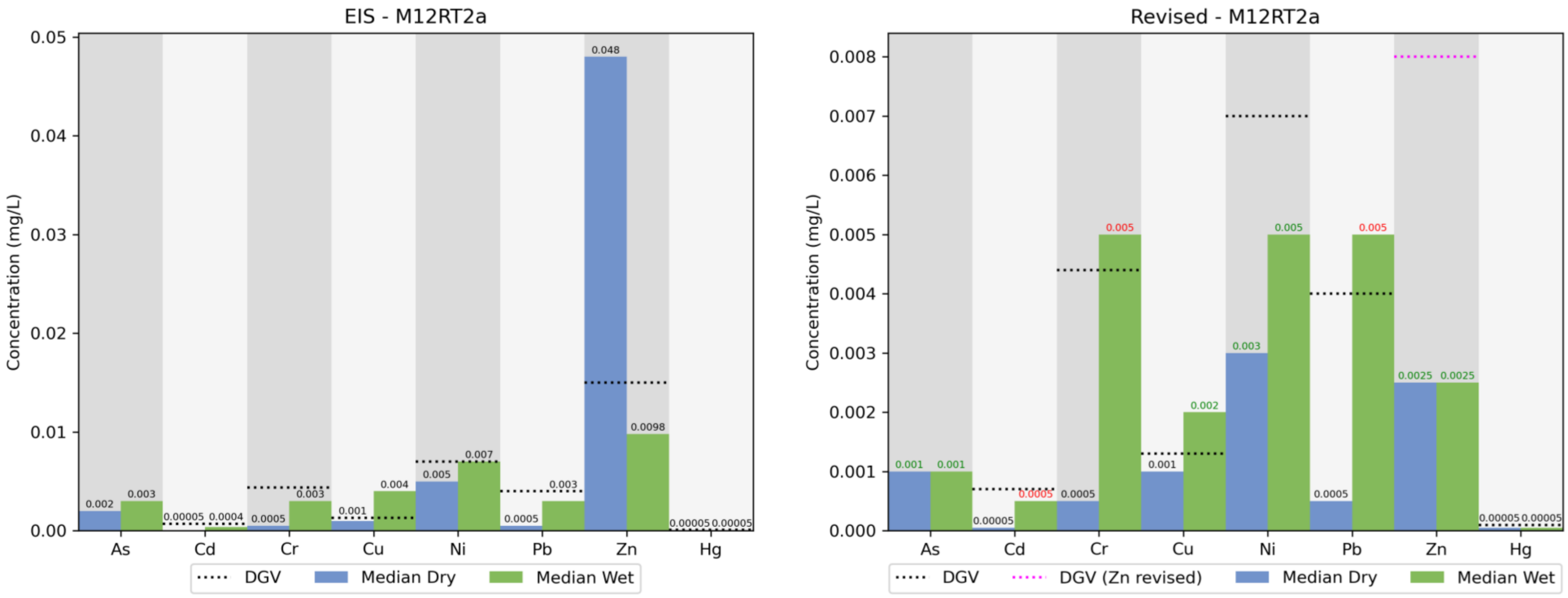
EIS - M12RT2
Concentration (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0.0015
0.0013
0.00005
0.00013
0.00125
0.0005
0.0025
0.0018
0.0095
0.005
0.00075
0.0005
0.009
0.008
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet



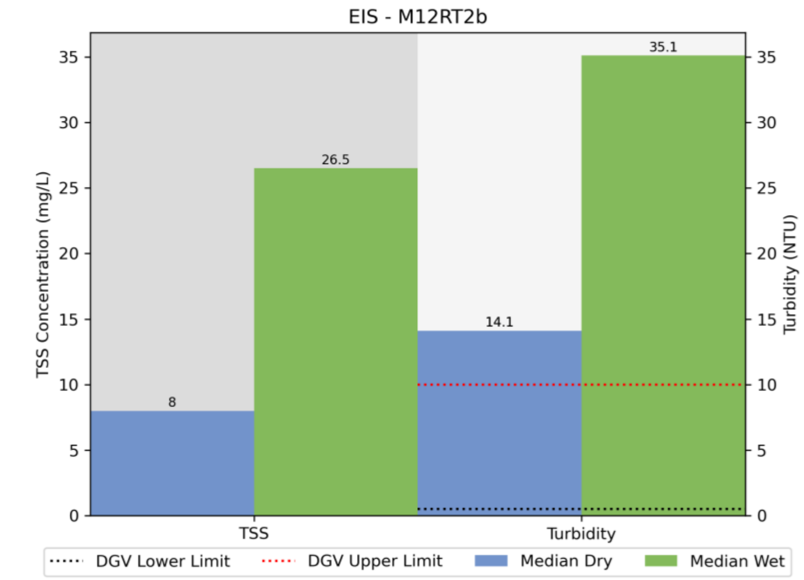
Revised - M12RT2
Concentration (mg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0.001
0.0005
0.00005
0.00005
0.0005
0.0005
0.00075
0.002
0.006
0.002
0.0005
0.0005
0.007
0.012
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

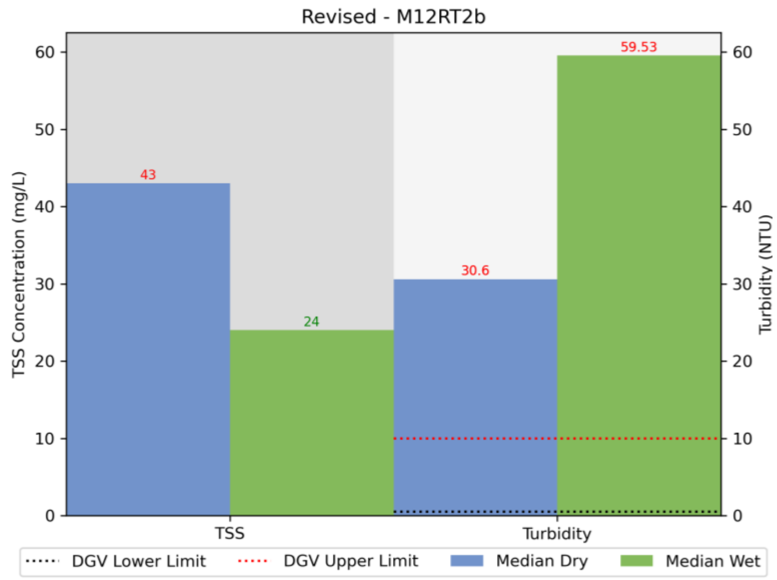
Purgatory Creek (M12RT2a)

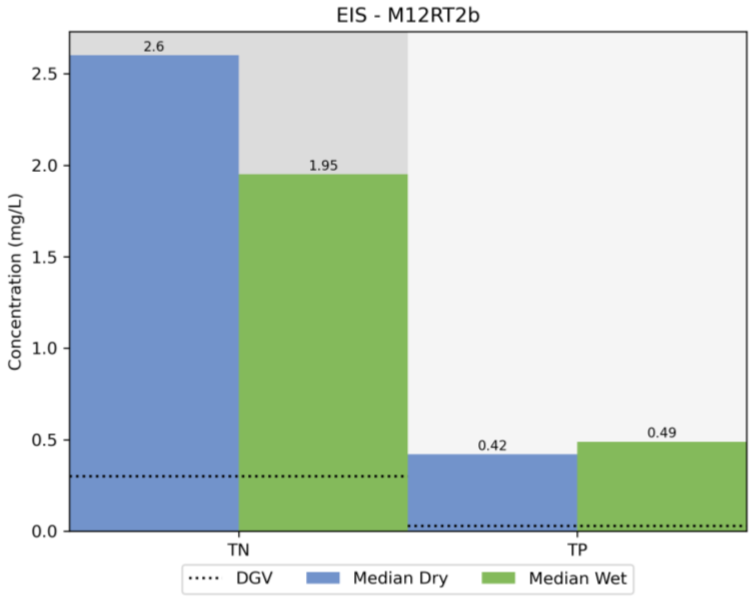


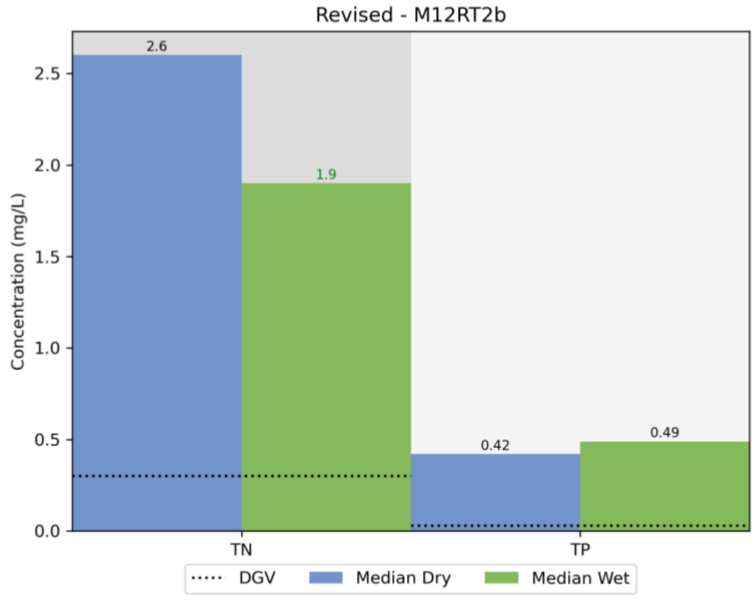

EIS - M12RT2a
Revised - M12RT2a
Concentration (mg/L)
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

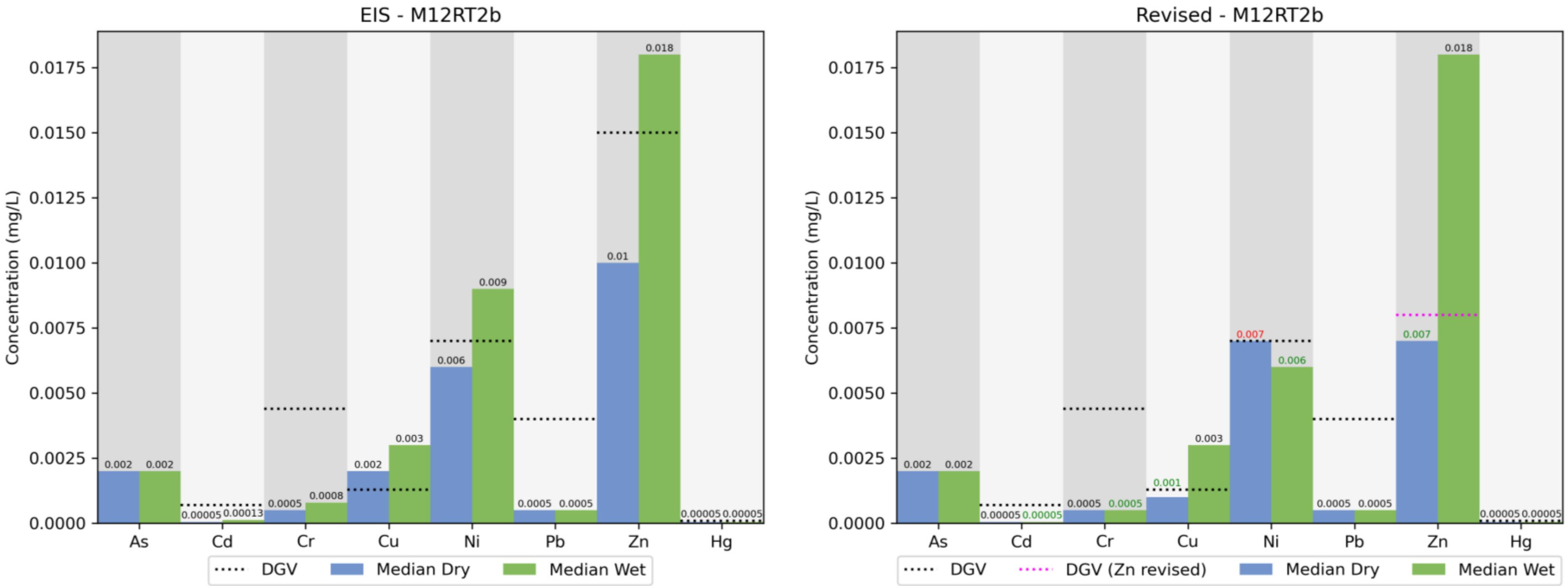
Purgatory Creek (M12RT2b)





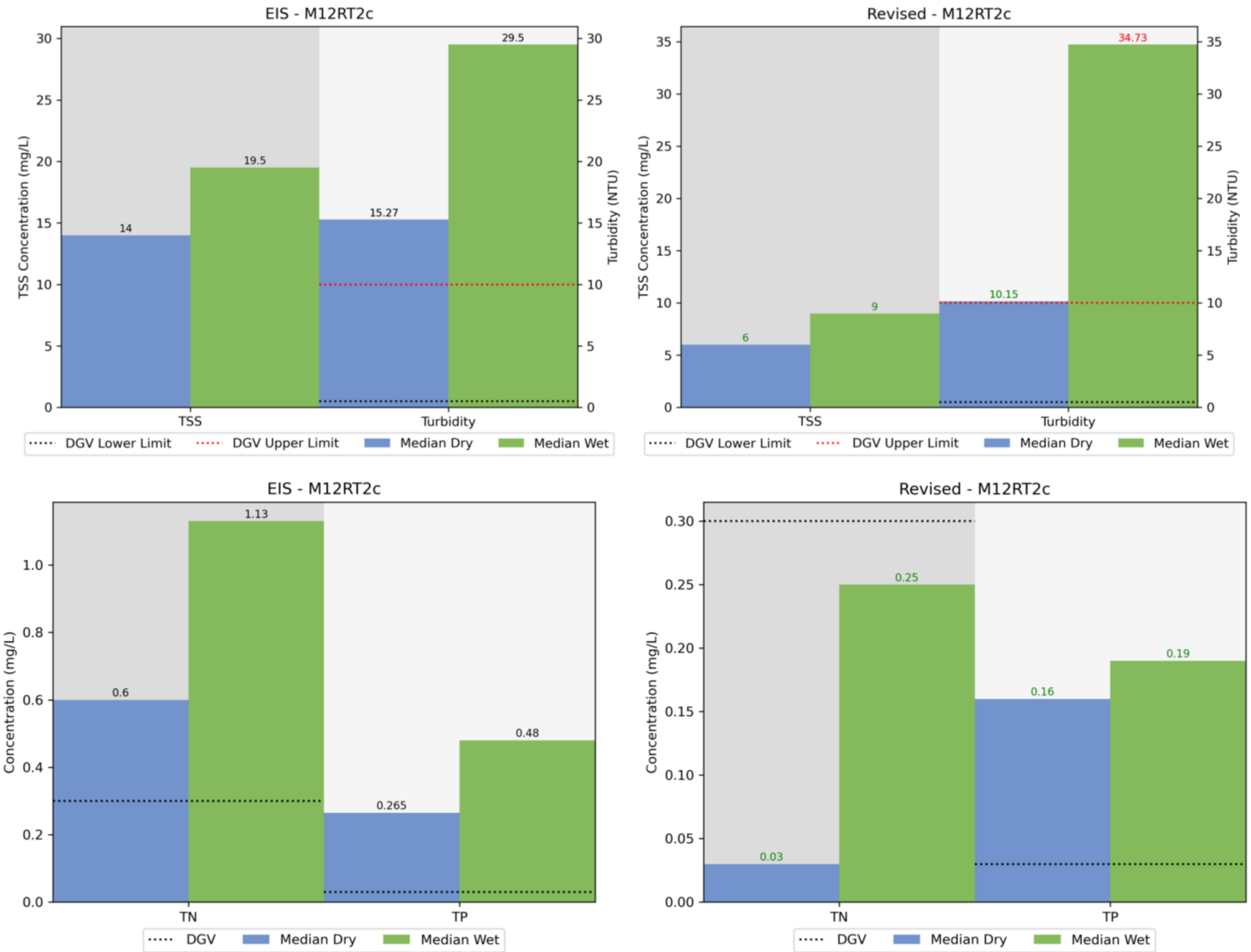


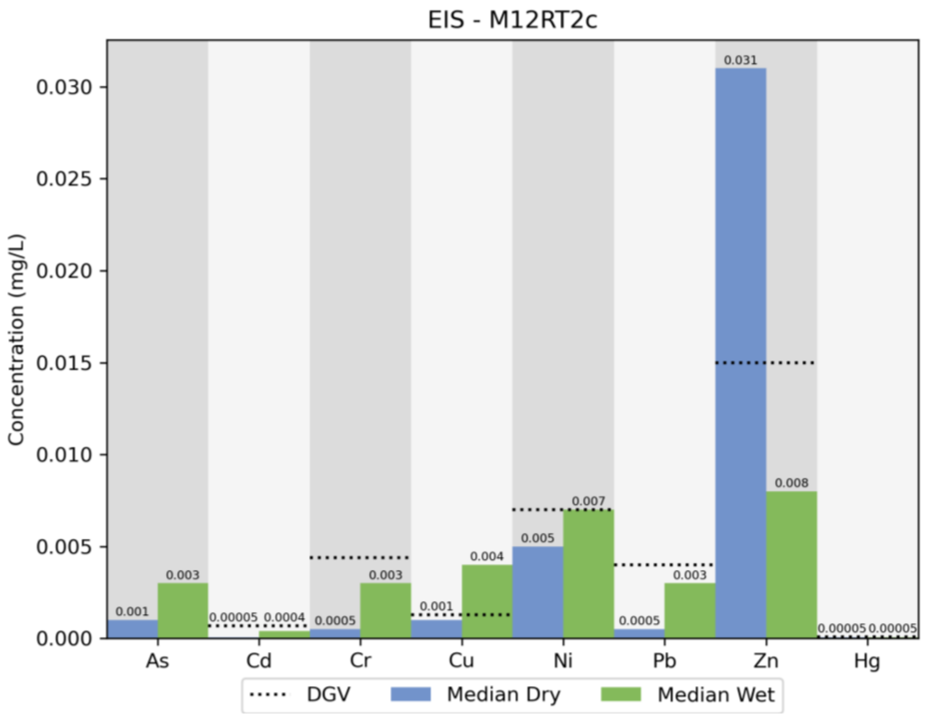




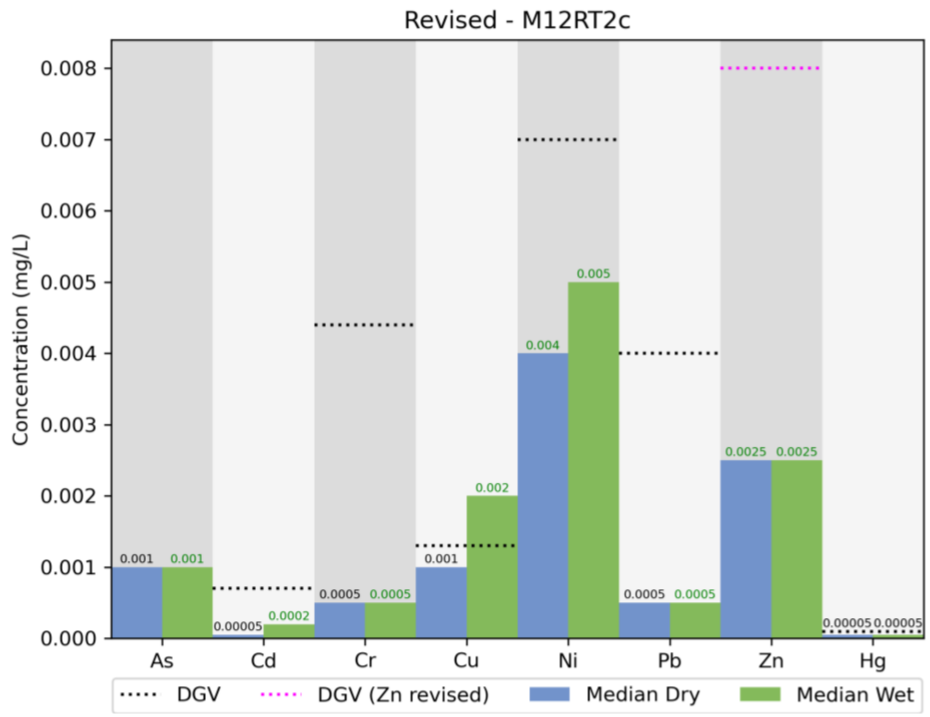
EIS - M12RT2b
Concentration (mg/L)
0.0000
0.0025
0.0050
0.0075
0.0100
0.0125
0.0150
0.0175
0.002
0.002
0.00005
0.00013
0.0005
0.0008
0.002
0.003
0.006
0.009
0.0005
0.0005
0.01
0.018
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet
Revised - M12RT2b
Concentration (mg/L)
0.002
0.002
0.00005
0.00005
0.0005
0.0005
0.001
0.003
0.007
0.006
0.0005
0.0005
0.007
0.018
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

Purgatory Creek (M12RT2c)



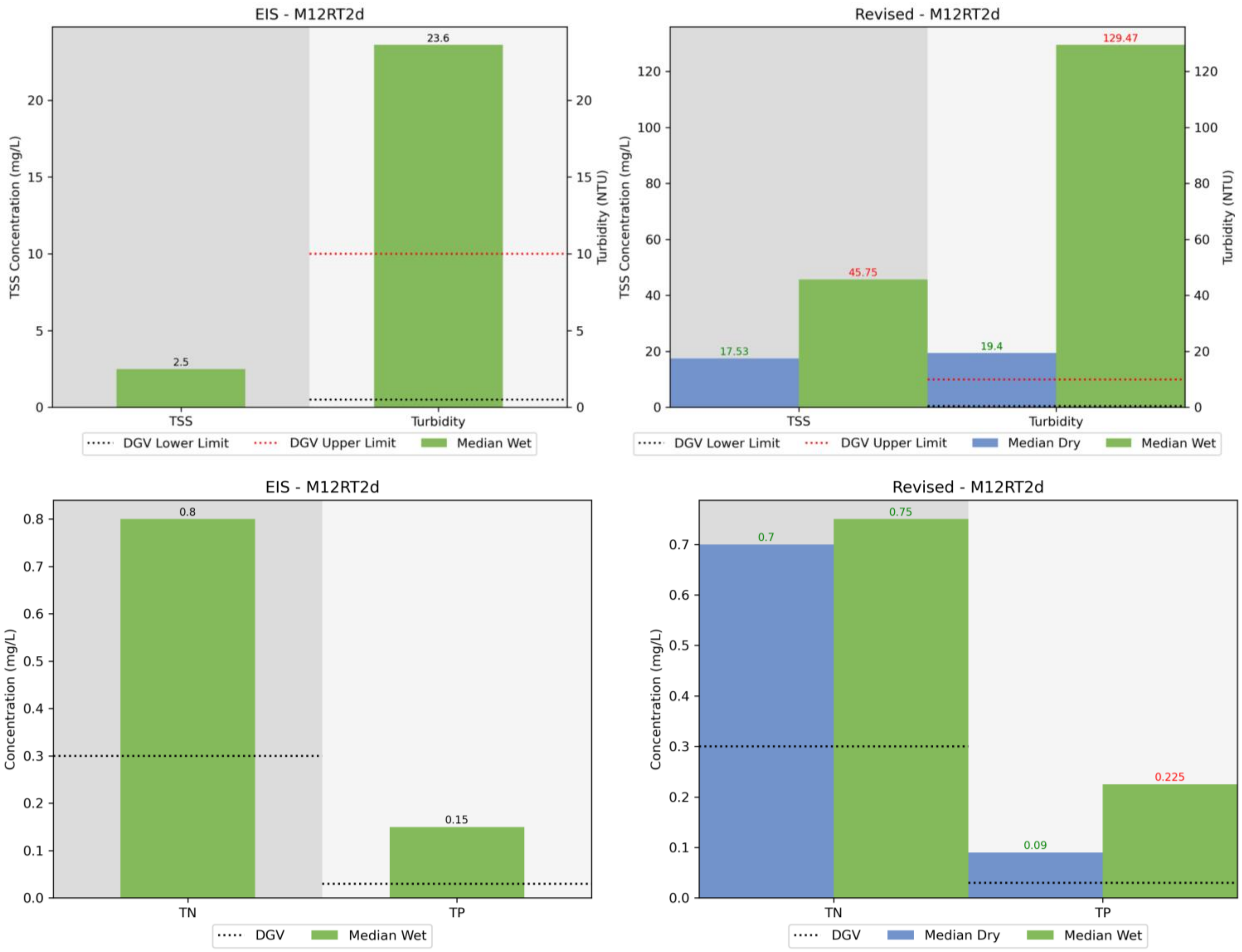


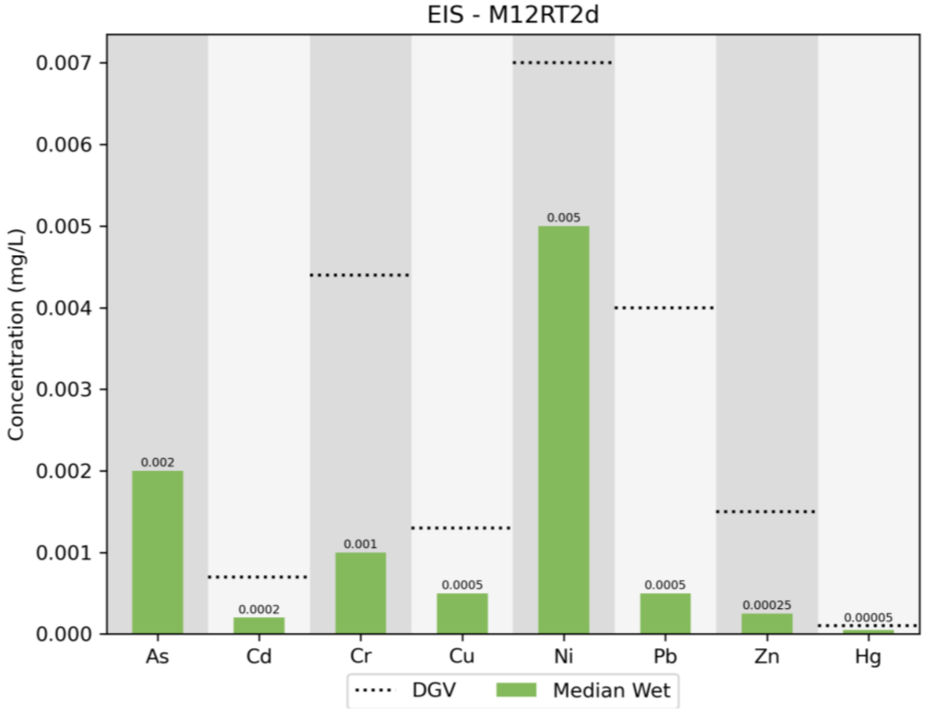
EIS - M12RT2c
Concentration (mg/L)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.001
0.003
0.00005
0.0004
0.0005
0.003
0.001
0.004
0.005
0.007
0.0005
0.003
0.031
0.008
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet

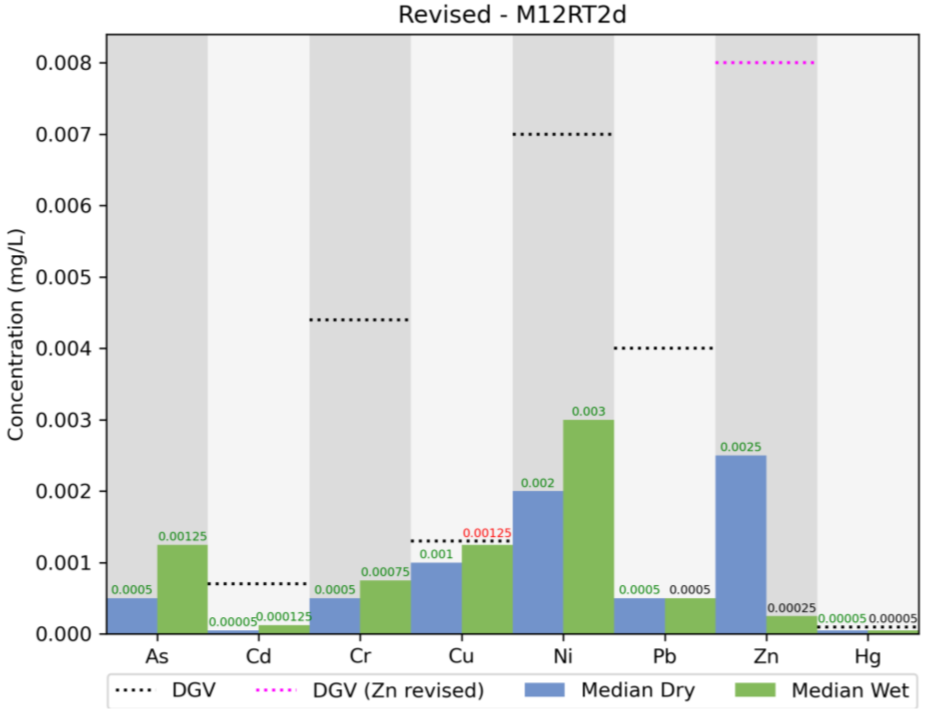


Revised - M12RT2c
Concentration (mg/L)
0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.001
0.001
0.00005
0.0002
0.0005
0.0005
0.001
0.002
0.004
0.005
0.0005
0.0005
0.0025
0.0025
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

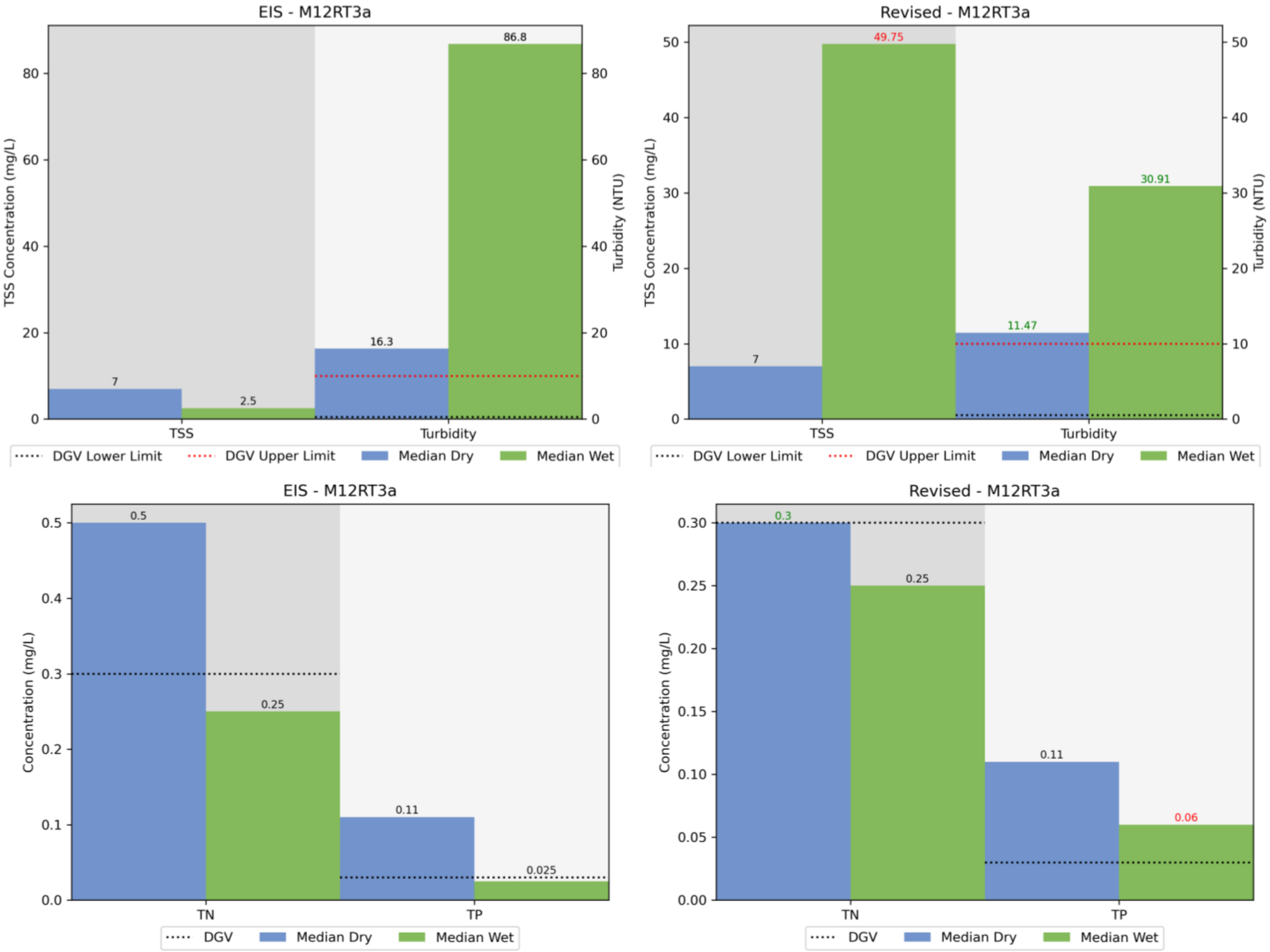
Purgatory Creek (M12RT2d)

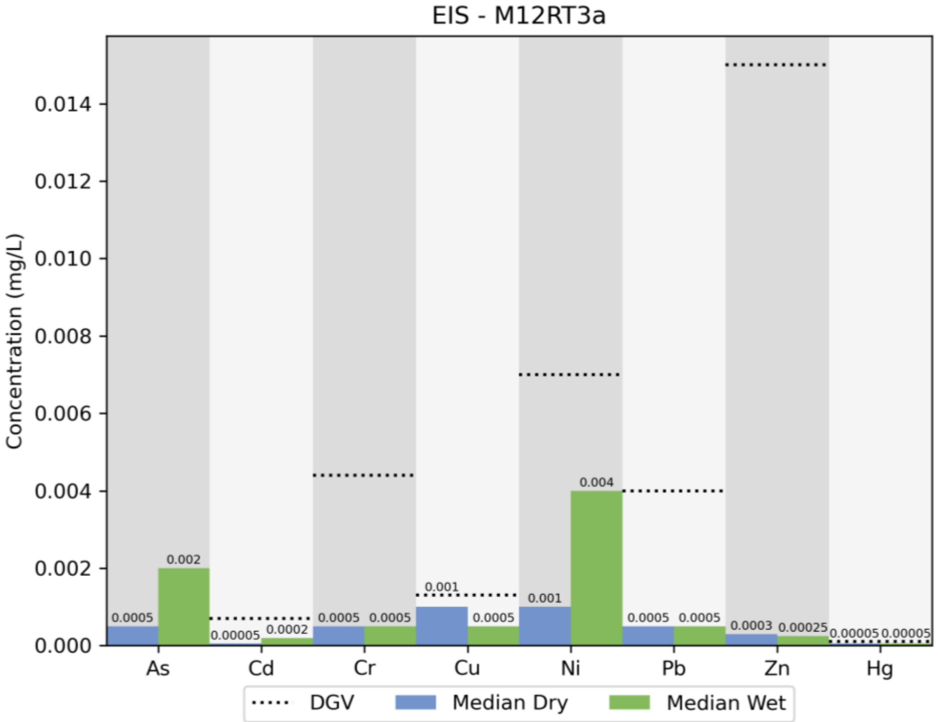


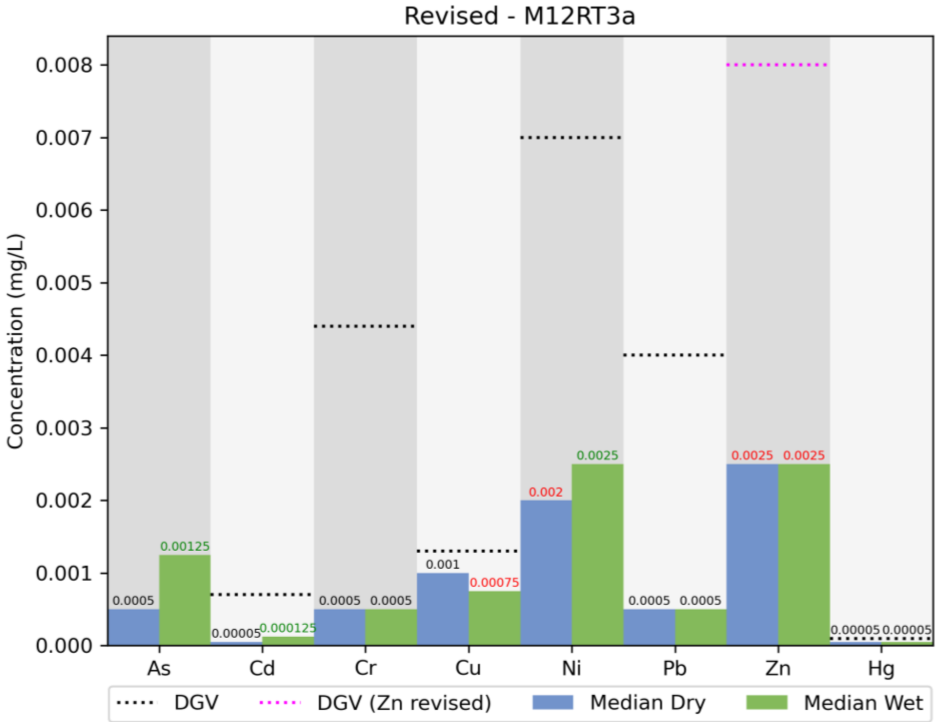

EIS - M12RT2d
Concentration (mg/L)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.002
0.0002
0.001
0.0005
0.005
0.0005
0.00025
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Wet


Revised - M12RT2d
Concentration (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.0005
0.00125
0.00005
0.000125
0.0005
0.00075
0.001
0.00125
0.002
0.003
0.0005
0.0005
0.0025
0.00025
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

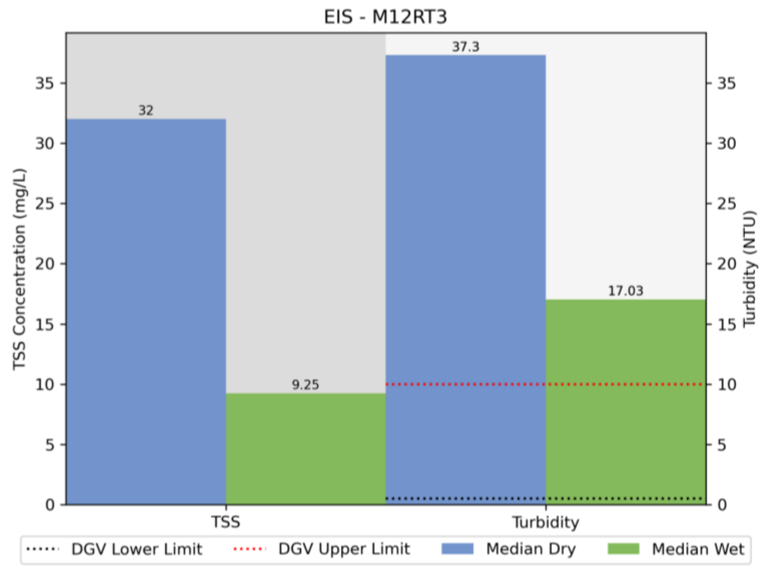
Hunter River (M12RT3a)

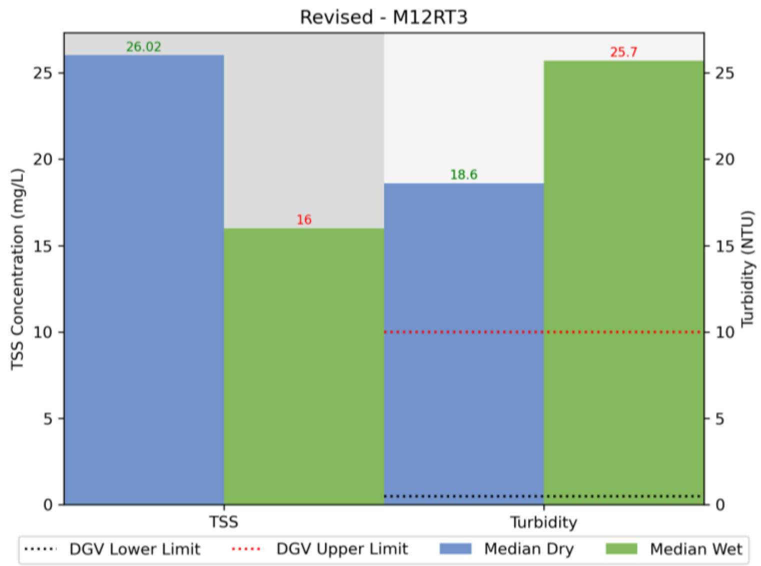


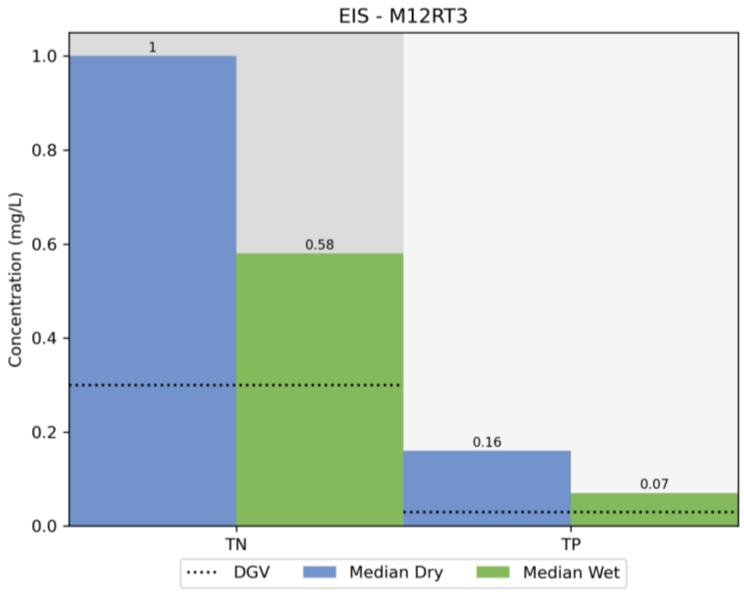

EIS - M12RT3a
Concentration (mg/L)
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
0.0005
0.002
0.00005
0.0002
0.0005
0.0005
0.001
0.0005
0.001
0.004
0.0005
0.0005
0.0003
0.00025
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet

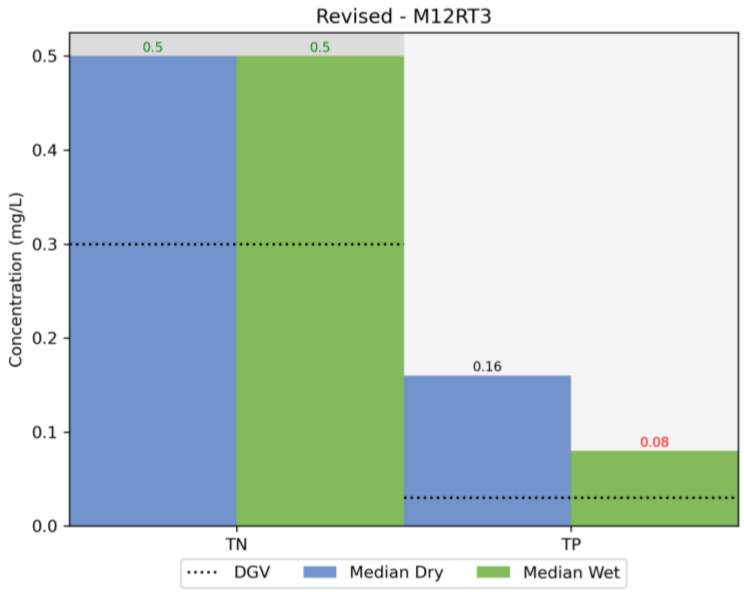

Revised - M12RT3a
Concentration (mg/L)
0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.0005
0.00125
0.00005
0.000125
0.0005
0.0005
0.001
0.00075
0.002
0.0025
0.0005
0.0005
0.0025
0.0025
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

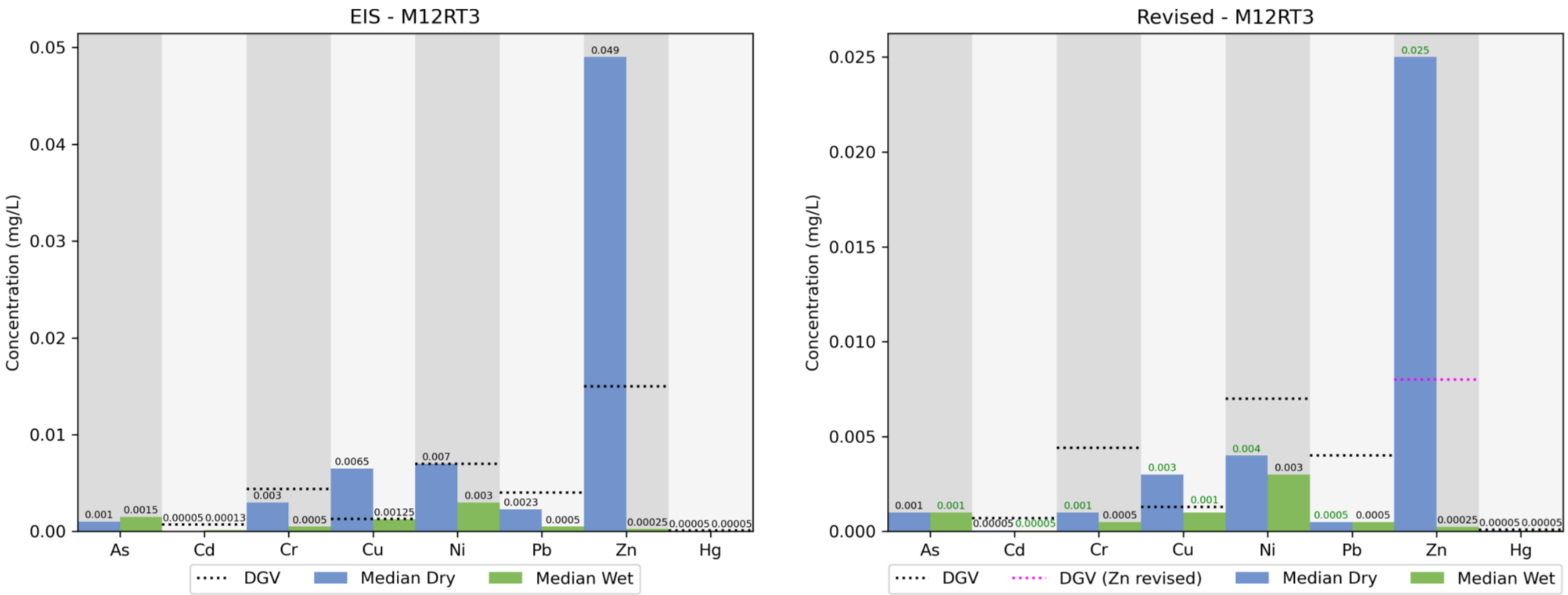
Hunter River (M12RT3)



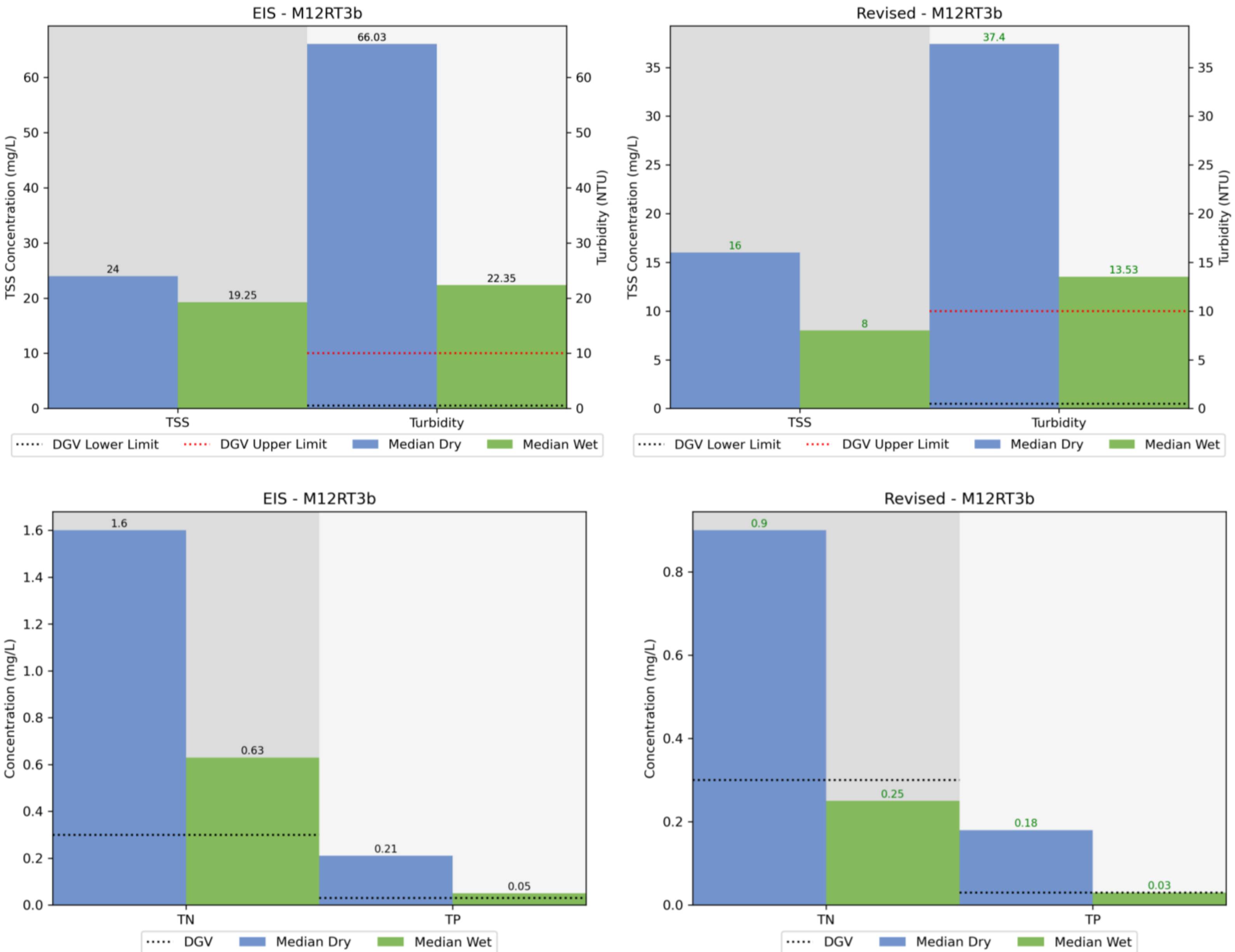


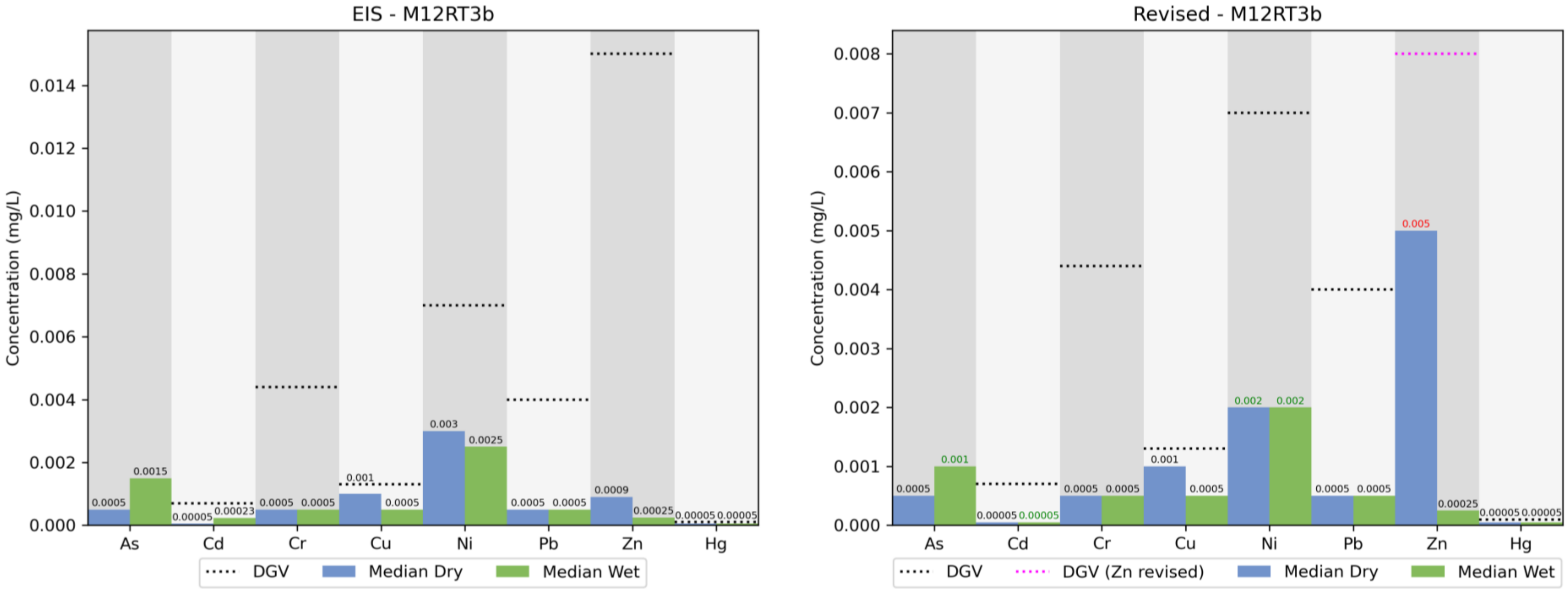





EIS - M12RT3
Concentration (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0.001
0.0015
0.00005
0.00013
0.003
0.0005
0.0065
0.00125
0.007
0.003
0.0023
0.0005
0.049
0.00025
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet
Revised - M12RT3
Concentration (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
0.001
0.001
0.00005
0.00005
0.001
0.0005
0.003
0.001
0.004
0.003
0.0005
0.0005
0.025
0.00025
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

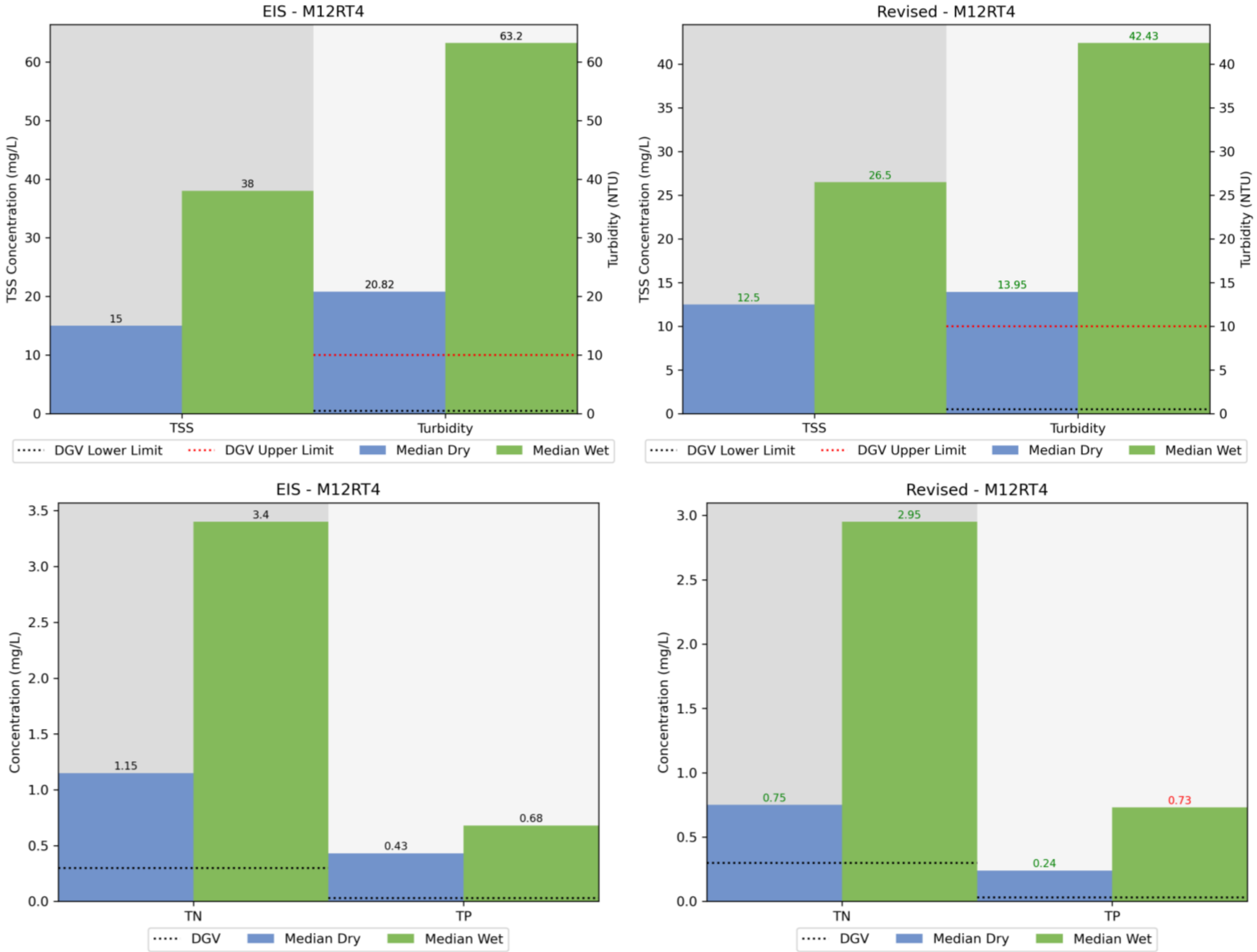
Hunter River (M12RT3b)

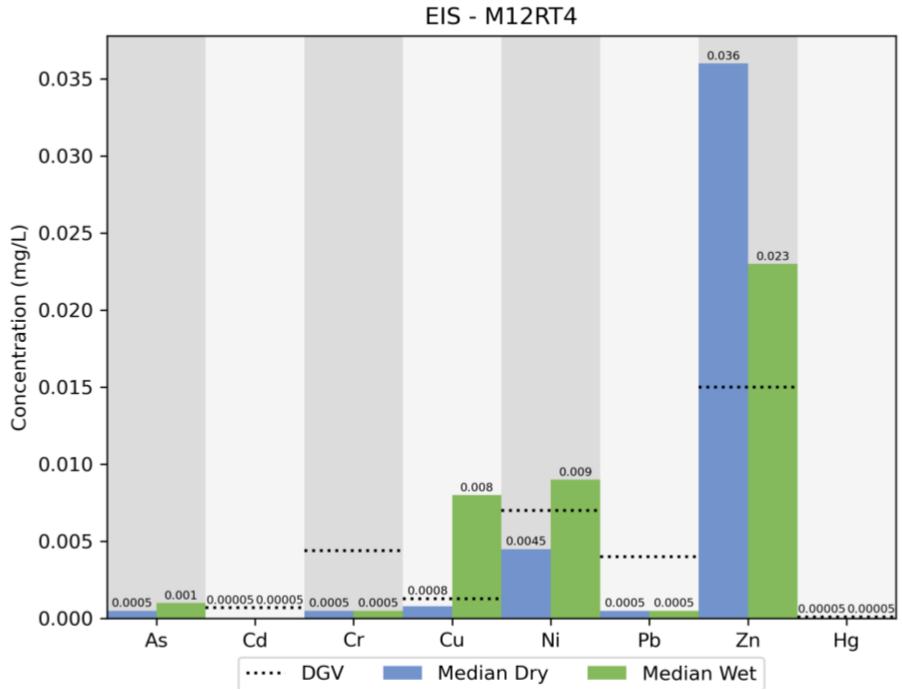


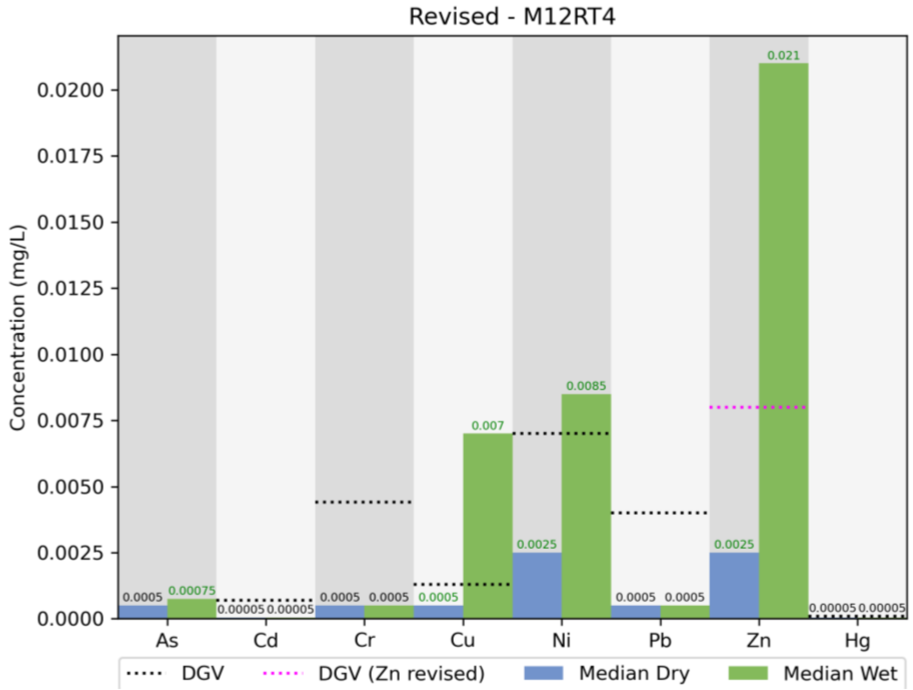


EIS - M12RT3b
Concentration (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0.0005
0.0015
0.00005
0.00023
0.0005
0.0005
0.001
0.0005
0.003
0.0025
0.0005
0.0005
0.0009
0.00025
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet
Revised - M12RT3b
Concentration (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.0005
0.001
0.00005
0.00005
0.0005
0.0005
0.001
0.0005
0.002
0.002
0.0005
0.0005
0.005
0.00025
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

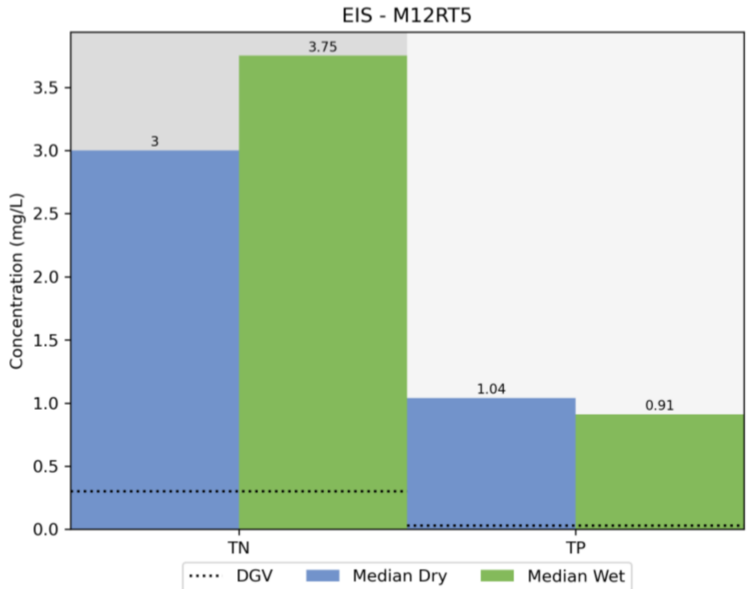
Hunter River Drain (M12RT4)

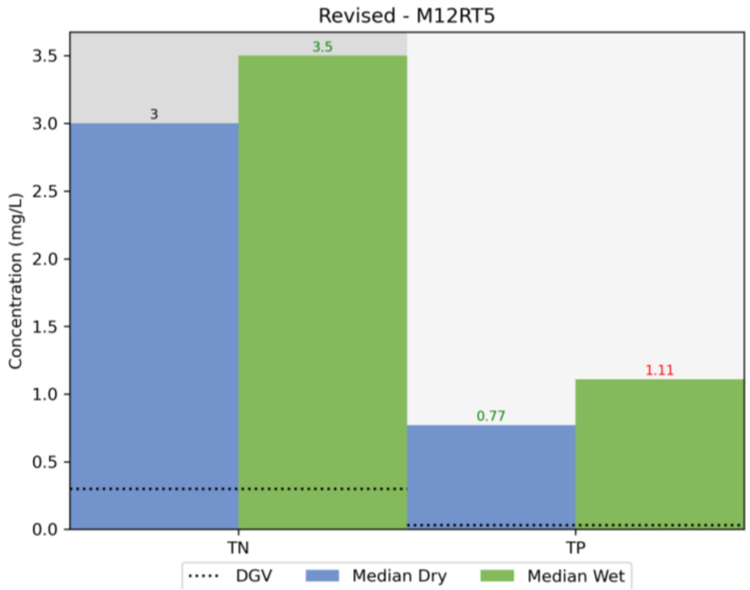


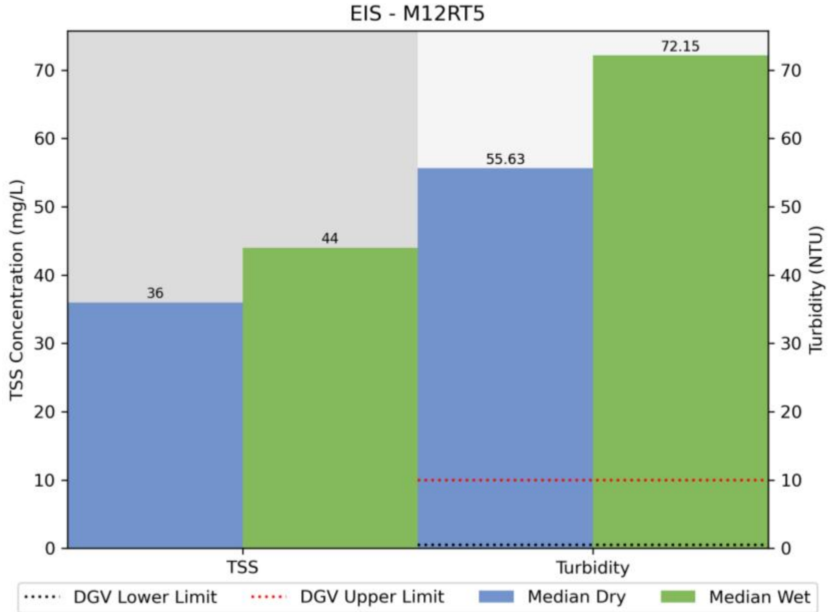

EIS - M12RT4
Concentration (mg/L)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.0005
0.001
0.00005
0.00005
0.0005
0.0005
0.0008
0.008
0.0045
0.009
0.0005
0.0005
0.036
0.023
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet

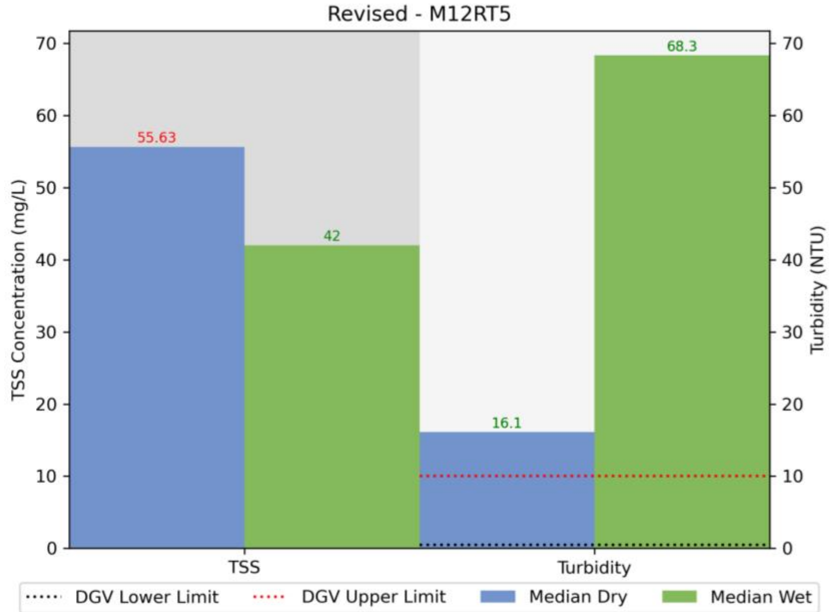

Revised - M12RT4
Concentration (mg/L)
0.0000
0.0025
0.0050
0.0075
0.0100
0.0125
0.0150
0.0175
0.0200
0.0005
0.00075
0.00005
0.00005
0.0005
0.0005
0.0005
0.007
0.0025
0.0085
0.0005
0.0005
0.0025
0.021
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

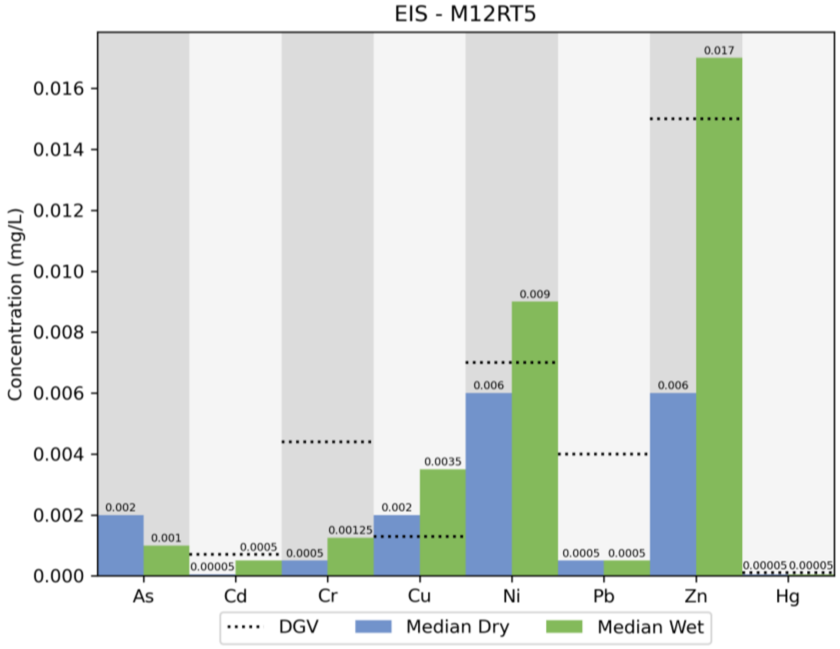
Hunter River Drain (M12RT5)

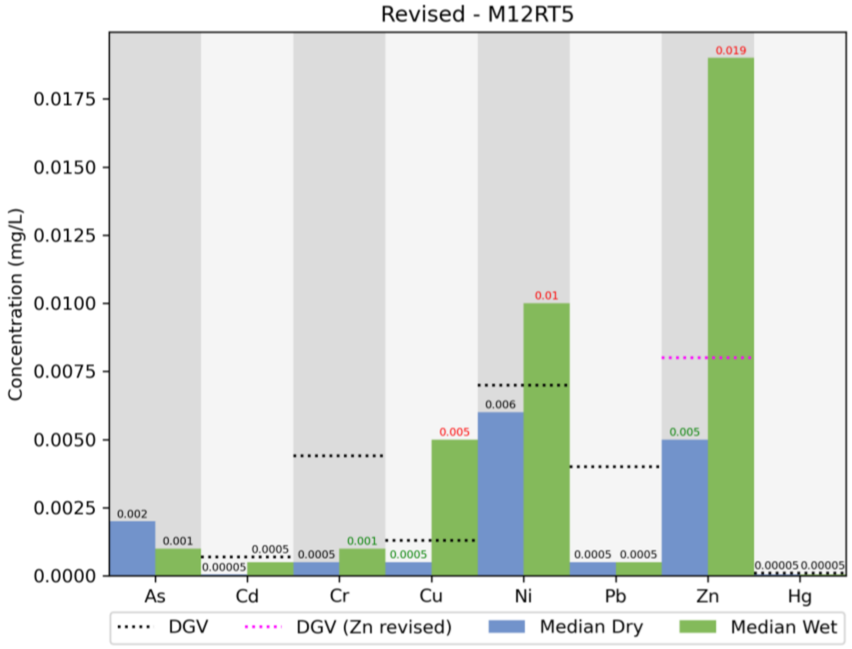




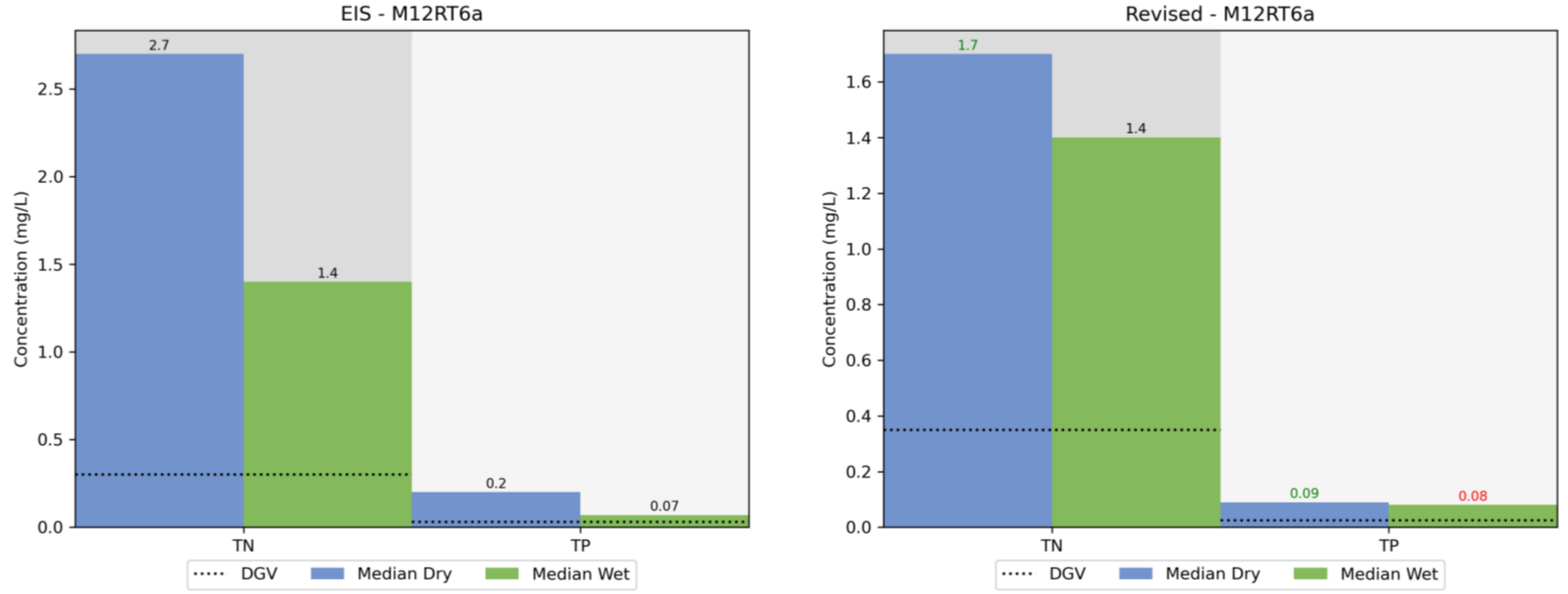


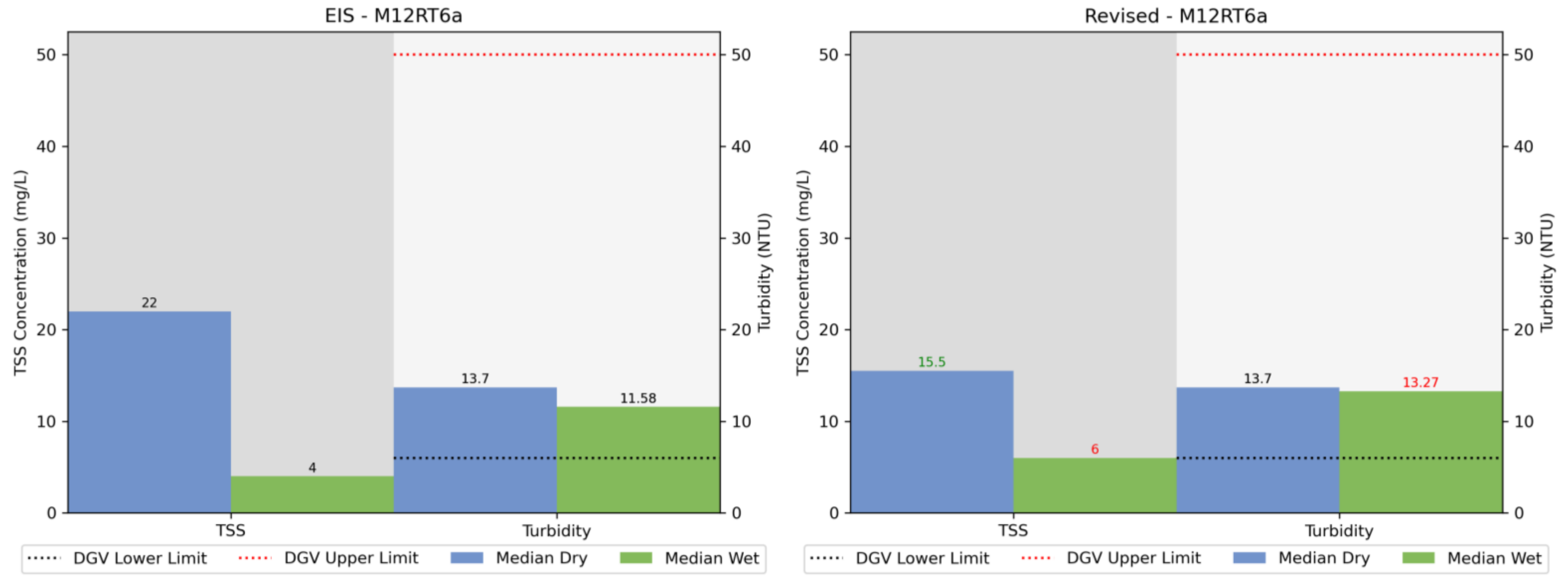


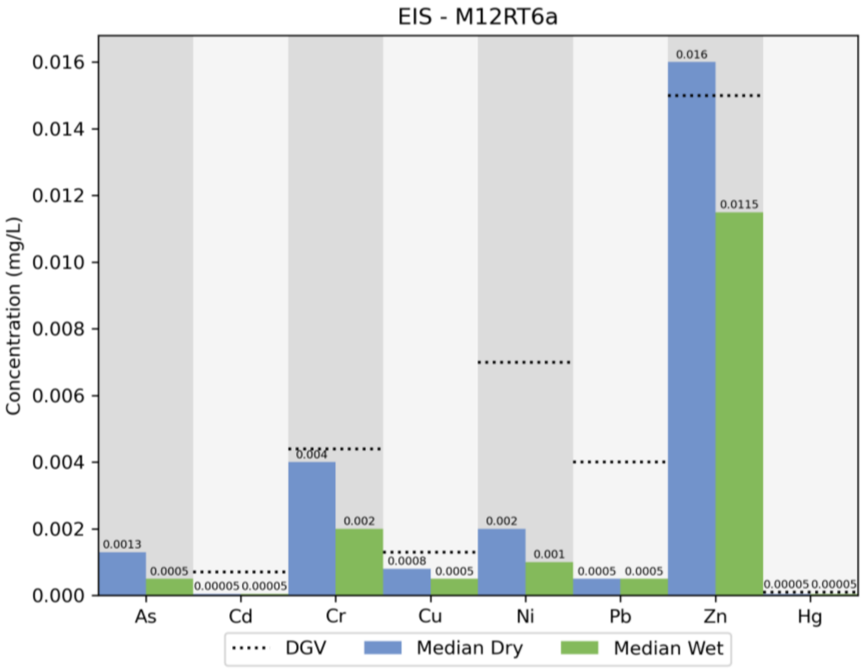

EIS - M12RT5
Concentration (mg/L)
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0.002
0.001
0.00005
0.0005
0.0005
0.00125
0.002
0.0035
0.006
0.009
0.0005
0.0005
0.006
0.017
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet

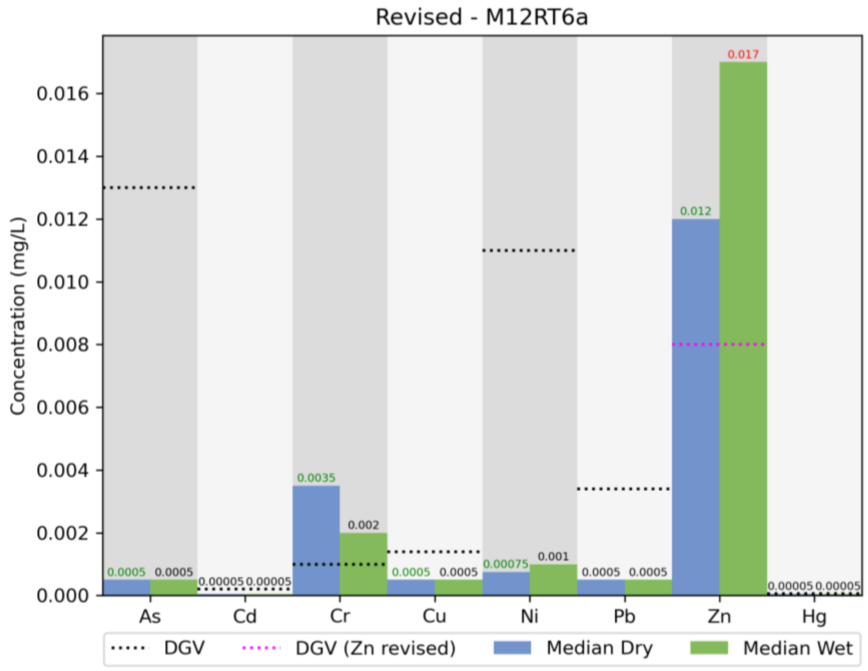

Revised - M12RT5
Concentration (mg/L)
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.002
0.001
0.00005
0.0005
0.0005
0.001
0.0005
0.005
0.006
0.01
0.0005
0.0005
0.005
0.019
0.00005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

Windeyers Creek (M12RT16a)

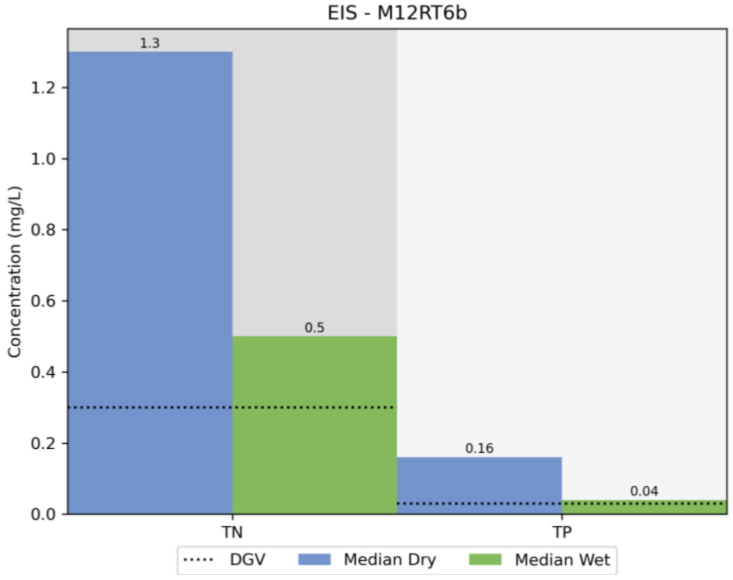


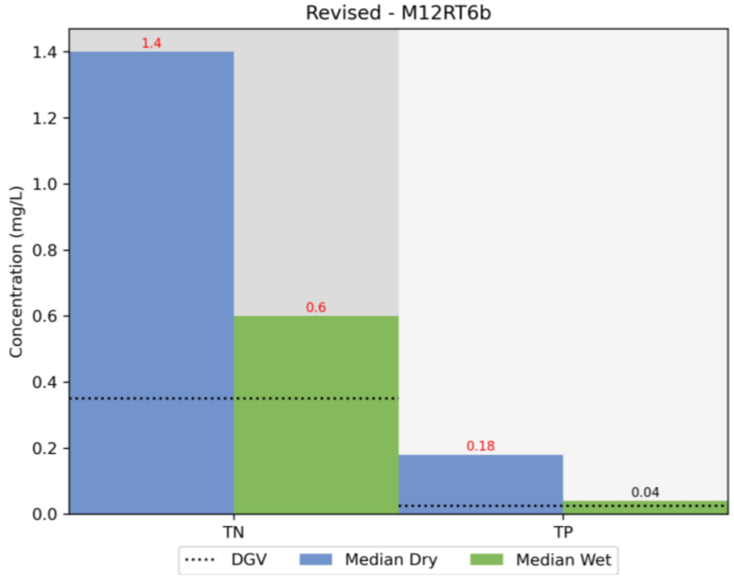


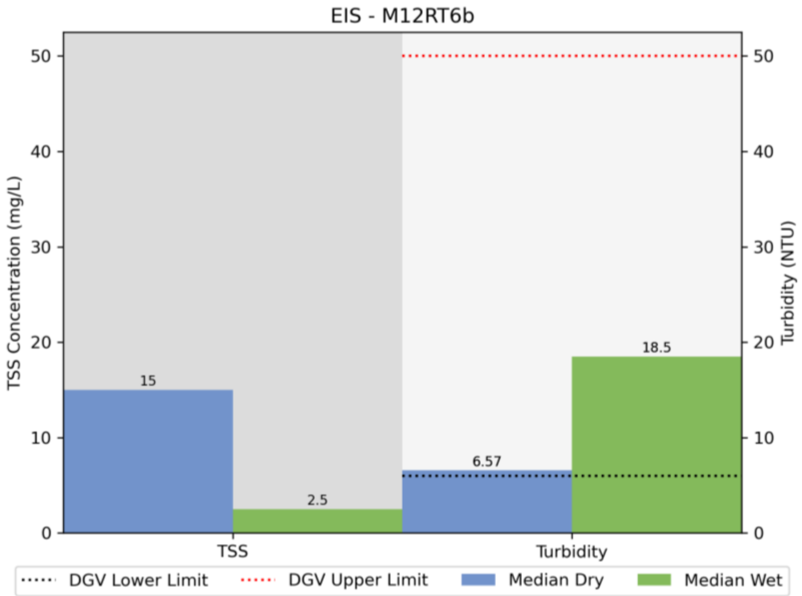

EIS - M12RT6a
Concentration (mg/L)
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet

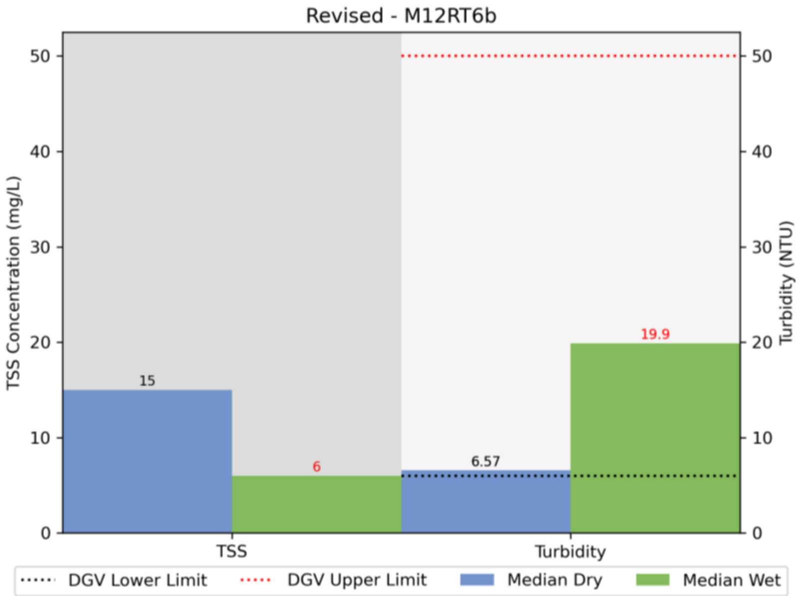

Revised - M12RT6a
Concentration (mg/L)
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

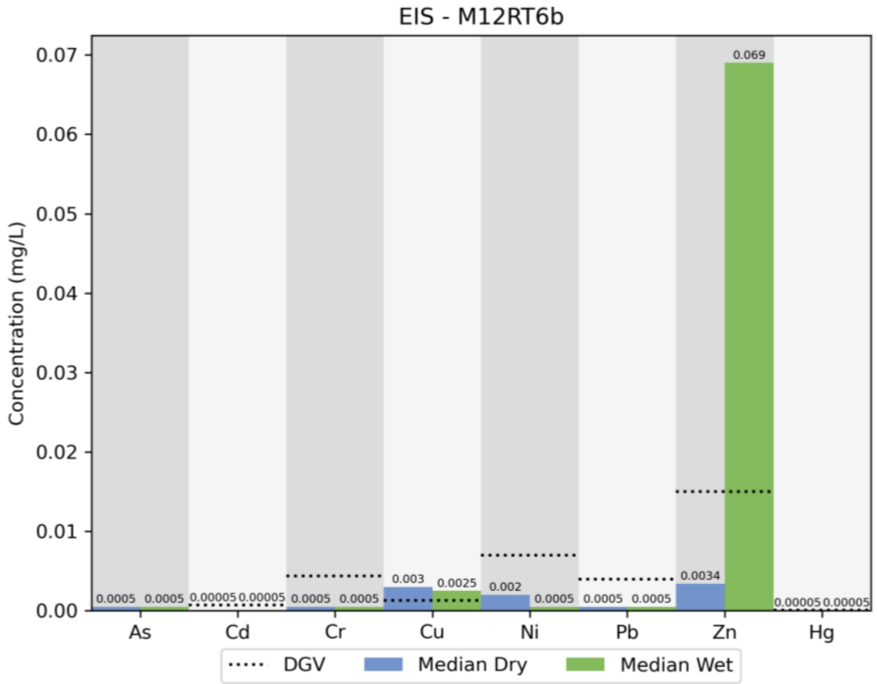
Windeyers Creek (M12RT16b)



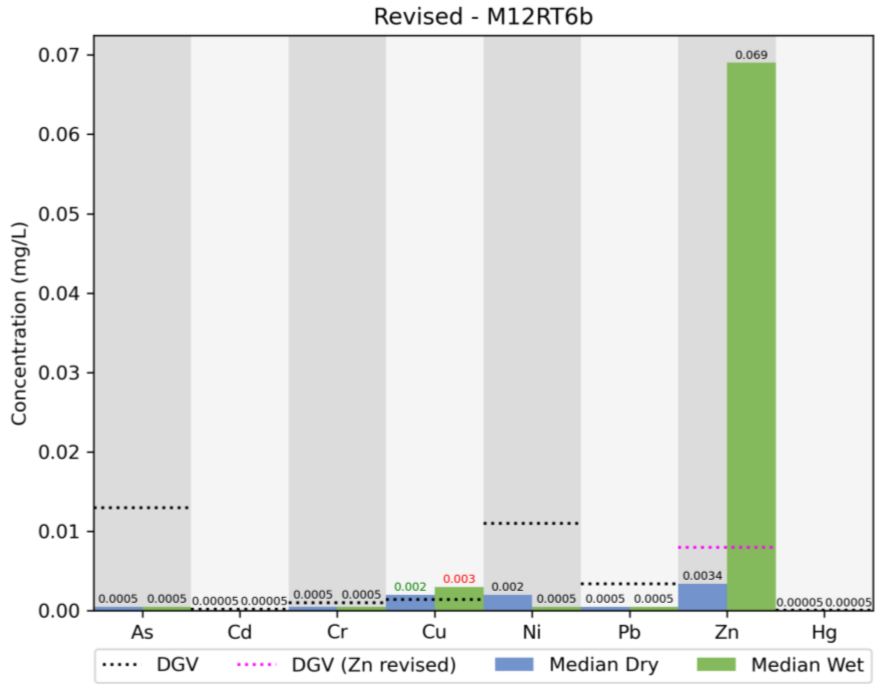






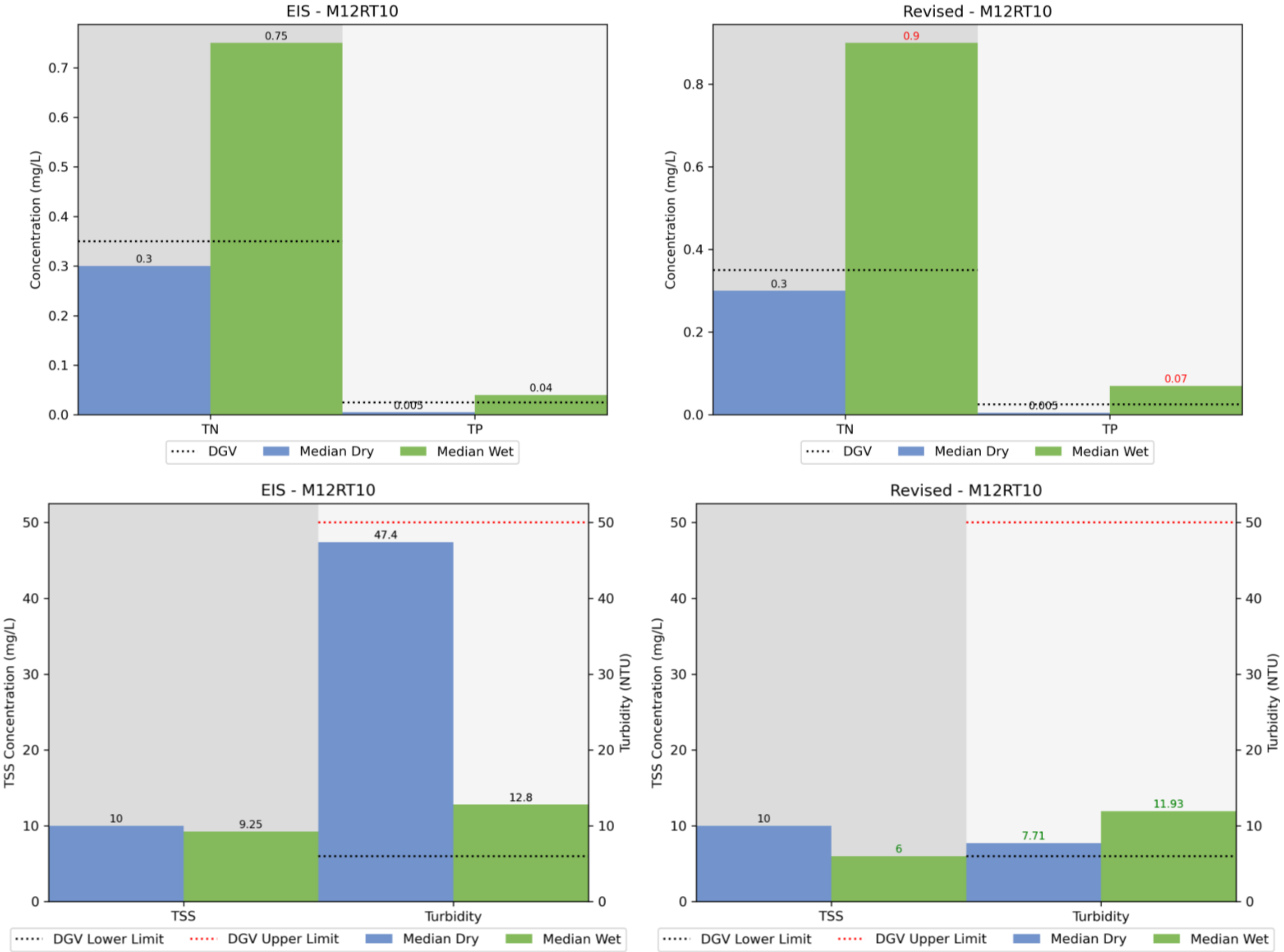


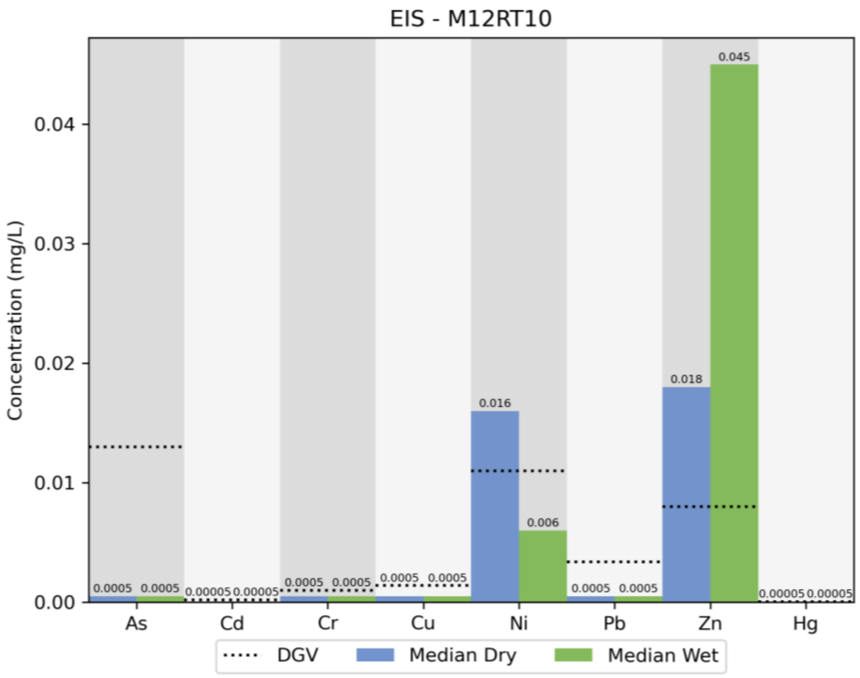
EIS - M12RT6b
Concentration (mg/L)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
0.0005
0.00005
0.003
0.0025
0.002
0.0034
0.069
DGV
Median Dry
Median Wet

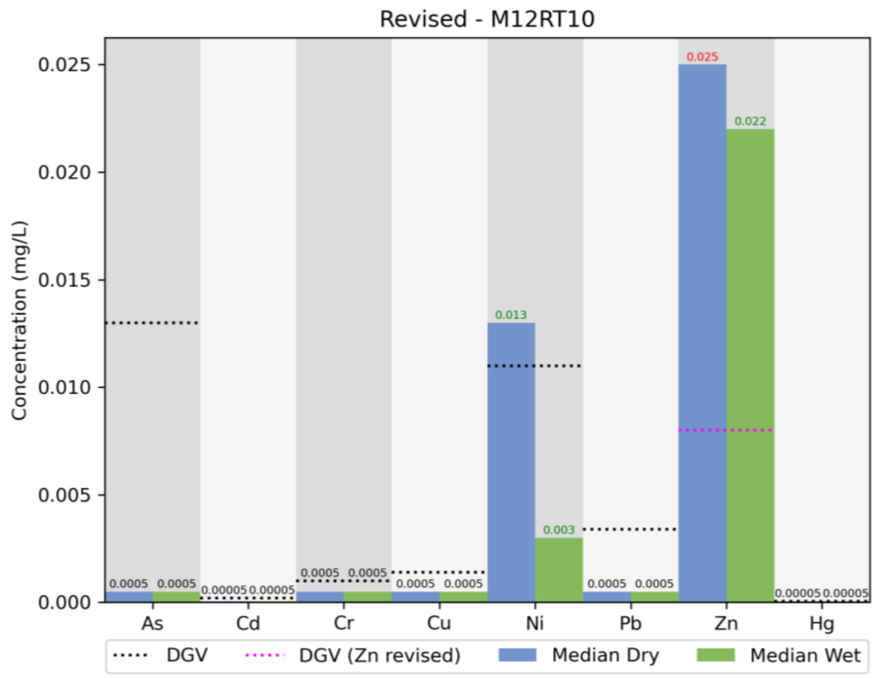


Revised - M12RT6b
Concentration (mg/L)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
0.0005
0.00005
0.002
0.003
0.0034
0.069
DGV
DGV (Zn revised)
Median Dry
Median Wet

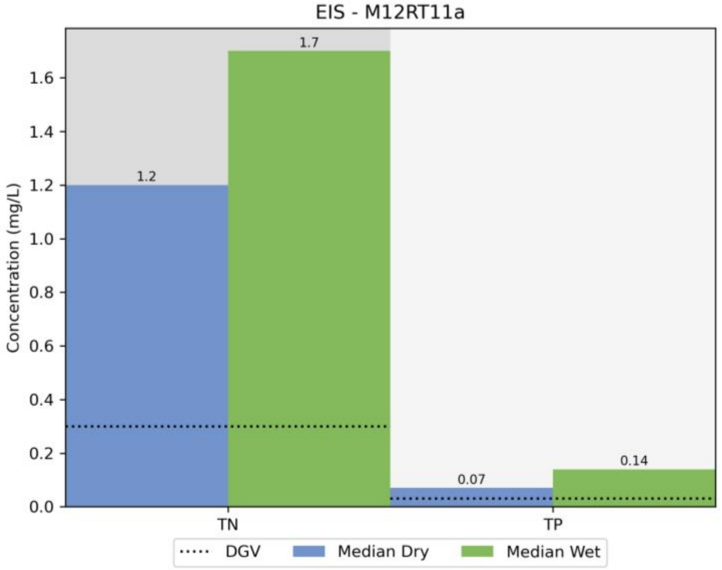
Grahamstown Drain (M12RT10)

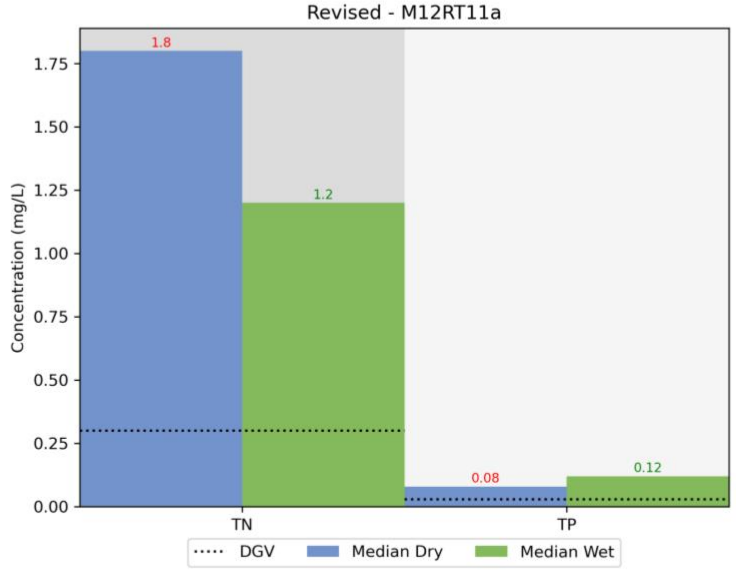


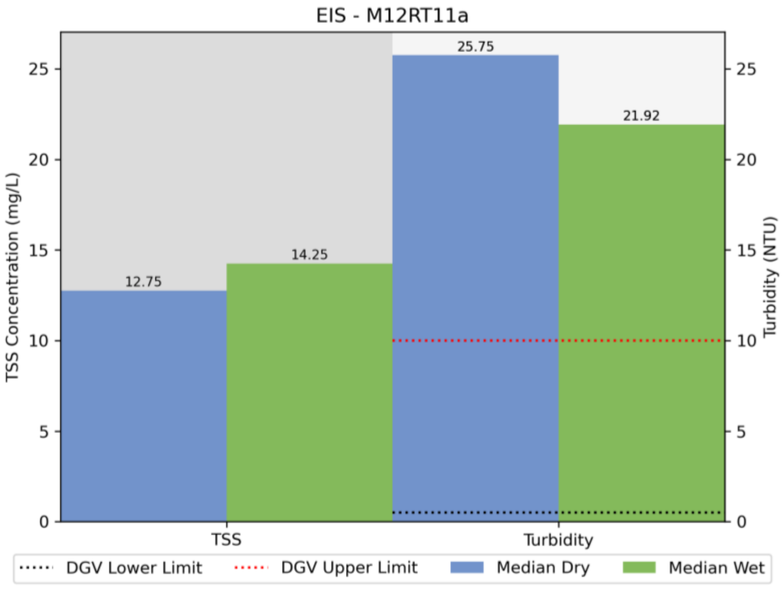

EIS - M12RT10
Concentration (mg/L)
0.045
0.018
0.016
0.006
0.0005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet

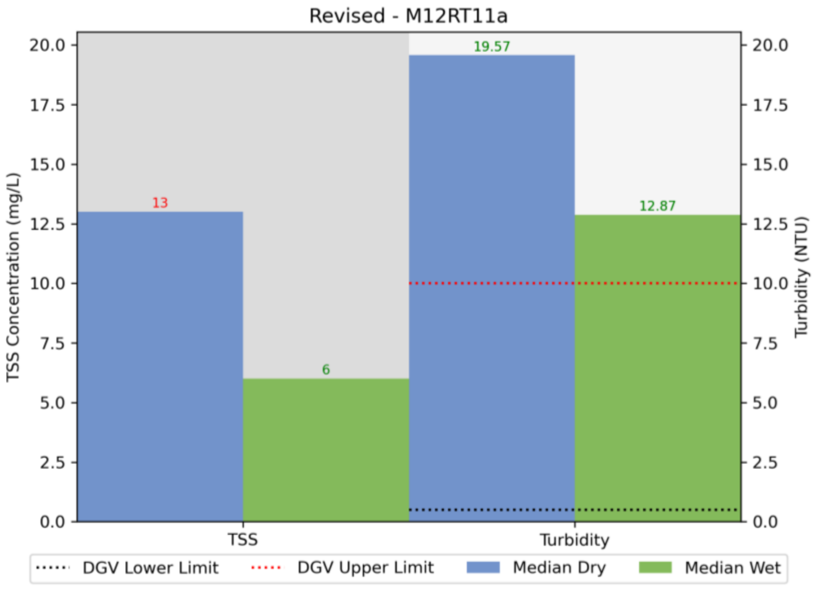

Revised - M12RT10
Concentration (mg/L)
0.025
0.022
0.013
0.003
0.0005
0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

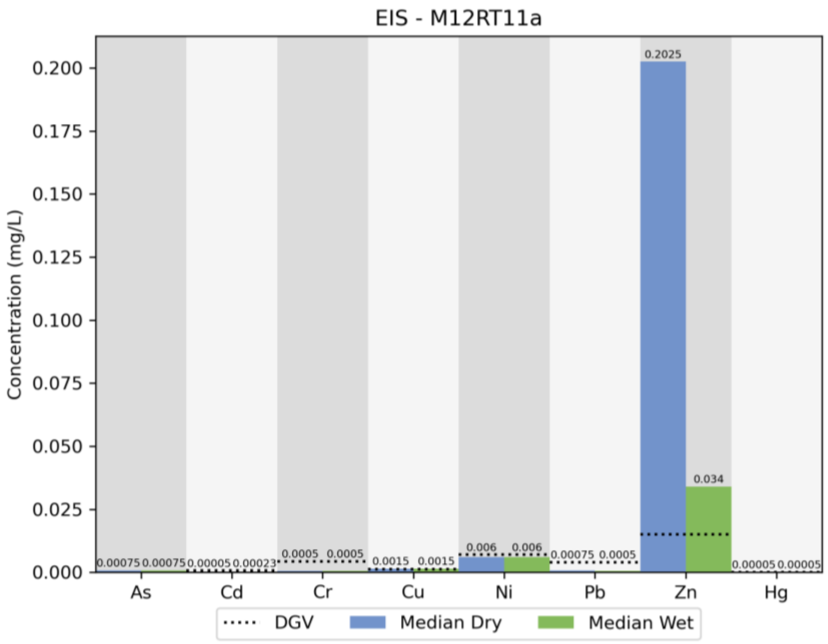
Unnamed Coastal Wetland (M12RT11a)

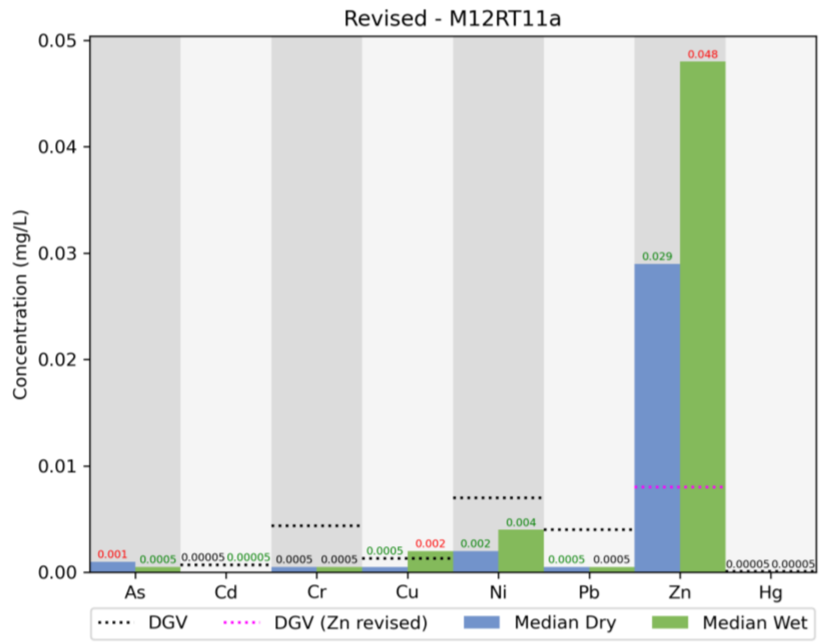




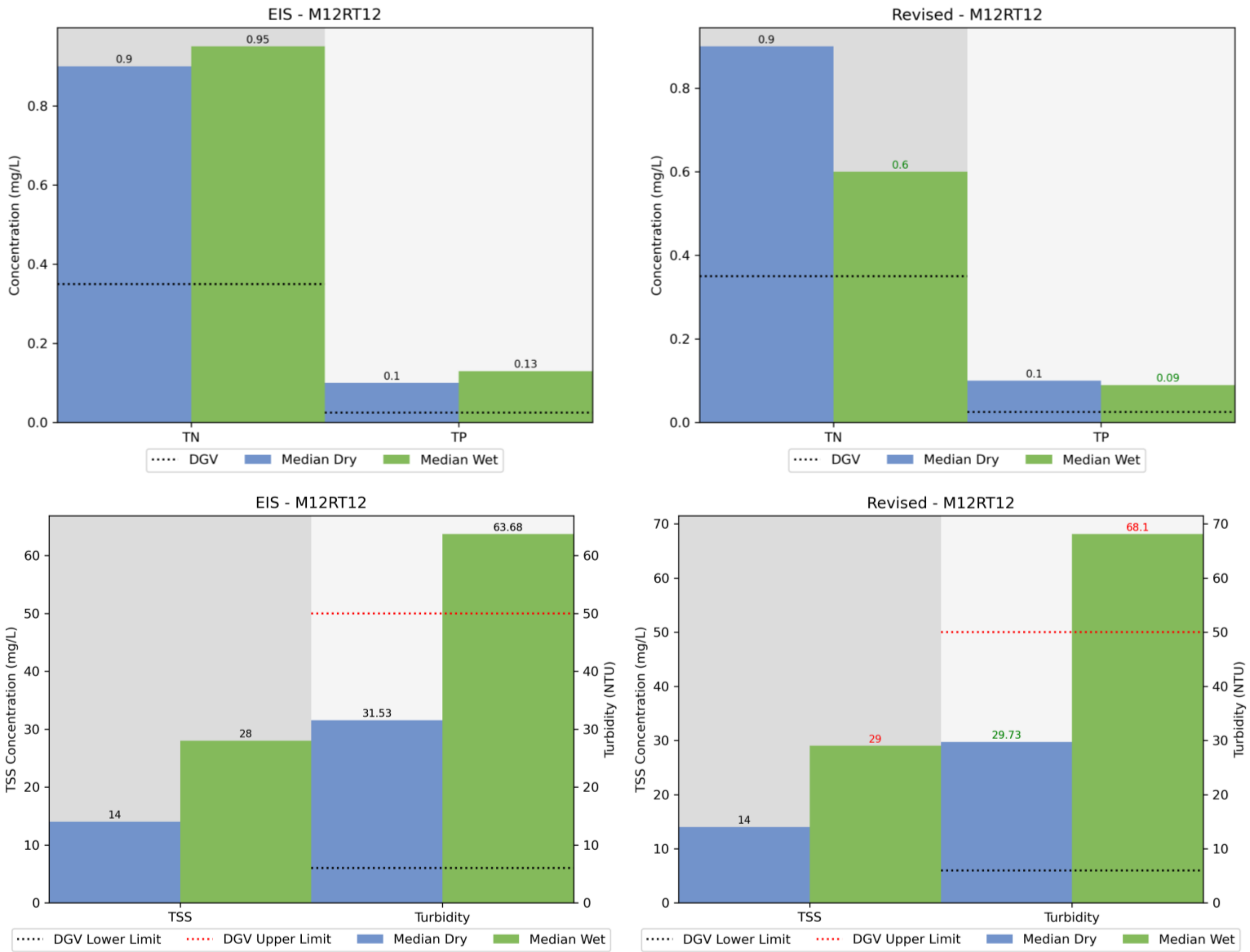


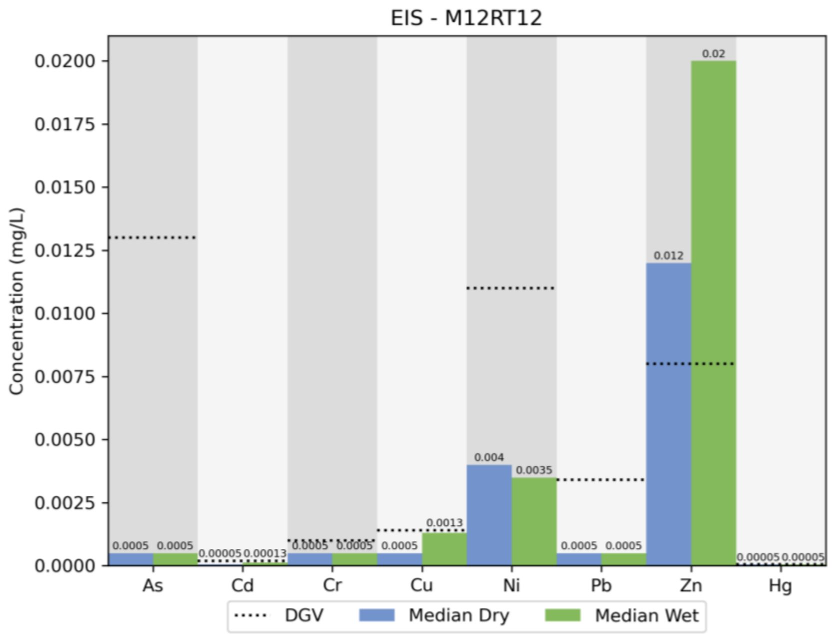


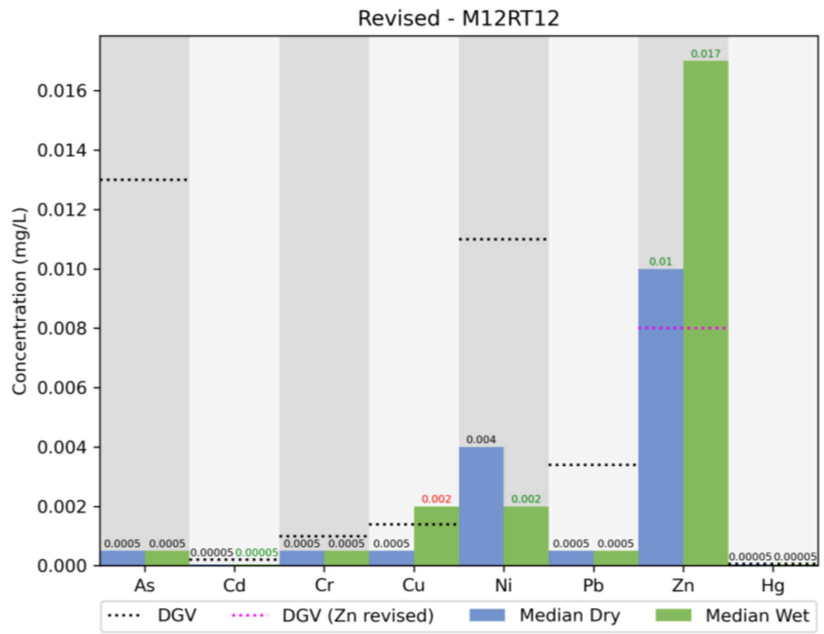

EIS - M12RT11a
Concentration (mg/L)
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0.00075 0.00075
0.00005 0.00023
0.0005 0.0005
0.0015 0.0015
0.006 0.006
0.00075 0.0005
0.2025
0.034
0.00005 0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
Median Dry
Median Wet


Revised - M12RT11a
Concentration (mg/L)
0.00
0.01
0.02
0.03
0.04
0.05
0.001 0.0005
0.00005 0.00005
0.0005 0.0005
0.0005 0.002
0.002 0.004
0.0005 0.0005
0.029
0.048
0.00005 0.00005
As
Cd
Cr
Cu
Ni
Pb
Zn
Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

Viney Creek (M12RT12)




EIS - M12RT12
Concentration (mg/L)
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.0005 0.0005
0.00005 0.00013
0.0005 0.0005
0.0005 0.0013
0.004 0.0035
0.0005 0.0005
0.012 0.02
0.00005 0.00005
As Cd Cr Cu Ni Pb Zn Hg
DGV
Median Dry
Median Wet


Revised - M12RT12
Concentration (mg/L)
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0.0005 0.0005
0.00005 0.00005
0.0005 0.0005
0.0005 0.002
0.004 0.002
0.0005 0.0005
0.01 0.017
0.00005 0.00005
As Cd Cr Cu Ni Pb Zn Hg
DGV
DGV (Zn revised)
Median Dry
Median Wet

Appendix C. Rainfall data

Design Rainfall Data System (2016)

Conditions of Use | Help | New IFD feedback

New Search >

Analysis - Single Point

Design Rainfalls

- ○ Very Frequent
- ◉ IFDs (Frequent and Infrequent)
- ○ Rare

Standard Durations

- ☑ 1 - 45 minutes
- ☐ 1 - 18 hours
- ☐ 24 - 168 hours

- Non-Standard Durations

Duration: [ ] minutes +

+ Observed Rainfalls

Update Reset

Other Options

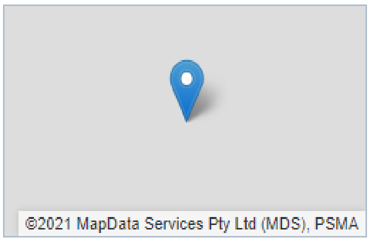
- ☐ Coefficients
- ☐ Seasonality

Location

Label: M12RT

Latitude: -32.881 [Nearest grid cell: 32.8875 (S)]

Longitude: 151.756 [Nearest grid cell: 151.7625 (E)]



IFD Design Rainfall Intensity (mm/h)

Issued: 21 November 2021

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table | Chart

Unit: mm/h

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	133	153	220	269	320	392	451
2 min	111	129	186	227	269	325	369
3 min	103	119	172	210	248	301	343
4 min	96.9	112	161	197	234	284	325
5 min	91.7	106	152	186	221	270	309
10 min	72.8	83.7	120	147	175	215	249
15 min	60.8	69.9	100	123	147	180	208
20 min	52.5	60.4	86.8	106	127	156	180
25 min	46.4	53.4	76.9	94.1	112	138	159
30 min	41.8	48.1	69.3	84.8	101	124	143
45 min	32.6	37.6	54.2	66.3	78.9	96.6	111

Australian Rainfall and Runoff terminology

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI	Uses in Engineering Design
Very frequent	**12**				
	6	99.75	1.002	0.17	Water sensitive urban design
	4	98.17	1.02	0.25	
	3	95.02	1.05	0.33	
	2	86.47	1.16	0.50	
Frequent	**1**	**63.2**	1.58	1.00	Stormwater/pit and pipe design
	0.69	**50.00**	2	1.44	
	0.5	39.35	2.54	2.00	
	0.22	**20.00**	5	4.48	
	0.2	18.13	5.52	5.00	
Infrequent	0.11	**10.00**	10.00	9.49	Floodplain management and waterway design
	0.05	**5.00**	20	20.0	
	0.02	**2.00**	50	50.0	
	0.01	**1.00**	**100**	100	
Rare	0.005	0.50	**200**	200	
	0.002	0.20	**500**	500	
	0.001	0.10	**1000**	1000	
Extremely Rare	0.0005	0.05	**2000**	2000	Design of high-consequence infrastructure (eg major dams)
	0.0002	0.02	5000	5000	
			↓		
Extreme			PMP		

Appendix D. Pollution Model inputs (basin flows and decant water quality)

D.1 Construction phase

There are two types of discharges from the construction phase temporary sediment basins, these are the controlled and overflow discharges which are further explained below. An assessment has been undertaken to estimate these two types of discharge flow rates for the purposes of the mixing assessment which has used this data.

D.1.1 Controlled discharges

The controlled discharges generally occur in dry weather after a storm event when the basins either full or partially full depending on the preceding amount of rainfall and runoff from the storm event.

The basins are generally emptied by pumping but in some cases, they can be emptied by gravity through a low flow pipe and valve where the topography around the basins allows.

The discharge out of the basins starts when the Total Suspended Solids (TSS) concentration drops below 50mg/L which is the typical requirement of an NSW EPA Environmental Protection License (EPL). The discharge and emptying of the basin need to occur within a period of five days following the storm event. If the TSS concentration is not reduced sufficiently (i.e. below 50mg/L), then super fine gypsum flocculation is normally applied to the basin to assist in the settlement of the soil particles out of the water column. Other stronger flocculants can also be used if required with the permission of the NSW EPA.

To estimate the controlled discharge flow rates out of the sediment basins, a number of assumptions were made. The adopted basin volumes in the design report have been used with an assumed eight hour constant pumping duration for the pump-out to be completed. Drawdown from the basin by the contractor on site is normally used to provide water for dust suppression spraying and also for soil compaction where moist conditions are needed for optimum compaction. The assumption that constant pumping of water at less than 50mg/L TSS would occur over a period of eight hours from a full basin is considered to be conservative. The reason is that the basin would not always fill up after a storm event and the reuse of water. These conditions would require pumping for a shorter duration.

The flow rates of the controlled discharges are estimated for each basin that has a different volume by assuming that the pumping rate would be selected such that the entire basin can be emptied within a period of eight hours. Therefore, the controlled flow rates would be different for each basin.

Table D-1 provides the controlled flow rates for each basin, and **Figure D-1** shows a plot of these numbers.

D.1.2 Overflow discharges

Overflow discharges represent peak flows from the sediment basin during a storm event that has exceeded the Blue Book (Soils and Construction) rainfall depth design criteria that has been used to size the sediment basins. When this occurs, the basin fills up to its full capacity and then overflows and keeps discharging until the rainfall runoff from the storm event ceases.

A design event needs to be selected for this assessment. Since the construction period is assumed to be between one to two years, an appropriate ARI to adopt is for a similar duration. The other assessments that feed into the mixing assessment have used a 50% AEP and therefore the same design event has been used in this assessment.

The 50% AEP is equivalent to the 1.44 ARI, this means that the probability of this event occurring is once every approx. 1.44 years.

The Bureau of Meteorology rainfall intensities (mm/hr) have been derived for the M12RT project (refer to **Appendix C**). Different intensities ranging from approximately 50mm/hr to 85mm/hr have been used for the peak flow estimations depending on the time of concentration (tc) which is dependent on the catchment size. The rational method has been used to derive the peak flows using an assumed runoff coefficient (C=0.5) to represent the disturbed status of the exposed land during the construction phase.

Table D-1 provides the overflow and controlled flow rates for each basin, and **Figure D-1** shows a plot of these numbers.

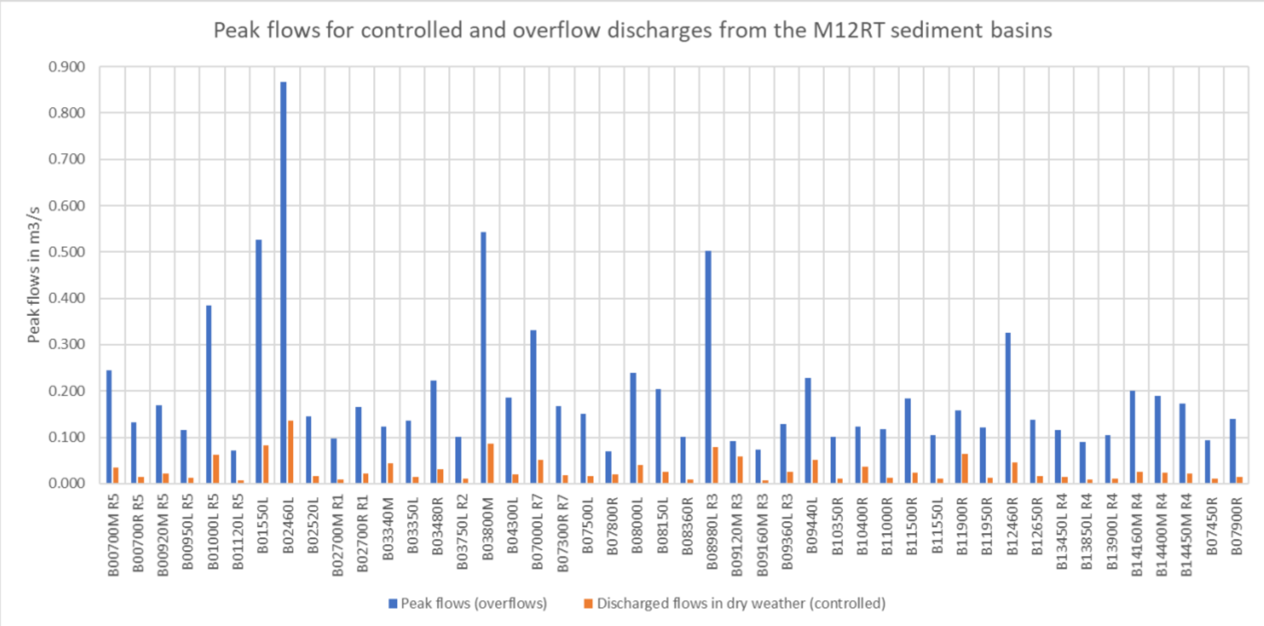


Figure D-1 Estimated discharges from the construction phase sediment basins

Table D-1 Sediment basins flow rates (controlled and overflow)

Waterway	Basin #	Basin Code	Basin outflow (L/s) – peak flows (overflow)	Basin outflow (L/s) – discharged flows in dry weather (controlled)
Glenrowan Creek	TPB06	B02460L	866	135
	TPB07	B02520L(s)	146	16
	TPB08	B02700R	166	21
	TB03	B02700M(s)	97	9
Purgatory Creek	TPB09	B03340M	123	44
	TPB10	B03750L(s)	100	11
	TPB11	B03800M	542	86
	TB05	B03350L(s)	136	15
	TB04	B03480R	223	31
	TB06	B04300L	186	20
Hunter River Drain	TPB19	B08980L	503	78
	TPB18	B09120M	92	59
	TPB20	B09160M	74	7
	TPB22	B09440L	228	52

Waterway	Basin #	Basin Code	Basin outflow (L/s) – peak flows (overflow)	Basin outflow (L/s) – discharged flows in dry weather (controlled)
Windeyers Creek	TPB27	B12650R	138	17
	TPB28	B13450L	115	15
	TPB30	B13850L(s)	89	8
	TPB29	B13900L	5	11
	TPB31	B14160M	201	25
	TPB32	B14400M	190	24
	TPB33	B14450M	172	22
Viney Creek	TPB01	B00700R(s)	133	14
	TPB02	B00700M	245	34
	TPB03	B00920M	169	21
	TPB04	B01000L(s)	384	62
	TPB05	B01120L(s)	72	7
	TB01	B00950L(s)	117	13
Hunter River	TPB12	B07150L	248	39
	TPB13	B07300R	167	18
	TPB16	B08000L	239	40
	TPB17	B08150L	204	25
	TB07	B07000L	331	52
Unnamed Coastal Wetland	TB10	B08360R	101	9
	TPB14	B07500L	150	16
	TPB16	B08000L	239	40
	TPB17	B08150L	204	25
	TPB15	B07800R	70	20

D.2 Operational phase

There are 34 water quality basins that discharge to downstream receiving waterways during the operational phase of the project. In order to run the pollution impact model, the 50% AEP peak flow rate at each outlet to the basins was determined. MUSIC modelling was also used to determine the decant concentration of TSS, TN and TP from each basin. The flow rate and decant water quality for operational water quality basins is provided in **Table D-2**.

Table D-2 Operational water quality basin flow rates and decant water quality

Waterway	Basin #	Basin Code	Basin outflow (L/s)	Decant TSS (mg/L)	Decant TN (mg/L)	Decant TP (mg/L)
Glenrowan Creek	PB07	B02460L	1609	22.2	0.393	0.05
	PB08	B02520L(s)	426	52.5	0.705	0.109
	PB09	B02700R	132	50.5	0.686	0.105

Waterway	Basin #	Basin Code	Basin outflow (L/s)	Decant TSS (mg/L)	Decant TN (mg/L)	Decant TP (mg/L)
Purgatory Creek	PB10	B03340M	762	36.7	0.771	0.093
	PB12	B03750L(s)	218	20.5	0.338	0.046
	PB13	B03800M	1082	36	0.56	0.083
	PB11	B03440M	127	32.6	0.516	0.075
	PB14	B05700L	586	46.5	0.607	0.094
Hunter River Drain	PB25	B08980L	131	29	0.304	0.058
	PB24	B09120M	902	24.1	0.24	0.046
	PB26	B09160M	323	23.6	0.295	0.047
	PB28	B09440L	703	28.4	0.314	0.054
Windeyers Creek	PB33	B12650R	261	32.4	0.529	0.072
	PB34	B13450L	332	31.9	0.707	0.082
	PB36	B13850L(s)	33	34.3	0.431	0.076
	PB35	B13900L	175	33	0.83	0.091
	PB37	B14160M	72	20.8	0.255	0.037
	PB38	B14400M	193	37.3	0.614	0.084
	PB39	B14450M	62	21.6	0.237	0.038
Viney Creek	PB01	B00560M(s)*	278	35	0.677	0.083
	PB02	B00700R(s)	124	27.6	0.433	0.054
	PB03	B00700M	62	26.9	0.438	0.061
	PB04	B00920M	39	45.5	0.662	0.098
	PB05	B01000L(s)	223	27.3	0.467	0.063
	PB06	B01120L(s)	54	66.6	0.87	0.141
Hunter River	PB15	B06100L	123	30.5	1.34	0.121
	PB17	B07150L	320	15.6	0.372	0.041
	PB19	B07300R	51	35.3	1.15	0.111
	PB16	B07005L	731	21.7	0.968	0.144
	PB18	B07300M	72	53.9	1.96	0.19
Unnamed Coastal wetland	PB20	B07500L	113	47.2	0.721	0.103
	PB22	B08000L	586	51.1	0.701	0.106
	PB23	B08150L	87	15.6	0.625	0.093
	PB21	B07800R	174	50.1	0.693	0.102

Appendix E. Water Pollution Impact Assessment

Water Quality Assessment Tool

The water quality assessment tool is an excel-based tool. It uses an equation supplied by Transport (in Section 4.1 of ‘Guideline for Impact Assessment of Sediment Detention Basin Decant Water to Waterways’ (Transport, in draft)) to calculate the water quality in a waterway. The formula is shown in **Figure E-1**.

$$T_{mixed} = \frac{V_{waterway} \cdot L_{mixing} \cdot D_{mixing} \cdot T_{waterway} + Q_{discharge} \cdot T_{discharge}}{V_{waterway} \cdot L_{mixing} \cdot D_{mixing} + Q_{discharge}}$$

Figure E-1 Simple mixing equation used in the tool

The inputs to the equation are provided in **Figure E-2** and include:

- L_{mixing} = Distance from the shore that mixing would immediately occur over
- D_{mixing} = Depth that mixing would immediately occur over
- $T_{discharge}$ = Water quality of the water being discharged
- $V_{waterway}$ = Velocity in the waterway near/at the point of discharge
- $T_{waterway}$ = Water quality of the waterway before mixing with the discharge
- $Q_{discharge}$ = Flow rate of discharge from the sedimentation basin.

Basin #	Inputs							
				Vwaterway			Qdischarge	
	Lmixing	Dmixing	Tdischarge	(upper)	(lower)	Twaterway	(peak)	(dry)
	m	m	(units vary)	m/s		(units vary)	L/s	
			mg/L			mg/L		
TPB01	1	0.5	50	1.88	1.02	27.5	133	14

Figure E-2 Inputs section of the tool

The result of the equation is the water quality in a waterway after mixing with sediment-laden discharge from a sedimentation basin:

- T_{mixed} = Water quality of the waterway after mixing with the discharge.

Three of the six inputs are outputs from other models and calculations which include:

- Waterway velocity ($V_{waterway}$) – determined from the Drains model
- Median water quality of waterway before discharge ($T_{waterway}$) – determined from water quality sampling
- Controlled and overflow basin discharge rate ($Q_{discharge}$) – determined from the MUSIC model.

The remainder are either design values (in the case of the basin discharge quality during controlled pumped discharge) or assumptions sourced from the Transport guidelines.

Up to four indicators were included in the assessment resulting in four sets of outputs depending on the type of basin (construction or operation). The indicators were:

- Total Suspended Solids (mg/L)
- Turbidity (NTU)
- Total Nitrogen (mg/L)
- Total Phosphorus (mg/L).

These were calculated by entering each of the above measures into the equation in place of the two water quality components (‘$T_{discharge}$’ and ‘$T_{waterway}$’).

In the results section of the tool, each calculated value of T_{mixed} for each water quality measure is assessed against a water quality objective and an ambient water quality specific to each waterway (**Figure E-3**).

Basin #	Results: T_{mixed} (units vary)	WQ objective met?	Ambient T_{mixed}	Result less than ambient conditions?
	NTU		NTU	
TPB01	52.05	YES	55	YES
TPB02	59.17	NO	55	NO

Figure E-3 Example of the results section of the tool where the resultant water quality (T_{mixed}) is assessed

The WQO is set by ANZG (2018) and defined in the tool by the user, while the ambient water quality is taken to be the 80th percentile of existing water quality of the waterway before discharge occurs and is also defined by the user in the tool.

Two project phases are assessed in the tool, each with a different discharge flow rate:

- Construction phase:
  - While construction is ongoing, the basins are emptied between rainfall events using pumps. This results in a controlled rate of discharge which is much lower than the discharge rate that occurs at the peak of a rainfall event
  - During this phase a peak discharge during a natural weather event can still occur and so a peak discharge water quality impact is also calculated for this phase.
- Operation phase:
  - After the project is finished the water quality basins would fill and spill due to natural weather events. These natural weather events result in a peak discharge rate. There is no controlled discharge in this phase and so no dry weather discharge input or output.

A 50% AEP storm was selected as an indicative storm for the overflow discharge, while the controlled discharge uses pump rate data/modelling results based on 8 hours of pumping within 5 days of the rain event (refer **Section D.1** for more information).

The model has a toggle which allows selection of flow rate and velocity. The two flow scenarios, controlled and peak (overflow) discharges, and the velocity can be toggled in the tool using the toggle above the results section as shown in **Figure E-4**.

As a range of waterway velocities are possible, the model has been set up with the maximum and minimum velocities. These can be changed by the user of the tool in the inputs section. The minimum velocity is the worst-case in terms of water quality impact, and the maximum the best-case.

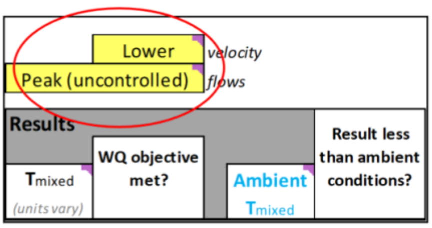


Figure E-4 The flow and velocity toggles found above the results section in the tool

The model also calculates a worst-case scenario. This is what the water quality impacts would be if all basins were to discharge into a waterway at the same point. The model does this by calculating the pollutant load (in kg/day) of either Total Suspended Solids, Total Nitrogen, or Total Phosphorus for each basin. These pollutant loads are summed and compared to the sum of all discharge rates to derive a '$T_{discharge}$' output.

Where the conditions are right, the equation can be used to calculate the minimum required length of mixing zone (given an assumed mixing depth) required to meet either the water quality target or match the existing ambient water quality (**Figure E-5**).

Required			
Target Tmixed (units vary)	Dmixing m	Lmixing *(for TARGET Tmixed)* m	Lmixing *(for AMBIENT Tmixed)* m
NTU			
50	0.5	**1.2**	**0.32**
50	0.5	**2.3**	**0.58**

Figure E-5 Tool showing the length of the mixing zone required to either meet the required water quality, or match the existing ambient water quality

Where the conditions are not right for the equation to be used in this way, the tool informs the user why (**Figure E-6**). In the case of the water quality target this is either because:

- The quality of the water in the sedimentation basin is already better than the quality of the waterway into which it is being discharged ("decant water quality less than target"), or
- The quality of the waterway prior to discharging is already worse than the target water quality, in which case, regardless of discharge quality, the water quality target cannot be met ("upstream water quality fails target").

Required		
Target Tmixed (units vary)	Dmixing m	Lmixing *(for TARGET Tmixed)* m
0.8	0.5	*Decant quality less than target*
0.8	0.5	*Decant quality less than target*

Required		
Target Tmixed (units vary)	Dmixing m	Lmixing *(for TARGET Tmixed)* m
0.35	0.5	*Upstream quality fails target*
0.35	0.5	*Upstream quality fails target*

Figure E-6 Where the length of the mixing zone required to meet the water quality target cannot be calculated, the tool alerts the user to one of two messages

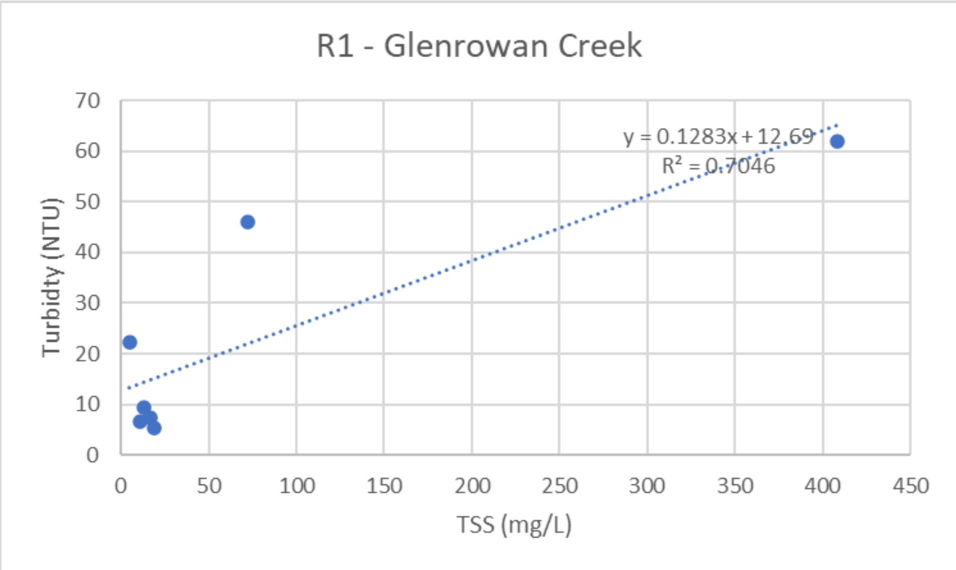
Where it is not possible to match the ambient water quality the user is alerted by the tool as to why that is. This is either because:

- The quality of the water in the sedimentation basin is already better than (i.e. the water quality measure is less than) the ambient quality of the waterway into which it is being discharged, or
- The quality of the waterway prior to discharging, according to the input used for $T_{waterway}$, is already worse than the ambient water quality.

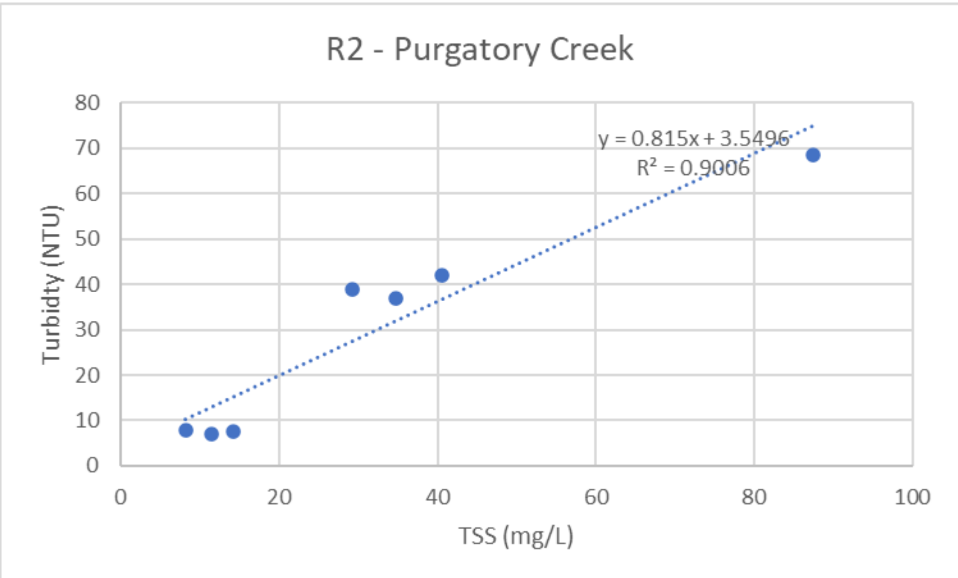
Appendix F. Turbidity/TSS correlation plots

As stated in the *M1 Pacific Motorway extension to Raymond Terrace Environmental Impact Statement* (Transport for NSW 2021), the DECCW (2006) WQOs and the ANZG (2018) guidelines for protection of aquatic ecosystems only provide a guideline limit for turbidity, not TSS, and MUSIC modelling is only reported for TSS. Therefore a linear regression model between turbidity and TSS based on the use of a statistical technique known as linear regression analysis was produced as part of the EIS (Kusari et al, 2013). As shown in the charts below the data was plotted from which a linear regression equation was derived for the conversion of all TSS data to turbidity. Since the EIS, updated linear regressions were undertaken to incorporate additional water quality monitoring data to provide updated correlation equations which was used to convert modelled TSS discharge concentrations to turbidity. It should be noted that where a poor correlation was observed no correlation was undertaken and under some circumstances extreme outliers were removed from the dataset.

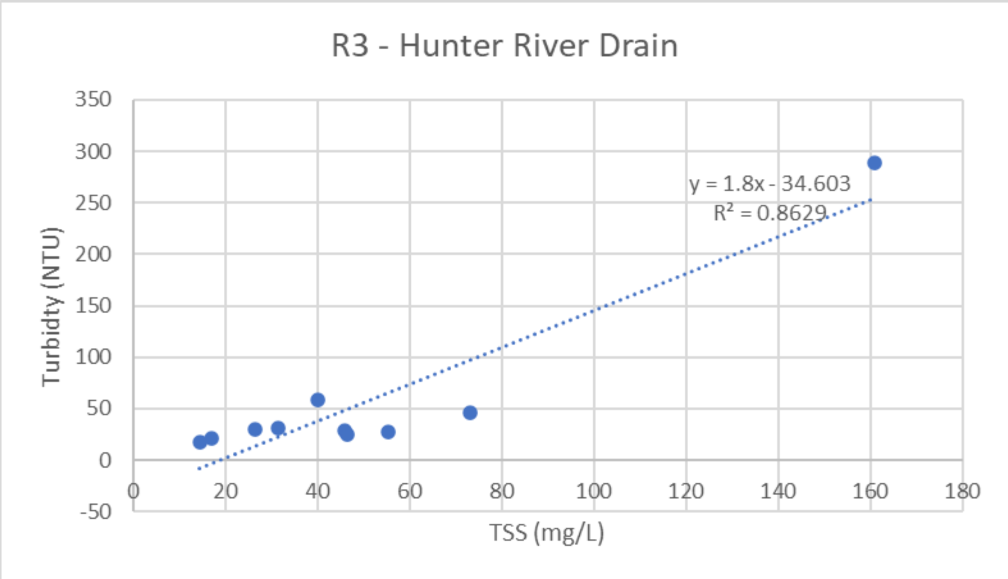
Glenrowan Creek



Purgatory Creek

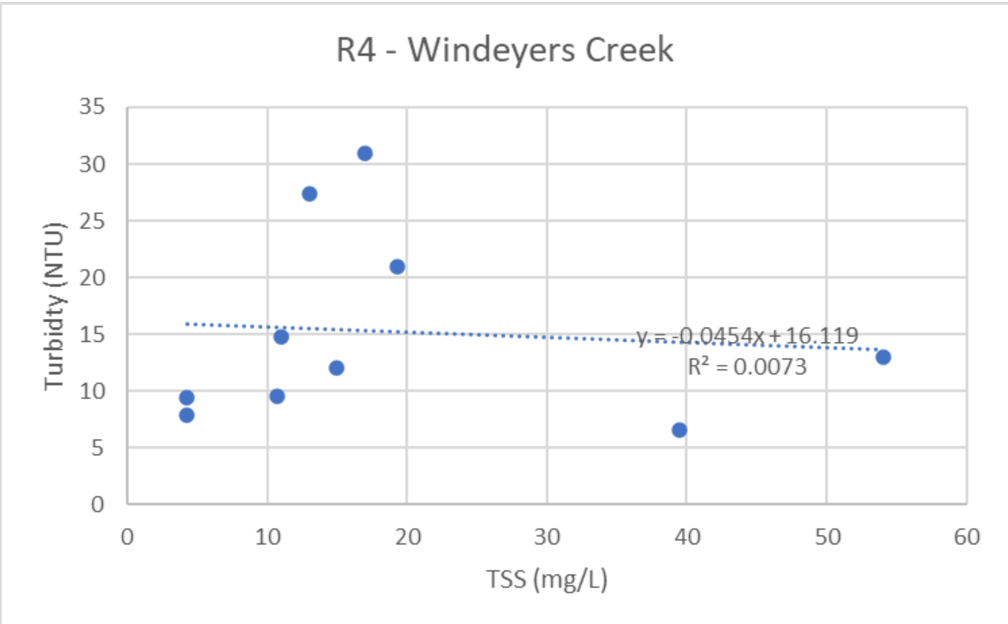


Hunter River Drains

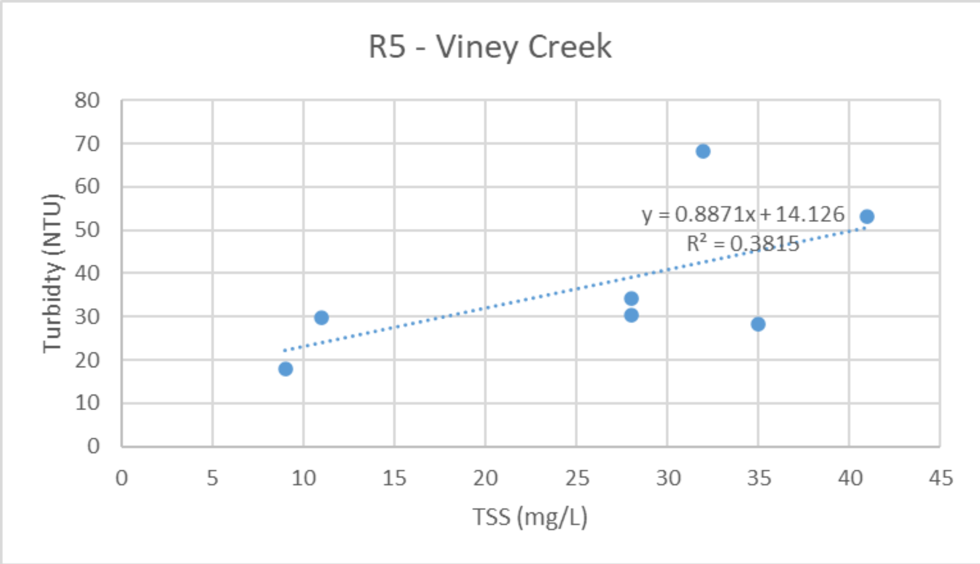


Windeyers Creek

TSS/Turbidity correlation very low confidence and not used

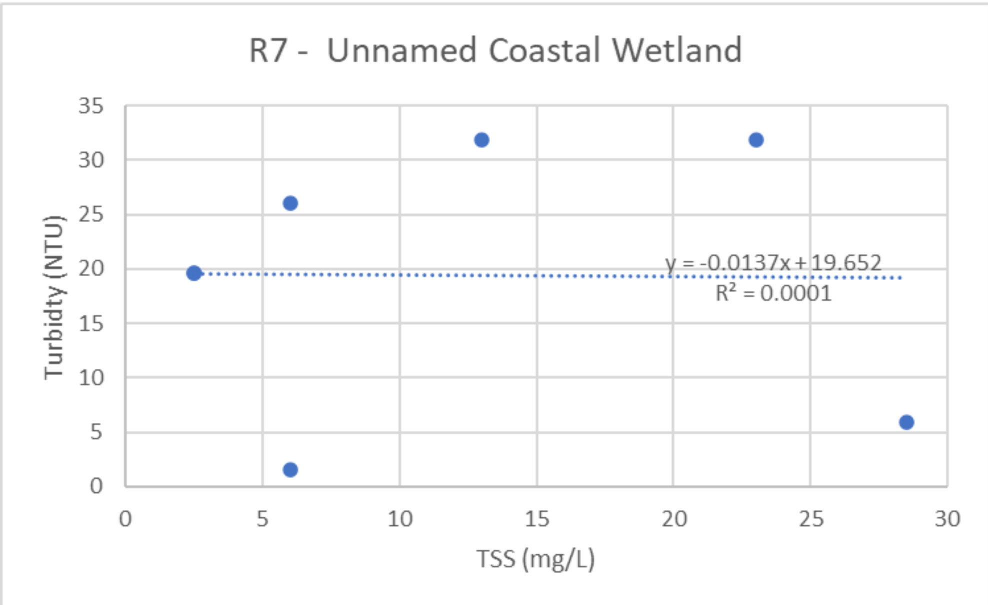


Viney Creek

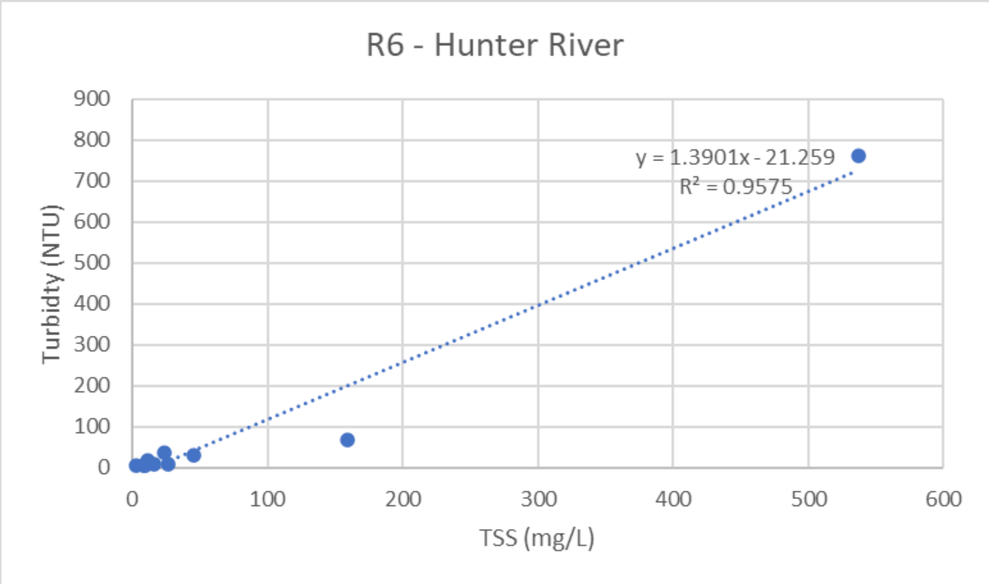


Unnamed Coastal Wetland

TSS/Turbidity correlation very low confidence and not used.



Hunter River



Appendix G. Revised sediment basin locations

Revised construction footprint

Revised project

Bridges/ viaduct

Sediment basin

Temporary to permanent basin

Temporary basin

Waterways

Creek diversion

0 150 300 m

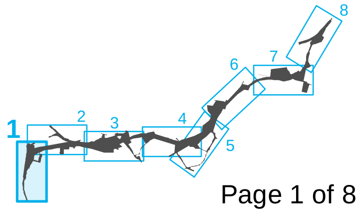


Figure G-1 Revised temporary construction sediment basins (map 1 of 8)

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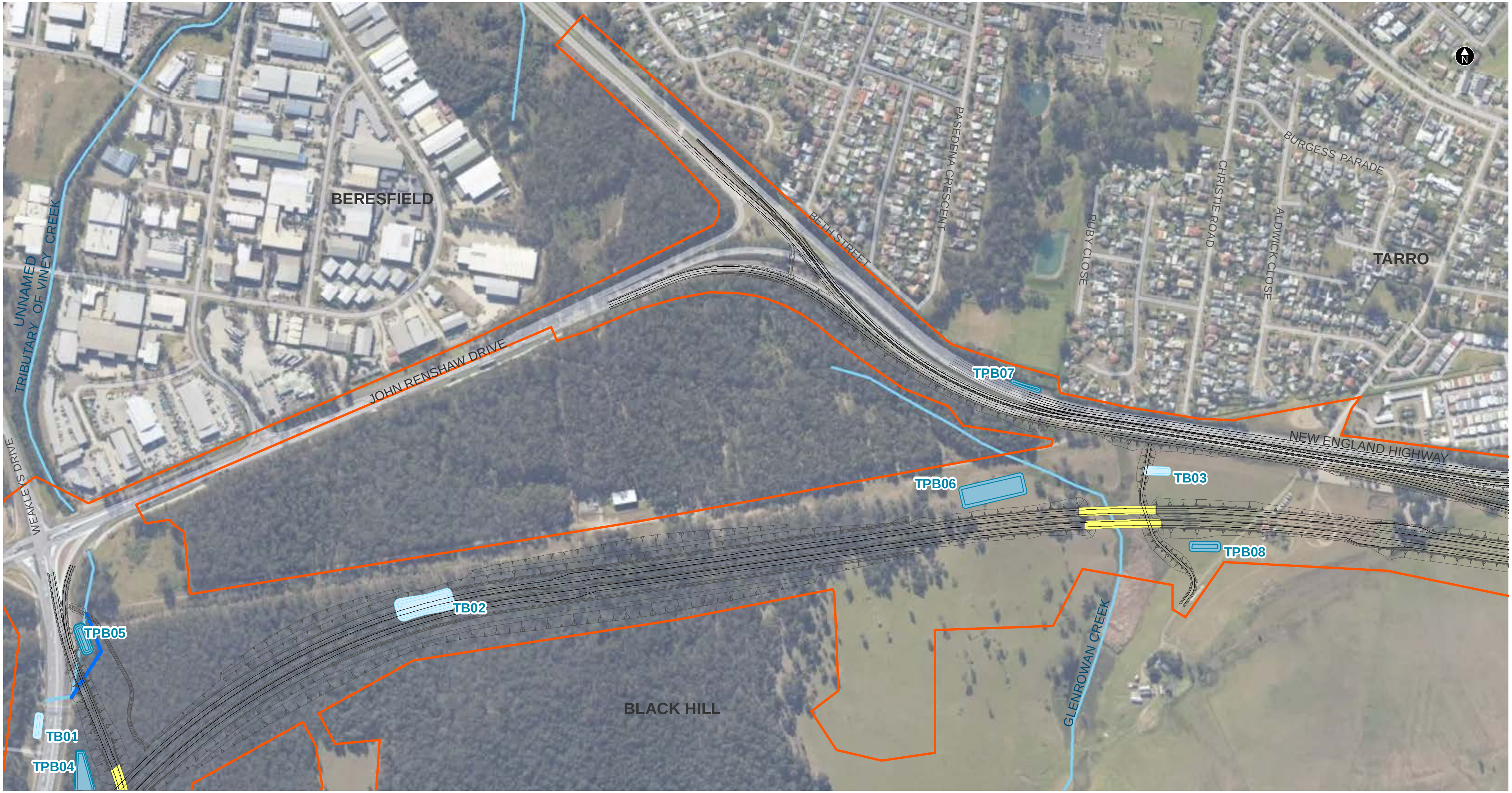

Revised construction footprint

Revised project

Bridges/ viaduct

Sediment basin

Temporary to permanent basin

Temporary basin

Waterways

Creek diversion

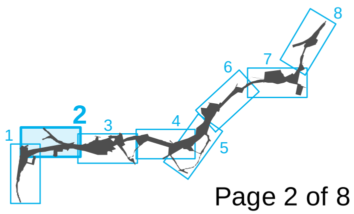

Figure G-1 Revised temporary construction sediment basins (map 2 of 8)

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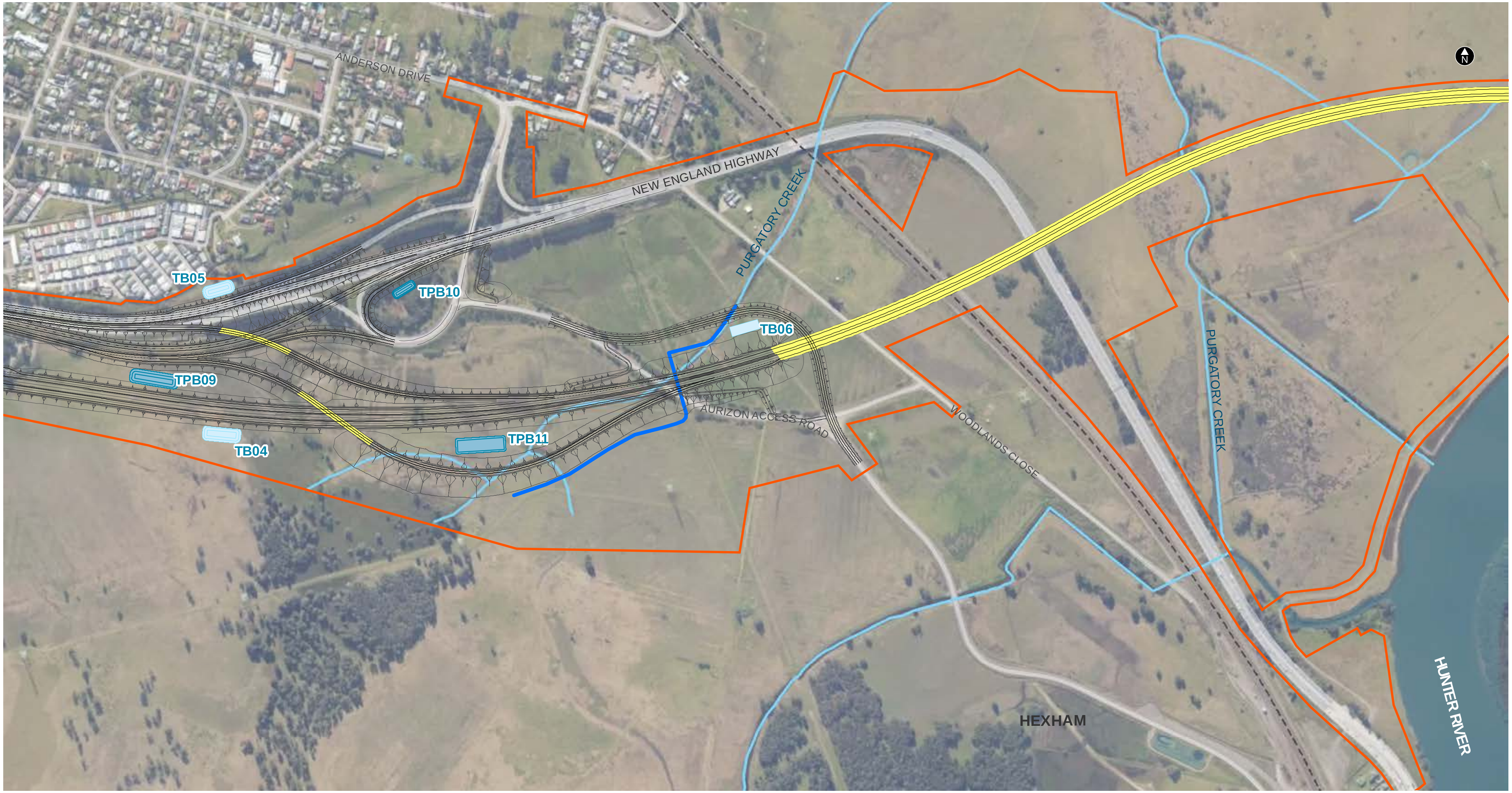

Revised construction footprint
Revised project
Bridges/ viaduct

Sediment basin

Temporary to permanent basin
Temporary basin
Waterways
Creek diversion

0 150 300 m

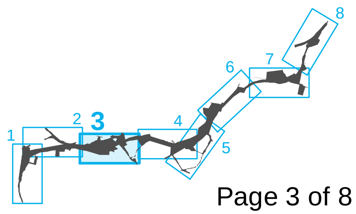

Figure G-1 Revised temporary construction sediment basins (map 3 of 8)

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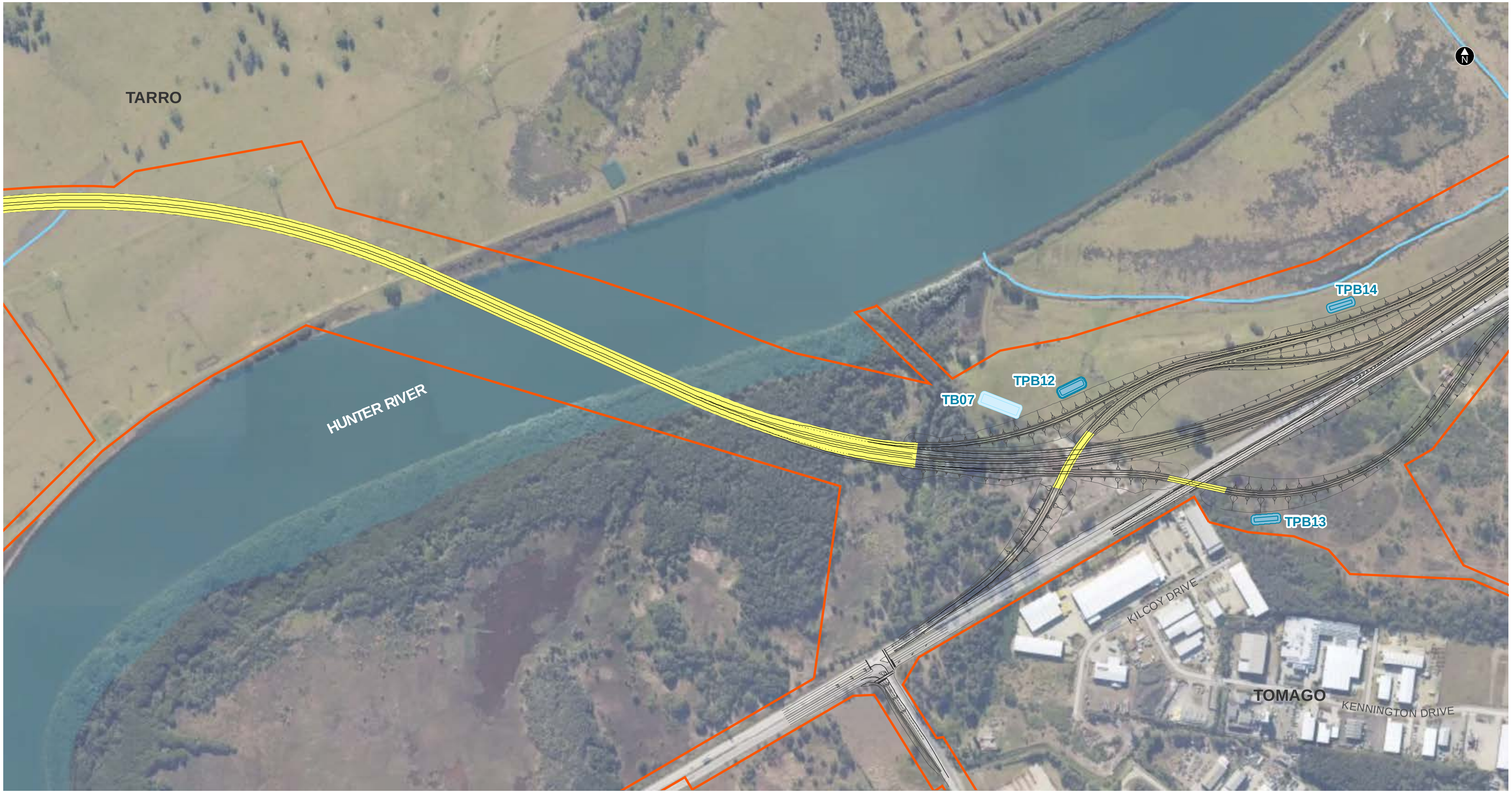

Revised construction footprint

Revised project

Bridges/ viaduct

Sediment basin

Temporary to permanent basin

Temporary basin

Waterways

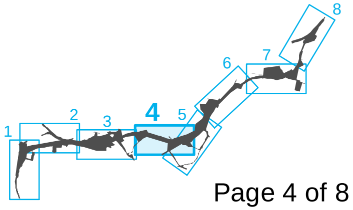

Figure G-1 Revised temporary construction sediment basins (map 4 of 8)

Page 4 of 8

Date: 17/03/2022 Path: \\Jacobs.com\ANZ\IE\Projects\04_Eastern\IA230000\22_Spatial\GIS\Directory\Templates\Figures\Water_Quality\Water_Quality_20200325\IA230000_CD_F008_ConstructionDrainageBasins_JAC_r1v2.mxd

Revised construction footprint

Revised project

Bridges/ viaduct

Sediment basin

Temporary to permanent basin

Temporary basin

Tomago Sandbeds Catchment Area

Waterways

0 150 300 m

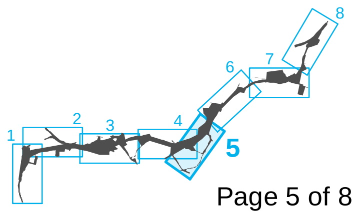

Figure G-1 Revised temporary construction sediment basins (map 5 of 8)

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Revised construction footprint
Revised project
Bridges/ viaduct

Sediment basin
Temporary to permanent basin

Tomago Sandbeds Catchment Area
Waterways

0 150 300 m

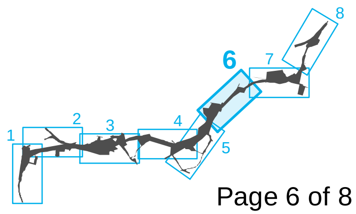

Figure G-1 Revised temporary construction sediment basins (map 6 of 8)

Date: 17/03/2022 Path: \\Jacobs.com\ANZ\IE\Projects\04_Eastern\IA230000\22_Spatial\GIS\Directory\Templates\Figures\Water_Quality\Water_Quality_20200325\IA230000_CD_F008_ConstructionDrainageBasins_JAC_r1v2.mxd

Revised construction footprint
Revised project
Bridges/ viaduct

Sediment basin
Temporary to permanent basin
Temporary basin

Tomago Sandbeds Catchment Area
Waterways

0 150 300 m

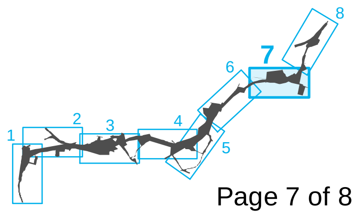

Figure G-1 Revised temporary construction sediment basins (map 7 of 8)

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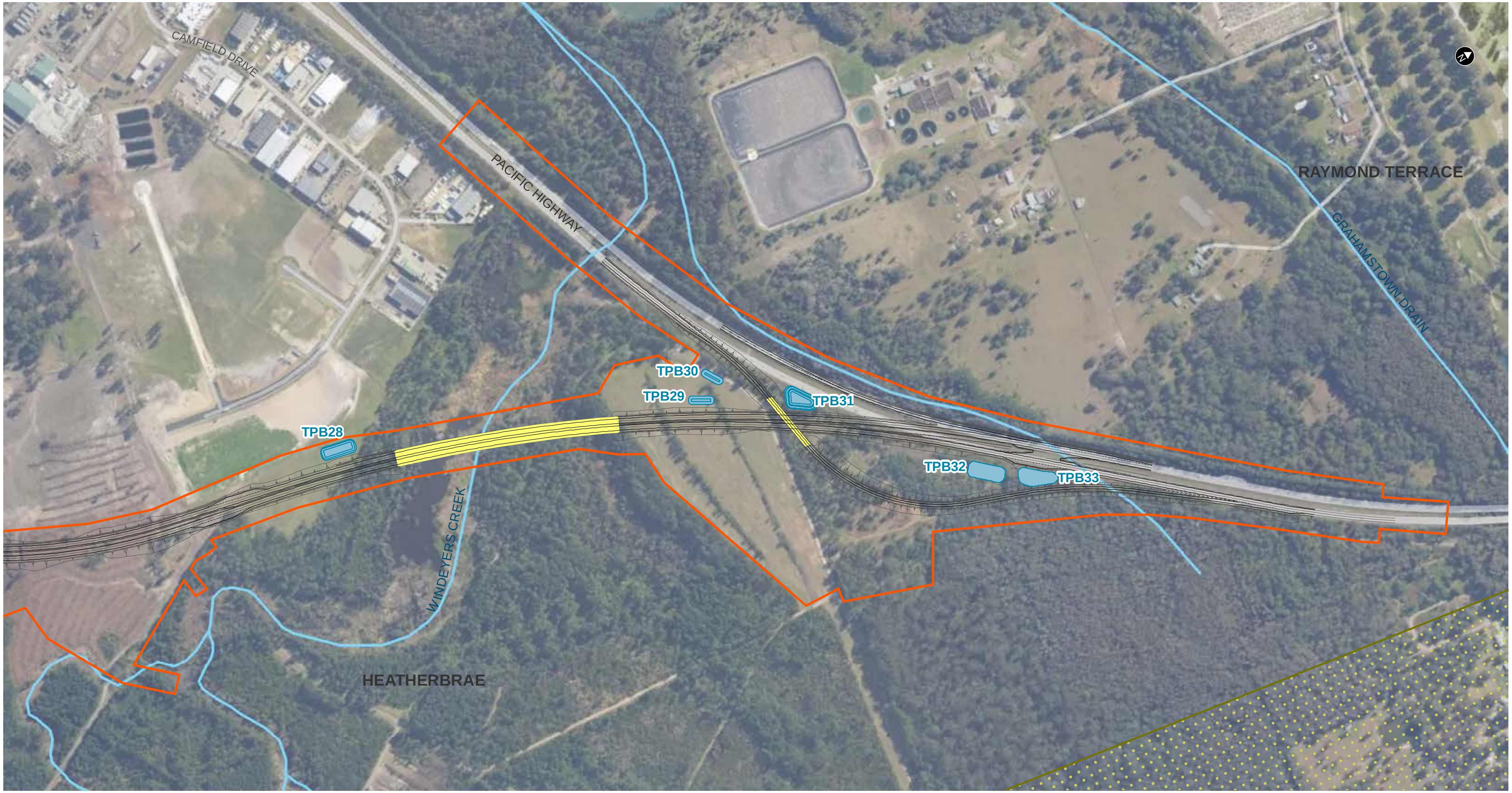

Revised construction footprint

Revised project

Bridges/ viaduct

Sediment basin

Temporary to permanent basin

Tomago Sandbeds Catchment Area

Waterways

0 150 300 m

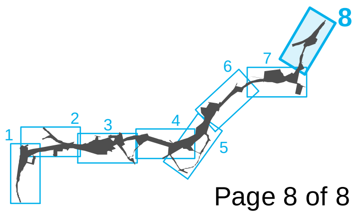

Figure G-1 Revised temporary construction sediment basins (map 8 of 8)

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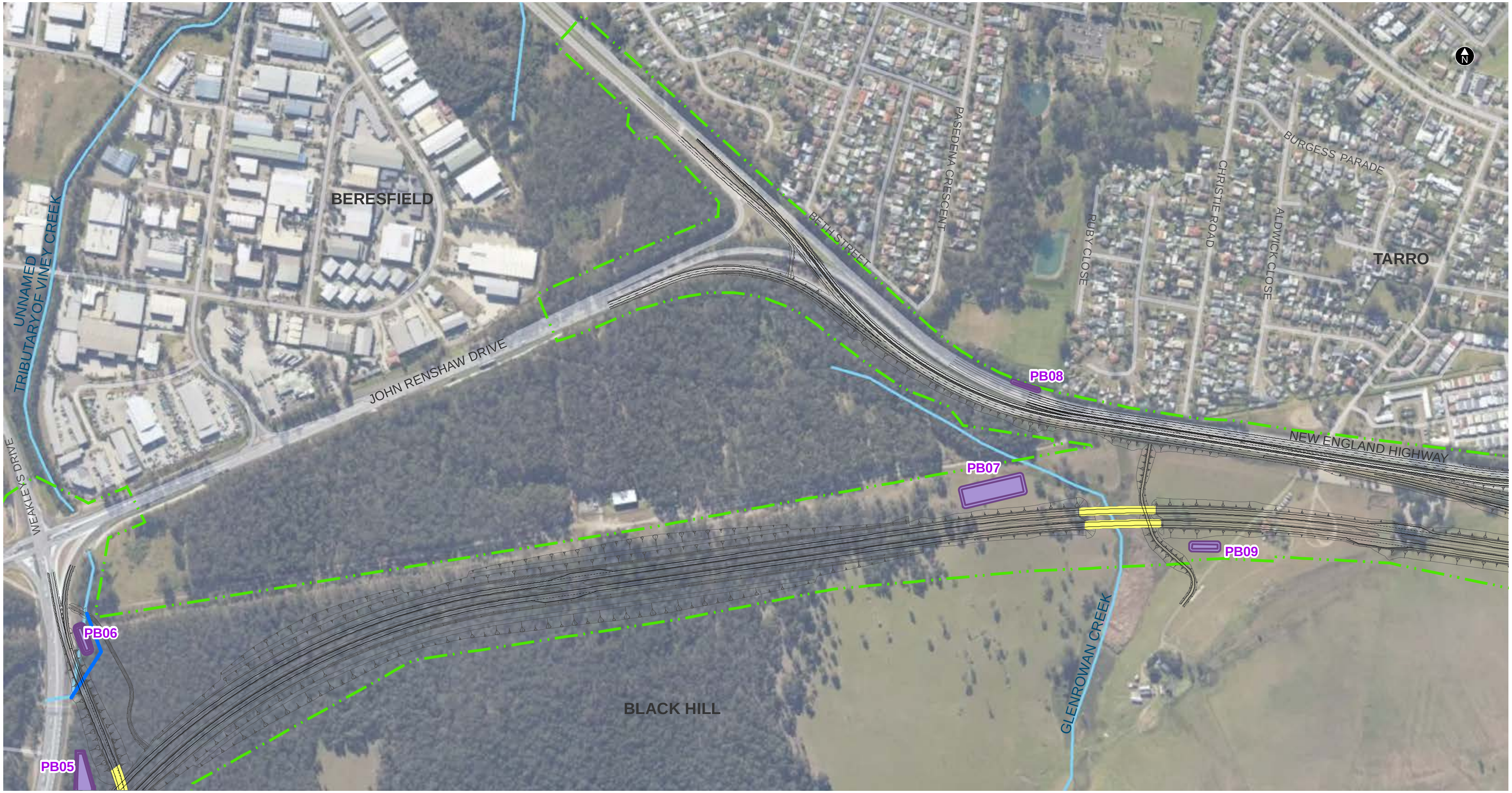
Appendix H. Revised permanent water quality basin locations

Figure H-1 Revised permanent operational water quality basins (map 1 of 8)

Date: 17/03/2022 Path: \\Jacobs.com\ANZ\IE\Projects\04_Eastern\IA230000\22_Spatial\GIS\Directory\Templates\Figures\Water_Quality\Water_Quality_20200325\IA230000_CD_F009_OperationalDrainageBasins_JAC_r1v3.mxd



Revised operational footprint

Revised project

Bridges/ viaduct

Water quality basins

Proposed location of operational water quality basins

Waterways

Creek diversion

0 150 300 m

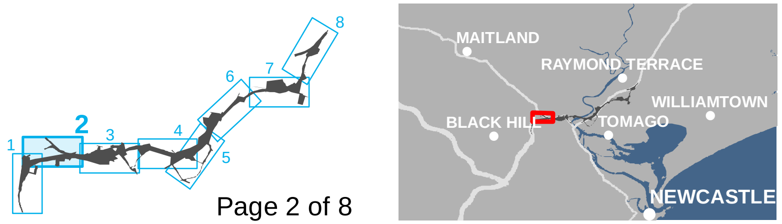


Figure H-1 Revised permanent operational water quality basins (map 2 of 8)

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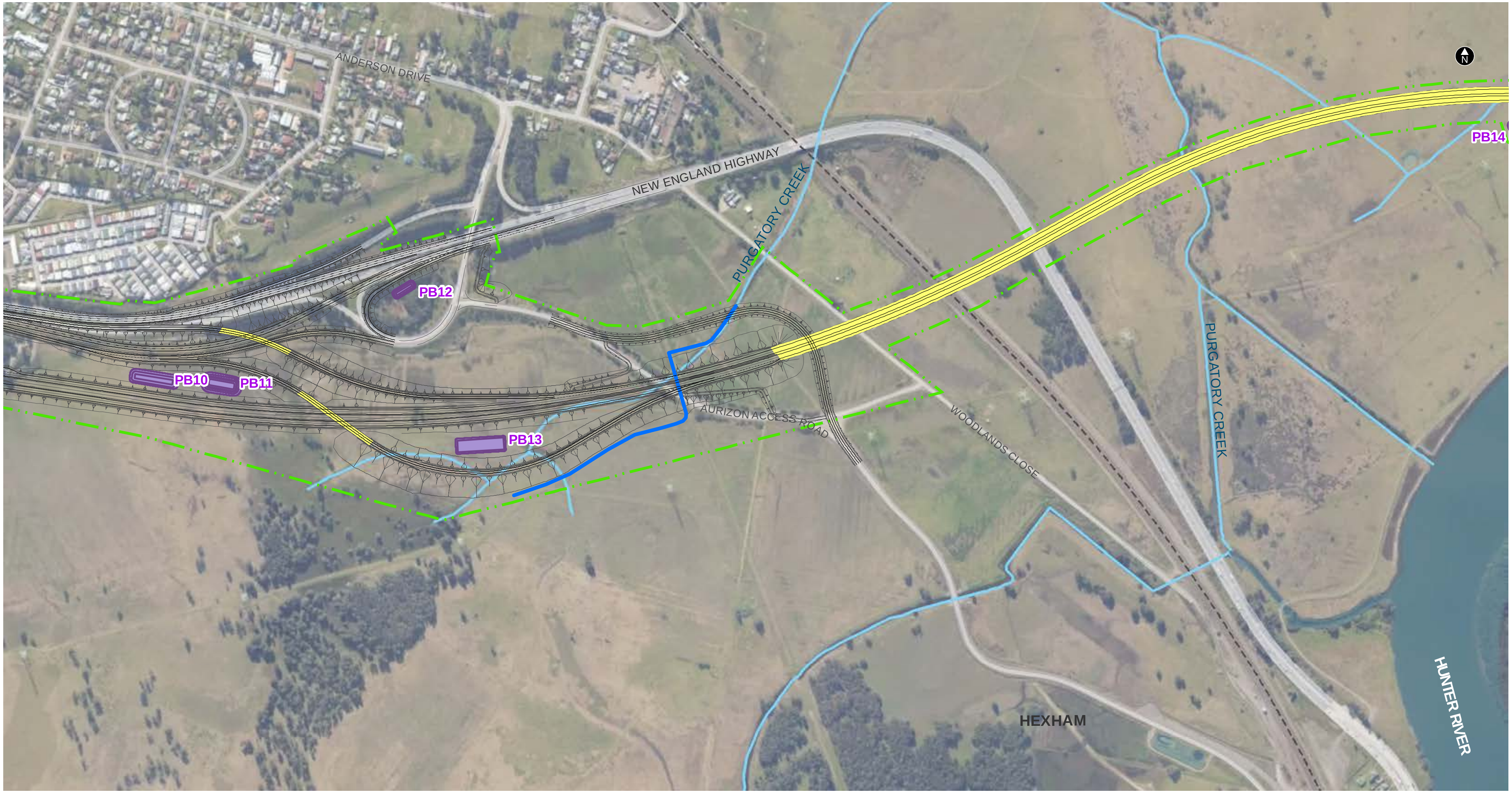

Revised operational footprint
Revised project
Bridges/ viaduct

Water quality basins

Proposed location of operational water quality basins
Waterways
Creek diversion

0 150 300 m

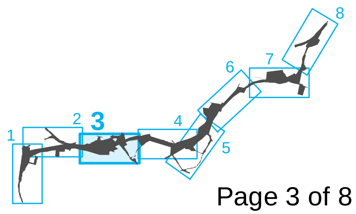

Figure H-1 Revised permanent operational water quality basins (map 3 of 8)

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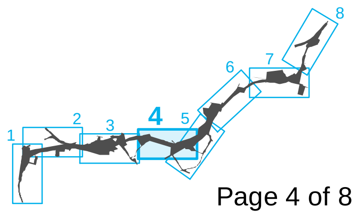
Revised operational footprint
Revised project
Bridges/ viaduct

Water quality basins

Proposed location of operational water quality basins
Operational biofiltration
Waterways

0 150 300 m



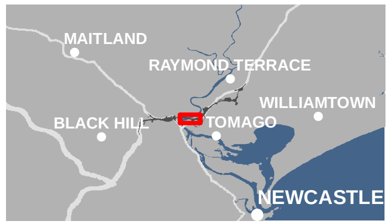


Figure H-1 Revised permanent operational water quality basins (map 4 of 8)

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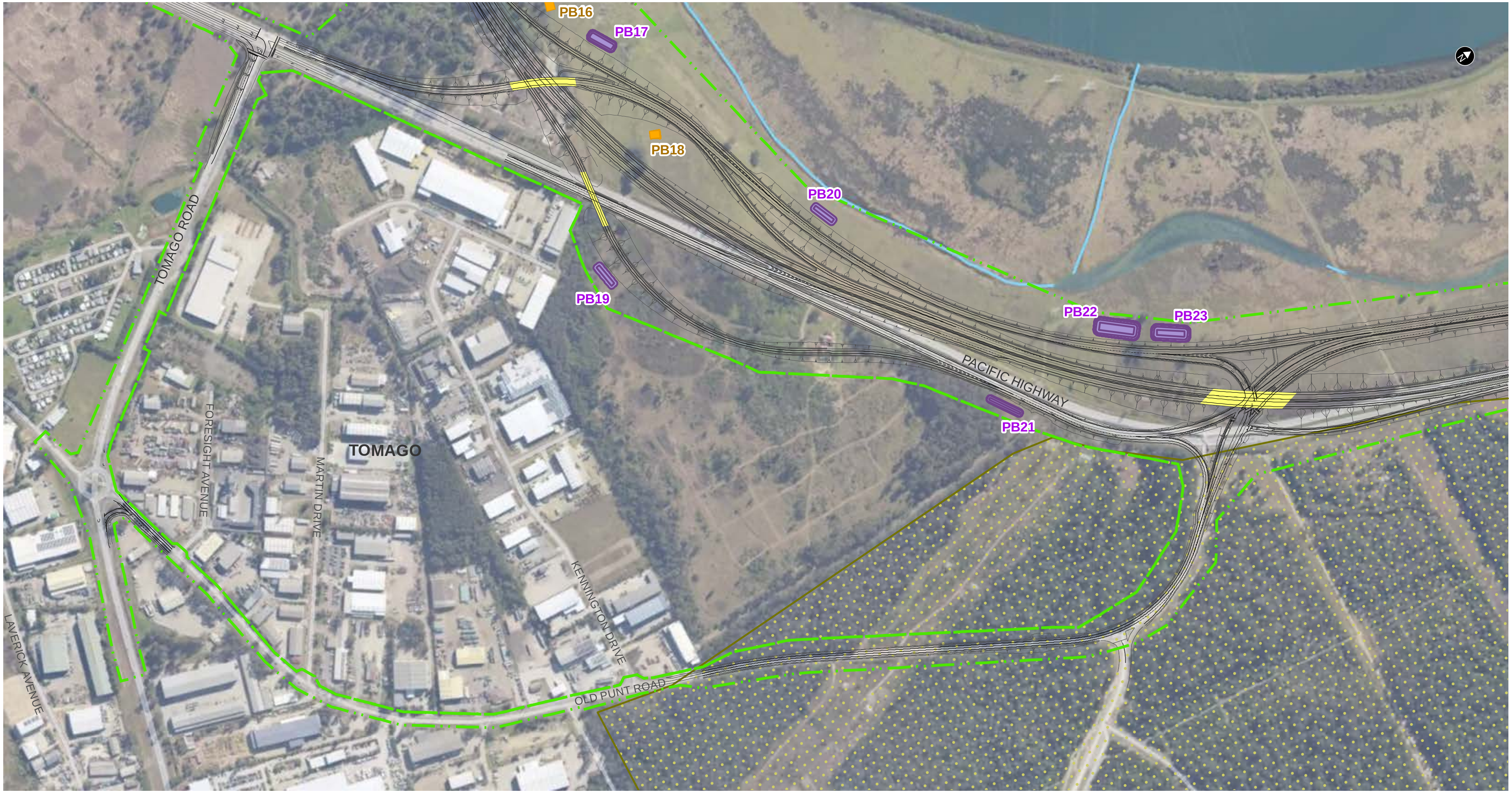

Revised operational footprint

Revised project

Bridges/ viaduct

Water quality basins

Proposed location of operational water quality basins

Operational biofiltration

Tomago Sandbeds Catchment Area

Waterways

0 150 300 m

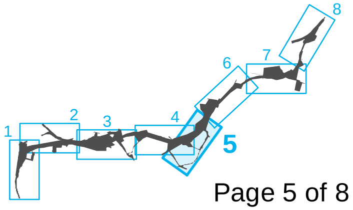

Figure H-1 Revised permanent operational water quality basins (map 5 of 8)

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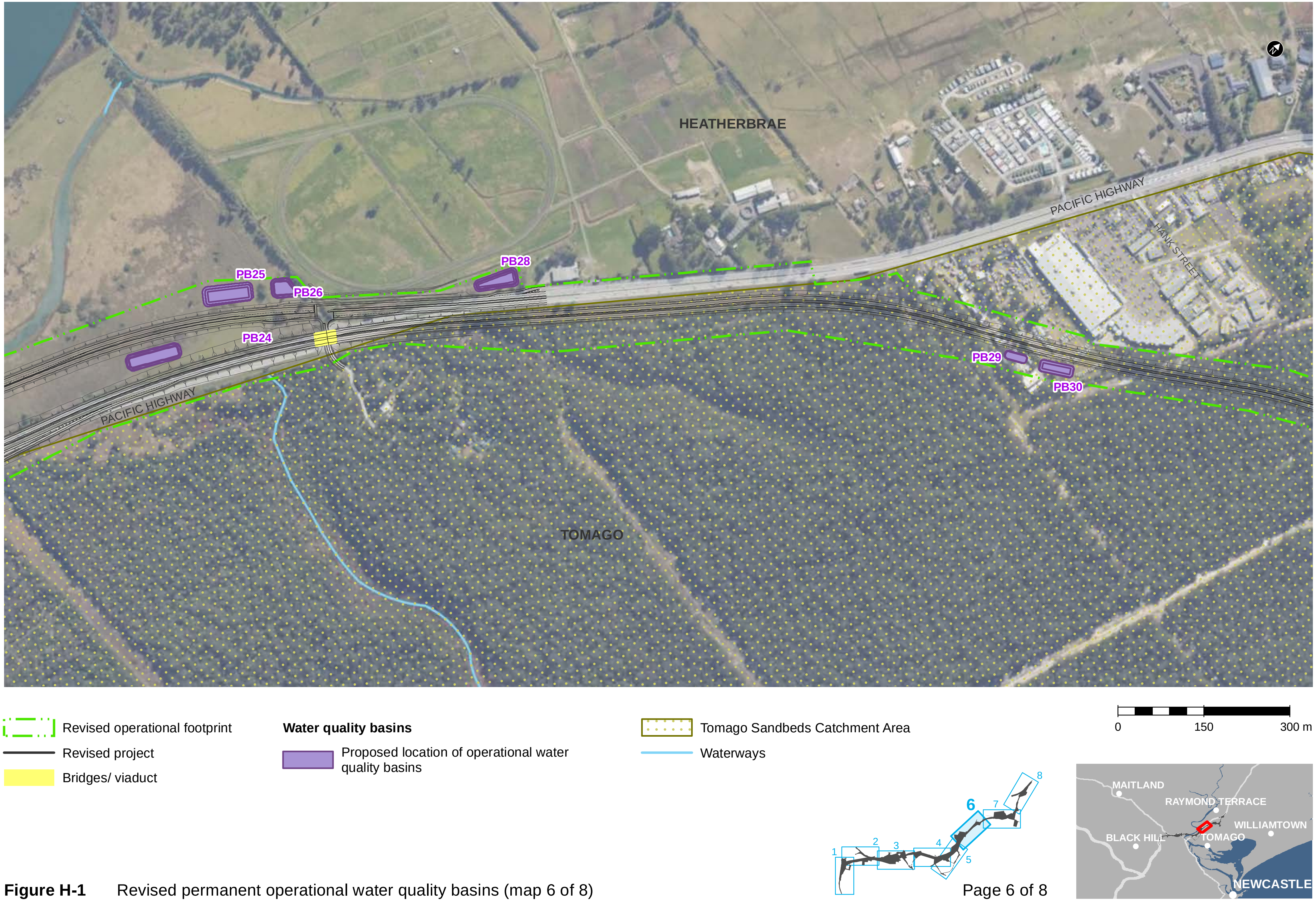

Figure H-1 Revised permanent operational water quality basins (map 6 of 8)

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Revised operational footprint
Revised project
Bridges/ viaduct

Water quality basins

Proposed location of operational water quality basins

Tomago Sandbeds Catchment Area
Waterways

0 150 300 m

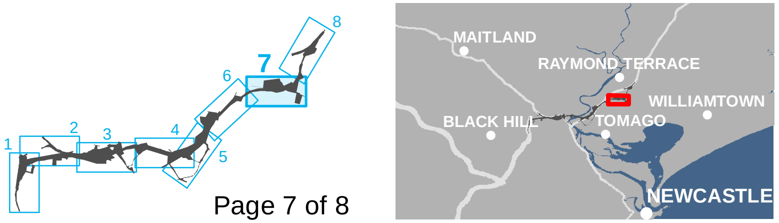

Figure H-1 Revised permanent operational water quality basins (map 7 of 8)

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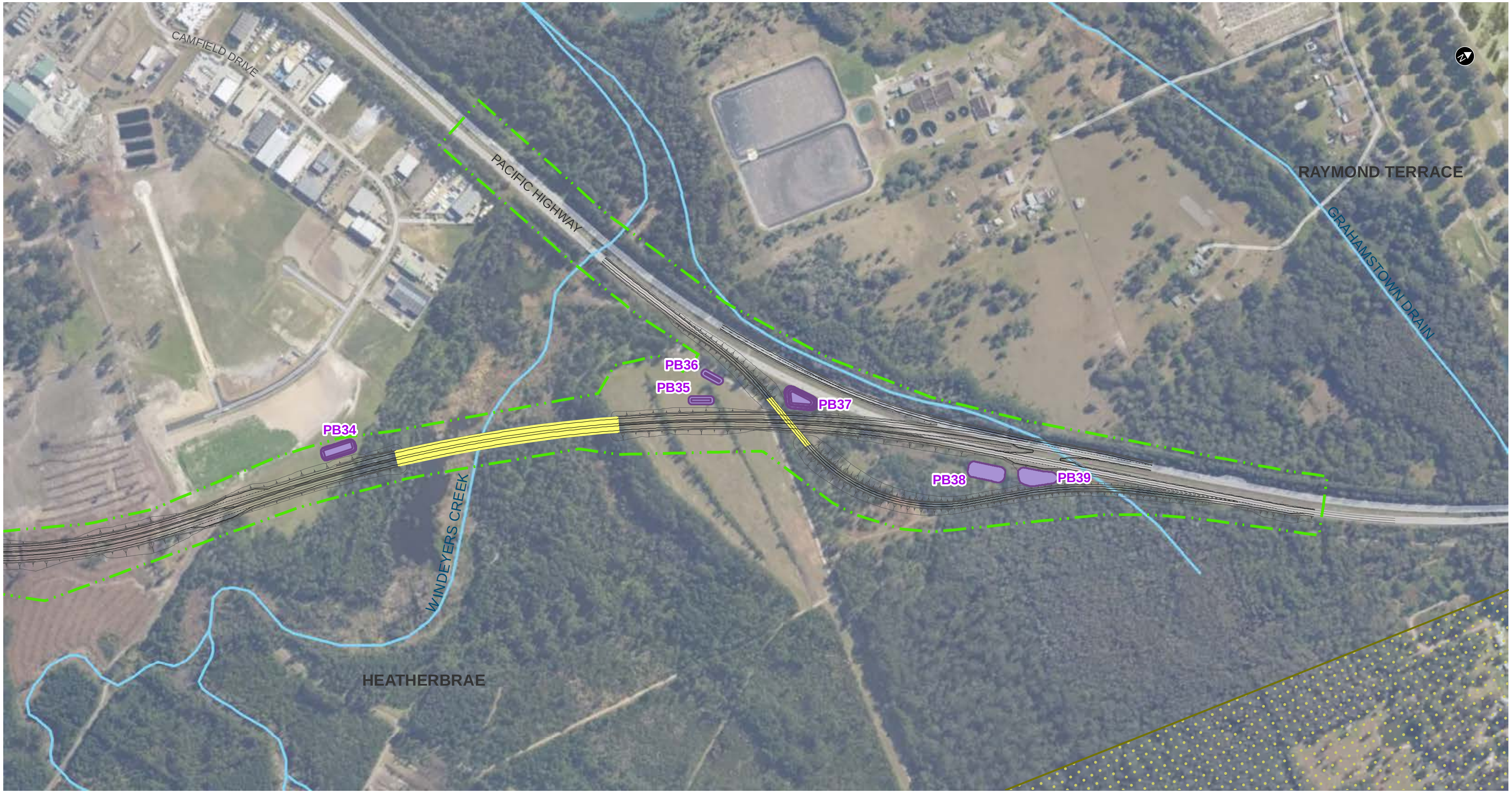


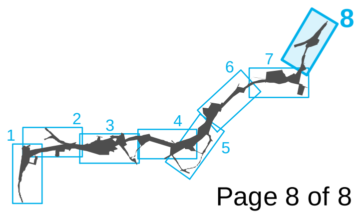
Revised operational footprint
Revised project
Bridges/ viaduct

Water quality basins

Proposed location of operational water quality basins

Tomago Sandbeds Catchment Area
Waterways

0 150 300 m



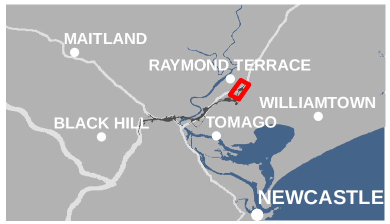


Figure H-1 Revised permanent operational water quality basins (map 8 of 8)

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Appendix I. Water Quality Monitoring Program

I.1 Groundwater quality monitoring program

The groundwater quality monitoring program will be carried out during the pre-construction, construction and operational stage of the project to gain an appreciation of background water quality, to observe any changes in groundwater quality that may be attributable to the project and to inform appropriate management responses.

The location, frequency and indicators of the groundwater quality monitoring program are presented in **Table I-1**, however, where required, TARP monitoring sites will be included.

Table I-1 Location, frequency and indicators for groundwater quality monitoring

	Additional baseline data	Construction phase	Operational phase
Location	As per **Figure I-1**		
Frequency	Two monthly for at least 12 months prior to construction	Quarterly for the duration of construction	Quarterly for a period of 12 months during operation of the project (i.e. 12 months post construction)
Indicators	• Field parameters (electrical conductivity, pH, turbidity, dissolved oxygen and temperature) • Total dissolved solids • Major ions (sodium, magnesium, calcium, chloride, bicarbonate/carbonate and sulfate) • Nutrients (ammonia, nitrate, TN, TP)[2] • Dissolved metals (aluminium, arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, iron and manganese) [2]		

1. Some sites may need to be rationalised or additional sites added (e.g. TARP sites) during detailed design. As a result, the locations shown in **Figure I-1** are indicative only and subject to change.
2. Monitoring for this indicator to be carried out quarterly (every three months)

I.2 Surface water quality monitoring program

The proposed surface water quality monitoring program will aim to continue monitoring sites previously monitored as shown on **Figure I-1**. Where required, TARP monitoring sites will be included. The location, frequency and indicators of the surface water quality monitoring program is presented in **Table I-2**.

Table I-2 Location, frequency and indicators for surface water quality monitoring

	Additional baseline data[1]	Construction phase	Operational phase
Location	As per **Figure I-1**[2]		
Frequency	Quarterly (wet and dry[3]) for a minimum of six months prior to construction	Quarterly (wet and dry) for the duration of construction Visual turbidity monitoring immediately outside the silt curtain during dredging operations	Quarterly (wet and dry) for a period of 12 months during operation of the project (i.e. 12 months post construction)

	Additional baseline data[1]	Construction phase	Operational phase
Indicators	• Field parameters (electrical conductivity, pH, turbidity, dissolved oxygen and temperature) • Visible oil and grease[4] • total dissolved solids and total suspended solids • Total nitrogen • Total phosphorus • Dissolved metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, iron and manganese)		

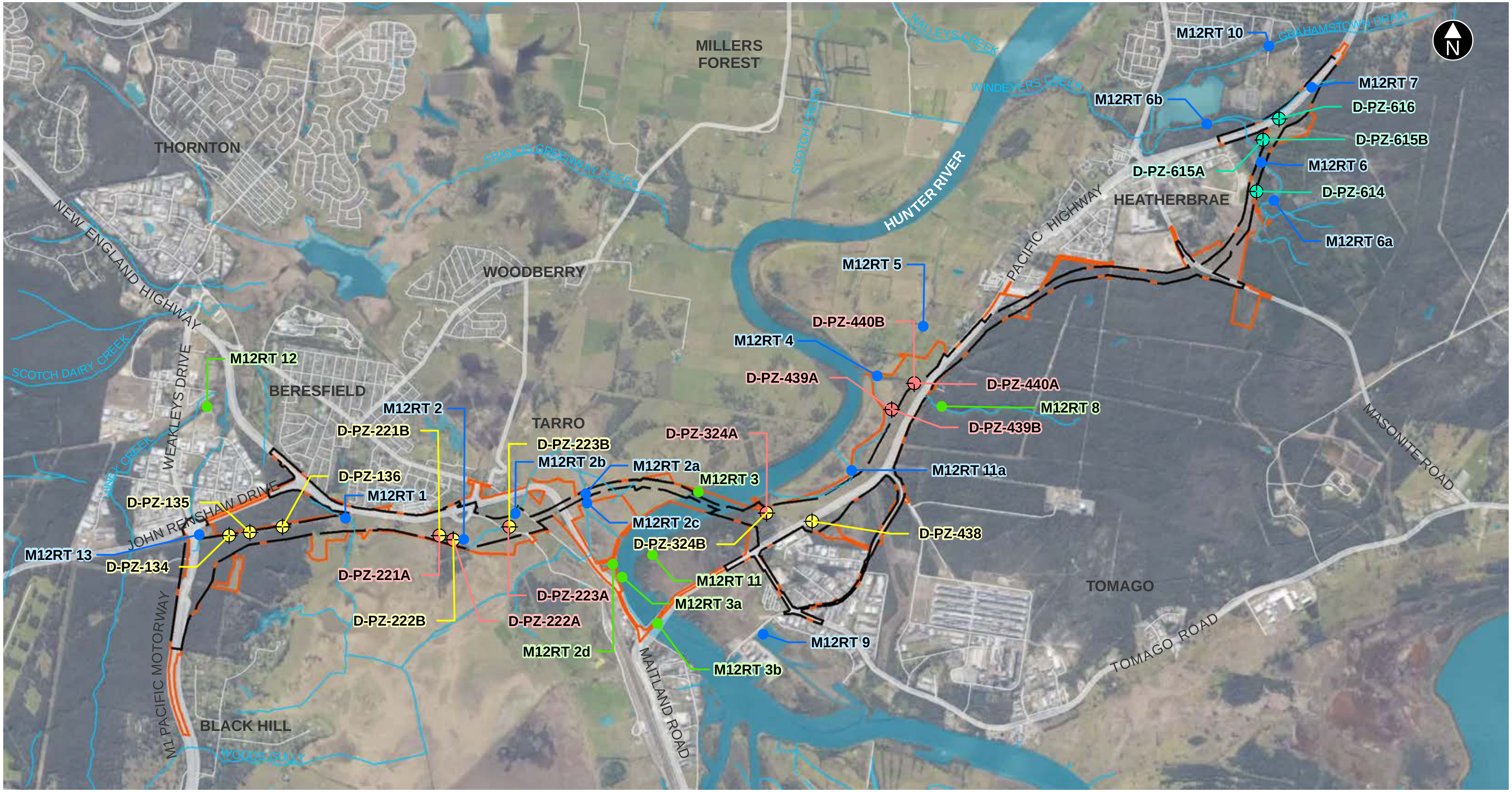
1. In addition to the existing baseline dataset
2. As described above, the necessity for some of the monitoring sites may be rationalised during detailed design. As a result, the locations shown in **Figure I-1** are indicative only and subject to change
3. As wet weather event is classified as 20 millimetres or more of rain within 24 hours, as recorded at the Newcastle University BOM rainfall gauge (#061390). Sampling would occur within 24 hours of the rain event. If rainfall events are regularly less than 20mm, opportunistic wet weather monitoring would be carried out to ensure that some wet weather data is collected.
4. If oil and crease visibly, sample to be assess for total petroleum hydrocarbons

I.3 TARP Monitoring

A TARP for water quality impacts related to the project would be developed and detailed within the project Water Quality Monitoring Program. Water quality triggers will take into consideration:

- The ANZG (2018) water quality guideline trigger values for 95% species protection (as per **Table 2-3**)
- the baseline water quality monitoring data for sites that are determined to not be meeting the relevant DGVs for achieving the WQOs based on baseline water quality data.

If an indicator is determined to exceed the nominated trigger value (or outside background water quality) for three consecutive monitoring events, an investigation will be carried out to identity the cause and subsequently an appropriate management response will be implemented to rectify the issue. Water quality monitoring sites and TARP sites will be appropriately located to allow for determining the possible cause of poor water quality should results fall outside acceptable range.



Revised construction footprint

Revised operational footprint

Groundwater monitoring locations

- Hunter Alluvium and Tomago Coal Measures paired bore location
- Hunter Alluvium
- Tomago Coal Measures
- Tomago Sandbeds

Surface water monitoring locations

- Monitoring site - Sensitive Receiving Environment
- Monitoring site - Non Sensitive Receiving Environment

Waterways

0 1 2 km

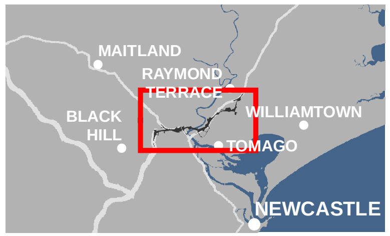


Figure I-1 Surface water and groundwater monitoring locations

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