Technical Memorandum
Interim Baseline State for Dissolved Oxygen and Ecosystem Metabolism in Taranaki Rivers

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Purpose

The purpose of this memorandum is to provide an interim assessment of the baseline state of two dissolved oxygen attributes and the ecosystem metabolism attribute as a measure of ecosystem health, as required by the National Policy Statement for Freshwater Management 2020 (NPS-FM). Where this has not been possible, actions required to complete the baseline identification process have been recommended. This memorandum will be updated when further information becomes available.

Overview of dissolved oxygen and ecosystem metabolism

Dissolved oxygen

Dissolved oxygen is important for fish and other aquatic life to breathe. Oxygen is able to enter water by diffusion from the atmosphere, through aeration of the water as flow becomes turbulent passing over rocks, riffles, and waterfalls, and as a product of photosynthesis. The level of dissolved oxygen in a waterbody, measured in mg/L (milligrams per litre), provides an indication of the health of aquatic ecosystems and the quality of the life-supporting capacity of natural waters.

Excessive plant and algae growth and decomposition in response to increasing nutrients in waterways can significantly affect the amount of dissolved oxygen available (Goodwin & Young, 2022). The oxygen content of water will decrease as nutrients and organic materials increase, impacting on aquatic life. Sources of nutrients and organic material include industrial wastewater, sewage discharges, and runoff from land. Fish will tend to avoid waterbodies with decreased dissolved oxygen, with death usually occurring when levels reach 2 mg/L or less (Franklin, 2014).

Ecosystem Metabolism

Ecosystem metabolism refers to the metabolic processes that transform oxygen, carbon and energy and broadly measures the way carbon is cycled through an ecosystem. It is perhaps best described by Casanovas et al. (2022):

"There are two components of EM: gross primary productivity (GPP) and ecosystem respiration (ER). GPP (or photosynthesis) involves the use of energy from sunlight to produce organic matter, using carbon dioxide and releasing oxygen in the process. ER involves the consumption of energy stored in organic matter, using oxygen, and releasing carbon dioxide in the process. The balance between these two components provides an indication of the net flows of energy in an ecosystem and can be represented as the difference between GPP and ER (referred to as net ecosystem metabolism, NEM) or the ratio of GPP:ER.

Ecosystems that produce more organic matter than is being consumed (i.e., GPP>ER) will either store or export organic matter, while ecosystems that consume more energy than is produced on-site (i.e., GPP<ER) require a source of organic matter from outside the system to maintain respiration rates. The latter situation is common in river ecosystems, where inputs of organic matter from upstream or the surrounding catchment are required to fuel metabolic activity in the river channel."

The unit of measure for ecosystem metabolism is g O_2 m^{-2} d^{-1} (grams of dissolved oxygen per square metre per day). Using ecosystem metabolism to assess the health of a water body must take into account factors affecting individual sites as well as seasonal variations, but can be summarised by the ratio of GPP to ER. To simplify the relationships, if GPP/ER is greater than one, a net addition of energy is occurring in the system, whereas if GPP/ER is less than one, the system is losing energy. The addition of energy to the system can potentially lead to undesirable environmental outcomes such as excessive macrophyte and algae growth. Conversely, a system losing energy can potentially lead to a reduction of macrophyte and algae levels. A GPP/ER value close to one would indicate a system in balance, while values significantly higher or lower than one would indicate potentially harmful effects that would need to be investigated on a site specific basis.

Dissolved oxygen, ecosystem metabolism and the National Objectives Framework

The National Policy Statement for Freshwater Management 2020 (NPS-FM) sets out requirements for councils and communities to maintain or improve freshwater (where it is degraded). It includes a National Objectives Framework (NOF) that specifies nationally applicable standards for particular water quality parameters (referred to as 'attributes').

Dissolved oxygen

Dissolved oxygen in rivers is one of those attributes and is closely related to the ecosystem metabolism attribute. Table 1 and Table 2 set out the NOF attribute criteria for dissolved oxygen in rivers and in rivers below point source discharges.

Table 1: NOF Attribute – Dissolved oxygen (rivers). Source: MfE (2020).

Value (and component)	Ecosystem health (Water quality)	
Freshwater body type	Rivers	
Attribute unit	mg/L (milligrams per litre)	
Attribute band and description	**Numeric attribute state**	
	7-day mean minimum	1-day minimum
A No stress caused by low dissolved oxygen on any aquatic organisms that are present at matched reference (near pristine) sites.	≥8.0	≥7.5
B Occasional minor stress on sensitive organisms caused by short periods (a few hours each day) of lower dissolved oxygen. Risk of reduced abundance of sensitive fish and macroinvertebrate species.	≥7.0 and <8.0	≥5.0 and <7.5
C Moderate stress on a number of aquatic organisms caused by dissolved oxygen levels exceeding preference levels for periods of several hours each	≥5.0 and <7.0	≥4.0 and <5.0

Value (and component)	Ecosystem health (Water quality)	
Freshwater body type	Rivers	
Attribute unit	mg/L (milligrams per litre)	
Attribute band and description	**Numeric attribute state**	
	7-day mean minimum	1-day minimum
day. Risk of sensitive fish and macroinvertebrate species being lost.		
National Bottom Line	**5.0**	**4.0**
D Significant, persistent stress on a range of aquatic organisms caused by dissolved oxygen exceeding tolerance levels. Likelihood of local extinctions of keystone species and loss of ecological integrity.	<5.0	<4.0
The 7-day mean minimum is the mean value of 7 consecutive daily minimum values. The 1-day minimum is the lowest daily minimum across the summer period (1 November to 30 April).		

Table 2: NOF Attribute – Dissolved oxygen (rivers, below point sources only). Source: MfE (2020).

Value (and component)	Ecosystem health (Water quality)	
Freshwater body type	Rivers (below point sources only)	
Attribute unit	mg/L (milligrams per litre)	
Attribute band and description	**Numeric attribute state**	
	7-day mean minimum	1-day minimum
A No stress caused by low dissolved oxygen on any aquatic organisms that are present at matched reference (near-pristine) sites.	≥8.0	≥7.5
B Occasional minor stress on sensitive organisms caused by short periods (a few hours each day) of lower dissolved oxygen. Risk of reduced abundance of sensitive fish and macroinvertebrate species.	≥7.0 and <8.0	≥5.0 and <7.5
C Moderate stress on a number of aquatic organisms caused by dissolved oxygen levels exceeding preference levels for periods of several hours each day. Risk of sensitive fish and macroinvertebrate species being lost.	≥5.0 and <7.0	≥4.0 and <5.0
National Bottom Line	**5.0**	**4.0**
D Significant, persistent stress on a range of aquatic organisms caused by dissolved oxygen exceeding tolerance levels. Likelihood of local extinctions of keystone species and loss of ecological integrity.	<5.0	<4.0
The 7-day mean minimum is the mean value of seven consecutive daily minimum values. The 1-day minimum is the lowest daily minimum across the whole summer period (1 November to 30 April).		

Ecosystem metabolism

No attribute bands have been set for ecosystem metabolism within the NPS-FM, and the method to calculate this metric is also yet to be certified and included in the list of material incorporated by reference as per Clause 1.8 (3). Table 3 sets out the criteria for the ecosystem metabolism attribute under the NPS-FM.

Table 3: NOF Attribute – Ecosystem metabolism. Source: MfE (2020).

Value (and component)	Ecosystem health (Ecosystem processes)
Freshwater body type	Rivers
Attribute unit	g O2 m-2 d-1 (grams of dissolved oxygen per square metre per day)
Attribute band and description	**Numeric attribute state**
Derived from at least 7 days of continuous dissolved oxygen monitoring to be collected at least once during the summer period (1 November to 30 April), using the method of Young RG, Clapcott JE, Simon K. 2016. Ecosystem functions and stream health. Advances in New Zealand Freshwater Science. NZ Freshwater Sciences Society, NZ Hydrological Society. (see clause 1.8)	

Monitoring of dissolved oxygen and ecosystem metabolism in the Taranaki region

Dissolved oxygen (regional)

The Taranaki Regional Council (TRC) receives data from nine permanent dissolved oxygen monitoring sites within the region. All of these monitoring sites are maintained by the TRC, with data being continuously recorded at an interval of 15 minutes, as per the National Environmental Monitoring Standard (NEMS) for Dissolved Oxygen (NEMS, 2016). In determining the appropriate dataset to inform baseline state, available site data was assessed for the best state against the options set out in the NPS-FM section 1.4(1).

Several sites that have been in place for less than 12 months (Piakau Stream at Airport Farms and Mangaehu River at the bridge) had their baseline states determined from within that period only. Although these sites have been in place for less than 12 months, they have been in operation across an entire summer period (1 November to 30 April) where specified monitoring for 1-day minimum dissolved oxygen is to occur. The length of the sample record for each monitoring site is displayed in Table 4.

Table 4: Length of sample record for dissolved oxygen monitoring sites.

FMU	Site	Monitoring start date	Summer period included in sample record	Length of sample record (months)
Coastal Terraces	Waitaha Stream at SH3	21/11/2018	Yes	54
	Mangati Stream at SH3	11/11/2016	Yes	79
Pātea	Patea River at Skinner Road	1/11/2016	Yes	79
	Piakau Stream d/s of Airport Farm	1/11/2022	Yes	7
	Piakau Stream u/s of Airport Farm	1/11/2022	Yes	7
	Mangaehu River at Bridge	1/11/2022	Yes	7
Volcanic Ringplain	Kaupokonui River at Glenn Road	6/03/2018	Yes	63
	Waingongoro River at SH45	1/11/2019	Yes	43
	Kapoaiaia Stream at Cape Egmont	1/12/2022	Yes	6

Dissolved oxygen (below point sources only)

A dissolved oxygen monitoring network for below point sources does not currently exist in Taranaki. A network will need to be developed to monitor dissolved oxygen below point sources in order to meet NPS-FM requirements. An inventory of discharges to water within the region has been compiled from consented discharge permits and is summarised in Table 5.

Table 5: Discharge permits by subtype within Taranaki.

Type	Subtype	N
Discharge Permit	Land/Water - Animal Waste	180
Discharge Permit	Land/Water - Earthworks	21
Discharge Permit	Land/Water Industry	93
Discharge Permit	Water - Animal Waste	291
Discharge Permit	Water - Cooling	9
Discharge Permit	Water - Earthworks	12
Discharge Permit	Water - Industry	48
Discharge Permit	Water - Misc	10
Discharge Permit	Water - Stormwater	135
Discharge Permit	Water to Water	9
Total		808

Further investigations to determine the order of significance amongst discharges to water are underway in order prioritise dissolved oxygen monitoring below point sources. Discharges to water for the animal waste sub-type are primarily from dairy farming. Discharges to the land/water subtype will require further investigation to determine what proportion of the total discharge is to water, as opposed to land.

The State of New Zealand's Environment 1997 report (MfE, 1997) identified the major point sources in New Zealand as sewage treatment plants, industrial vegetable or meat processing, dairy sheds, piggeries, septic tanks, and stock stream "crossings". In Taranaki priority should be given to industrial and municipal point source discharges as these consents usually contain conditions which require discharge quality and quantity data to be provided, which can assist to characterise the nutrient loads in the discharge. Some discharges such as storm water and discharges of water to water will generally not require monitoring in relation to this attribute, as these types of discharges do not fit the standard criteria of a point source discharge that the attribute is tailored towards (i.e. a continuous discharge of wastewater from a designated outlet).

Following the establishment of a baseline monitoring network for dissolved oxygen below point sources, setting limits and actions will require an understanding of all of the drivers of low dissolved oxygen below point sources. However, management actions may include setting discharge limits within consent conditions, having regard to 'reasonable mixing' zones below the point source.

Where numerous consent holders are discharging to water at lower rates, but at a combined level that is significant within a defined catchment or sub catchment area, a single dissolved oxygen meter below these combined point sources may be more appropriate. In this situation the costs of a dissolved oxygen meter and its associated monitoring could be divided amongst relevant consent holders.

Ecosystem metabolism

The nine existing dissolved oxygen monitoring sites are recording the necessary data for assessing ecosystem metabolism; noting however, that the monitoring network has not been designed specifically for this purpose. Appropriate methods for further processing of the existing continuous dissolved oxygen monitoring data are currently being implemented by TRC in order to enable calculation of gross primary production and ecosystem respiration.

The current unaudited data used to determine interim dissolved oxygen baselines is not suitable for calculating ecosystem metabolism at this time, as a large amount of data with a minimum time series interval is required to be entered. When data processing is complete this document will be updated with the relevant ecosystem metabolism baselines and associated data values.

A review of the current dissolved oxygen monitoring network is being undertaken as part of a review of the overall freshwater SoE monitoring programme. This review aims to improve monitoring coverage to achieve better representation of sites across the region.

Baseline states for dissolved oxygen and ecosystem metabolism

The NPS-FM requires all regional councils to identify baseline states for all attributes described in Appendix 2A and 2B of the NPS-FM within each Freshwater Management Unit (FMU). When compared against national bottom lines and the relevant objectives for an FMU, baselines provide the reference point from which councils must either maintain or improve an attribute, which in turn will contribute toward achieving freshwater objectives for each compulsory and non-compulsory value. Waterbodies must not be allowed to degrade, or remain below an identified baseline state unless that state is determined to be naturally occurring. If a waterbody is already at or below the national bottom line, then it must be improved to either achieve the national bottom line or better.

The baseline state is defined in Clause 1.4 (1) of the NPS-FM as the attribute's best state out of the following:

a) the state of the attribute on the date it is first identified by a regional council under Clause 3.10(1)(b) or (c)

b) the state of the attribute on the date on which a regional council set a freshwater objective for the attribute under the National Policy Statement for Freshwater Management 2014 (as amended in 2017)

c) the state of the attribute on 7 September 2017

The Council has not previously set freshwater objectives under the NPS-FM 2014 (as amended in 2017) for dissolved oxygen, so the state of the dissolved oxygen attributes under Clause 1.4 (b) could not be calculated and was excluded. Therefore the best state out of Clause 1.4 (a) and (c) were used to identify the baseline state for each of the dissolved oxygen attribute criteria.

Under Clause 1.6 of the NPS-FM, local authorities must use the best information available at the time (and if practicable, using complete and robust data) to give effect to the NPS-FM. In the absence of complete and robust data, the best information available should be use which may include modelling, partial data, and local knowledge, and preferably use sources that provide the greatest level of certainty (or take all practicable steps necessary to reduce uncertainty).

Under the NPS-FM, dissolved oxygen and ecosystem metabolism attributes are associated with the Ecosystem Health value, which is a compulsory value within the NOF (NPS-FM, Appendix 1A). Dissolved oxygen (below point sources) is included in the NOF as an Appendix 2A attribute, requiring the setting of limits, while dissolved oxygen (regional) and ecosystem metabolism are Appendix 2B attributes and require the development of action plans. It is necessary for baseline states to be identified by TRC for the Taranaki region to ensure that target attribute states for all dissolved oxygen criteria are set at a level that either achieve or exceed the best baseline state for that attribute and (at a minimum) achieve the national bottom line.

The remainder of this memo summarises the monitoring and work carried out by TRC to identify baseline states for dissolved oxygen in the region's rivers. Currently there is insufficient data to identify baseline states for dissolved oxygen below point source discharges and ecosystem metabolism, however, these are discussed further in terms of developing monitoring networks, and processing data to enable assessment of these attributes in the near future.

Criteria for identifying baseline states

Data used for determining these draft baseline states was unaudited. This means that sudden dissolved oxygen fluctuations referred to as "noisy data" may be affecting some values. The cause of this is well known, as dissolved oxygen sensors without automatic cleaning features require (and receive) physical cleaning to remove algal growth every two weeks. Within those two weeks however, algal levels can build up enough to influence results.

As the dissolved oxygen data was not able to be audited at the time of writing this memorandum, it was unable to be used for calculating ecosystem metabolism values which is discussed further in that section. The raw dissolved oxygen data used for each monitoring site are shown in Appendix I and Appendix II.

Dissolved oxygen data is currently being processed and this document will be updated once complete.

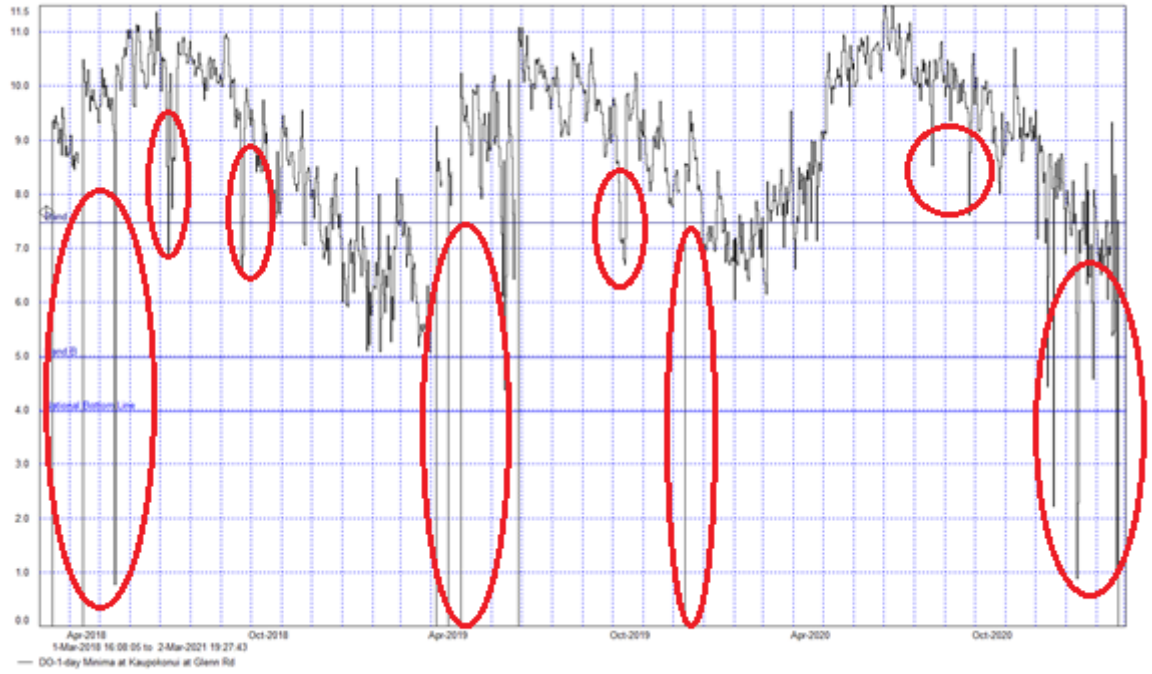

Figure 1: Unaudited dissolved oxygen data used for determining 1-day minimum at the Kaupokonui at Glenn Rd site showing examples of "noisy" data.

Site-based baseline states

An assessment of site-based baseline state is presented below in Table 6 and Figure 1. These results are also summarised by FMU in Table 7 and Table 8.

The results show that dissolved oxygen concentrations at seven out of the nine sites included in this assessment remain above the national bottom line (band D). Two sites, in the Mangati and Waitaha Streams, recorded minimum dissolved oxygen concentrations that fell below the national bottom line for at least one of the 1-day minima and 7-day mean minima criteria. These two monitoring stations are positioned downstream of two of the largest industrial zones in the Taranaki region. It is possible that discharges from sites in these areas are having an influence on dissolved oxygen concentrations in these streams.

The Kaupokonui River at Glenn Road had the next lowest assessment of dissolved oxygen state; graded in band C for the 7-day mean minimum, and band B for 1-day minimum. This site is located in the lower reaches of a large agricultural catchment. The Pātea River at Skinner Road had the same grades, with slightly higher

minima recorded. This monitoring station is located in the middle reach of a large agricultural catchment, and is also downstream from three industrial discharges.

The baseline state at the remaining sites fell between band B and band A. These monitoring stations were positioned in a variety of locations around the region, including both upper and lower catchment sites.

Notably, dissolved oxygen monitoring coverage only extends to the Coastal Terraces, Pātea and Volcanic Ringplain FMUs. As such, an assessment of dissolved oxygen baseline state in the Northern Hill Country, Waitara and Southern Hill Country FMUs was not possible.

Table 6: Site-based baseline state assessments for dissolved oxygen

FMU	Site name	7-day mean minimum			1-day minimum		
		DO (mg/L)	Record date	NOF grade	DO (mg/L)	Record date	NOF grade
Coastal Terraces	Waitaha Stream at SH3	1.3	8/03/2019	**D**	0.35	26/04/2022	**D**
	Mangati Stream at SH3	4.95	31/03/2017	**D**	4.35	28/01/2017	**C**
Pātea	Patea River at Skinner Road	6.00	22/12/2016	**C**	5.22	23/12/2016	**B**
	Piakau Stream d/s of Airport Farm	8.03	2/12/2022	**A**	7.23	27/11/2022	**B**
	Piakau Stream u/s of Airport Farm	8.67	4/02/2023	**A**	8.41	22/01/2023	**A**
	Mangaehu River at Bridge	8.35	20/01/2023	**A**	8.09	21/01/2023	**A**
Volcanic Ringplain	Kaupokonui River at Glenn Road	5.49	22/03/2019	**C**	5.09	1/02/2019	**B**
	Waingongoro River at SH45	7.34	19/02/2020	**B**	6.44	4/01/2023	**B**
	Kapoaiaia Stream at Cape Egmont	7.65	3/02/2023	**B**	7.19	6/02/2023	**B**

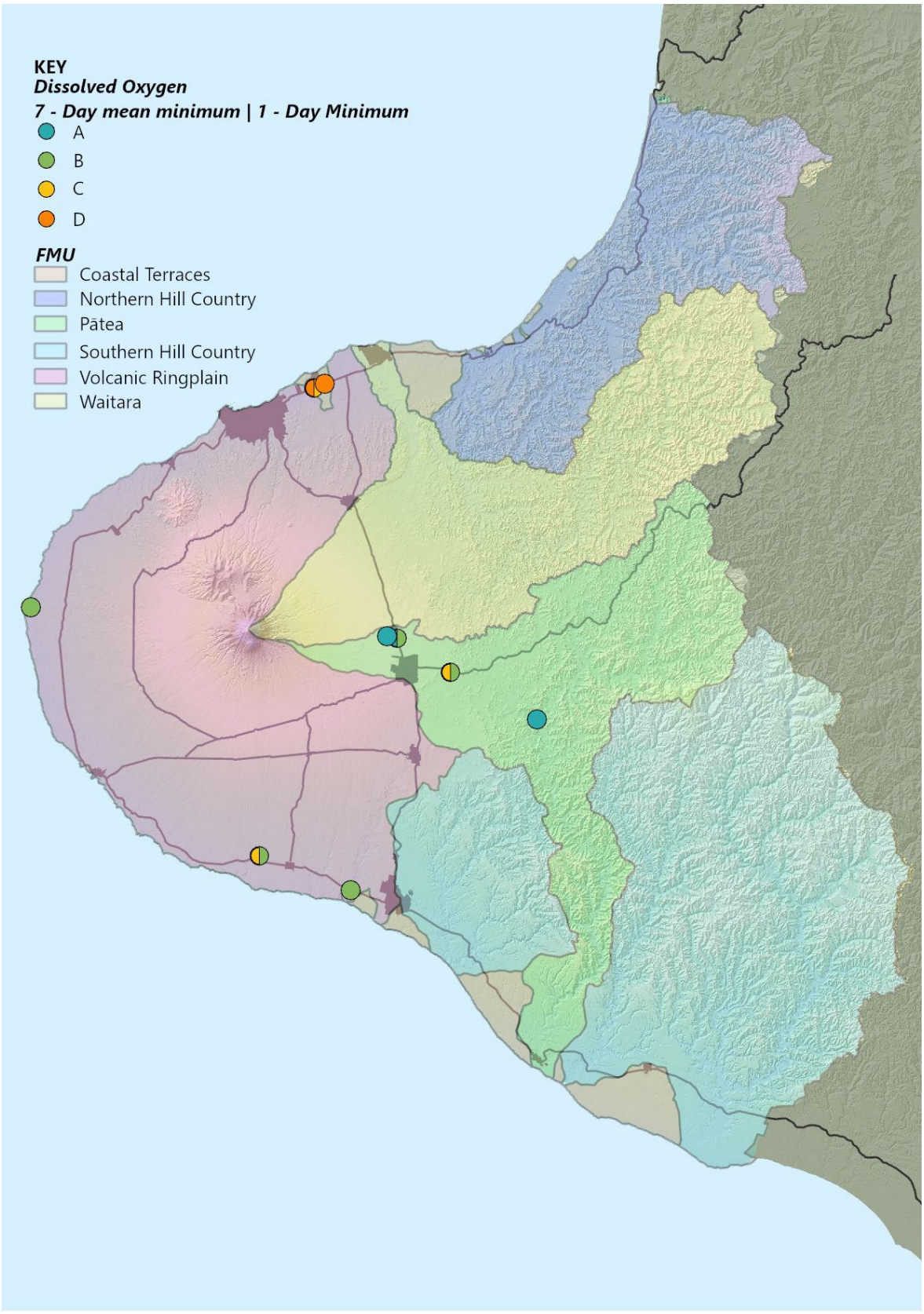

Figure 2: Site-based baseline state for dissolved oxygen (7-day mean minimum and 1-day minimum)

Table 7 and Table 8 show the proportion of sites in each attribute band, for dissolved oxygen 7-day mean minima and 1-day minima. While both sites in the Coastal Terraces were graded in the D band for at least one criteria, it is important to note that these sites may not be suitably representative of the wider FMU, given that they are located downstream of two large industrial zones which is not characteristic of the rest of the FMU. In the Pātea FMU, the baseline grades (ranging from A to C) reflect sites that positioned in upper and mid-catchment locations, with different degrees of pressure from land use and industrial discharges. In the Volcanic Ringplain, all three sites are graded between the B and C bands, which is indicative of the cumulative effects of land use and discharges, given that all three are located at the bottom of their respective catchments.

Table 7: Dissolved oxygen 7-day mean minimum NPS-FM baseline categories by FMU (proportion of sites shown in brackets).

FMU	NOF band by FMU (Dissolved oxygen) 7-day mean minimum				
	A	B	C	D	Total
Southern Hill Country	0	0	0	0	0
Coastal Terraces	0	0	0	2 (1.00)	2
Pātea	3 (0.75)	0	1 (0.25)	0	4
Volcanic Ringplain	0	2 (0.67)	1 (0.33)	0	3
Waitara	0	0	0	0	0
Northern Hill Country	0	0	0	0	0
Total	3 (0.33)	2 (0.22)	2 (0.22)	2 (0.22)	9

Table 8: Dissolved oxygen 1-day minimum NPS-FM baseline categories by FMU (proportion of sites shown in brackets).

FMU	NOF band by FMU (Dissolved oxygen) 1-day minimum				
	A	B	C	D	Total
Southern Hill Country	0	0	0	0	0
Coastal Terraces	0	0	1 (0.50)	1 (0.50)	2
Pātea	2 (0.50)	2 (0.50)	0	0	4
Volcanic Ringplain	0	3 (1.00)	0	0	3
Waitara	0	0	0	0	0
Northern Hill Country	0	0	0	0	0
Total	2 (0.22)	4 (0.44)	1 (0.11)	2 (0.22)	9

Baseline period and temporal state variability

The NPS-FM specifies that dissolved oxygen must be measured continuously between 1 November and 30 April in order for the data to be assessed against the dissolved oxygen NOF attribute. All sites, except for Kapoaiaia Stream at Cape Egmont, have data records that span at least one specified summer period. There is continuous dissolved oxygen data available from Kapoaiaia Stream since 1 December 2022; one month less than is required by the NPS-FM. However, it is considered to be best available data as required under Clause 1.6, and as such it has been used to inform baseline state.

Although the NPS-FM prescribes the seasonal range that this dissolved oxygen attribute is to be monitored during, it doesn't specify how many seasons the baseline period should comprise in order to assess state. All available dissolved oxygen data has been considered here, with 7-day mean minima, and 1-day minima selected from the entire data record at each site. However, any data that was recorded prior to 7 September 2017, has been considered separately, in accordance with Clause 1.4.

This baseline assessment has selected data that demonstrates the best state of the baseline periods defined in the NPS-FM. It should be noted that the TRC did not set freshwater objectives for this dissolved oxygen attribute, and therefore sub-clause 1.4(b) is not applicable. Furthermore, Pātea River at Skinner Road, and Mangati Stream at State Highway 3 are the only two sites with monitoring records that started prior to 7 September 2017. Therefore, the baseline period that was selected for the remaining sites was, by default, the date at which dissolved oxygen state was first identified (sub-clause 1.4(a)). For Pātea River, and the Mangati Stream, the best state was selected from two time periods; the full data record, and data recorded only prior to 7 September 2017. At both sites, the best state was identified based on the data recorded prior to 7 September 2017, and as such, the baseline state for these sites was identified in accordance with sub-clause 1.4(c).

A complete assessment of minimum dissolved oxygen values from the entire data record at each site will be included in an updated version of this memorandum once the data auditing process has been completed.

Freshwater Management Unit (FMU) coverage and representativeness

Dissolved oxygen

Monitoring data provides a direct measurement of water quality parameters, and therefore it is the preferred method for assessing environmental state due to its accuracy and certainty. However, attempting to evaluate state at the FMU or region-wide scale using site based monitoring data introduces site selection biases. This can result in under- or over-representation of rivers with certain characteristics.

Monitoring of dissolved oxygen is currently undertaken at nine sites across the Coastal Terraces, Pātea and Volcanic Ring Plain FMUs. The Southern Hill Country, Northern Hill Country and Waitara FMU's however, have no monitoring and require sites to be installed.

Representativeness within FMU's is limited, with sites in the Coastal Terraces FMU being confined to industrial areas. The Volcanic Ringplain FMU is lacking upper catchment sites, while the Pātea FMU lacks sites in the lower catchment.

Spatial modelling is a useful tool that can be used to help 'fill the gaps' between monitoring sites, and make predictions of water quality based on the catchment characteristics and land use. Modelling of dissolved oxygen (mg/L) has been investigated in previous New Zealand studies outside of Taranaki, with the variables temperature, flow, and chlorophyll-*a* being the best predictors in a study by Graham and Franklin (2017). The TRC does not currently have monitoring sites where these three variables are continuously monitored. Known distributions of freshwater fish were considered as a possible way to model dissolved oxygen within the region based on their unique tolerances to dissolved oxygen levels. This was ruled out however, as tolerances to dissolved oxygen for all species were below D band (Franklin, 2014). Therefore, modelling has not been pursued for the dissolved oxygen attribute within Taranaki at this point in time.

Recommendations

Interim baseline states have been calculated from unaudited data for monitoring sites, to identify the best known state for dissolved oxygen as an indicator of ecosystem health across each FMU. Data and associated attribute bands presented in this report are to be revised and updated if necessary when data auditing is complete.

Baseline state has not yet been determined for dissolved oxygen below point source discharges as the monitoring network for this is currently under development. Baseline states will be identified once the monitoring network is established and sufficient data has been collected.

Baseline state has not yet been determined for ecosystem metabolism, as the auditing of dissolved oxygen data to meet the requirements for this attribute is still in progress. Attribute bands for ecosystem metabolism have also not been stated within the NPS-FM at the time of writing this memorandum. As data auditing is completed and attribute bands are set, baseline state for ecosystem metabolism will be determined, and this memorandum will be updated.

Target attribute states will need to be set at a level that (at a minimum) achieves the best baseline state identified for each monitoring site, or exceeds the baseline state where this is necessary to achieve improvement. Further data and modelling would be required for both dissolved oxygen and ecosystem metabolism, if target states were to be set at broader spatial scales (e.g. at catchment or FMU scale) in addition to monitoring sites. The Council will investigate this option as part of the target setting process.

To support the target setting process, possible actions and mitigations that are available to promote the maintenance and improvement of freshwater in relation to dissolved oxygen and ecosystem metabolism (and ecosystem health more broadly) must be identified and assessed. This work is currently underway, with a range of contaminant source models under development to assess the impact of various mitigation actions on in-stream concentrations of nitrogen, phosphorous, sediment and *E. coli*. As an extension of this modelling, consideration should be given to the contaminant load reductions that are necessary to maintain or improve dissolved oxygen concentrations.

The SCAMP (Simplified Contaminant Allocation Modelling Platform) model that is being developed for Taranaki by LWP Ltd and RMA Science Ltd will help to assess the impacts of a range of mitigation scenarios on nutrient concentrations in rivers and streams (Cox et al., 2022). The existing mitigations that are already being investigated include the completion of riparian fencing and planting throughout the region, and redirecting all dairy effluent discharges from water to land. Further scenarios are also being considered, including implementation of other mitigation actions associated with good farm management practise, as well as a range of possible future mitigation measures. Considering a broad range of possible mitigation actions for improving water quality will help to inform the target setting process by providing an indication of what can realistically be achieved under different scenarios.

Finally, additional river monitoring sites will need to be established in order to achieve monitoring coverage in all FMUs, and appropriate representativeness across the region.

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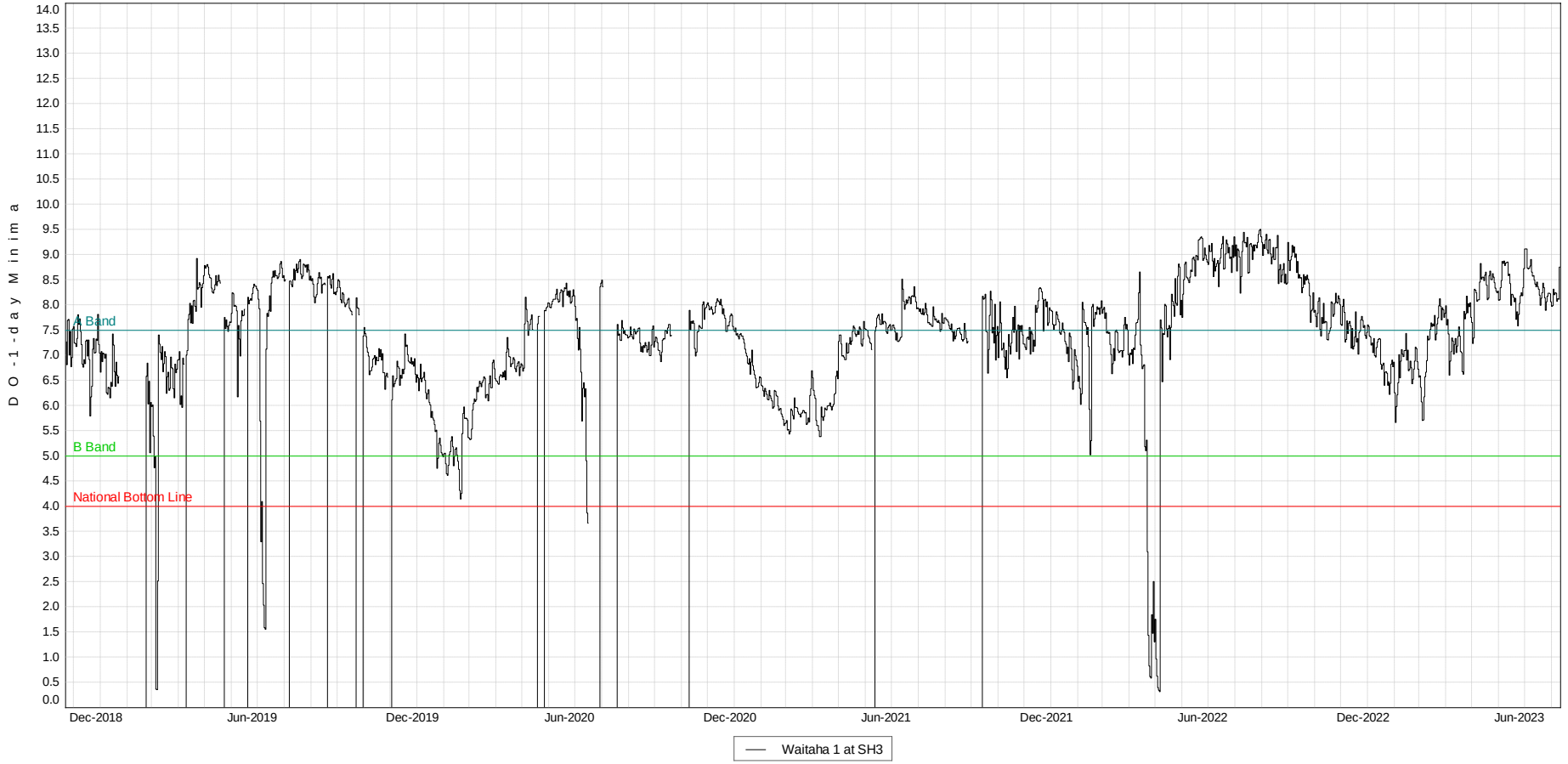
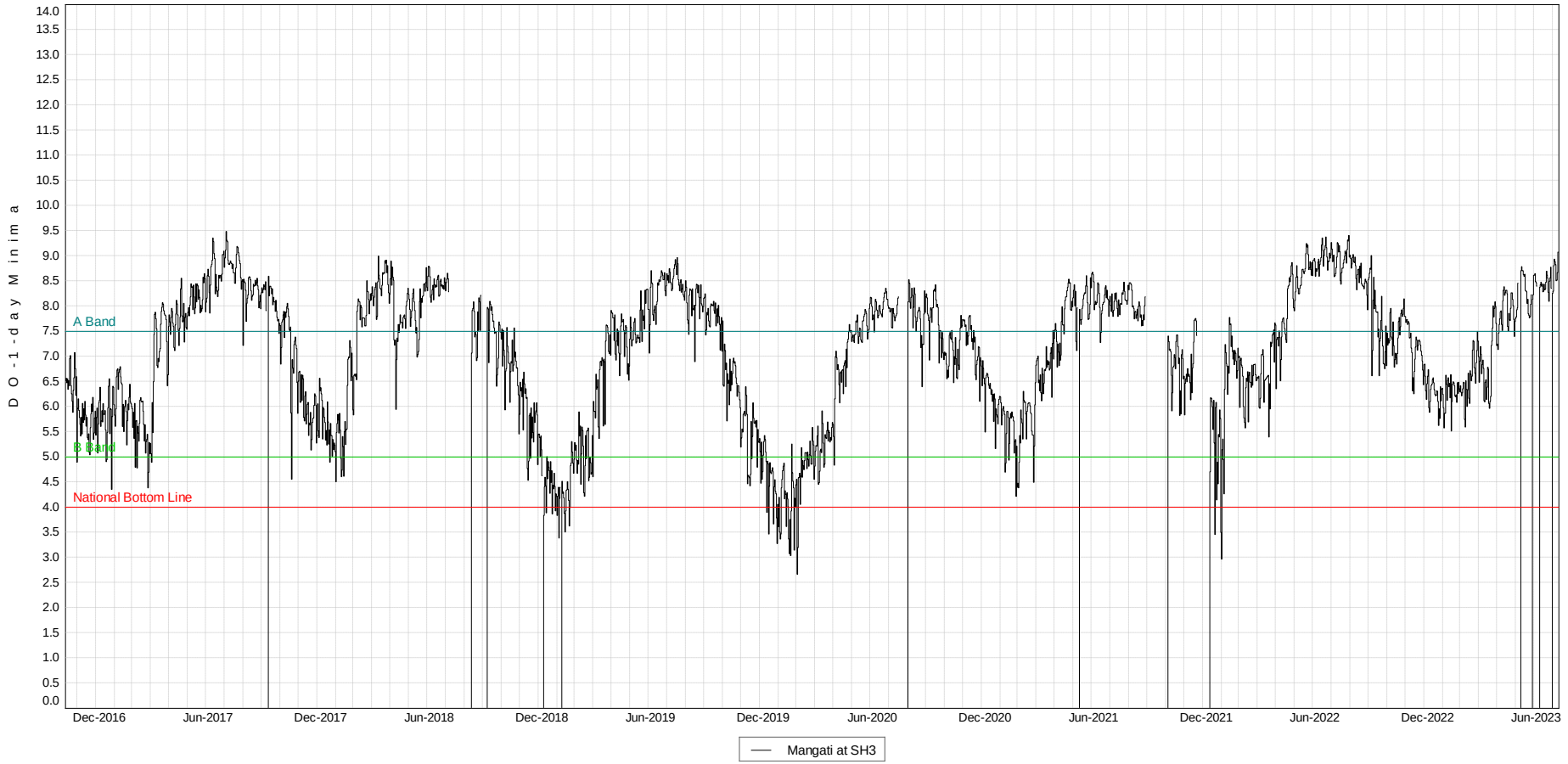
APPENDIX I Raw dissolved oxygen 1-day minimum plots of the current monitoring sites in Taranaki

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A Band
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National Bottom Line
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Jun-2021
Dec-2021
Jun-2022
Dec-2022
Jun-2023
Mangati at SH3


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A Band
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National Bottom Line
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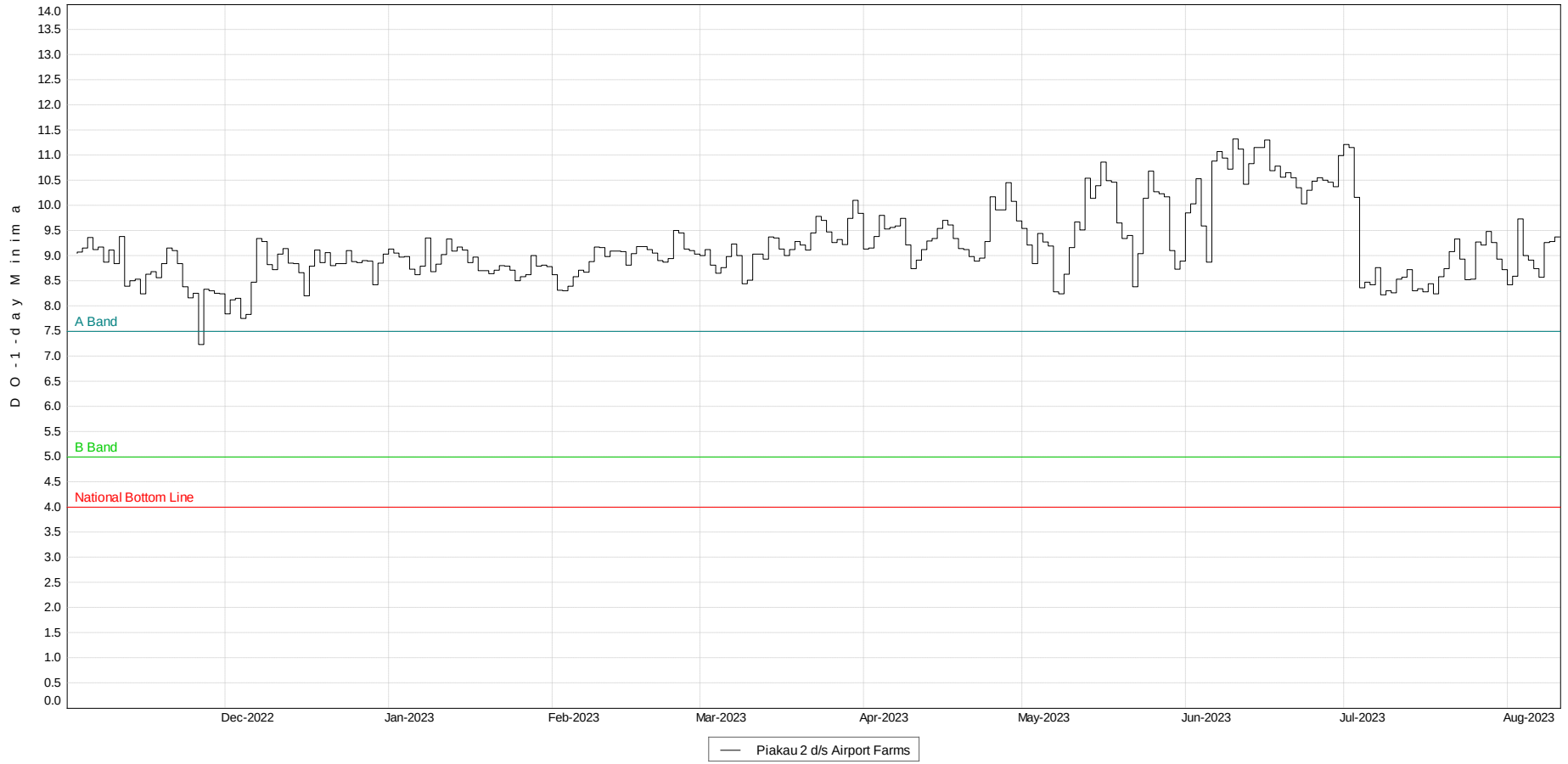
Patea at Skinner Rd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A Band
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National Bottom Line
Dec-2022
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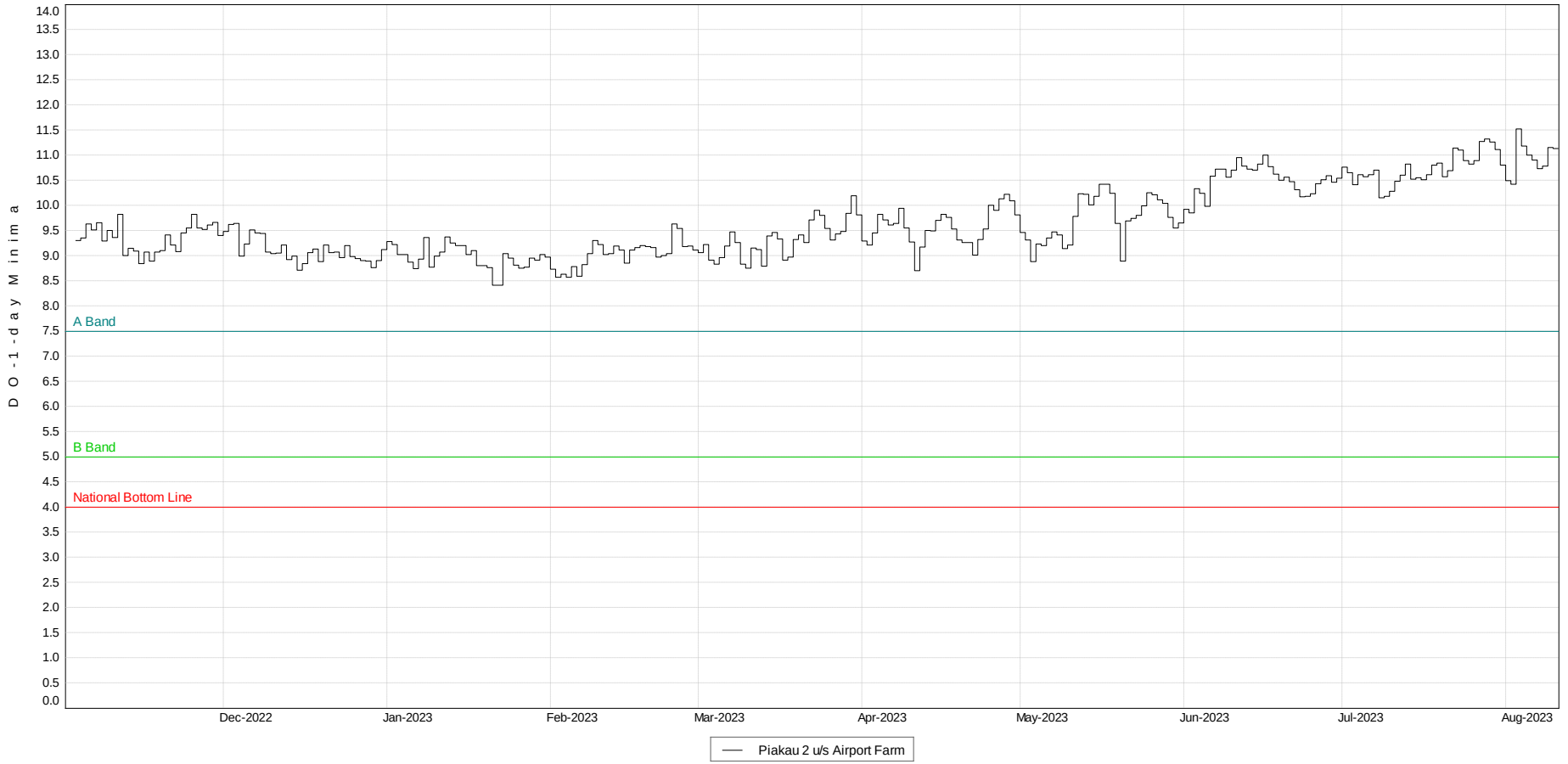
Piakau 2 d/s Airport Farms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A Band
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National Bottom Line
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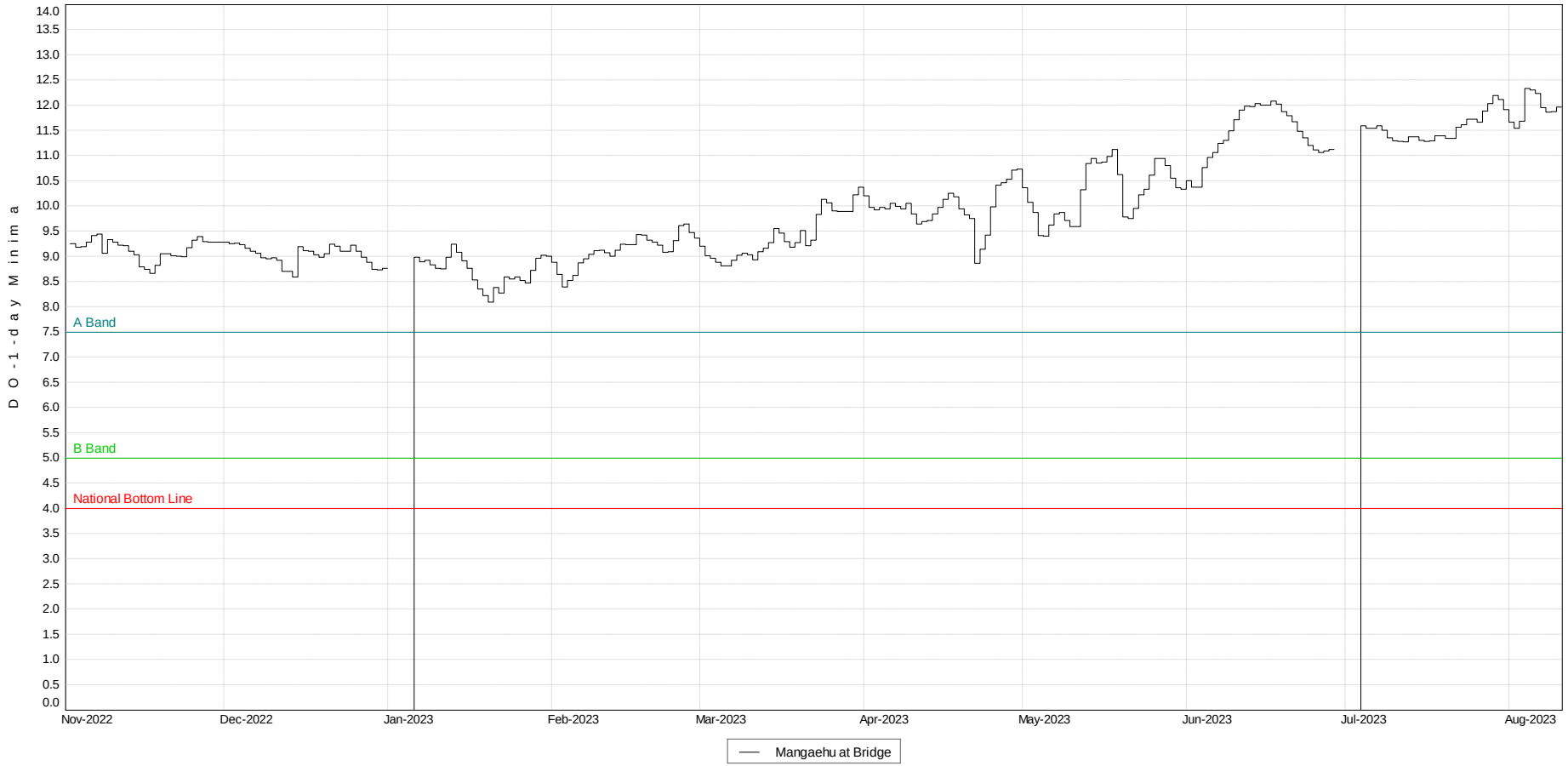
Aug-2023
Piakau 2 u/s Airport Farm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A Band
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National Bottom Line
Nov-2022
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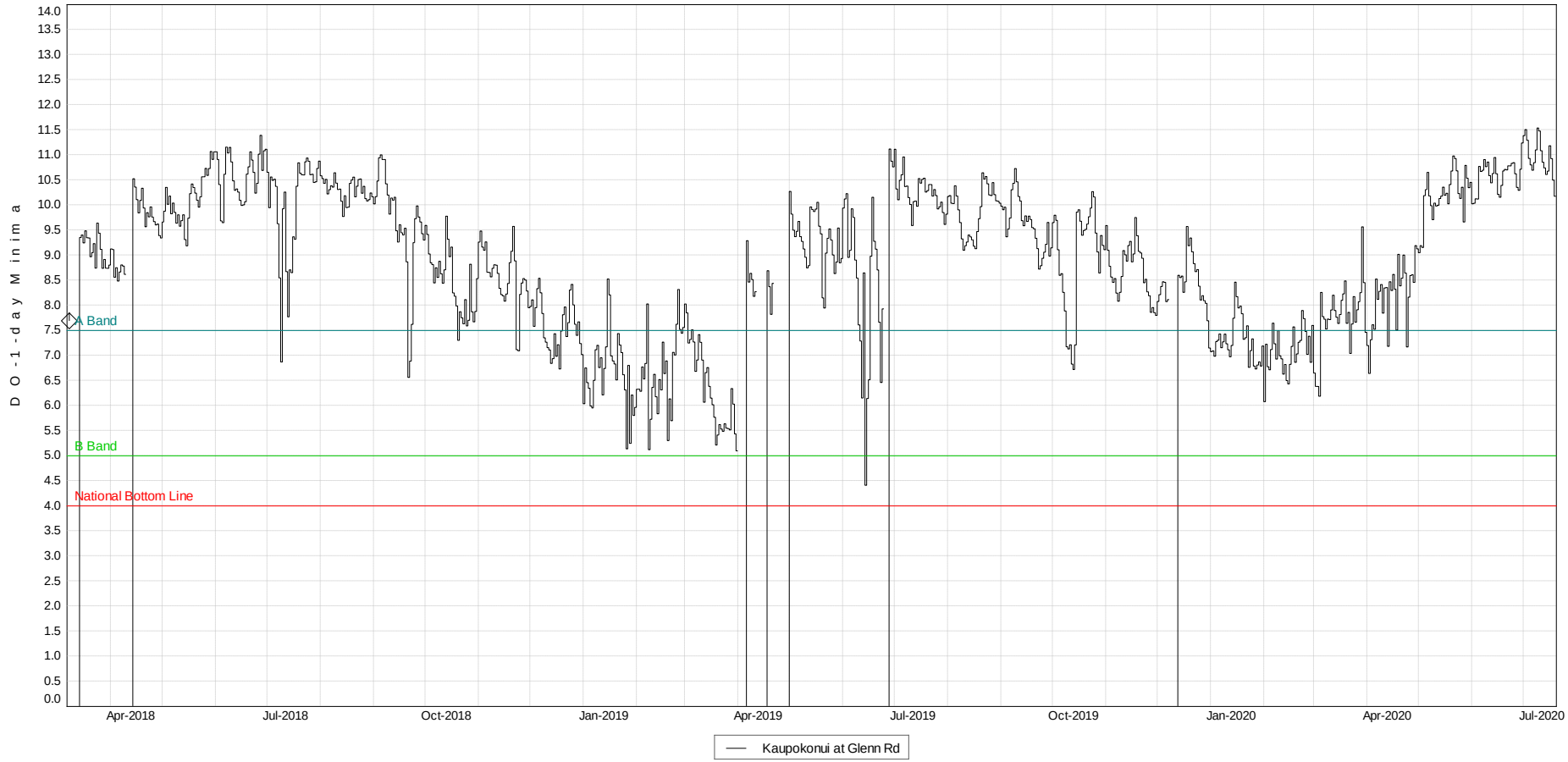
Mangaehu at Bridge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A Band
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National Bottom Line
Apr-2018
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Kaupokonui at Glenn Rd


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A Band
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National Bottom Line
Nov-2019
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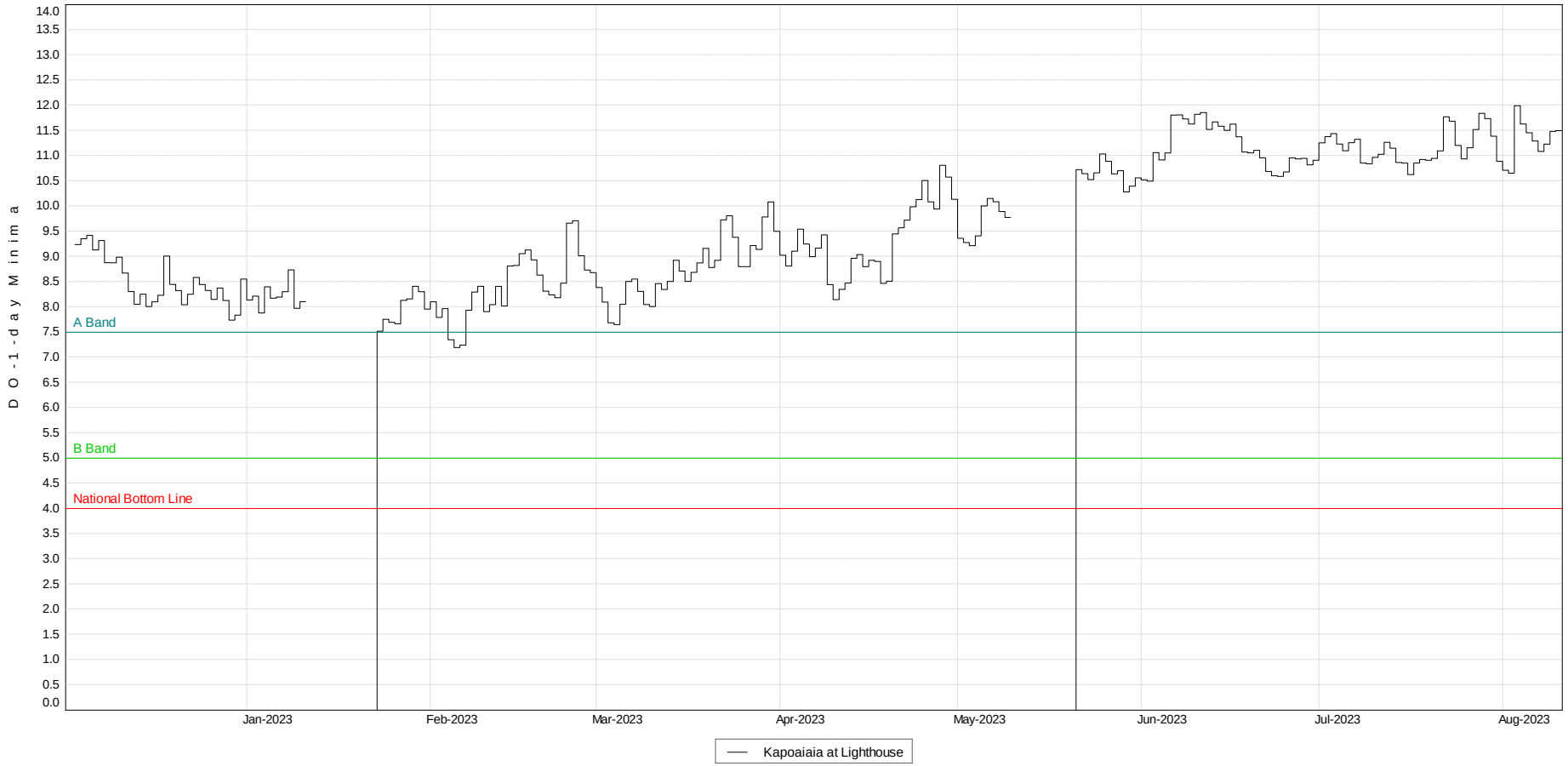
Nov-2022
May-2023
Waingongoro at SH45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A Band
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National Bottom Line
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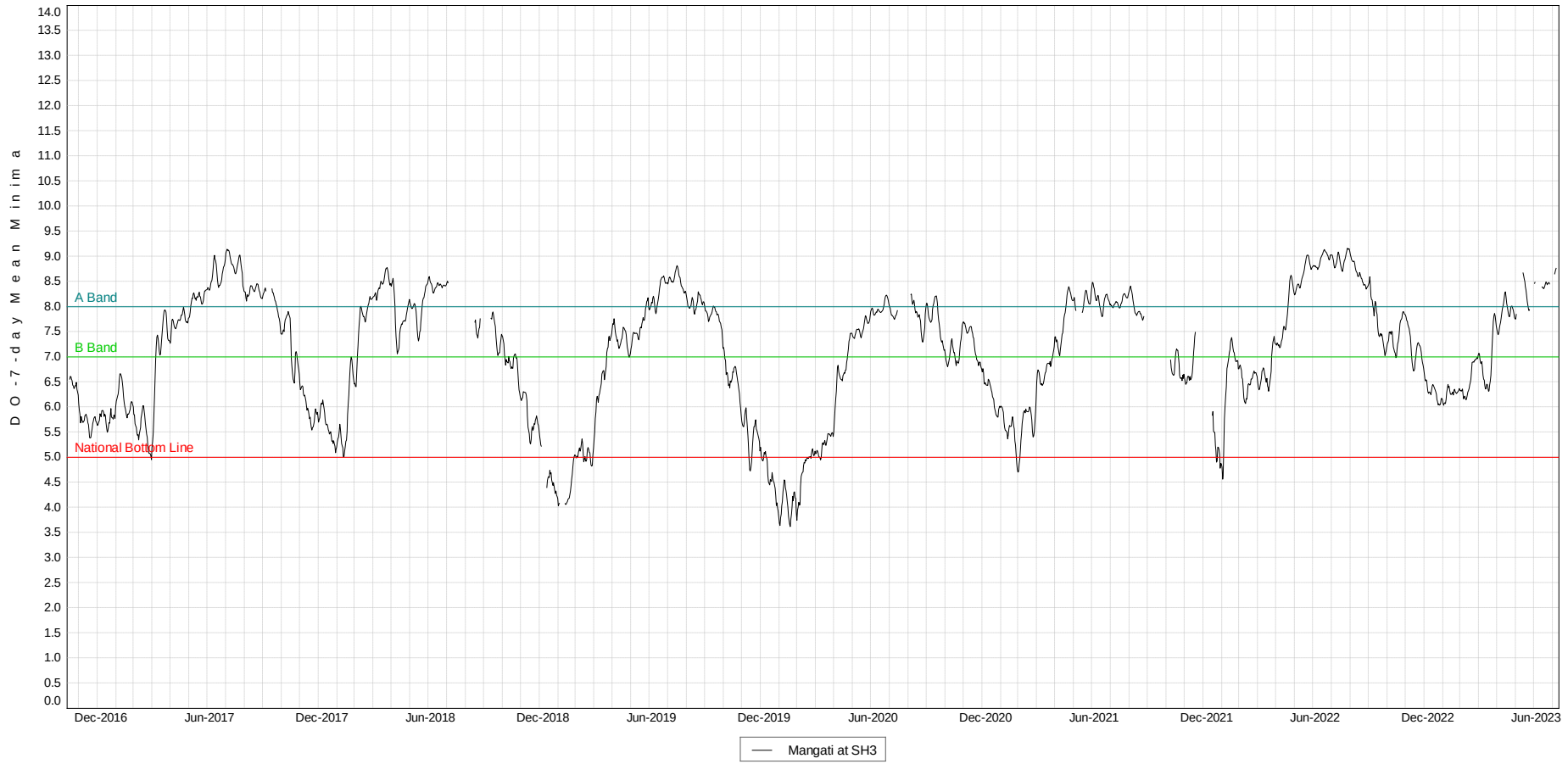
Kapoaiaia at Lighthouse

APPENDIX II Raw dissolved oxygen 7-day mean minimum plots of the current monitoring sites in Taranaki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A Band
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National Bottom Line
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Dec-2022
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Mangati at SH3


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A Band
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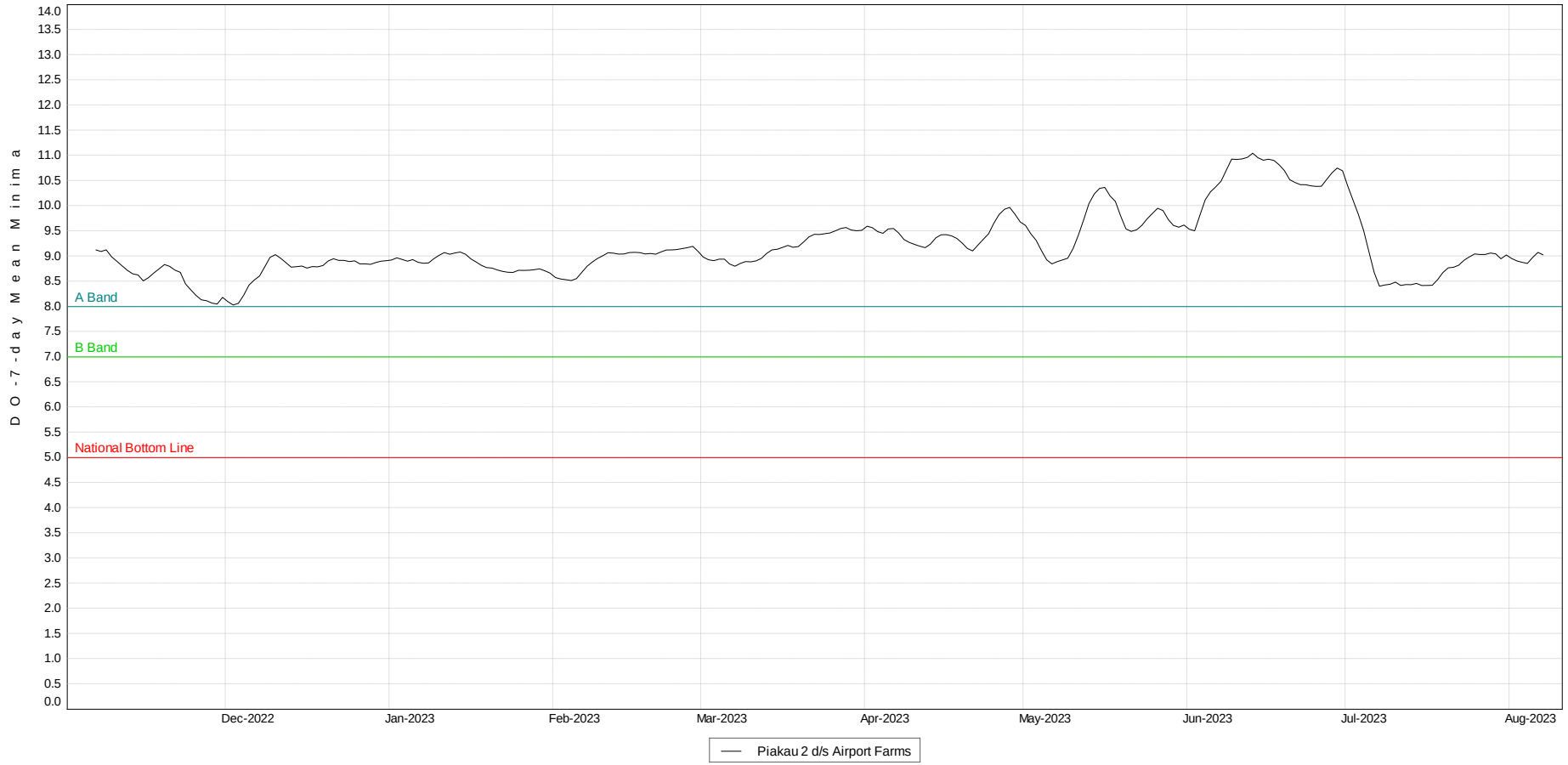
Patea at Skinner Rd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A Band
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National Bottom Line
Dec-2022
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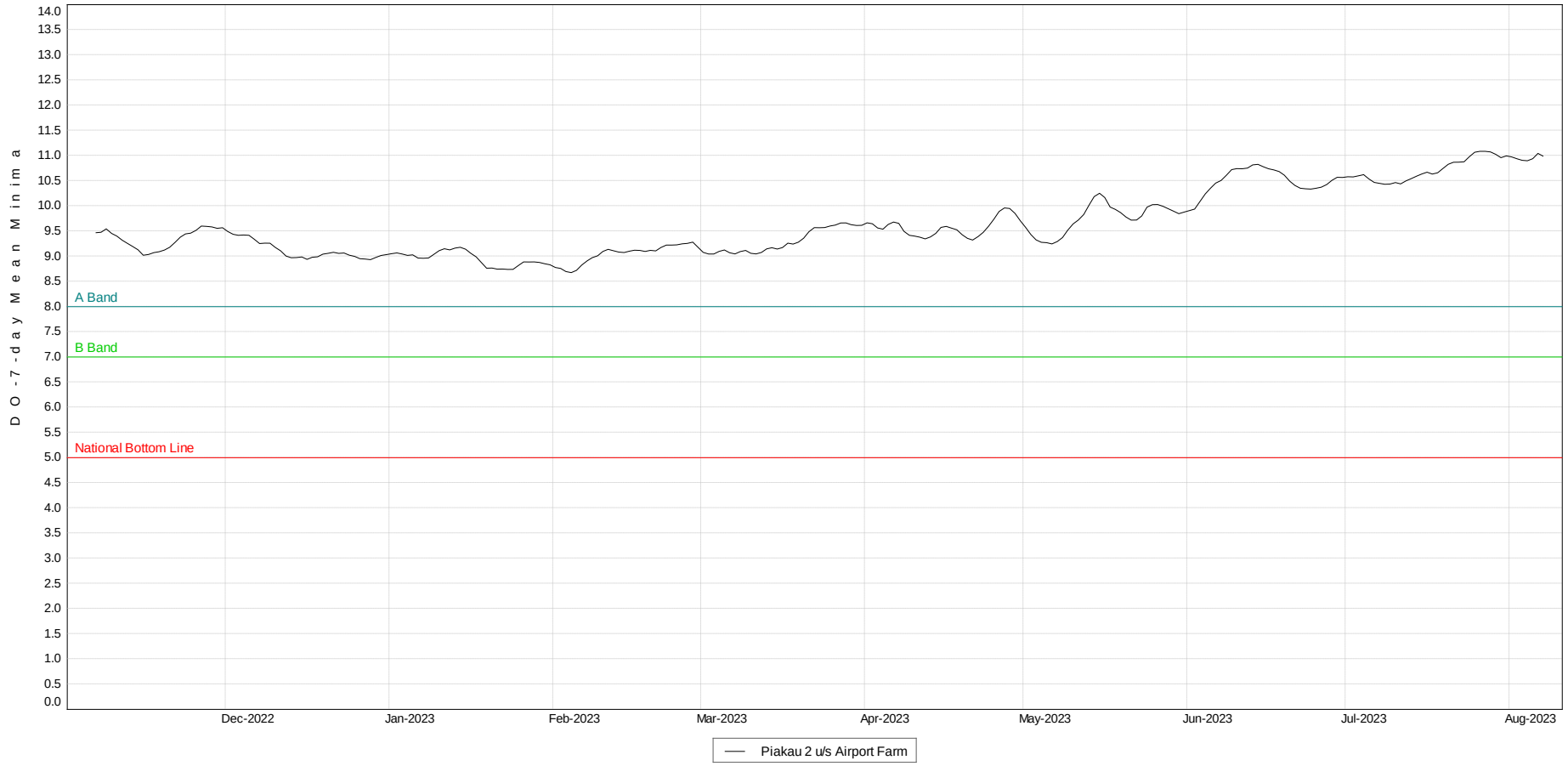
Piakau 2 d/s Airport Farms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A Band
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National Bottom Line
Dec-2022
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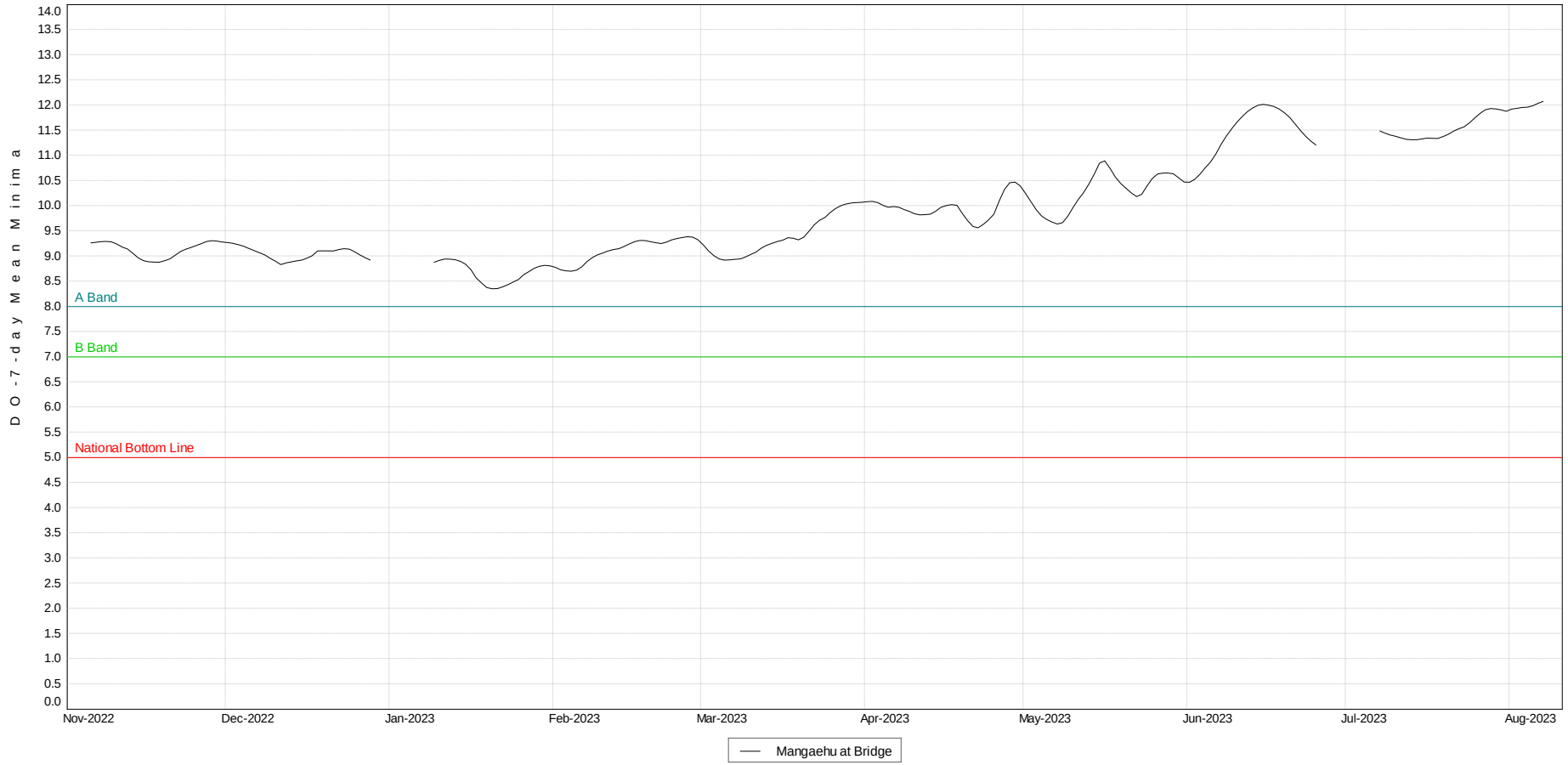
Aug-2023
Piakau 2 u/s Airport Farm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A Band
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National Bottom Line
Nov-2022
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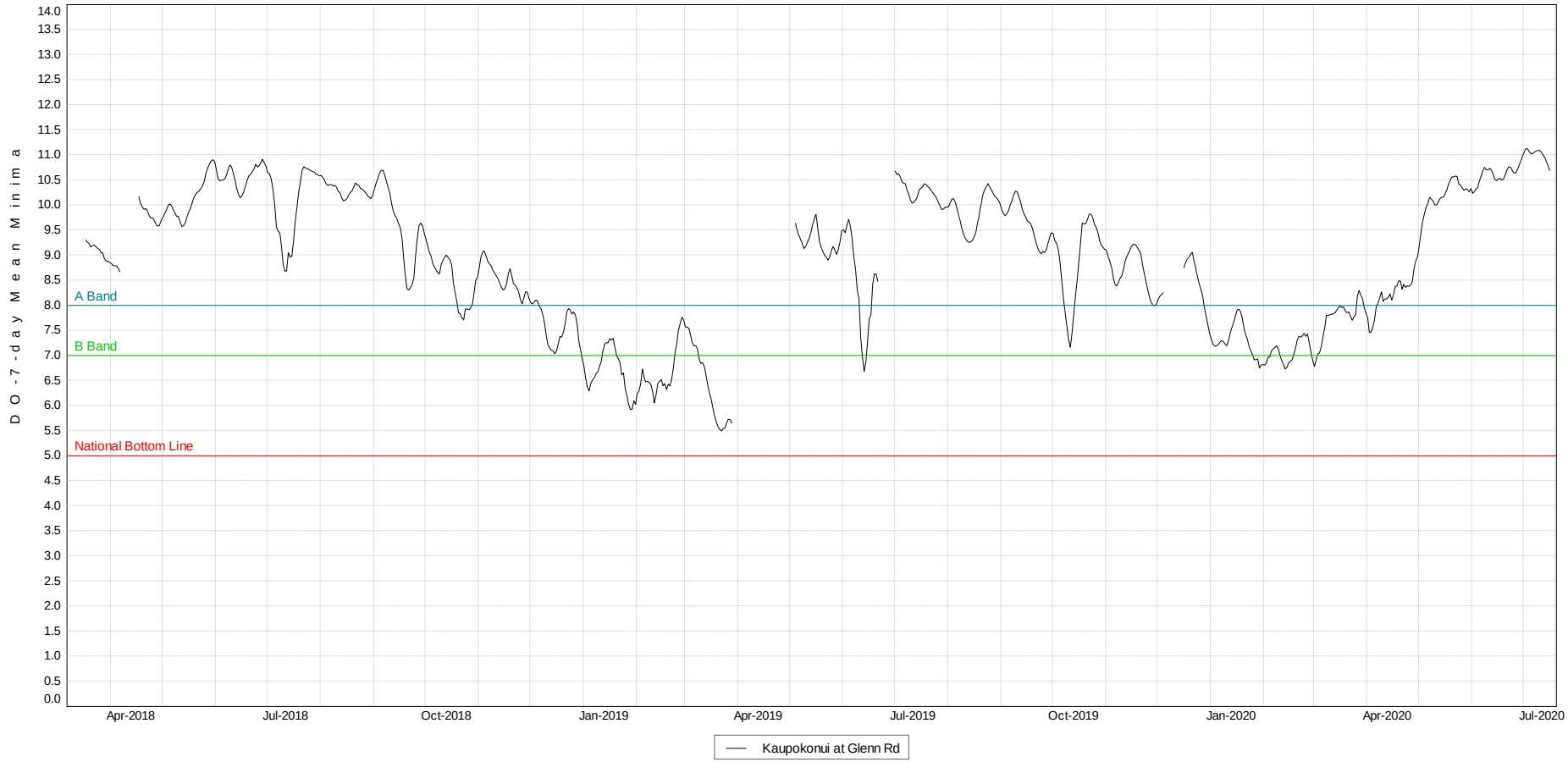
Mangaehu at Bridge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A Band
B Band
National Bottom Line
Apr-2018
Jul-2018
Oct-2018
Jan-2019
Apr-2019
Jul-2019
Oct-2019
Jan-2020
Apr-2020
Jul-2020
Kaupokonui at Glenn Rd


D O - 7 - d a y M e a n M i n i m a
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A Band
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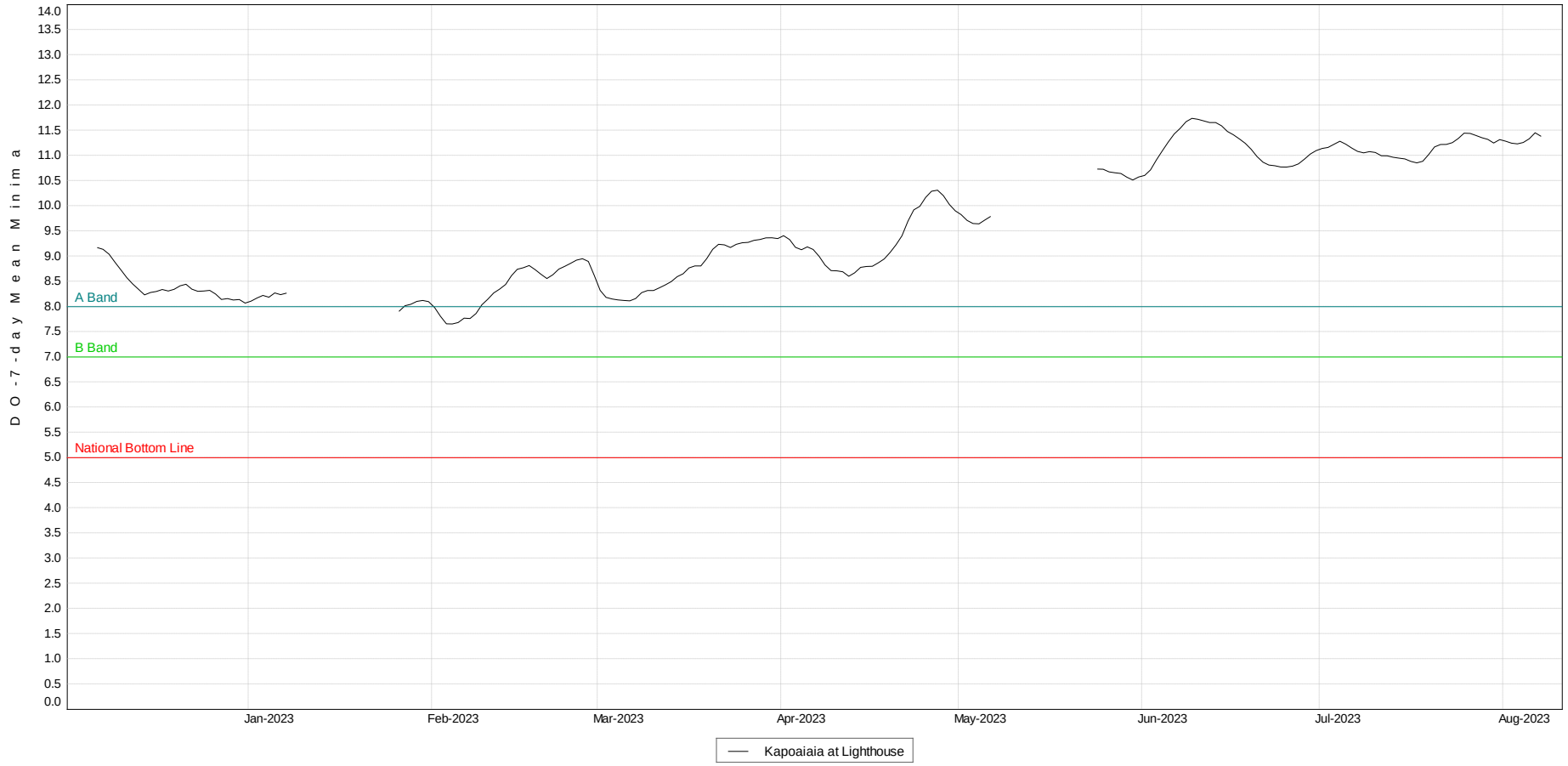
May-2022
Nov-2022
May-2023
Waingongoro at SH45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A Band
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National Bottom Line
Jan-2023
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Aug-2023
Kapoaiaia at Lighthouse